Analysis of Bank Credit Strategy Based on Ahp Comprehensive Evaluation

Chuanbo An, Yu Pei , Yahui Wang , Lingyi Wu

School of Statistics and Applied Mathematics, Anhui University of Finance and Economics, Bengbu, Anhui, 233030, China

Abstract: This paper builds a multi-level quantitative evaluation system for credit risk, average the weights obtained by three different methods, and use this indicator system to establish a credit risk grading model based on comprehensive evaluation to achieve credit Quantification of risk. Secondly, by establishing a comprehensive evaluation index threshold, the enterprises that exceed the threshold are removed twice; by establishing a credit amount double-mapping hierarchical ladder model, the credit risk level of the enterprise is mapped to the bank credit amount; finally, by considering the credit rationing theory Considering the relationship between the churn rate and interest rates of companies with different credit ratings, the minimum corresponding interest rate of the slope of the fitting curve is defined as the bank's optimal interest rate, and then the interest rates of companies with different credit ratings are graded; finally, comprehensive consideration is given to whether credit, Three aspects of credit line and preferential interest rate give the specific content of bank credit strategy.

1. Introduction

Small and medium enterprises in the relatively small, and lack of mortgage assets, so Banks are usually based on the enterprise credit policy of trade instrument information and the influence of the upstream and downstream enterprises, to strength Supply and demand and stable enterprise loans, and credit can be high credit risk of small business enterprise give preferential interest rates.

Generally speaking, the bank first, according to the strength of micro, small and medium enterprises credit for credit risk assessment, and then on the basis of credit risk factors, such as to determine whether to lending and credit strategy such as lending interest rates and duration In this paper, a comprehensive evaluation model based on AHP is established to quantitatively analyze the credit risks of 126 enterprises, and from the point of view of banks, the best lending interest rate is obtained by using the method of curve fitting, and the reasonable credit strategy is determined by comprehensively considering the credit risk factors after quantitative analysis.

2. Indicator Selection and Interpretation

Six secondary indicators are determined from the two aspects of enterprise strength and enterprise reputation. The specific data sources of secondary indicators and the mapping relationship between credit ratings of small and micro enterprises are explained in the following three aspects:

(1)Profitability: the ratio of the difference between the output value tax (P1) and the input value tax (P2) and the input value tax (P2) is used as the measure of the profitability of small and micro enterprises.

$$\frac{P_1 - P_2}{P_2}$$

(2)Upstream and downstream influence: the influence of the upstream and downstream enterprises, due to the net of the tax invoice recorded response categories of taxes are value-added tax, so the amount of data to measure the size of the enterprise to the size of the influence of the whole industry chain, we use the input tax of each enterprise and A_i with all the enterprise income tax and the A_n ratios reflect the influence of the enterprise to the upstream enterprise; The ratio of output tax and BI of each enterprise to output tax and BN of all enterprises is used to reflect the influence of enterprises on downstream enterprises.

$$\frac{A_i}{A_n} / \frac{B_i}{B_n}$$

(3)The stability of supply and demand: refers to the negative invoice invoice for trading activities, enterprises accounted for tax, after acquiring for return and refund need to issue the invoices, when repeatedly appeared negative invoice, supply and demand of the enterprise are unstable phenomenon, also affects the small micro enterprise credit risk rating. We use the ratio of the number of invalidated invoices of each enterprise's input, C_i, to the total number of invoices of each enterprise's input, C_n, to reflect the stability of the relationship between enterprises' demands. The stability of supply relationship of enterprises is reflected by the ratio of the number of invalidated invoices D_i to the total number of invoices D_n of sales items of each enterprise.

$$\frac{C_i}{C_n} / \frac{D_i}{D_n}$$

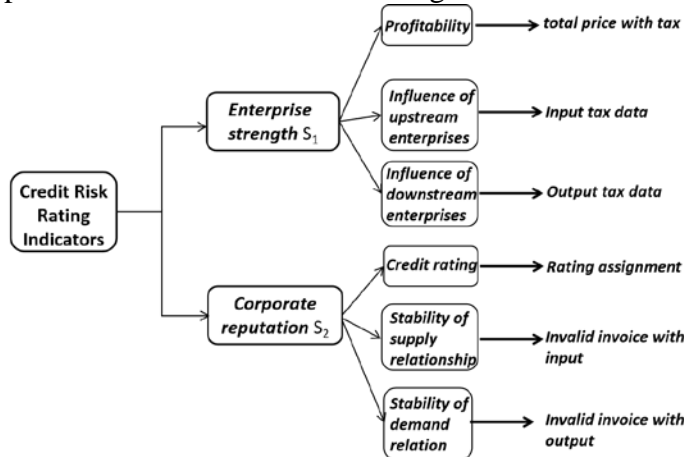The relationship of each index is shown in the figure below:

