Bank Credit Strategy Model Based on AHP-Fuzzy Comprehensive Evaluation

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Abstract

Credit risk control and credit strategy formulation of medium and micro enterprises have always been important strategic issues faced by commercial banks. Banks usually make corporate loan policies based on the credit degree, the information of trading bills and the relationship of supply-demand chain of the enterprise. In this paper, we established the AHP-Fuzzy comprehensive evaluation model for quantifying enterprise credit risk. Based on the relevant data of 123 enterprises with credit records, the credit strategy is formulated according to the three indicators of enterprise strength, enterprise reputation and stability of supply-demand relationship. This paper also combines the credit reputation, credit risk and supply and demand stability rating in order to establish the bank credit strategic planning model to decide whether to lend or not and the lending order. The conclusion shows that, under the condition of constant total loan amount, the enterprises with the highest credit rating should be given priority. Then, combined with the change of customer turnover rate with interest rate, we take the bank's maximize expected income as objective to calculate the optimal loan interest rate of different customer groups.

Keywords: AHP-Fuzzy Comprehensive Evaluation Model, Planning Model, Credit Policy

1. Introduction

Credit risk management and control of medium and micro enterprises has always been an important strategic issue faced by commercial banks. In practice, banks usually provide loans to companies with strength and stable supply and demand based on their creditworthiness, transaction bill information, and supply chain relationships, and implement corresponding credit decisions. Banks first evaluate the credit risks of small, medium and micro enterprises, and then determine whether to lend, credit lines, interest rates, and maturity credit strategies based on the evaluation results and other factors.

At present, the researches on credit rating prediction models are mainly divided into two categories: traditional models represented by analytic hierarchy process and artificial intelligence methods represented by machine learning. Robert C Merton (2014) investigated the credit risk management methods of 50 commercial banks in the U.S. financial market, and found that they mainly use the analytic hierarchy process to analyze the credit status of customers, and use different evaluation criteria to analyze different loan types to classify risk level of loan business. Altman E (2015) studied the methods used by commercial banks in the credit risk assessment of US manufacturing companies. It constructed a Z value model including 22 evaluation indicators, and calculated and compared the threshold and Z value of credit business to assess loan risk degree. Ohlson J A (2016) used neural network analysis methods to analyze corporate credit risk, and achieved good results by building a neural network model to predict the degree of risk. Ping Sun (2020) used the BP neural network method to evaluate the credit ratings of 52 life insurance companies. The selected indicators cover corporate risk management capabilities, financial liquidity, profitability and development prospects, and the model has a high accuracy rate. We found that the predictive indicators selected in previous studies are mostly on the macro level. The innovation of this article lies in the selection of the company's supply-demand chain relationship as one of the evaluation indicators from the micro perspective of the company, which improves the scientificity and

accuracy of the rating results.

2. Method

2.1 Selection of Related Indicators

2.1.1 Strength of Enterprises

Enterprise strength mainly includes profitability, operating capacity, debt solvency, production capacity, technical level, management level, etc. According to the data provided in this question, we initially choose to use the total tax price of in and out and the value-added tax payable 4 indicators to evaluate the strength of each enterprise [3].

Indicator meaning: total import and export price taxes: reflect the business scale of the company, representing operating capacity; value-added tax payable: reflect the scale of corporate tax payment, representing profitability.

2.1.2 Corporate Reputation

Indicator meaning: Invoicing efficiency of incoming and outgoing items: reflects the creditworthiness of enterprises and upstream and downstream manufacturers before transactions; negative invoice rate for incoming and outgoing items: reflects the creditworthiness of enterprises and upstream and downstream manufacturers after transactions.

2.1.3 Stability of Enterprise Supply and Demand

The stability of an enterprise is mainly analyzed based on the number and proportion of stable suppliers. For an enterprise, when its supply and demand relationship is stable, it has fixed suppliers and sellers, then the buyer unit code and the seller unit code will be relatively fixed, and when the number of suppliers and sellers is large and not fixed, it can Think that the stability of this enterprise is insufficient.

