Research on credit evaluation of enterprises in supply chain finance business

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Abstract: As a crucial link in the survival and development of enterprises nowadays, supply chain finance covers all aspects of enterprises and financial institutions. This study is dedicated to using techniques such as big data mining, mathematical modeling, industry standard definition and visualization analysis to apply the relationship between enterprises and each enterprise into a weighted directed network, determine credit rating weights using entropy weight method and TOPSIS, and monitor the information changes of enterprises in real time. With the relationship as the core, we collect and integrate enterprise credit information by means of feature extraction and graph construction, early warning risks, visualize and present complex business relationships, accurately supervise and serve the collateral and pledges by means of information technology, and timely grasp the operation status of goods and commodity price fluctuations staring the market, and visualize and present complex business relationships.

Keywords: Supply Chain Finance, TOPSIS, K-means Analysis

1. Introduction

As a crucial link in the survival and development of enterprises nowadays, supply chain finance covers all aspects of enterprises and financial institutions [1-2]. This study is dedicated to using techniques such as big data mining, mathematical modeling, industry standard definition and visualization analysis to apply the relationship between enterprises and each enterprise into a weighted directed network, determine credit rating weights using entropy weight method and TOPSIS, and monitor the information changes of enterprises in real time[3-4]. With the relationship as the core, we collect and integrate enterprise credit information by means of feature extraction and graph construction, early warning risks, visualize and present complex business relationships, accurately supervise and serve the collateral and pledges by means of information technology, and timely grasp the operation status of goods and commodity price fluctuations staring the market, and visualize and present complex business relationships [5].

2. Assessment index construction and solution for supply chain credit risk

2.1 Assessment index construction of supply chain credit risk

By reviewing a large amount of literature and combining our complex network model, we constructed four first-level indicators for small and medium-sized financing enterprises, core enterprises, supply chain relationships, and enterprise assets[6-7], and finally obtained the rating system as shown in Table 1.

For the selection of indicators, we followed the following four basic principles.

Comprehensiveness: Most of the current supply chain finance is "M+1+N" model, therefore, when constructing the credit risk evaluation system, we should not only evaluate a single category of indicators, but also examine the core enterprises, upstream and downstream enterprises of the core enterprises, the strength of the relationship between the supply chain and the asset status in a comprehensive and complete way, and try our best to achieve a multi-faceted and deep-seated We should try our best to show the operation and status of each enterprise from multiple perspectives and deep levels. In addition, the linear relationship between enterprises in the complex network and the market environment are also the focus of the evaluation model.
Table 1: Evaluation index system

<table>
<thead>
<tr>
<th>First-order index</th>
<th>Secondary index</th>
<th>Three-level index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management personnel</td>
<td>Management level ((X_1))</td>
<td>(X_1)</td>
</tr>
<tr>
<td>Profitability of small and medium-sized financing enterprises</td>
<td>Return on equity ((X_2))</td>
<td>Net operating margin ((X_3))</td>
</tr>
<tr>
<td>Management ability</td>
<td>Gross profit ratio ((X_4))</td>
<td>Inventory turnover ((X_5))</td>
</tr>
<tr>
<td>Solvency</td>
<td>Accounts receivable turnover rate ((X_6))</td>
<td>Quick ratio ((X_7))</td>
</tr>
<tr>
<td>Development ability</td>
<td>Current ratio ((X_8))</td>
<td>Interest cover multiple ((X_9))</td>
</tr>
<tr>
<td>Sales capacity</td>
<td>Net profit growth rate ((X_{11}))</td>
<td>Growth rate of total assets ((X_{12}))</td>
</tr>
<tr>
<td>Innovation ability</td>
<td>Sales staff turnover rate ((X_{13}))</td>
<td>Net profit rate on sales ((X_{14}))</td>
</tr>
<tr>
<td>Core enterprise</td>
<td></td>
<td>Credit standing ((X_{15}))</td>
</tr>
<tr>
<td>Solvency</td>
<td>Shareholders’ equity ratio ((X_{16}))</td>
<td>Credit rating ((X_{17}))</td>
</tr>
<tr>
<td>Supply chain relationship</td>
<td>Relationship strength</td>
<td>Transaction frequency ((X_{20}))</td>
</tr>
<tr>
<td>Enterprise assets</td>
<td>Asset position</td>
<td>Inventory turnover rate ((X_{21}))</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accounts receivable period ((X_{22}))</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Return on invested capital ((X_{23}))</td>
</tr>
</tbody>
</table>

Scientific: We have selected three levels of indicators to reflect the actual situation of the enterprise in Mo, while each indicator follows the principle of independence and is not related to each other. We adopt a scientific and rigorous method to screen the indicators and apply the criteria of financial standards to ensure the scientific nature of the selection of indicators.

