Research on Computer Aided Risk Evaluation Model through Fuzzy Hierarchical Analysis

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Abstract. China does not yet have a set of standardized and easy-to-operate decision-making system for banks to refer to and apply to MSMEs, so it is crucial to establish a set of credit risk assessment strategies that meet the characteristics of MSMEs. The financial risk of MSMEs can be assessed by the combination of both financial and non-financial indicators. The financial indicators can be refined into three indicators: solvency, profitability and growth ability, among which, solvency can be reflected by credit rating and default or not, profitability can be reflected by operating profit margin and return on assets, and growth ability can be reflected by the growth rate of total assets; non-financial indicators can be refined into industry prospect risk, enterprise operation risk, management quality and enterprise's influence on upstream and downstream. influence. Finally, in order to quantitatively analyze the credit risk of the enterprise, the weights of the indicators of the credit risk assessment system should be determined. In this paper, we use fuzzy hierarchical analysis to quantitatively describe the problem. Thus, the comprehensive credit risk rating score of each enterprise is calculated, and it is graded to find the loan amount and operating profit margin under the corresponding level, and finally the bank credit strategy is given. Then, the total sales data and credit rating of several enterprises are used as the input and output layers of the 3-layer neural network for training, respectively. Based on this, the relationship between annual loan rate and customer churn rate is analyzed, and a multi-objective planning model is built with the objective of minimizing customer churn rate and maximizing bank profitability to determine the bank lending strategy through MATLAB.

Keywords: Fuzzy hierarchical analysis, corporate solvency, credit risk rating

1. Introduction
MSMEs are an important force in promoting national economic development and social progress, but due to their small scale and lack of asset collateral, they have difficulties in financing during their development [1]. In order to alleviate the financing difficulties, evaluation factors such as credit policies, information on the enterprise's transaction certificates and the degree of influence of upstream and
downstream enterprises have become important evaluation indicators for the banking industry to grant loans to MSMEs [2, 3]. At present, there is not yet a set of standardized and easy-to-operate decision-making system for banks to refer to and apply to MSMEs, so it is crucial to establish a set of credit risk assessment strategies that meet the characteristics of MSMEs [4].

The loan amount of a bank for an enterprise to be lent is RMB 100,000,000, and the annual interest rate is 4%-15%; the loan term is 1 year. Based on the data related to 123 enterprises with credit records, 302 enterprises without credit records and 2019 statistics on the relationship between loan interest rate and customer churn rate, a mathematical model is established to study the credit strategy for MSMEs.

2. Credit risk assessment system model building

2.1. Determination of credit risk assessment system

When conducting enterprise credit risk assessment, financial indicators have a more significant impact on the banking industry’s decision compared with non-financial indicators. However, due to the small scale and relatively poor financing ability of Chinese MSMEs, financial indicators cannot play a decisive role, so this paper mainly analyzes credit risk comprehensively from two aspects: financial indicators and non-financial indicators, and constructs a perfect assessment system. Financial indicators include solvency, profitability and growth ability. Non-financial indicators include industry prospect risk, enterprise management risk and management quality. Among the three financial indicators, solvency is measured by credit rating and default, profitability is measured by operating profit margin and return on assets, and growth is measured by growth rate of total assets.

The qualitative consideration of non-financial indicators should not be underestimated on the impact of the loaned enterprises. In terms of industry prospect risk, the expansive macroeconomic policies and competitive advantages of the industry will reduce the loan risk of MSMEs; in terms of enterprise operation risk, sound enterprise management mechanism and good enterprise product sales ability will have a positive effect on the future economic development and credibility of the enterprise; in terms of management quality, reliable character quality and management credit status can, to a certain extent, reflect the solvency of the enterprise. In terms of management quality, reliable character quality and management credit status can, to a certain extent, reflect the solvency of the enterprise, which has a great reference value for banks to issue loans or not.