Fig.1 Indicator Type of Our Project

3. Data Sources and Preprocess

3.1 Data Source

The data in this paper mainly comes from Question C of Mathematical Modeling for National College Students in "Higher Education Cup", including the credit rating (A-D) of 123 enterprises (E1-E123) with credit records and 373,431 invoice data of each enterprise's import and export items. Each invoice data includes 6 indexes, such as amount, tax amount, and total price and tax. In addition, it also includes 29 statistics on the relationship between the annual interest rate of bank loans and customer churn rate of enterprises with different credit ratings.

3.2 Data Preprocessing

(1)Consistent treatment of evaluation index types
In the index system established above, the index set may contain either "very large", "very small" or "intermediate" indicators. Therefore, the evaluation indexes must be consistent before evaluation. Here, we unify all indexes into extremely large indexes. After analysis, the final maximum value of credit rating changes, the specific transformation methods are as follows;(Where Mi is the maximum possible value of index xi.)

$$x_j = M_i - x_i (x_i > 0, i = 1,2,3,4,5,6)$$

(2)The dimensionless treatment of evaluation indexes
In this paper, there is a deviation of measurement units among the evaluation indicators, which will lead to the final calculated credit risk indicators are not in the same order of magnitude, thus resulting in unreasonable comprehensive evaluation results. Therefore, we conducted dimensionless processing on the data after the consistent processing to eliminate the difference influence of the original index data. 74 small and micro enterprises were set as evaluation objects, and the positive matrix composed of 6 evaluation indexes including the stability of upstream and downstream enterprises was as follows:

$$W = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1m} \\ w_{21} & w_{22} & \cdots & w_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ w_{n1} & w_{n2} & \cdots & w_{mm} \end{bmatrix}_{74 \times 6}$$

$$Z_{ij} = \frac{w_{ij}}{\sqrt{\sum_{i=1}^{n} w^2_{ij}}}$$

4. Credit Risk Grading Models

4.1 Determining the Weight of Evaluation Indicators Based on Ahp

Comprehensive above the selected six secondary indicators are: profitability, the influence of the upstream and downstream enterprises, stability of supply and demand, credit rating, credit risk evaluation ultimately decided jointly by the six indicators, here we use the AHP to determine each secondary index to the specific weight of credit risk, using the analytic hierarchy process   and comprehensive evaluation method [6] for credit risk evaluation.

For judgment matrix in the AHP, we according to the relative importance of each target, after get the judgment matrix, we first use of Matlab to the judgment matrix, consistency check random consistency index $CI = \dfrac{\lambda_{\max} - n}{n-1} = 0.0494$, according to the random consistency index table to find the RI = 1.26, finally it is concluded that consistency ratio is 0.0886 < 0.1, the consistency of judgement matrix can be thought acceptable, namely the judgment matrix by consistency check.

Different methods will give different weight results. In order to make the weight setting more reasonable, we use arithmetic average method, geometric average method and eigenvalue method to solve the problem. The average weight of the three methods is obtained, and the specific results are shown in Table 1.

Table 1 Weight Determination Table for Rating Indicators

Model	Arithmetic average	Geometric average	Eigenvalue	Average weight
Profitability	0.0313	0.0296	0.0304	0.0304
Influence of upstream enterprises	0.2544	0.2608	0.2556	0.2569
Influence of downstream enterprises	0.1612	0.1601	0.1612	0.1608
Stability of supply relationship	0.4108	0.414	0.4168	0.4139
Stability of demand relation	0.0855	0.0818	0.082	0.0831
Credit rating	0.0568	0.0537	0.054	0.0548