Indicator meaning: stable number and proportion of suppliers: reflecting the stability of the upstream of the enterprise; stable number and proportion of distributors: reflecting the stability of the downstream of the enterprise.

2.2 AHP——Fuzzy Comprehensive Evaluation Model

The fuzzy analytic hierarchy process is an evaluation method that combines the analytic hierarchy process and the fuzzy comprehensive evaluation method. The principle is: First, the evaluation index system is hierarchized, and then the analytic hierarchy process is used to determine the weight value of each evaluation index, and then the fuzzy comprehensive evaluation is performed, and the comprehensive evaluation result is obtained. The steps of the fuzzy hierarchy comprehensive evaluation method are as follows:

Step1: Design of indicator system structure. According to the construction principle of the index system, establish an evaluation index system.

Step2: Determine the factor set of the evaluation object. The factor set of the risk evaluation object refers to the collection of various factors of the evaluated object, denoted by U.

$$U = \{u_1, u_2, u_3, \cdots u_m\} \tag{1}$$

Where, u_i = influencing factors

The values of these factors usually have varying degrees of ambiguity.

Step3: Determine the set of comments for the rating. The scoring rating comment set refers to the collection of multiple evaluation results of the state of each factor, denoted by V.

$$V = \{v_1, v_2, v_3 \cdots v_n\} \tag{2}$$

Where, v_j = evaluation results

Step4: The weight of evaluation factors. Generally, the importance of each evaluation factor is different for the evaluated object, so it is necessary to determine a weight number $w_i (i = 1, 2, \ldots, m)$ for each factor $u_i (i = 1, 2, \ldots, m)$, the fuzzy evaluation conclusions sometimes obtained by different weight values are completely different. This article uses the AHP to determine the weight of each evaluation factor.

Step5: Single factor evaluation, determine the fuzzy matrix R. Single-factor fuzzy evaluation is used to determine the degree of membership of the evaluation object to the elements of the comment set. In other words, determine the membership degree of the evaluation object to the fuzzy subset of each level from a single factor, and then obtain the fuzzy relationship matrix R:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{3}$$

Step6: Fuzzy comprehensive evaluation. Single-factor fuzzy evaluation is to evaluate from a single factor, and what is needed is to comprehensively consider the influence of all factors and obtain the correct evaluation result. This is the so-called fuzzy comprehensive evaluation.

Different rows in R reflect the membership degree of a certain rating object to the fuzzy subset of each level from different single factors. By using the fuzzy weight vector W and the single-factor fuzzy matrix R to perform fuzzy operations, the fuzzy comprehensive evaluation result vector B is obtained.

$$B = W \cdot R = (w_1, w_2, \cdots w_m) \cdot \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} = [b_1, b_2, \cdots, b_n] \qquad (4)$$

Where, b_j = fuzzy comprehensive evaluation index

Step7: Processing of fuzzy comprehensive evaluation index. The principle of maximum membership is used to determine the final evaluation result.

2.3 Enterprise Strength Evaluation Model

Step1: According to the selection of enterprise strength indicators in the model preparation stage, set the factor set $U = \{u_1, u_2, u_3, u_4\}$ for enterprise strength evaluation

Where, u_1 represents the total input price tax, u_2 represents the total output price tax, and u_3 represents the input item Effective invoice rate, u_4 represents the effective invoice rate of output items.
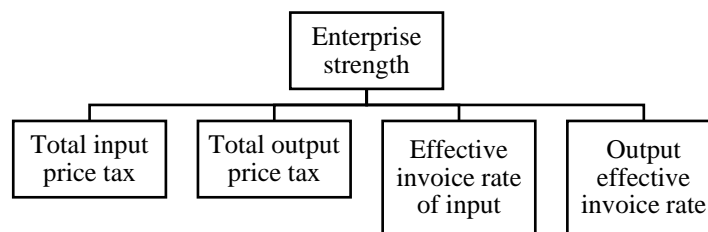

Figure 1. Factors of corporate strength

Step2: Similar to the corporate reputation rating, this article sets the company's strength review set as $V = \{v_1, v_2, v_3, v_4\}$, where, v_1, v_2, v_3, v_4 represent the four levels of corporate strength rating A, B, C, and D, Among which A grade represents the strongest enterprise strength, descending successively, and D grade represents the weakest enterprise strength.

