Financial Engineering and Risk Management (2021) 4: 84-90
Clausius Scientific Press, Canada
DOI: 10.23977/ferm.2021.040108
ISSN 2523-2576

Credit decision-making of small and medium-sized enterprises

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Keywords: data mining, analytic hierarchy process, neural network, nonlinear programming, least square matrix scatter diagram.

Abstract: In this paper, we mainly mine the input and output data in the appendix, and use the analytic hierarchy process, neural network, nonlinear programming, least square fitting curve, spss to draw matrix scatter diagram and other methods and tools to get the credit index, credit risk and other factors of the enterprise, and then determine whether the bank lends to the enterprise and the credit strategy such as loan amount, interest rate and term. Through quantitative analysis of a certain number of enterprises, this paper gives the credit decision of banks to small, medium and micro enterprises. Firstly, we quantitatively analyze the reputation of enterprises according to the reputation grade and whether there are default records, and then quantify the reputation index and reputation risk of 123 enterprises according to the results of data mining in Annex 1,The comprehensive strength of enterprises and other variables stipulate that enterprises below a certain reputation index will not lend, and enterprises that do not meet the requirements of reputation index will be removed, and then 91 enterprises will be screened out for loan quota allocation after removing abnormal data. Analytic hierarchy process, nonlinear programming, matrix scatter diagram and other methods and tools are mainly used.

1. Restatement of the problem

In real life, because the scale of small and medium-sized enterprises is relatively small, and many small and medium-sized enterprises lack mortgage assets, before lending, banks first need to assess their credit risk according to the strength and reputation of small and medium-sized enterprises, and then determine whether to lend or not according to credit risk and other factors, as well as credit strategies such as loan amount, interest rate and term. Banks are mainly based on credit policies, information on corporate transaction bills and the influence of upstream and downstream enterprises, providing loans to enterprises with strong strength and stable relationship between supply and demand, and giving preferential interest rates to enterprises with high reputation and low credit risk.

This paper quantitatively analyzes the credit risk of 123 enterprises, and determines and gives the credit strategy of the bank to these enterprises when the annual total credit is fixed

2. Problem analysis

Firstly, according to the credit rating and whether there is default record, we make quantitative analysis of credit risk, calculate the credit index and credit risk of each enterprise, stipulate that enterprises below a certain credit index will not lend, and exclude some enterprises that do not meet the requirements of credit index,Then, taking the bank's judgment of small and medium-sized enterprises as the basis for judging the comprehensive strength of small and medium-sized enterprises, we calculate the comprehensive strength vector of enterprises by using the analytic hierarchy process model,The profit equation of each grade A B C is obtained by fitting profit and loss rate,Finally, the calculation equation is listed to maximize the bank's profit and minimize the risk,According to the calculation results, the bank's credit strategy for these enterprises is allocated when the annual total credit is fixed.

3. Establishment and solution of three models

3.1 Data Processing and Variable Definition

Credit risk: (whether to lend, limit 1)

According to the credit rating in Annex 1 and whether there is default record, we make the following quantitative analysis of credit risk, which is defined as follows: the credit rating of an enterprise is expressed by credit index R, the credit rating is rx, the default risk is ry, and the credit rating rx={4 A, 3 B, 2 C, 1 D}, In order to maximize the interests of banks, the purpose of deciding whether to lend to a company is to minimize the number of defaults in one lending. Reputation index r should not only reduce the credit index of companies with default records to the lowest, but also clearly distinguish the credit indexes of A, B, C and D. Risk of default ry={0.5 (this value is expressed by ry1), if it violates the rules, it will not violate the rules},in order to clearly distinguish the credit indexes of a, b, c and d, we decide:

The reputation index r=rx*ry

According to Annex 1, we calculate the credit index of each enterprise, in which the credit risk is reflected by 1/r. After calculation, 〈 in order to achieve a better risk classification, the credit risk Dan is normalized to 1 $0.25 \leq \frac{1}{r} \leq 2$ r = 1r2.

Through the calculation of Annex 1, we get the reputation index of each enterprise in Annex 1 as shown in Figure 1 (Appendix 1), It is observed that the reputation index R of Company D is less than 1, which stipulates that companies with r<=1 will not lend, After screening, the number of enterprises lending is determined to be 9 among these 123 enterprises.

