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A study on bank lending strategy based on multi-objective planning model

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Abstract: This paper focuses on the credit decision problem of MSMEs. Based on the multi-objective planning model based on Topsis evaluation, the credit scheme for 123 enterprises with fixed total credit amount and its optimization scheme based on the multi-objective optimization model of game theory are formulated; a dual-objective planning model based on the principle of multiple allocations is established to give the credit scheme of banks for MSMEs under unexpected factors. Firstly, the epidemic is selected as the credit policy background, and the credit amount is allocated according to the principle of multiple allocations, taking into account the national situation and the operational essence of banks. Based on the social contribution rate of each industry, the lending rate of each industry is then calculated. Then, a secondary distribution was made within the industry by introducing indicators such as enterprise size and customer service rate, and using principal component analysis to score the creditworthiness of enterprises within each industry, which led to the conclusion that the annual interest rate for logistics and pharmaceutical enterprises was reduced and the credit amount was increased. Finally, the model was tested by searching the data related to the economic impact on Chinese MSMEs under the epidemic, and the reliability of the model was verified.

1. Introduction

In recent years, the worldwide economic situation has drifted, and the impact of the epidemic has caused the growth of China's economy to slow down year by year, and the steady growth of the domestic economy has become the main goal. In China's economy and society, MSMEs have a special position in the overall economy and are of great importance to employment growth, import and export trade, improvement of people's living standards and promotion of innovation. In order to enable the gradual and healthy development of MSMEs, the state has introduced a series of credit policies to promote the support of commercial banks for MSMEs. In reality, the scale of operation of MSMEs is relatively small and they do not have enough fixed assets for collateral. Therefore, banks provide a certain amount of loans to them based on their business ability and credit rating. Prior to this, the bank conducts a series of risk assessments to determine the specific credit strategy of the lender.

Banks offer loans to lenders in the range of 100,000 YUAN to 1 million YUAN, with annual interest rates of 4% to 15% and a term of one year [1]. Based on the data about 123 enterprises with

credit records, 302 enterprises without credit records and statistical data about the relationship between the interest rate of the loan and the bank's customer turnover rate in 2019 for one year [2]. Taking into account the credit risk of each enterprise and the impact of possible uncertainties on each enterprise, in order to ensure the production and economic efficiency of the enterprise, the credit adjustment strategy of the bank at the total annual credit amount of 100 million is given.

2. Model Construction

2.1 Comprehensive evaluation of Topsis based on combination weights

The enterprise credit risk degree is scored according to some important indicators. Considering the requirements of comprehensiveness and rationality that the scoring system needs to meet, the entropy method commonly used in the objective assignment method and the hierarchical analysis method commonly used in the subjective assignment method are used to analyze the combined weights of each indicator. At the same time, the Topsis method is introduced into the evaluation problem of enterprise credit risk. The principle is to list the problems to be evaluated into a matrix, determine the optimal state solution and the worst state solution through matrix normalization, calculate and compare the distance between each evaluated object and these 2 solutions, and derive the optimal object solution. And the characteristics of the optimal selection object that is closest to the optimal solution solution and farthest from the worst solution solution.

(1) Influence of the factors on the credit situation

All the five influencing factors have a significant impact on the credit risk rating, which proves that the selection of the influencing factors is reasonable. Among them, the most influential one on the credit risk rating is the amount of the total net income of the enterprise, if the amount of net income of the enterprise's annual turnover is higher, then the bank scores its credit rating relatively higher. Scoring of each enterprise

(2) Credit strategy plan

By scoring the credit risk profile of each enterprise, it was found that most of the medium-sized enterprises have higher loan amounts and relatively lower annual interest rates given by the banks, and these companies have a high and stable level of annual net income. For some small and micro enterprises, although the annual turnover is not high, but the operation trend is going well and the business income is very stable, the bank will lend relatively high amount for this kind of enterprises.