2.2. Establishment of index weights of credit risk assessment system

In this paper, FAHP (Fuzzy Hierarchy Analysis) is used to determine the weights of the indicators of the credit risk assessment system. In the calculation of the fuzzy judgment matrix, the priority relationship matrix M is first summed up by rows as the following equation:

\[ p_i = \sum_{k=1}^{n} m_{ik} \]  

The weights of each index of the credit risk assessment system were obtained using the geometric mean method. The formula for the geometric mean method is as follows.

\[ W_i = \frac{\left( \prod_{j=1}^{n} n_{ij} \right)^{\frac{1}{n}}}{\sum_{i=1}^{n} \left( \prod_{j=1}^{n} n_{ij} \right)^{\frac{1}{n}}} \quad i = 1, 2, ..., n \]
The FAHP method is used to establish the index weights of the credit risk assessment system, and in the process of establishing the fuzzy judgment matrix, the judgment matrix composed first needs to conform to the consistency in general, and then the hierarchy is divided according to the relative importance, and the matrix is further processed for fuzzy consistency, thus the consistency test of the judgment matrix can be omitted. From the perspective of the banking industry, the order of importance of the financial indicators is: Solvency B1 > Profitability B2 > Growth B3.

### Table 1. Matrix of priority relationships of financial indicators

|     | A1 | B1 | B2 | B3 | Pi |
|-----|----|----|----|----|----|
| B1  | 0.5| 1  | 1  | 2.5|
| B2  | 0  | 0.5| 1  | 1.5|
| B3  | 0  | 0  | 0.5| 0.5|

### Table 2. Fuzzy judgment matrix of financial indicators and indicator weights

|     | A1 | B1 | B2 | B3 | W  |
|-----|----|----|----|----|----|
| B1  | 0.5| 2/3| 5/6| 0.454|
| B2  | 1/3| 0.5| 2/3| 0.335|
| B3  | 1/6| 1/3| 0.5| 0.21|

### Table 3. Fuzzy judgment matrix of solvency and index weights

|     | C1 | C2 | Pi |
|-----|----|----|----|
| B1  | 0.5| 1  | 1.5|
| C2  | 0  | 0.5| 0.5|

Following the same method as above, the weighting coefficients of other financial indicators can be calculated. Also obtained by the Delphi method of repeatedly consulting experts, the weights of financial and non-financial indicators are 70% for financial indicators and 30% for non-financial indicators.

### 2.3. Calculation of credit risk rating composite score

Taking enterprise E1 as an example, the calculated operating profit margin, return on assets and total assets growth rate data are dimensionless and the formula is as follows.

\[
Y_{ij} = 50 + \frac{X_{ij} - X_{min}}{X_{max} - X_{min}} \cdot 50
\]  

(3)
In general, the dimensionless normalization speeds up the gradient descent to find the optimal solution, and the dimensionless normalization allows the features between different dimensions to be numerically comparable, which greatly improves the accuracy of the classifier. Therefore, the normalization process is performed using the mapminmax function, and then linear variation is performed to obtain the standard values of each index.

The comprehensive score of financial indicators for E1 enterprises in 2018 is calculated as 65.78, and that for E1 enterprises in 2019 is 63.861. According to the Guidelines for Loan Classification formulated by the People's Bank of China, this paper classifies credit risk into five levels according to risk level: normal, concern, subordinate, doubtful, and loss, and constitutes the set of rubrics \( V = \{ \text{Normal}, \text{Concern}, \text{Subordinate}, \text{Doubtful}, \text{Loss} \} \), with the following values: Normal (\( V > 85 \)), Concern (\( 75 < V < 85 \)), Subordinate (\( 65 < V < 75 \)), Doubtful (\( 55 < V < 65 \)), Loss (\( V < 55 \)). The median value was taken to the rubric set value of (90, 80, 70, 60, 50). According to the principle of fuzzy comprehensive evaluation method, the Delphi method [5] is used to repeatedly seek the opinions of experts, and the comprehensive score of non-financial indicators can be obtained, by which the scores of three aspects of non-financial indicators of enterprise E1 are obtained.

\[
A = SR = (90, 80, 70, 60, 50) \begin{pmatrix}
0.2 & 0.4 & 0.3 \\
0.1 & 0.3 & 0.5 \\
0.3 & 0.1 & 0.1 \\
0.3 & 0.3 & 0.1 \\
0.1 & 0.1 & 0
\end{pmatrix} = (70, 78, 80)
\]

Therefore, the composite score of the credit risk rating of enterprise E1 in 2019 = composite score of financial indicators + composite score of non-financial indicators = 63.861 + 70 × 0.0065 + 78 × 0.118 + 80 × 0.118 = 87.055 > 85, which is a normal level. Repeating the above method, the composite scores of credit risk ratings of other enterprises were obtained, as shown in Table 4.