3.2 Establish and analyze the model to determine the comprehensive strength of the enterprise

3.2.1 Symbol Declaration

The total amount of lending by enterprises is Y, and the number of lending enterprises is n=97, which is easy to know 9.7 million < Y < 97 million

Banks usually provide loans to enterprises with strong strength and stable relationship between supply and demand based on information such as credit policies, trading bills of enterprises and the influence of upstream and downstream enterprises. We refer to the strength of the enterprise, the stability of the relationship between supply and demand, and the reputation of the enterprise as the comprehensive strength of the enterprise. In order to quantify the comprehensive strength of an enterprise, the variable of comprehensive strength is defined as POWER.

By processing the data of input invoice and output invoice in Annex 1, we get the data that can represent the strength. Definition: total input cost p1, number of input invoices p2, effective input ratio p3, total output cost p4, number of output invoices p5, effective output ratio p6, reputation index p7(p7=r/4) and annual profit p8 of the same company

Total input cost p1: sum of all input valid invoices of the same company

$$\mathrm{p1} = \sum_{n=1}^{p2*p3} x1 * x2$$

Input effective proportion p3: the proportion of effective invoices in the input invoices of the same company

$$\mathrm{p3} = \frac{\sum_{n=1}^{p3*p2} x2}{\mathrm{p2}}$$

Total cost of output p4: sum of all valid invoices for output of the same company

$$\mathrm{p4} = \sum_{n=1}^{p5*p6} x3 * x4$$

Output effective proportion p6: the proportion of effective invoices in the output invoices of the same company

$\mathrm{p8} = \frac{\mathrm{p4-p3}}{3}$ Annual profit P8: x

Let P=[p1,p1,p3,p4,p5,p6,p7,p8]

In order to calculate the digital POW of the comprehensive strength of the enterprise, we first normalize all pi(p1-p8) to get Figure 6 (Appendix 2)

$$\mathrm{pi} = \frac{\mathrm{pi}}{\mathrm{max(pi)}}$$

Taking p1-p8 as criteria, we use analytic hierarchy process to determine the value of POW

3.2.2 Establish an analytic hierarchy process model

The problem of evaluating the comprehensive strength of enterprises is decomposed into three levels, the top level is the target level, that is, to determine the comprehensive strength of enterprises; The middle layer is the criterion layer,Through the study of the given data, we determine that the angles of judging an enterprise's comprehensive strength include input cost, profit amount, input effective proportion, reputation index, output effective proportion, output cost, input invoice number and output invoice number,The bottom layer is the scheme layer, which determines the loan amount of each enterprise.

3.2.3 Model solving

CI=0.0795, RI=1.41, and CR=CI/RI=0.0564<0.1, which passed the one-time test.

Let the weights of p1-p8 be w1, w2, ..., w8,w=[w1,w2,w3,…,w8]

(1) the arithmetic average method to calculate the weight:

$$\text{wi1} = \frac{1}{8} * \sum_{j=1}^{8} \frac{pij}{\sum_{k=1}^{8} pkj}$$

w1=[0.0503, 0.2653, 0.0382, 0.3042, 0.0594, 0.1042, 0.0841, 0.0944]

(2) Calculating weights by geometric average method:

$$\text{wi2} = \frac{\left(\prod_{j=1}^{8} pij\right)^{\frac{1}{8}}}{\sum_{k=1}^{8}\left(\prod_{j=1}^{8} (pkj)^{\frac{1}{8}}\right)}$$

w2=[0.0460, 0.2710, 0.0374, 0.3082, 0.0548, 0.1070, 0.0821, 0.0935]

(3) Eigenvalue method to calculate the weight:

w3=[0.0481, 0.2706, 0.0374, 0.3080, 0.0575, 0.1038, 0.0822, 0.0924]

$$\begin{cases} \text{Wi} = \dfrac{\text{wi1} + \text{wi2} + \text{wi3}}{3} \quad i = 1, 2, \ldots, 8 \\ \text{W} = \dfrac{\text{w1} + \text{w2} + \text{w3}}{3} \end{cases}$$

W=[0.048133333 0.268966667 0.037666667 0.3068 0.057233333 0.105 0.0828 0.093433333]

$\text{POW} = \text{p} * \text{w}^{\text{T}}$ Comprehensive strength of an enterprise:

We deleted the data of 97 enterprises, deleted the enterprises with abnormal data, and selected 91 enterprises to make loans. Assume that the comprehensive strengths of these enterprises that meet the lending conditions are POW1,POW2,…, POW91, the comprehensive strength vector is pow=[POW1, POW2,…, POW91]. Comprehensive strength vector POW is shown in appendix 2

3.3 Processing data to determine the enterprise loan amount

3.3.1 Fitting the curve of profit and loss rate to determine the credit rating equation

Approximate estimation: the reputation index R = 3,2,1 is approximately equal to the reputation grades A, B and C.

