Bank Lending Mdel for SME

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Abstract

In this paper, we gradually establish the credit strategy model of the enterprise by analyzing the large amount of data of small, medium and micro enterprises to help the bank make the best decision. First, we collected corporate information. Here, we have defined six evaluation indicators for banks: gross profit, business revenue, reputation score, proportion of positive invoices, number of upstream and downstream companies, and industry development. Use the pivot table in EXCEL to analyze the data. Next, we adopted a three-layer analytic hierarchy process to construct a judgment matrix through the relationship between the two indicators, and calculate the weight vector w to determine the weight of each indicator. Then, we use the gray comprehensive evaluation method to de-dimensionalize the index data, and calculate the gray correlation coefficient by comparing the series with the reference series. Combining the weights of each index obtained previously, the decision index r_i of each enterprise is finally calculated. The larger the r_i, the higher the comprehensive evaluation of the enterprise. We rank companies based on r_i, screen out the companies that are lower in the ranking, and make a decision not to lend. The specific selection principles are described in the article. Then, according to the size of the decision index r_i and the change trend of the company's ranking, we score the loan level of the companies that are determined to give loans, and we can get the loan proportion q_i (i is the corresponding code of the company) that can be allocated to each company. When the total annual credit Y is fixed, the loan amount allocated by the enterprise $z = Y \cdot q_i$ can be obtained. Finally, we obtain the linear function relationship between the annual bank loan interest rate l and the customer churn rate p by analyzing Annex III, and divide the formulas into three categories according to the credit rating A, B, and C, and establish an equation to make the bank's The total benefit W is maximized, and the interest rate that the bank should charge for the three types of enterprises A, B, and C is calculated.

Keywords

Analytic Hierarchy Process; Grey Comprehensive Evaluation Method.

1. Introduction

Small, medium and micro enterprises account for a large proportion in the market, but because of their small scale, they often choose to borrow money from banks in the business stage. Usually, the bank will first evaluate the enterprise based on the strength, reputation, development prospects and other factors, and then give the loan amount and interest rate according to the evaluation results and the bank's own situation. In this paper, we analyze a large number of data of small and medium-sized micro enterprises, and gradually establish the enterprise credit strategy model to help banks make the optimal decision.

2. Comprehensive evaluation model

2.1 Model assumptions

(1) The name of the company can represent the company's main business and industry, and the survival status of the company can be judged by the development trend of the industry.

(2) When calculating the company's income, the costs other than input expenses, such as employee salaries, company processing costs, are not considered.

2.2 Data Processing

Through data collection and sorting, we have obtained a total of 123 companies that include company names, defaults, and output input invoices[1]. By processing this information, we can get 6 data information about corporate reputation, total annual input amount, total annual input amount, annual business income, annual gross profit, proportion of positive invoices, number of upstream and downstream enterprises, and industry development statu[2].

2.3 Analytic Hierarchy Process

We summarized the comprehensive evaluation indicators for the company into four major aspects: corporate reputation, corporate strength, stability of supply and demand, and upstream and downstream corporate influence. The six data information mentioned above can affect four indicators. Below, we use the Analytic Hierarchy Process to find the direct relationship between 6 items of data and the company's rating[3].

By constructing a comparison matrix, according to the importance evaluation criteria given by experts, the following matrix A is obtained.

$$A = \begin{bmatrix} x_{11} & 5/7 & 6/5 & 7/5 \\ 7/5 & 1 & 8/5 & 91/50 \\ 5/6 & 5/8 & 1 & 1 \\ 5/7 & 50/91 & 1 & 1 \end{bmatrix}$$

Use the feature vector corresponding to the largest feature root λ_{max} as the weight vector $w^{(2)} = (0.2547 \quad 0.3457 \quad 0.2068 \quad 0.1927)^T$ of the second layer.

In the same way, we judge the importance of the third layer to the second layer. Get the weight vector $w_1^{(3)} \sim w_4^{(3)}$.

Mark $w_b^{(3)} = w_1^{(3)} w_2^{(3)} w_3^{(3)} w_4^{(3)}$.

Next, we combine the weight vectors.

Finally, we get the combined weight vector of the target layer to the solution layer$w = w_b^{(3)} \cdot w^{(2)} = [0.1817 \quad 0.1503 \quad 0.1917 \quad 0.1647 \quad 0.1585 \quad 0.1530]^T$. That is, the index gross profit, business income, reputation score, proportion of positive invoices, number of upstream and downstream companies, and industry development status are the final direct weights of the company's evaluation.

2.4 Grey Comprehensive Evaluation Method

Below we use the grey comprehensive evaluation method to make the final ranking of each enterprise [4][5].