Targeted: We have added a new indicator to reflect the relationship strength of the supply chain, which is reflected by the frequency of transactions between each independent enterprise. Compared with the previous monolithic evaluation, we have upgraded the indicators to be more targeted according to the characteristics of the supply chain credit chain, and the prediction of credit risk is more targeted.

Operability: In the actual operation process, in order to avoid the problems of difficult data search and incomplete information, we choose clear and highly operable indicators to build the credit evaluation system. At the same time, most of the indicators are available in corporate information disclosure websites such as Flush, Choice, etc. We simplify the information screening process while making the evaluation of indicators quantifiable and avoiding the influence of subjectivity on credit ratings.

2.2 Supply Chain Credit Risk Resolution

We currently have different solutions for the credit risk of three different financing models.

For accounts receivable financing model, it is difficult to supervise the authenticity of the trade as well as the destination of the financing money.

For the core enterprises and small and medium-sized trade, it is difficult to monitor the authenticity of the trade and to supervise the destination of the financing money. With the use of big data storage technology, all transaction records can be traced, and financial institutions can judge the financing credit of SMEs by discovering the credit relationship of related enterprises. At the same time, we can determine the financing amount based on the traced historical transaction records as well as various payment categories and whereabouts, providing a basis for the next credit assessment. This approach can effectively solve the information asymmetry problem between SMEs and financing institutions, and each transaction of SMEs will be open to all financial institutions, thus effectively avoiding the credit risk caused by opaque information[8].

For the prepaid financing account model, banks and other financial institutions can determine the amount of financing by confirming the number of SME deposits and the sales of goods of SME financing...
enterprises as well as the repurchase ability of core enterprises due to the sales of goods of SME financing enterprises and the repurchase ability of core enterprises. Therefore, when faced with such a situation, if the downstream financing company has credit problems or the core company is unable to repurchase the goods, we will use this as the basis to determine whether the SME should be financed and the amount of financing[9-10].

In response to the credit problems that exist in traditional inventory pledge financing, banks and other financial institutions can choose whether to finance SMEs by confirming whether the logistics and warehousing sector has the ability to keep the pledged items and the ability to properly assess the value of the pledged items due to the problems of supervising warehouses and third-party logistics companies. We can build a digital logistics information network through GPS locators and other means to supervise in real time thus ensuring the stability of transactions and effectively avoiding risks.

3. Evaluation model building and solving

3.1 TOPSIS superiority and inferiority solution distance method

The above indicators are all very large indicators, using TOPSIS superior and inferior solution distance method, the original data matrix to normalize the original data, to get

\[
Z = \begin{bmatrix}
    Z_{11} & Z_{12} & \cdots & Z_{1n} \\
    Z_{21} & Z_{22} & \cdots & Z_{2n} \\
    \vdots & \vdots & \ddots & \vdots \\
    Z_{n1} & Z_{n2} & \cdots & Z_{nn}
\end{bmatrix}
\]

(1)

The best and worst values of each index form the best value vector \( Z^+ \) and the worst value vector \( Z^- \), respectively.

\[
Z^+ = (z_{1}^+, z_{2}^+, \cdots, z_{p}^+); Z^- = (z_{1}^-, z_{2}^-, \cdots, z_{p}^-)
\]

(2)

\[
z_{j}^+ = \max \{z_{ij}, z_{2j}, \cdots, z_{pj}\}, \quad j = 1, 2, \cdots, p
\]

(3)

\[
z_{j}^- = \min \{z_{ij}, z_{2j}, \cdots, z_{pj}\}, \quad j = 1, 2, \cdots, p
\]

(4)