Fitting profit feed(f) and loss rate (ls) curves:

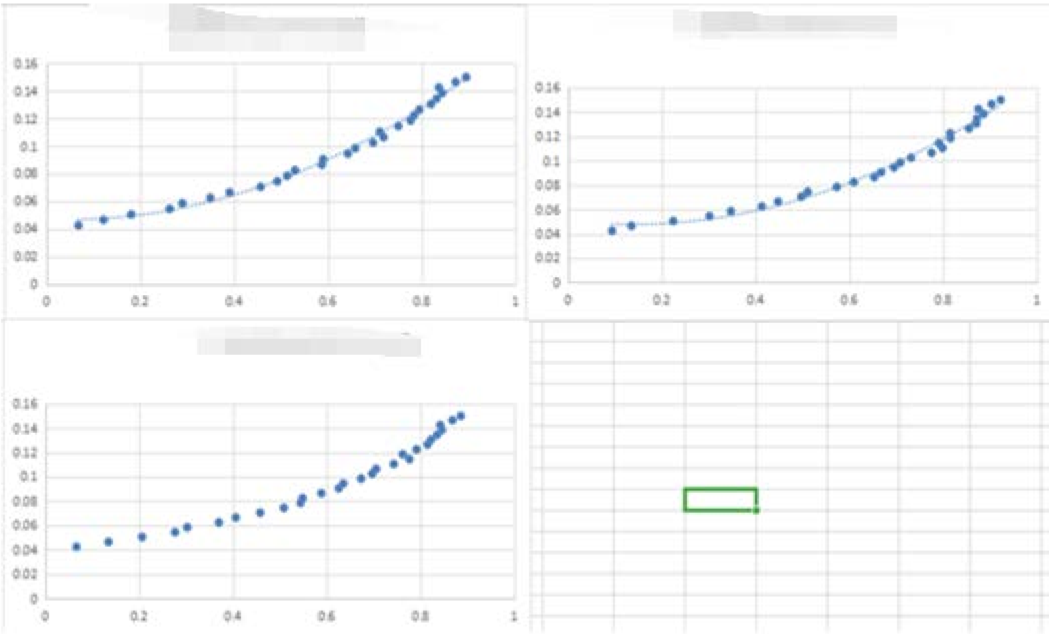

Figure. 1

3.3.2 Analyze and determine the loan amount of each enterprise

Let sum be the total amount of bank loans, and let fbx be the profit of the bank for x consecutive years. Let's assume that the bank loans to 91 companies are s1, s2, s3, …, s91. Let the loan vector be s={s1,s2,…, s91}, then

$$\mathrm{sum} = \mathrm{s}1 + \mathrm{s}2 + \ldots + \mathrm{s}91$$

In order to allocate loans to each company, it is necessary to minimize the loan risk, that is, the loan amount to a company should adapt to the comprehensive strength of the company, so as to ensure that the company has the ability to repay the loan. Because POW={pow1,pow2,…, pow91}, the comprehensive strength vector of enterprises represents the comprehensive strength of each enterprise. The comprehensive strength of an enterprise also represents the loan ability of an enterprise,The stronger the comprehensive strength, the stronger the loan repayment ability, that is, the lower the loan risk of the enterprise, so 1/POW can be used to express the loan risk of the enterprise.

$\frac{si}{\sum_{i=1}^{91} si}$ $\frac{powi}{\sum_{i=1}^{91} powi}$ Try to reduce the difference between¿and¿. $\begin{cases} \frac{powi}{\sum_{i=1}^{91} powi} = \frac{si}{\sum_{i=1}^{91} si} \\ s1 + s2 + \ldots s s91 = sum \end{cases}$ By limiting the loan amount of each company and the total loan amount of the bank, the inconsistency between the two formulas can be met at the same time

$\frac{si}{\sum_{i=1}^{91} si}$ $\frac{powi}{\sum_{i=1}^{91} powi}$ $\frac{powi}{\sum_{i=1}^{91} powi} - \frac{si}{\sum_{i=1}^{91} s}$ On the other hand, in order to maximize the profits of the Bank, we must ensure that fbx is the largest, and the sum of squares of o in this 910 enterprise indicates the closeness between o and o, which is called profit risk Dan.

$$\mathrm{Dan} = \left(\frac{powi}{\sum_{i=1}^{91} powi} - \frac{s}{\sum_{i=1}^{91} si}\right) * \left(\frac{powi}{\sum_{i=1}^{91} powi} - \frac{s}{\sum_{i=1}^{91} si}\right)^T$$