(1) Construct a series of indicators for each company

There are m number of evaluation objects and n number of evaluation indicators. List the number of indicators for each enterprise

$$\begin{cases} x_1 = \{x_1(1), x_1(2) \dots \dots x_1(n),\} \\ x_2 = \{x_2(1), x_2(2) \dots \dots x_2(n),\} \\ \vdots \\ \vdots \\ x_m = \{x_m(1), x_m(2) \dots \dots x_m(n),\} \end{cases} \quad (1)$$

Here, m takes 123 and n takes 6.

(2) Determine the reference series

Set reference series$x_0 = \{x_0(1), x_0(2) \dots \dots x_0(n)\}$. Each element of the reference sequence takes the best value of each indicator, and the indicators we use are all efficiency indicators, and the maximum value of this column is taken. For cost indicators, take the minimum value of this column.

(3) De-dimensionalization

Here we use the mean value method to de-dimensionalize the data.

$$x_i(k) = \frac{x_i(k)}{\overline{x(k)}} \tag{2}$$

(4) Determine the importance coefficient of each indicator

Use the above-mentioned analytic hierarchy process to get the weight of each indicator

(5) Calculate the correlation coefficient

Define the correlation coefficient of the comparison sequence x_i to the reference sequence x_0 on the k-th index as ξ_i

$$\xi_i(k) = \frac{min_{(s)}min_{(t)}|x_0(t)-x_s(t)|+\rho\cdot max_{(s)}max_{(t)}|x_0(t)-x_s(t)|}{|x_0(k)-x_i(k)|+\rho\cdot max_{(s)}max_{(t)}|x_0(t)-x_s(t)|} \tag{3}$$

(6) Calculate grey weighted relevance

The gray weighted relevance degree is represented by r, r_i is the gray weighted relevance degree of the i-th evaluation object to the ideal object, and the calculation formula of r_i is:

$$r_i = \sum_{k=1}^{n} w_i\, \xi_i(k) \tag{4}$$

(7) Evaluation Analysis

The larger r_i, it means that the closer the enterprise is to the ideal enterprise, and the better the comprehensive capabilities of the enterprise. Therefore, the amount of bank lending to enterprises is determined by the index. In the following discussion, we will name the index as the decision-making index. According to the size of r_i, the decision index r_i is sorted in descending order, and the companies can be ranked. See the table below for several rankings. (E for firm code)

Table 1. Firm Ranking

Firm	r_i	Ranking
E4	14.35612	1
E15	2.8654	10
⋮		
E25	0.9524	40
E62	0.6388	65
⋮		
E110	0.4236	98

2.5 Determine Loan Grade

Let's observe the ranking situation to filter the companies.

In the rankings, the decision-making index r_i of companies with low credit ratings is very low, and we decided not to lend.

We further screened the low-ranking companies, roughly using r_i=0.424651 as the limit. After excluding the companies with lower ratings, there are still 6 companies. Because of their weaker overall strength, we also stipulate that they are not allowed to lend.

We visualize the decision index and observe the general trend of its value, as shown in figure 1.

Observing the trend of the decision-making index, we can find that there is a big difference between the index of the enterprises before and after, and the enterprises have obvious strength stratification. We distribute according to the change trend of the curve according to the asynchronous length. For example, the top-ranked companies are set in pairs with a step length of 10; the middle-ranked companies have a step length of 5; for the bottom-ranked companies, their decision-making indexes are not much different, so we set the step length to 0.5.