Table 4. Average table of comprehensive scores of enterprise credit risk evaluation
2.4. Bank credit strategy
Calculate the comprehensive credit risk score of the enterprise and determine the loan amount range attribution. The bank issues a fixed amount of loan to the enterprise according to the loan amount range. Take enterprise E48 as an example, the loan is granted according to the above credit strategy. The credit risk rating of E8 is 87.855, and the credit rating of 123 enterprises with credit records is A, which shows that the enterprise has high reputation, low credit risk, strong strength, and stable supply and demand relationship. With the loan at this interest rate, the customer turnover rate is low and the profit range obtained from the bank loan is [3280, 6500].

3. Credit strategy based on BP neural network
The total sales data tax can measure the asset capacity of an enterprise, which in turn reflects the repayment capacity of the enterprise, and the repayment capacity reflects the credit rating of the enterprise to a certain extent. Firstly, the 4 levels of credit rating are converted into the probability of on-time repayment. Then, the BP network with 1N1 is constructed by taking the total sales data price and tax as the input layer and the on-time repayment probability as the output layer, where N denotes the number of hidden neurons.
Figure 1. Training curve

After the training of the BP network with 123 enterprises with known credit rating and total sales data valuation and taxation, the total sales data valuation and taxation of the 302 enterprises without credit records are used as the simulation set to input the network, and the on-time repayment probability of the 302 enterprises is finally obtained and their credit rating is classified. The relationship between loan APR and customer churn rate is obtained by MATLAB plotting, and this is fitted by quadratic polynomial using MATLAB's curve fitting toolbox, and the obtained fitting results are shown in Figure 2.
Figure 2. Quadratic Fit of Loan APR and Customer Churn Rate

Table 5. Table of credit strategies for MSMEs

| Enterprise Number | Loan Amount (Yuan) | Loan Term (Year) | Loan Interest Rate (%) | Profit (Yuan)   |
|-------------------|--------------------|------------------|------------------------|----------------|
| E126              | 248280.6147        | 1                | 11.64                  | 28899.86355    |
| E127              | 251134.5698        | 1                | 11.6                   | 29131.6101     |
| E128              | 253988.525         | 1                | 11.56                  | 29361.07349    |
| E129              | 256842.4802        | 1                | 11.52                  | 29588.25372    |
| E130              | 259696.4353        | 1                | 11.48                  | 29813.15078    |
| E131              | 262550.3905        | 1                | 11.44                  | 30035.76467    |
| E132              | 265404.3457        | 1                | 11.4                   | 30256.09541    |
| E133              | 268258.3008        | 1                | 11.36                  | 30474.14298    |
| E134              | 271112.256         | 1                | 11.32                  | 30689.90738    |
4. Conclusion
Quantitative analysis of credit risks of multiple companies is conducted and gives the bank's credit strategy when the total annual credit amount is fixed. In order to develop a reasonable credit strategy, it is crucial to establish a comprehensive, scientific and reasonable credit risk assessment system. First, the credit risk of MSMEs can be considered by considering the combination of both financial and non-financial indicators. Financial indicators can be subdivided into three indicators: solvency, profitability and growth, among which, solvency can be reflected by credit rating and default or not, profitability by operating margin and return on assets, and growth by total assets growth rate; non-financial indicators can be subdivided into industry prospect risk, business risk and management quality. Secondly, in order to quantitatively analyze the credit risk of enterprises, it is necessary to determine the weights of credit risk assessment system indicators. Fuzzy hierarchical analysis is used to describe the problem quantitatively. Then, a comprehensive score study of credit risk rating is conducted, a grading process is performed, and finally a bank credit strategy is given.

The credit risk of 302 enterprises was quantitatively analyzed, the total loan amount had an upper limit, the relationship between loan interest rate and customer churn rate was known, and there was a lack of information on enterprise credit rating, so it was necessary to find an effective method to rate enterprise credit in order to develop a credit strategy so as to improve the reliability of enterprise credit rating. Given that the total sales data valuation tax can reflect the enterprise credit rating to a certain extent, the BP neural network is used to train the relationship between the known credit rating and the total sales valuation tax of an enterprise, so as to provide credit rating for enterprises with unknown credit rating. When the weight of each index of the credit risk assessment system is changed, the comprehensive credit risk rating score needs to be recalculated. Based on this, the relationship between annual loan rate and customer churn rate is analyzed to determine the bank's lending strategy.

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