4.2 Establishment of Complex Mapping Hierarchical Model of Credit Amount

The comprehensive evaluation model of credit risk is to "synthesize" the evaluation value of multiple indicators into a comprehensive evaluation value through a certain mathematical model or algorithm to realize the comprehensive evaluation of credit risk. After weighting by AHP, the composite index is calculated by linear weighting. Set F_P as the appraisal value of the p first-level appraisal index, and F_{PQ} as the appraisal value of the q second-level appraisal index of the p first-level appraisal index. The appraisal value of the comprehensive appraisal index of different levels is weighted by the corresponding weight coefficient, and the weighted sum is taken as the comprehensive appraisal value of credit risk:

$y = n_p F_p + n_q F_q = n_p n_{pq} F_{pq} + n_q n_{qp} F_{qp}$

We grade small, medium enterprises according to the evaluation value Y of credit risk of enterprises. The lower the evaluation value of credit risk of enterprises, the smaller the credit risk of enterprises, the higher the number of grades obtained after the grading, and the larger the amount of bank loans obtained. On the contrary, the higher the evaluation value of enterprise credit risk, the greater the enterprise credit risk, the lower the grade, the smaller the amount of bank loan. Therefore, the complex mapping hierarchical model is established. We first establish the mapping f(y) of the comprehensive index of enterprise credit risk corresponding to the credit risk Level, and then establish the mapping f(L) of the Level to the amount of loans issued by banks (Capital). The specific mapping relationship is shown in Table 2:

Table 2 Standard Setting Table

Level	1st	2sec	3rd	4th	5th	6th
y	[0-0.01)	[0.01-0.02)	[0.02-0.03)	[0.03-0.04)	[0.04-0.05)	[0.05-0.1)
Capital	[85-100)	[70-85)	[55-70)	[40-55)	[25-40)	[10-25)

According to the established hierarchical model of loan amount, we believe that the risk of small enterprises with comprehensive evaluation value over 0.1 is too high and no loans will be granted. Finally, four small and micro enterprises, E4, E55, E43 and E1, are screened out and eliminated.

4.3 The Model Results

Matlab is used to obtain the comprehensive evaluation value. According to the evaluation value, the statistical table of the number of credit risk levels of each enterprise and the grading situation are as follows:
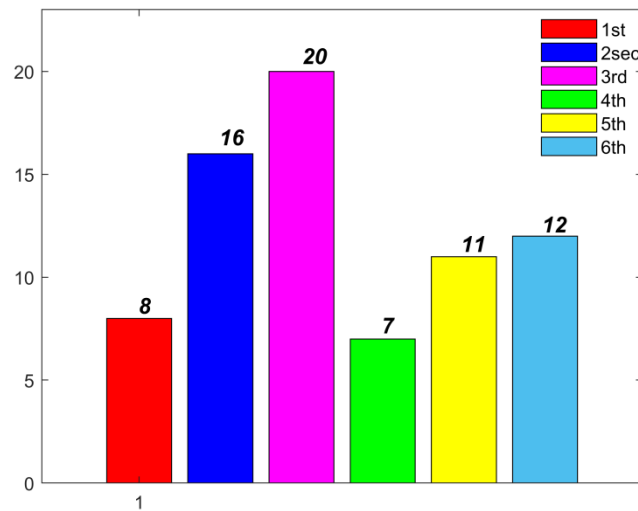
5. Bank Interest Rate Grading Model Based on Curve Fitting

Modern credit rationing theory believes that credit rationing is to realize credit transactions between borrowers and borrowers through rationing after examining interest rate, price, risk, profit and other aspects. From the perspective of banks, rationing theory means that banks should comprehensively consider various factors to maximize their profits. Therefore, we establish the optimal interest rate model of banks based on the relationship between interest rate and customer churn rate.

The Linear Fiting function in the Cftool of MATLAB is used to fit the customer churn rate (Y_i) curves of three types of enterprises with credit ratings of A,B and C to interest rate (X_i), and the sizes of the fitting equations and goodness of fit R^2 obtained are shown in Table 3 :

Table 3 Fitting Curve Equation

Curve	Fitting Curve Equation	R^2
A	$y_1 = -20.17\sin(x_1 - \pi) - 84.34x_1^2 - 0.6945$	0.9545
B	$y_2 = -18.64\sin(x_2 - \pi) - 74.67x_2^2 - 0.6481$	0.9550
C	$y_3 = -18.07\sin(x_3 - \pi) - 65.35x_3^2 - 0.6370$	0.9650

Here we consider the actual meaning of the slope of the curve, $K = \frac{\Delta Y}{\Delta X}$ means that for every unit of interest rate change, the unit of change of customer churn degree can be defined as the change rate of customer churn rate. For a bank, the minimum value of this slope is the optimal interest rate pursued by the bank.