Step3: According to economic significance, to assess the strength of an enterprise, the total tax price of the enterprise has an important position, while the effect of the effective invoice ratio is relatively small. The judgment matrix of the company's strength factor set is constructed according to the analytic hierarchy process:

$$A = \begin{bmatrix} 1 & 1/2 & 4 & 5 \\ 2 & 1 & 3 & 4 \\ 1/4 & 1/3 & 1 & 1/2 \\ 1/5 & 1/4 & 2 & 1 \end{bmatrix} \qquad (5)$$

The weight result of the evaluation factor $W = (0.35, 0.45, 0.10, 0.10)$.

Step4: This paper takes the self-employed E01 as an example, scores it, determines the membership degree of the evaluation object to the fuzzy subset of each level, and obtains the fuzzy judgment matrix:

$$R = \begin{bmatrix} 0.32 & 0.43 & 0.23 & 0.04 \\ 0.23 & 0.30 & 0.39 & 0.09 \\ 0.15 & 0.15 & 0.44 & 0.26 \\ 0.09 & 0.22 & 0.30 & 0.39 \end{bmatrix} \qquad (6)$$

After determining the fuzzy relationship matrix, the fuzzy vector on the factor set U is changed into the fuzzy vector B on the comment set V through fuzzy transformation. After calculation, the final fuzzy vector $B = W \cdot R = (0.23 \ 0.32 \ 0.36 \ 0.09)$, so the company's strength rating should be rated as C level.

2.4 Evaluation Model of Enterprise Supply and Demand Stability

Step1: According to the selection of the stability index of the supply and demand relationship of the enterprise in the model preparation stage, set the factor set $U = \{u_1, u_2, u_3, u_4,\}$ for the evaluation of the stability of the supply and demand relationship of the enterprise, where u_1 is the input effective invoice rate, u_2 is the output invoice Effective, u_3 represents the proportion of stable suppliers, u_4 represents the proportion of stable distributors.

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            │ Enterprise supply and │
            │   demand stability   │
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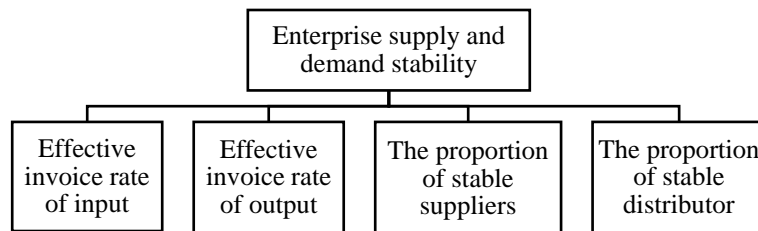
Figure 2. Factors that constitute a stable enterprise supply and demand relationship

Step2: Similar to the corporate strength evaluation model, this article sets the corporate strength comment set as $V = \{v_1, v_2, v_3, v_4\}$, where v_1, v_2, v_3, v_4 represent the four corporate strength ratings A, B, C, and D grade.

Step3: First, determine the weight distribution of each factor in the factor set through the analytic hierarchy process; secondly, conduct a single-factor fuzzy evaluation of each enterprise to determine the fuzzy relationship matrix; finally, use fuzzy transformation to change the fuzzy vector on the factor set U into the fuzzy vector B on the comment set V, and get the stability rating result of the supply and demand relationship of the enterprise.