Calculate the distance of each evaluation unit from the optimal and inferior values

\[
D_{i}^+ = \frac{1}{p} \sum_{j=1}^{p} (z_{ij} - z_{j}^+)^2; D_{i}^- = \frac{1}{p} \sum_{j=1}^{p} (z_{ij} - z_{j}^-)^2
\]

(5)

Calculate the relative proximity of each evaluation unit to the optimal value

\[
C_i = \frac{D_{i}^-}{D_{i}^+ + D_{i}^-}, \quad i = 1, 2, \cdots, n
\]

(6)

In order of relative proximity, the larger \( C_i \) indicates that the i-th evaluation unit is closer to the optimal level. Finally, we can normalize \( C_i \). We can also normalize \( C_i \) to obtain the score of enterprise credit as the nodal power, and through the z-score model. We can effectively obtain the enterprise bankruptcy risk.

3.2 Z Fractional Model

According to Altman's Z-score model, which is also known as multivariate model, liquidity, profitability, leverage ratio, debt-servicing ability and activity are the five factors that affect the probability of debt default. The basic expression of the Z-score model is:

\[
Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.999X_5
\]

(7)

The specific meaning of each indicator is shown as follows: \( X_1 \) indicates the liquidity of the enterprise's assets and the size characteristics. \( X_1 \) indicates the liquidity and size characteristics of the
company's assets, and is expressed as working capital at the end of the period/total assets at the end of the period, which is positively correlated with the liquidity of the company's assets. The larger the value, the stronger the company's ability to compete in the market and its ability to innovate; X3 indicates the company's ability to continue to repay its debts with EBIT / total assets at the end of the period, which is used to measure the company's profitability, the larger the value, the stronger the company's profitability and the lower the risk of debt; X4 indicates the financial structure of the company. X4 indicates the financial structure of the enterprise, and the market value of equity capital/total book value of liabilities at the end of the period, which is used to measure the investment value of the company, and the larger the value, the more it indicates that the company is worth investing; X5 indicates the ability of the enterprise to generate and create income from assets, and the revenue from main business/total assets at the end of the period, which is used to measure the liquidity of the enterprise, and the larger the value, the stronger the liquidity of the enterprise. The Z-value model is used as a comprehensive indicator of financial default risk. The Z-value is inversely proportional to the likelihood of financial risk, and a smaller Z-value means a higher likelihood of financial risk. Altman believes that the threshold value of risk is \( Z > 2.675, Z < 1.81 \), which indicates that the enterprise's financial situation deteriorates and there is a risk of bankruptcy; \( 1.81 < Z < 2.675 \), which indicates that the enterprise's financial situation is extremely unstable and may lead to risk; \( Z > 2.675 \), which indicates that the enterprise's financial situation is good and there is no risk of bankruptcy.

### 3.3 K-means analysis

The extracted eigenvalues were analyzed by K-means using SPSS, and the analysis process is shown in Figure 1.

![Figure 1: K-means analysis flow](image)

Finally, we perform regression predictions to test for heteroskedasticity using BP test and White's test, respectively, to adjust the goodness of fit.

### 4. Conclusions

This paper uses complex network, modeling, visualization and other related technologies to infer enterprise credit, enhance the cost of violation, and apply the credit relationship between core enterprises and their upstream and downstream SMEs in the complex network diagram around the "M+1+N" scheme, so that the credit relationship between them is clear and three-dimensional; it is conducive to the transfer
of high-quality credit lines from core enterprises to supply chains, and creates conditions for financing of SMEs. On the one hand, theoretically, we use a series of methods such as complex network, Z-score model, entropy weight method, TOPSIS, cluster analysis, multiple regression, etc. to overcome the credit risk in traditional supply chain finance in a targeted way, and propose a more accurate prediction model through quantitative research and digital description of the risk, so as to propose a new direction for the research of credit risk in supply chain finance. On the other hand, in reality, we use its accurate risk warning capability to effectively reduce risk monitoring costs and improve risk management efficiency of financial institutions. Core enterprises are more willing to grant credit to small and medium-sized platforms in the regulatory platform, and as a result, the efficiency of SME financing is significantly improved. The better financing credit status between the upstream and downstream of the industry will also further form a negative feedback regulation, increasing the efficiency of the transaction between the upstream and downstream of the industry, and enterprises deepen the business relationship between.

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References