$\frac{\partial y}{\partial x} = 0$ The optimal interest rate points of the above three curves are 11.85%, 12.65% and 13.85% respectively. Therefore, we define the interval [0.1185, 0.1385] as the optimal interest rate interval. According to this interval, interest rates are divided into prime interest rate, optimal interest rate and normal interest rate. With the gradual rise of credit rating, its preferential interest rate gradually increased.

[0.04,0.1185)   Preferential Interest Rate
[0.1185,0.1385) The Optimal Interest Rate
[0.1385,0.15)   Normal Interest Rate

6. Banks' Credit Strategies

To sum up, we use the AHP comprehensive evaluation method to quantify the credit risk index, divide it into 6 levels according to the loan amount, fit the correlation curve of interest rate and customer churn rate according to the rationing theory, get the optimal interest rate classification, and match it with the above credit enterprises of different levels. The specific contents of credit strategies of banks are given by comprehensively considering the three aspects of whether to lend money, the size of the loan amount and the preferential interest rate.

Do you lend money? - out of consideration for bank credit security, credit rating companies do not provide loans for D, in addition, according to established hierarchical ladder model, the loan amount that we think that the comprehensive evaluation value of more than 0.1 micro, small and medium enterprises risk is too high, also not be loans, eventually E4, E55, E43, E1 was filtered and four small micro enterprise, plus the code-named E36, E52, E82 24 credit rating of D company, bank of 28 companies shall not lend, within the valid data, for the rest of the 70 companies according to different credit policy lending.

Model of credit amount? - the credit risk level of an enterprise is mapped to the amount of loans issued by a bank to correspond one-to-one. For eight credit risk level for enterprise respectively 1 [10, 25) floating credit amount , about 16 credit risk level for enterprise respectively 2 [25,40) floating credit amount to 20 credit risk level for enterprises respectively 3 [40,55) floating credit amount, the seven credit risk level for enterprise respectively 4 [55,70) floating credit amount, about 11 credit risk level for enterprises, respectively, (70,85) floating credit amount, A floating credit amount of [85,100] is provided to 12 enterprises with credit risk level 6.

What's the prime rate? - by curve fitting credit rating respectively. A, B, C three kinds of the relationship between interest rate and turnover rate of the enterprise, considering the practical significance of the slope of the curve, the minimum value of the slope is the optimal rate, we define the less than optimal for preferential interest rates, interest rates, for normal interest rate is greater than the optimal rate of credit rating for A enterprise provide preferential interest rates [0.04, 0.1185), the credit rating of B provides the optimal interest rate [0.1185, 0.1385), the credit rating of C enterprises provide normal interest rates [0.1385, 0.15).

References

[1] He Ren, Liu Bingyong, Wang Jingjing. The relationship between bank and enterprise, institutional environment and credit availability of small, medium and micro enterprises [J]. Financial Research,2012(11):103-115.

[2] Hou Zhanyun, Huang Jingwen. A brief discussion on the pricing method of loans to small, medium and micro enterprises in commercial banks [J]. Eastern Corporate Culture,2012(17):188+182.

[3] Wang Miao. Research on Proportional Risk Sharing of Credit Guaranteed Loans for Small, Medium and Micro-sized Enterprises -- A Two-party Cooperative Game Model for Government Subsidities [J]. Business Economics and Management,2017(03):62-68.

[4] Lin Lefen, Li Xuan. The Impact of Heterogeneity of Banking Financial Institutions and Loan Technology on Credit Availability of Small, Medium and Micro Enterprises: Based on the Questionnquestionnaire of 128 Commercial Banks [J]. University, 2017 (03) : 91-99.

[5] Lin Lefen, Li Yongxin. Journal of Nanjing University (Philosophy, Humanities and Social Sciences),2016,53(06):39-48+155. (in Chinese)

[6] Jiang Qiyuan, Xie Jinxing, Ye Jun, Mathematical Model (3rd edition), Beijing, Higher Education Press, 2006.9.12;