2.2 Multi-objective optimization model based on game theory ideas

Consider that there are 302 lending MSMEs in the object of lending studied in this paper, and each enterprise has the right to apply for a loan. Denote by $g_i \in [0,+\infty)$ the number of tasks taken up by enterprise $(i=1,2,\cdots,302)$, then the total number of bank lending amounts $G=g_1+g_2+\cdots+g_n$. Denote by v the average amount of each firm's application to the loan, assuming that v is a function of G. Each loan issued corresponds to a certain credit risk of the bank, so the amount of loan placed to each enterprise is limited, and the upper limit of the amount of credit issued by the bank is noted as G_{max}: when $G < G_{max}$, $v(G) > 0$; when G_{max}, $v(G) = 0$. When the total amount of all types of enterprises applying for loans is small, adding one or two more enterprises 27 to their lending will not have too much impact on the loan proceeds already invested, and at the same time can cater to the national policy of encouraging the development of small, medium and micro enterprises, but when the amount of bank lending is too much, the average amount that each enterprise can lend will drop sharply, so it can be assumed that when $G < G_{max}$, $v(G) < 0$ and $v(G) < 0$. In this game, the strategy chosen by bank i, i.e., participant i in the game, is the number of enterprises g_i he lends to. Assuming that the

probability of an enterprise applying for a loan and completing the return on schedule is c, when the number of credits granted by the bank to other MSMEs is $(g_1,\cdots,g_{i-1},g_{i+1},\cdots,g_n)$, the payoff function for the number of g_i loans granted by bank i is.

$$u_i(g_1,\cdots,g_n)=g_i\times v(g_1+\cdots+g_{i+1}+g_i+g_{i+1}+\cdots+g_n)-cg_i \tag{1}$$

In solving the model, several different sets of adjustment ratios of lending amounts and interest rates are set to obtain 302 The results are not shown here because of the large data size.

2.3 Presentation of indicators

As we can see from our national situation, most of the lending to small, medium and micro enterprises is done by the policy-oriented banks of the country, and the lending of these banks is determined by the relevant policies issued by the state as well as their own earnings. Therefore, in the event of a major public health event, the first consideration of these banks is whether the type of enterprises they credit can alleviate the economic pressure in our country to a certain extent. Therefore, the 302 enterprises are classified by industry and the following indicators are introduced Indicators.

(1) Social Contribution Index φ_i

(2) Economic loss indicators Φ_i

2.4 One time distribution

Based on the above proposed indicators, the amount of credit for each sector is allocated once and a dual target planning model is established. The planning model.

①Social contribution rate R: Banks maintain socio-economic stability by lending to MSMEs and other aspects. Therefore, priority should be given to lending to industries with high social contribution, so the objective function should be.

$$\max R=\sum_{i=1}^{n}\varphi_i x_i \tag{2}$$

where x_i represents the amount lent by the bank to type i enterprises.

②Bank economic loss indicator H: Due to the special period, the bank's own operation and profitability are also affected The economic loss function should be proposed to minimize the economic loss for the bank as much as possible because the bank's own operation and profitability have been affected considerably during the special period.

$$\max H=-\sum_{i=1}^{n}\phi_i k_i x_i \tag{3}$$

where k_i is the number of firms in the i-th industry.

Observe the above indicators, the objective function contains two: ① the highest social contribution rate ② the bank economic loss as small as possible. The bank should first consider whether the type of credit enterprises can, to a certain extent, alleviate the economic pressure in our country so in the actual lending, the evaluation level of each enterprise for credit risk varies greatly, if the bank is given a fixed interval of economic loss, the cost of the bank is limited to the interval, then it will be possible to simplify the dual-objective planning problem to a single-objective planning problem:

Objective function.

$$\max R = \sum_{i=1}^{n} \varphi_i x_i \tag{4}$$

Constraints.

$$\text{s.t} \begin{cases} 10 \le x_i \le 100 \\ H = -\sum_{i=1}^{n} \phi_i k_i x_i \le A, A \text{ is Constant value} \\ k_i \ , \varphi_i \ , \phi_i \ \text{ All are constants} \end{cases} \tag{5}$$

2.5 Secondary distribution

The average loan amount of enterprises in each industry is obtained from the primary planning, and the following secondary allocation is made within the industry Allocation. Since the average loan amount of some enterprises is the upper limit of bank lending of 1 YUAN million or the lower limit of 100,000YUAN, no secondary allocation is made to these enterprises. The average loan amount of some enterprises is the upper limit of bank lending or the lower limit of 100,000 YUAN, so no secondary allocation is made to these enterprises. For the average loan amount between 100,000 and 1,000,000, the average loan amount of these enterprises is considered. Considering the indicators proposed in question 1 and question 2, the following indicators are introduced.