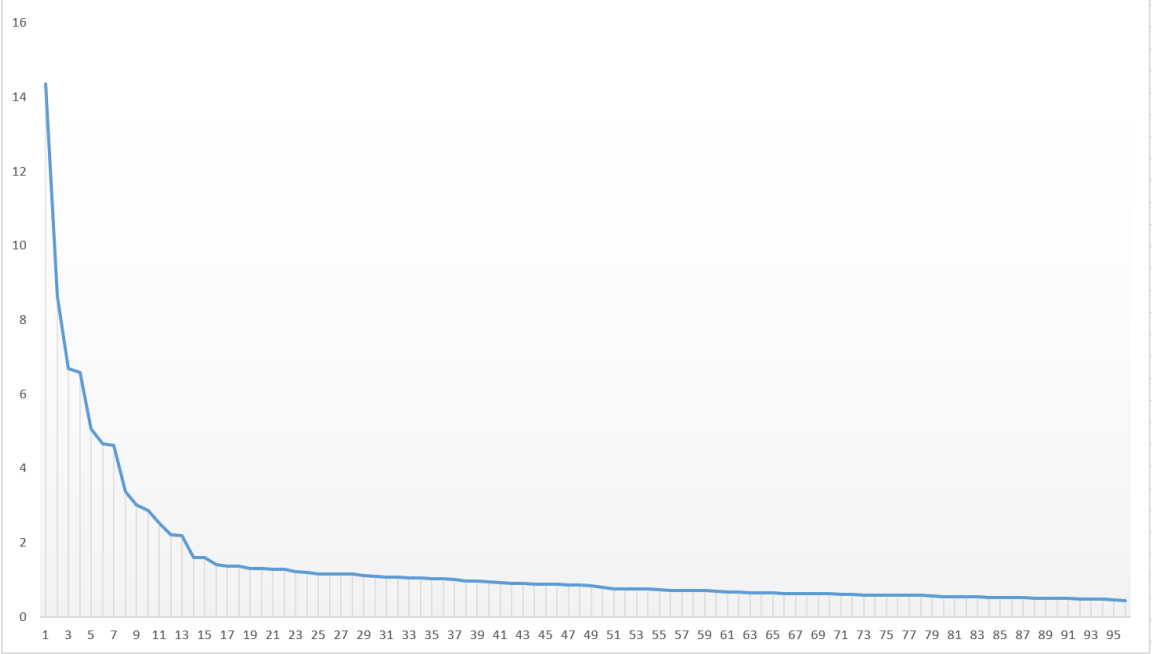

Fig. 1 Decision index trend chart

2.6 Determine Annual Interest Rate

After the loan grade is determined, normalize the data of the loan grade to obtain the loan proportion q_i that can be allocated to each enterprise. After the screening, the enterprise that does not lend will directly record q_i=0, where i represents the corresponding number of the enterprise. Remember that the bank's total annual credit is Y. It can be concluded that for an enterprise, the loan amount that can be allocated $z = Y \cdot q_i$.

By using the SPSSAU tool to fit the relationship between the annual interest rate of bank loans and the customer churn rate, we found that there is a clear positive correlation between the annual interest rate of bank loans and the customer churn rate, that is, the greater the annual bank loan interest rate, the greater the customer churn rate. Therefore, we guess that there may be a functional relationship between the annual bank loan interest rate and the customer churn rate, and it is highly likely to be linear.

In addition, we also found that under the same loan annual interest rate, the credit rating of the company will be different, and there will be some differences in the customer churn rate. Generally speaking, the higher the credit rating, the greater the customer churn rate. This is also in line with the actual situation. The higher the credit rating of a company, the more likely it is to make timely interest payments, and more banks will be willing to provide loans to the company. The company will inevitably choose banks with low interest rates. At the time, if the bank's interest rate is higher than that of other banks, the possibility of the bank losing customers will increase. In response to this situation, we separate the reputation ratings of A, B, and C. Fitting three curves of reputation ratings and customer churn rate can also make the solution of the entire problem more detailed.

Based on the above conjecture, we use the linear regression fitting function in SPSSAU to study the relationship between the annual loan interest rate l and the customer churn rate p, and obtain the linear regression function:

$$\begin{aligned} p_A &= 0.098 + 7.524 * l \\ p_B &= -0.118 + 7.351 * l \\ p_c &= -0.138 + 7.468 * l \end{aligned} \tag{5}$$

Among them, the R^2 values in the three cases of A, B, and C are 0.935, 0.926, and 0.911, respectively, indicating that the linear function fits well; the significant difference p of l is almost 0, which passed

the F test. The regression coefficient values of the annual loan interest rate are 7.524, 7.351, and 7.468, which means that the annual loan interest rate will have a significant positive impact on the customer churn rate.

In the following model, we only discuss the companies that determine the grant of loans. From the above, we get that the total number of companies that have confirmed loans is m, and the number of companies with credit ratings of A, B, and C are m_1, m_2, m_3, respectively.

In order to maximize the interest of the bank, we define the bank's efficiency index as W, and remember that the interest rate that the bank will charge for loans to enterprises with credit ratings of A, B, and C is l_a, l_b, l_c, and the benefits obtained by the bank are W_A, W_B, W_C.

The total amount of funds that the bank can provide for distribution is still defined as Y. According to the meaning of the question, Y is a fixed value.

The optimization function under the establishment conditions:

$$\begin{cases} \sum_{i=1}^{m} q_i = 1 \\ 0.04 \le l \le 0.15 \\ W_A = l_A(1-P_A)Y \cdot q_i \\ W_B = l_B(1-P_B)Y \cdot q_i \\ W_C = l_C(1-P_C)Y \cdot q_i \\ (max)W = W_A + W_B + W_C \end{cases} \tag{6}$$

Among them, q_i is the determined distribution ratio in the grey relational analysis model

Solved by MATLAB, l_A=0.066, l_B=0.0685, l_C=0.0689. Therefore, the interest rate of a company is determined according to the credit rating of the company. The annual interest rate for A-level companies is 6.6%, the interest rate for B-level companies is 6.85%, and the interest rate for C-level companies is 6.89%.

3. Conclusions

Bank loans to enterprises mainly depend on corporate reputation, corporate type, and corporate strength. The higher the corporate reputation rating, the stronger the corporate strength, and the greater the influence of the upstream and downstream companies, the lower the assessment risk of the company. The bank is also more willing to lend or loan a larger amount.

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