# A credit decision model for micro, small and medium enterprises based on the Fuzzy Comprehensive Evaluation model

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**Abstract:** We propose a credit decision model for micro, small and medium enterprises (MSMEs) based on the fuzzy comprehensive evaluation model to realize banks' scientific and reasonable lending to MSMEs. We made a preliminary prediction and analysis of credit risk influencing factors and successively used the Delphi method, hierarchical analysis, and fuzzy comprehensive evaluation to establish a specific and reliable comprehensive index system for enterprise credit risk assessment, and then proposed specific criteria for assigning values and carried out hierarchical total ranking to calculate the good ratio of the enterprise finally. Based on the expert grading opinion and "long-tail theory," the enterprise's credit risk level and credit policy are finally determined. Then, we added the influence of the emergent factors. The Delphi method, hierarchical analysis, and fuzzy evaluation method were used to classify further, process, and evaluate the influencing factors of enterprise credit risk assessment and optimize the previously obtained enterprise credit assessment model.

## 1. Introduction

In recent years, relying on strong support from the state, the ranks of MSMEs in China have gradually grown and made significant contributions to China's tax revenue, GDP growth, technological innovation, urban labor employment, and the number of enterprises. However, the shortcomings of small size, lack of collateral assets, and low credit rating of MSMEs themselves often make them encounter obstacles when applying for credit from banks.

At the same time, banks will also evaluate the credit and risk of enterprises by measuring the information of enterprise notes, the influence of upstream and downstream enterprises, and the national credit policy. Combining the strength and credibility of enterprises, they decide whether to lend and credit strategies such as loan amount, interest rate, and term and give specific interest rate preferences to enterprises with high credibility and low risk.

At this stage, a reasonable credit policy is essentially better to release the vitality of small and medium-sized enterprises, maintain good economic market order and promote China's economic development.

## 2. Model Establishment and Solution

### 2.1 Corporate credit risk assessment model

### 2.1.1 Construct a comprehensive index system for enterprise credit risk assessment

After rigorous data testing and verification, we found that the flow amount, total number of invoices, and total number of valid invoices can reflect an enterprise's scale of operation, profitability, and solvency. In contrast, the credit rating, default status, and percentage of valid invoices can reflect the credit rating of an enterprise. Combining these factors, we can initially determine a company's solvency, profitability, operating capacity, and cash flow [1].

In summary, we propose six specific influencing factors for corporate credit decisions, assign different weights according to the correlation coefficients of different factors, and use fuzzy comprehensive evaluation to derive an assessment formula. The scores of the different influencing factors are brought into the formula to obtain the final good ratio and rating. It can be used to decide whether lend to the enterprise, the size and interest rate of the lending, and the level of concessions.

Based on the characteristics of enterprise credit risk assessment, we can divide the comprehensive index system of enterprise credit risk assessment into the following three levels from the perspective of scientific rigor and practical simplicity with the help of the AHP principle of hierarchical analysis. The top-level is the target level, which is used to evaluate the enterprise credit risk situation; the second level is the criterion level, which considers the sub-targets of the upper level in terms of enterprise strength and credit rating; the bottom level is the indicator level, which is the evaluation/influencing factor of the upper level. Therefore, the specific structure of our given comprehensive indicator system is shown below.

Target Tier: Enterprise credit risk profile $A$

Criteria layer: corporate strength $A_1$, credit rating $A_2$

Indicator layer: $A_1$ corresponding to flow amount $C_{11}$, the total number of invoices $C_{12}$, the total number of valid invoices $C_{13}$; $A_2$ corresponding to credit rating $C_{21}$, default status $C_{22}$, percentage of valid invoices $C_{23}$.

For the influencing factors of the indicator layer, we used the method of four-level classification [5]. We can obtain the weights of each indicator in the comprehensive index system of enterprise credit risk assessment, and the specific weights are shown in Table 1.

Table 1. Indicator weights of enterprise credit risk assessment

|  |  | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{21}$ | $C_{22}$ | $C_{23}$ |
|---|---|---|---|---|---|---|---|
| 0.83 | $A_{11}$ | 0.73 | 0.19 | 0.08 |  |  |  |
| 0.17 | $A_{12}$ |  |  |  | 0.59 | 0.33 | 0.08 |

The comprehensive evaluation of enterprise $E$ is then based on the comprehensive evaluation formula.

$$Z = \left( T_{C_{ij}} \times W_{C_{ij}} \times W_{A_i} \right) \tag{1}$$

Finally, we calculate the company's good credit ratio.

$$R = Z/4 \times 100\% + x \tag{2}$$

where $x$ represents the probability of unpredictable eventualities, which should be considered in practical situations.