1) total net income B_{ij} : is the total amount of goods sold by the enterprise, i.e.

$$B_{ij} = \sum_{z=1}^{m} y_{ijz} - \sum_{z=1}^{n} x_{ijz} \tag{6}$$

2) Company service index w_{ij}: Analyzing the data in the invoices, we can count the number of customers of each company, and the number of customers reflects the breadth of the company's operations, thus giving the company service index.

$$\omega_{ij} = \frac{n_{ij}}{n_{i\max}} \tag{7}$$

3) Enterprise size π_{ij} : The daily financial inflows and outflows of each enterprise reflect, to a certain extent, the economic strength of an enterprise's economic strength. If the sum of the absolute value of the inflow and outflow of funds in the water of a certain enterprise is larger, then then it means that the company is larger. Under the strong impact of the epidemic on the economic system, the size of the enterprise largely determines whether the enterprise can The size of the firm largely determines whether the firm can sustain itself or not. Using the valid input and output invoices given in Annex I, the total amount of the total amount to estimate the firm's enterprise size, i.e.

$$\pi_{ij} = \sum_{z=1}^{n} x_{ijz} + \sum_{z=1}^{m} y_{ijz} \tag{8}$$

Based on the above indicators, we use principal component analysis to obtain the contribution of total net income, company service index, enterprise size and then the scores of each type of enterprises, taking industry as an example, are given in Table 1.

Table 1 Contribution scores of individual firms in the industry

Enterprise	Total net incomeB_{ij}	Company Service Index ω_{ij}	Enterprise size π_{ij}
Contribution Score	0.3705	0.1689	0.4606

2.6 Multi-objective planning model

The expected income of the bank is recorded as F.

$$F = \sum_{i=1}^{n} P_i \lambda_i x_i k_i \tag{9}$$

Where x represents the amount of bank lending to class *i* firms, λ_i represents the interest rate charged by banks to class *i* firms, and λ_i is between 0.04 and 0.15; Pi is the probability of compliance with credit for class *i* firms, AAA is the principal component analysis score of the *jth* firm in class *i* industry, and m_{max} is the firm with the highest principal component analysis score.

Record the bank's risk loss as *Q*.

$$Q = \sum_{i=1}^{n} (1 - P_i) x_i k_i \tag{10}$$

The total credit to the bank is recorded as Y.

$$Y = \sum_{i=1}^{n} k_i x_i = 10000 \tag{11}$$

Objective function.

$$\begin{cases} \max F = \sum_{i=1}^{n} P_i \lambda_i x_i k_i \\ \min Q = \sum_{i=1}^{n} (1 - P_i) x_i k_i \end{cases} \tag{12}$$

Constraints.

$$\text{s.t} \begin{cases} Y = \sum_{i=1}^{n} k_i x_i = 10000 \\ P_i = \dfrac{m_i}{m_{\max}}, i = 1, 2, \cdots, n \\ 0.04 \le \lambda_i \le 0.15 \\ 10 \le x_i \le 100 \end{cases} \tag{13}$$

Where, xi represents the amount lent by the bank to the firm in category *i*; P_i is the probability of credit compliance for the firm in category *i* and mi is the contribution rate score for the firm in category *i*; λ_i represents the interest rate charged by the bank for the firm in category *i*; and k_i is the number of firms in the firm in industry *i*.

3. Model solving and testing

3.1 Solution of the model

The simulated annealing method based on genetic algorithm [3] is chosen to solve the optimization model, which takes into account the advantages of genetic algorithm and simulated annealing algorithm and solves the problem of randomness of the genetic algorithm solution and the difficulty of determining the initial value solution of simulated annealing algorithm in the following steps.

Step1: Iterate the lower limit of the loan, solve the dual objective with the genetic algorithm separately, plot the social contribution rate and the economic loss of the bank, and select the lower limit of the loan amount of the trade-off.

Step2: Calculate the parameters of the dual objective under this lower limit of loan amount, and find the mean value as the initial solution of the simulated annealing method.

Step3: Set the initial temperature T, the length of each move, and the depth of iteration, and search the selected initial value solution with the simulated annealing algorithm to find the final loan amount and the total social contribution of each industry.