2.5 Credit Risk Assessment Model

The bank assesses its credit risk based on the strength and reputation of the company. This paper adopts the simple weighted average of corporate strength rating and reputation rating to obtain the credit risk assessment grade of the enterprise. Among them, the weight of corporate strength is 0.6, and the weight of corporate reputation is 0.4.
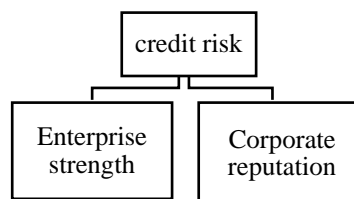
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            │ credit risk │
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        ┌───────┴────────┐
  ┌────────────┐  ┌────────────┐
  │ Enterprise │  │ Corporate  │
  │  strength  │  │ reputation │
  └────────────┘  └────────────┘
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Figure 3. Credit risk composition structure

2.6 Credit Strategy Model

2.6.1 Enterprise Classification

In fact, due to various comprehensive factors, bank credit strategies are not linear. Even for customers whose credit risk is A, the bank may not provide loans with the highest amount and the lowest interest rate. According to the previous evaluation model, we have determined the credit risk evaluation result, which is also equivalent to an evaluation of the company's repayment ability.

Step1: Assumptions of the probability of on-time repayment of enterprises of different levels. First of all, companies with a risk or credit rating of D are not allowed to issue loans, so it may be assumed that the risk assessment and the probability of repayment on time have the correspondence as Table 1.

Table 1. Corporate Credit Risk Level and Probability of Repayment on Time

Risk assessment level	A	B	C	D
Probability of repayment	100%	95%	85%	80%

Step2: Two-dimensional enterprise classification. From the two dimensions of credit rating and credit risk rating, all companies are divided into nine categories:

(risk A，reputation A) (risk A，reputation B) (risk A，reputation C)

(risk B，reputation A) (risk B，reputation B) (risk B，reputation C)

(risk C，reputation A) (risk C，reputation B) (risk C，reputation C)

2.6.2 The Relationship Between Annual Loan Interest Rate and Customer Loss

In addition to the risk that the bank has to bear in order to recover the loan this year, it will also face losses caused by the loss of customers in the future. Therefore, we deal with the data of customer churn rate under different interest rates as follows:
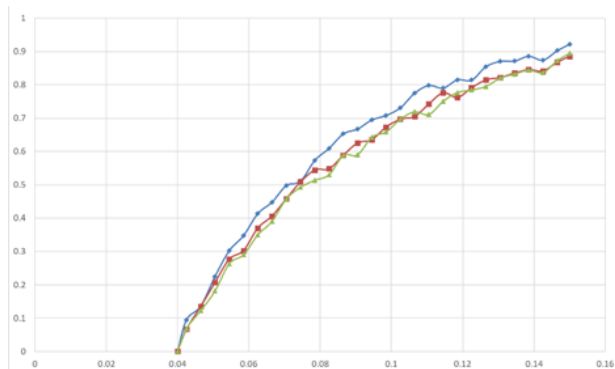
Step1: Point fitting

Figure 4. Customer Churn Rate of Companies with Different Credit Ratings and Bank Relationship

Step2: Function fitting

We use a quadratic function to fit it and get the following results:

$$I_1 = -76.41i^2 + 21.984i - 0.6971 \tag{7}$$
$$I_2 = -67.99i^2 + 20.21i - 0.6504 \tag{8}$$
$$I_3 = -63.94i^2 + 19.57i - 0.64 \tag{9}$$

2.6.3 Long-Term Bank Loan Expectations

Considering that both small and micro enterprises and banks have a certain degree of instability, consider a two-year cycle to examine the bank's profit expectations. When borrowing 10,000 from each company, take a company with risk assessment A and reputation A as an example, if its interest is q, the probability of repaying the money after one year is 100%, and the money received by the bank after one year is (1+q) ten thousand yuan. Since we only consider the maximum profit in a two-year cycle and do not consider future development, then, at the end of the second year, the expectation of the principal and interest received by the bank is as follows:

$$R_{Bank} = (1 - f(q))(1 + q) \times 1.15 + f(q)(1 + q) \tag{10}$$

Where, $f(q)$ represents the rate of lost customers at interest t. Compare all q to the maximum value, the maximum expectation of the principal and interest of the bank after two years is as Table 2. When obtaining the maximum expected principal and interest, the best interest rates of various companies are shown in Table 3.