We can give the corresponding rating and credit policies by combining the "long-tail theory" [3].

i. When $R \geq 80\%$, the credit rating of the enterprise is S, and the credit rate is distributed within the range of 4%-6% depending on the size, totaling4 10 million.

ii. When $60\% \leq R \leq 80\%$, the credit rating of the enterprise is A, and the credit rate is distributed within the range of 6%-8% depending on the size, totaling3 10 million.

iii. When $40\% \leq R < 60\%$, the credit rating of the enterprise is B, and the credit rate is distributed within the range of 8%-11% depending on the size, totaling2 10 million.

iv. When $20\% \leq R < 40\%$, the credit rating of the enterprise is C, and the credit rate is distributed within the range of 11%-13% depending on the size, totaling1 10 million.

v. When $R < 20\%$ The credit rating of the enterprise is D, and the loan will not be granted.

Within the reasonable interval given, the larger the firm, the lower the interest rate

## 2.2 Optimized corporate credit risk assessment model

In the enterprise credit evaluation model given in 2.1, in response to the requirement of coping with unexpected factors, we can add an indicator of resistance to coping with unexpected factors as an influencing factor to participate in the evaluation based on the original obtained model according to the question. We apply the Delphi method and fully consider expert opinions to grade the enterprises according to different types to derive specific criteria for the assigned values.

After obtaining a more comprehensive evaluation of the influencing factors, a more optimized model for credit evaluation of enterprises was developed using hierarchical analysis and fuzzy evaluation method. After optimizing the model, a more accurate rating is obtained by applying the enterprises whose ratings have been previously calculated for re-evaluation to make the data more accurate. It reduces the risk of bank lending and improves the accuracy of bank credit policies.

### 2.2.1 Delphi method

We refer to expert opinion. The enterprises are graded according to the level of impact by unexpected factors, which can be divided into four categories: not affected, less affected, more affected, and significantly affected. Among them, the unaffected category includes media, scientific research, and other industries; the less affected category includes agriculture, construction, environment, and other industries; the more affected category includes postal, public facilities management, and other industries; the significantly affected category includes catering, individual and other industries.

### 2.2.2 Establish specific criteria for matching values

With the help of the enterprise credit assessment model already established in 2.1, we add the resistance ability to cope with unexpected factors and propose a new matching value criterion, as shown in Table 2.

Table 2. Allocation criteria

| Factors | Allocation criteria | | | |
|---|---|---|---|---|
| | 1-2 points | | 3-4 points | |
| $C_{11}$ | 0-1.7 | | $\geq 1.7$ | |
| $C_{21}$ | D | C | B | A |
| $C_{22}$ | Yes | | No | |
| $C_{12}$ | 1-2000 | 2000-10000 | $\geq 10000$ | |
| $C_{13}$ | 1-2000 | 2000-10000 | $\geq 10000$ | |
| $C_{23}$ | < 80 | 80-90 | >90 | |
| Response to unexpected factors resistance capacity $C_{14}$ | Significant impact | Higher impact | Less impact | Unaffected |

The judgment matrix is obtained from top to bottom based on expert opinion. We can derive the weights corresponding to the 7 individual factors of the new indicator layer in turn, as shown in Table 3.

Table 3. Indicator weights of enterprise credit risk assessment

| | | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{21}$ | $C_{22}$ | $C_{23}$ |
|---|---|---|---|---|---|---|---|---|
| 0.83 | $A_{11}$ | 0.5 | 0.12 | 0.06 | 0.33 | | | |
| 0.17 | $A_{12}$ | | | | | 0.59 | 0.33 | 0.08 |

The good credit ratio of the firm can be calculated by Equation (1) and Equation (2).

## 3. Model evaluation and Extension

The hierarchical analysis method can determine the weight of influencing factors in different levels of enterprise credit risk by decomposing, comparing, and synthesizing logical thinking, achieving the quantification of risk required in the question, and making the analysis results more systematic.

The selection of the fuzzy comprehensive evaluation model fully considers the characteristics of the data given in the problem, solves the problem of multiple influencing factors and the difficulty of quantifying factor indicators, and classifies the grade of enterprise credit risk. Meanwhile, using the Delphi method, we can fully play the professionalism of expert opinions, making the results more realistic and objective.

The credit decision model of MSMEs based on the fuzzy comprehensive evaluation model proposed in this paper can be widely used in banks to give credit to MSMEs. According to this model, banks can better predict and grasp the credit risk of enterprises applying for credit, to give as low an annual interest rate as possible, giving more opportunities for the development of MSMEs and stimulating the vitality of China's economic development.

In addition, the model is of reference and relevance to banks when conducting lending operations to various enterprises for credit risk assessment.

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