Based on the randomness of the genetic algorithm [4], different loan floor amounts are explored, and the loan floor with the minimum economic loss of the bank is selected to be 400,000 within the range of the higher social contribution rate by integrating the economic loss of the bank and the social contribution rate. On this basis, the minimum loan floor is fixed, and the loan amounts of each industry corresponding to the two objective functions in the current situation are calculated separately. In order to make the solution of the model converge to the optimal solution, the mean value of the parameters under the dual objective function is now obtained as the initial value solution of the simulated annealing algorithm, which solves the drawback of the simulated annealing algorithm over-relying on the initial value solution [5]. Finally, the dual-objective planning problem is transformed into a single-objective planning planning problem, and the total social contribution is found to be 557.1342. the final solved average loan allocation amount for each industry is as Table 2.

Table 2 Average loan amount by industry

Industry	Average loan amount for enterprises	Industry	Average loan amount for enterprises
Agroforestry	99.8090	Business	87.7944
Industrial	93.8014	Information Network	91.9385
Architecture	0	Technology	89.1480
Wholesale	56.1457	Transportation and Logistics	99.5019
Retail	54.6257	Medicine	95.9531
Real Estate	0	Other	40

The interest rates for each industry are as follows.

Table 3 Loan rates by industry

Industry	Loan rates by industry	Industry	Loan rates by industry
Agroforestry	0.040	Business	0.143
Industrial	0.089	Information Network	0.0678
Architecture	0.150	Technology	0.0678
Wholesale	0.150	Transportation and Logistics	0.04
Retail	0.150	Medicine	0.04
Real Estate	0.150	Other	0.14

According to the analysis of the obtained results, it is found that banks do not issue loans to enterprises in the construction and real estate industries, while the amount of loans issued to the transportation and logistics and pharmaceutical industries [6] is relatively high, which is in line with the actual situation in the context of the epidemic. Considering the national policy and the current economic situation of MSMEs [7], banks can grant loans to enterprises that are more affected by the epidemic with a grace period for deferring repayment, and at the same time, they can grant credit preferences with lower annual interest rates to biomedical and logistics industries to promote the internal circulation of our economy.

3.2 Testing of the model

Some data on the business situation of MSMEs under the epidemic were found [8], and the proposed evaluation index set was used to The proposed set of evaluation indicators was evaluated and the results were obtained and compared with the economic income of each enterprise, and the results obtained are The following results were obtained.

Table 4 The economic loss of four types of industries

Small, medium and micro enterprises	Construction	Logistics Industry	Wood Industry	Information Industry
Economic loss	27.53%	-12.4%	19.7%	-31

The results of the analysis show that the construction and wood industries suffered more serious losses, considering that due to the impact of the epidemic, the large The logistics and information industries had a certain increase in turnover. The logistics and information industries had a certain degree of increase in turnover, considering that the nationals responded to the national call for autonomous quarantine during the epidemic, and electronic products were used more often. Considering the fact that during the epidemic period, the people responded to the national quarantine, more electronic products were used, and online shopping was also more frequent. Therefore, the model is consistent with the actual situation and is more reasonable.

4. Conclusion

Through a comprehensive analysis of our national conditions and the actual nature of our banks, the economic impact on our industry under the impact of a major public health event was considered. A multi-layer allocation method of loan amounts was used, which is of some interest. Firstly, a layer of allocation was carried out to divide 302 enterprises into 12 categories according to industries, introduce the social contribution rate of each industry, the damage rate of the industry and other indicators, and establish a multi-objective planning model to obtain the number of loans given by banks to each industry, and based on the size of the social contribution rate of each industry, the interest rate of each industry's loan was derived. In calculating the number of loans to each industry, because of too many variables, the equilibrium point of the objective function was first found out by genetic algorithm, and the equilibrium point was substituted into the simulated annealing algorithm as the initial value to find out a better result. Then, the secondary distribution was carried out within the industry by introducing indicators such as enterprise size, customer service rate, etc. The principal component analysis was applied to score the creditworthiness of enterprises within each industry, and the number of loans for each enterprise was given as an example for industry. Finally, a sensitivity analysis of the model was conducted and the model was tested by finding data on the web about the economic impact of the 2020 New Crown epidemic on China's industries to verify the rationality of the model. It is a good guide for future bank lending programs to MSMEs.

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