Table 2. The bank's maximum recoverable principal and interest expectation

	Risk assessment A	Risk assessment B	Risk assessment C
reputation A	1.206	1.101256995	0.974120293
reputation B	1.206	1.103144092	0.974890165
reputation C	1.206	1.103004177	0.975072903

Table 3. The best loan interest rates for different types of businesses

	Risk assessment A	Risk assessment B	Risk assessment C
reputation A	0.04	0.15	0.15
reputation B	0.04	0.15	0.15
reputation C	0.04	0.15	0.15

As can be seen from the above table, for a company with a risk assessment of C, regardless of the annual interest rate, the maximum expected principal and interest sum is less than the original loan principal, which will cause bank losses. Therefore, banks should try to avoid lending to risk-level C enterprise.

2.6.4 Bank Credit Strategy Results

First of all, the company decides whether to lend or not according to the corporate reputation rating. In principle, customers with a rating of D will not grant loans. Then, according to the credit risk rating and credit rating of the enterprise, the sorting table of the priority of lending order is as Table 4.

Table 4. Prioritization of corporate loans

	Risk assessment A	Risk assessment B	Risk assessment C
Reputation A	1	4	no lending
Reputation B	2	5	no lending
Reputation C	3	6	no lending

Start with companies with a risk assessment of Grade A, and then lend to customers with credit ratings of A, B, and C in turn, and then consider companies with a risk assessment of Grade B, and also lend in order from high to low credit ratings. From the previous "Bank Maximum Principal and Interest Expectation Table", it can be seen that for companies with a risk assessment of C, the bank is more likely to lose money after lending to them, and should try not to lend to risk C-level companies.

3. Results

A certain bank has a loan limit of 100,000 to 1 million yuan to an enterprise determined to lend; the annual interest rate is 4% to 15%; and the loan period is 1 year. There are currently statistics on the relationship between the relevant data of 123 companies with credit records and the customer churn rate in 2019. The bank calculated the overall rating results based on the data of these 123 small, medium and micro enterprises, as shown in the Table5.

Table 5. All-round rating results of some companies

Enterprise code	Credit rating	Enterprise strength	Corporate stability	Credit Risk
E01	A	A	D	A
E02	A	B	C	A
E03	C	A	D	B
E04	C	A	D	B
E05	B	A	D	A
E06	A	A	D	A
E07	A	A	C	A
…	…	…	…	…

3.1 Credit Strategy Results

Banks determine whether to lend or not based on factors such as credit risk and credit strategies such as loan limits, interest rates and maturity. Based on the above-mentioned credit strategy selection model, this article first makes it clear that customers with a credit rating of D will not issue loans, and then divides 123 companies into nine categories based on their credit risk and credit ratings. The number is shown as Table6.

Table 6. Number of enterprises of various levels

	Risk assessment A	Risk assessment B	Risk assessment C
reputation A	23	4	0
reputation B	6	27	5
reputation C	0	24	10

Based on the above results, the sequence of lending by commercial banks to these 123 companies is as Table7.

Table 7. Lending sequence

Enterprise code	Credit Risk	Credit rating	Enterprise strength	Corporate stability
E07	A	A	A	C
E01	A	A	A	D
E06	A	A	A	D
E13	A	A	A	D
E16	A	A	A	D
E17	A	A	A	D
E18	A	A	A	D
…	…	…	…	…

4. Discussion

The AHP fuzzy comprehensive evaluation model used in this paper plays a good role in quantifying the problem when there is less known information and it is difficult to accurately measure the credit risk with data. The fuzzy comprehensive evaluation method established in this paper on the basis of fuzzy sets comprehensively evaluates the subordination status of the evaluated index from multiple indicators, and divides the change interval of the evaluated index, which not only considers the hierarchy of the object, but also makes the ambiguity of evaluation criteria and influencing factors is reflected. Fuzzy comprehensive evaluation can combine qualitative and quantitative factors, expand the amount of information, improve the validity of the evaluation, and make the evaluation conclusion credible.

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