Bank profit is

$$\mathrm{fbx} = \mathrm{k1}\sum_{i=1}^{91} si * feed + k2 * \sum_{i=1}^{91} si * feed * (1 - lsi(feed)) + \dots$$

$$+ kn * \sum_{i=1}^{91} si * feed * (1 - lsi(feed))^{n-1} + \dots$$

$\mathrm{kn} = \frac{1}{\mathrm{n}^2}$ Among them, x

$\frac{1}{\mathrm{n}^{\mathrm{p}}}$ P series, （ convergence when p>1, divergence when p<=1,

$$\begin{cases} 10 < si < 100 \\ sum = s1 + s2 + \dots + s91 \\ \min \mathrm{Dan} = \left(\frac{powi}{\sum_{i=1}^{91} powi} - \frac{s}{\sum_{i=1}^{91} si}\right) * \left(\frac{powi}{\sum_{i=1}^{91} powi} - \frac{s}{\sum_{i=1}^{91} si}\right)^T \\ max\, fbx = s * feed * (s * feed)^T + \frac{1}{2^2} * feed * (s * feed)^T * (1 - ls(feed)) + \dots \\ + \frac{1}{2^2} * feed * (s * feed)^T * (1 - ls(feed))^n + \dots \end{cases}$$

translate into

$$\begin{cases} 10 < si < 100 \\ sum = s1 + s2 + \dots + s91 \\ max \frac{fbx}{Dan} \end{cases}$$

Another expression is to use linear programming:

$$\begin{cases} 10 < si < 100 \quad i = 1, 2, \dots, 91 \\ 0.04 < feed < 0.5 \\ \min Dan = \sum_{i=1}^{91}\left(\frac{powi}{\sum_{i=1}^{91} powi} - \frac{si}{\sum_{i=1}^{91} powi}\right)^2 \\ max\, fbx = k1 * \sum_{i=1}^{91} si * feed + k2 * \sum_{i=1}^{91} si * feed(1 - lsi(feed)) + \\ k2 * \sum_{i=1}^{91} si * feed(1 - lsi(feed))^2 \end{cases}$$

Convert to:

$$\begin{cases} 10 < si < 100 \quad i = 1,2,...,91 \\ 0.04 < feed < 0.15 \\ sum = s1 + s2 + \ ... \ + s3 \\ \max \dfrac{fbx}{Dan} \end{cases}$$

Matlab nonlinear programming fmincon () function verifies that when sum=3000, max (fbx/Dan)=146900, profit f=0.0996080293160429 (profit)

3.4 Solution results

The solution result of the model is in the form of loan vector, and the loan vector S is shown in Figure 6 (Appendix 2)

4. Suggestions

When we evaluate the credit risk of each company, besides the data given in the appendix, we can further evaluate the soft power of the company, such as the 5C index of enterprise leaders. In addition, when building the model, we found that under different loan interest rates, the loss rates of different credit ratings are approximately the same,On the premise of seeking the maximum benefit of banks, we believe that we can appropriately reduce the loanable amount of companies with low credit ratings and reduce the number of non-performing assets. When some companies fail to repay their debts, we can consider exchanging debts for securities to increase cash liquidity and avoid the accumulation of non-performing assets.

When facing different industries, banks can add industry categories as parameters to the evaluation of enterprise strength, For some industries supported by the state, they can appropriately tilt policies to increase loan quota and reduce loan interest. In the face of some large-scale emergencies, such as this year's epidemic, banks can properly adjust their policies on the premise of ensuring the safety of their own funds, reduce loan interest for enterprises with serious losses, extend the interest repayment time, and appropriately increase the loan amount.

References

[1] Shan Guangnian,Research on Credit Risk Management Strategy of Commercial Banks under the Background of Big Data [J], Business Economics, 2020(08): 164-165.

[2] Pi Changxing, Thinking on credit risk management of SMEs under the new financial normal [J], Financial and Economic Circles, 2020(26): 24.

[3] Gu Ming 'en, Deng Zhuo, Tang Zude, Chen Yu, Yang Yonghong, Quantitative evaluation of complete streets based on fuzzy comprehensive analytic hierarchy process [J/OL], Highway, 2020(09): 226-231 [2020-09-12]

[4] Zhang Zhiping, Zhu Siying, Lu Fengguang,Study on the capital market shock effect of COVID-19 epidemic [J],Friends of Accounting, 2020(18): 131-137.

[5] Xie lihui, risk prevention and control strategy analysis of small and micro enterprise loans of commercial banks under the impact of epidemic situation [J], science and technology economic market, 2020(07): 72-74.