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Research Article

Multiobjective Programming Strategy of Small- and Medium-Sized Microenterprise Credit Based on Random Factors

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In this paper, we select eight indicators from the aspects of an enterprise's bill transaction information, namely, whether the enterprise's loan is in breach of contract, effective invoice rate, total utilization rate of price and tax, negative invoice rate, strength of enterprise, coefficient of variation, flow efficiency of assets, and influence of upstream and downstream enterprises; then, we construct an evaluation index system. According to different industries, different categories, and the impact of random factors, we divide the types of enterprises into 10 categories. Then, we use three kinds of Poisson random numbers to carry out numerical simulation on the total price and tax of enterprises in different industries under the influence of COVID-19.

1. Background

When banks provide loans to small- and medium-sized and microenterprises (small- and medium-sized and microenterprises are abbreviated as SMMEs), they often judge whether to lend or not through credit risk assessment. Because of the lack of mortgage assets in SMMEs, the bank will make credit risk assessment based on the credit policy, influence, strength, and stability of supply and demand relationship of the enterprise, and then determine whether to lend, loan amount, interest rate and term, and other credit strategies. Some corporate banks have credit records, some have no credit records. However, in the face of the impact of sudden random factors on enterprises, how to give the credit strategy when the annual total credit is fixed.

2. The Selection of Credit Risk Quantitative Index

This paper analyzes the relevant data indicators of enterprises with credit records, takes into account the actual situation affecting the credit problems of SMMEs and refers to the advanced international standards, and selects eight quantitative indicators affecting the credit risk of enterprises according to China's national conditions and the bank's credit policy:

(1) Whether the enterprise loan is in breach of contract is an important indicator for the bank to examine whether the enterprise can bring the money. Default is 0 and nondefault is 1. W_i means whether ith enterprise is in breach of contract. $W_i = 0$ means the enterprise defaults, while $W_i = 1$ means that the enterprise has not breached the contract

(2) Effective invoice rate: it is equal to the ratio of the number of valid invoices to the total number of invoices. B_i is used to denote the effective invoice rate of the ith enterprise, YF_i indicates the number of valid invoices for the ith enterprise, and A_i represents the total invoice number of the ith enterprise. Thus, the corresponding formula of the effective invoice rate of the ith enterprise is as follows:

$$B_i = \frac{YF_i}{A_i}. \quad (1)$$

(3) Utilization rate of total price and tax: it is equal to the ratio of the total price and tax of the valid invoice to

the total price and tax of all invoices. Putting β_i represents the utilization rate of the total price and tax of an effective invoice of the ith enterprise

(4) Negative rate of invoice z_i: it is equal to the ratio of the number of invoices of the ith enterprise whose value of the total invoice price and tax is "-" to the number of total invoices of the ith enterprise

(5) EVA_i: it is equal to the ratio of the difference between the total price and tax of the output and input of the ith enterprise to the total price and tax of input, which indicates the strength of the enterprise. Putting S_i represents the total price and tax of the output (sales revenue) of the ith enterprise, and J_i represents the total price and tax of the ith enterprise's input (purchased products), which uses the following corresponding formula:

$$\mathrm{EVA}_i = \frac{S_i - J_i}{J_i}. \tag{2}$$

(6) Coefficient of variation: it indicates the stability of supply and demand relationship of enterprises. Using c_i represents the coefficient of variation of the ith enterprise. x_{ij} represents the total input price and tax of the ith enterprise in the jth month, s_{ij} is the total output value tax of the ith enterprise in the jth month, and I_{ij} represents the net income of the ith enterprise in the jth month. If $x_{ij} = 0$, let us take directly $\mathrm{EVA}_{ij} = 0$. The corresponding formula is follows:

$$\begin{aligned} I_{ij} &= S_{ij} - x_{ij}, \\ \mathrm{EVA}_{ij} &= \frac{I_{ij}}{x_{ij}}, \\ c_i &= \frac{\sqrt{(1/n)\sum_{j=1}^{12}\left(\mathrm{EVA}_{ij} - \overline{\mathrm{EVA}_{ij}}\right)^2}}{(1/n)\sum_{j=1}^{12}\mathrm{EVA}_{ij}}, \end{aligned} \tag{3}$$

where $\overline{\mathrm{EVA}_{ij}}$ represents the average value of EVA_{ij} in 12 months of the ith enterprise

(7) Liquidity efficiency of assets: it refers to the comparative relationship between current assets and current liabilities of SMMEs in the same period, that is, the short-term solvency of SMMEs

The following table shows the asset flow data of the ith enterprise in 12 months, as shown in Table 1.

The net income of the previous month is transferred to the next month as part of the next month's input, which shows the liquidity of funds. The liquidity efficiency of the ith enterprise asset μ_i can be expressed as follows:

$$\mu_i = \frac{m}{12}, \tag{4}$$

where 12 represents 12 months, and m refers to the number greater than 0 in EVA_{ij} of ith enterprise in 12 months. In fact, μ_i is the proportion of the number of months whose value is greater than 0 to the total number of months. The larger the value indicates that the better the flow efficiency of ith enterprise.

(8) Influence of upstream and downstream enterprises v_i: the influence is expressed by the maximum number of effective cooperation between the ith enterprise and upstream and downstream enterprises. In order to quantitatively describe the influence of upstream and downstream enterprises, the influence function of upstream and downstream enterprises is introduced with reference to the negative exponential function of the psychological curve [1]:

$$v_i = 1 - e^{-(n_i)^{1/3}}, \tag{5}$$

where n_i refers to the largest number of input invoice and output invoice of the ith enterprise in 12 months. Following the increase of n_i, the influence of upstream and downstream enterprises v_i will also increase.

In the quantitative index system affecting the credit risk of SMMEs, the first to fourth indexes reflect the reputation of enterprises, the fifth index reflects the strength of enterprises, the sixth index reflects the stability of the supply and demand relationship of enterprises, the seventh index reflects the size of the credit risk of enterprises, and the eighth index reflects the influence of enterprises and upstream and downstream enterprises.

3. Comprehensive Evaluation of Credit Risk Quantitative Index System

In order to eliminate dimension and the positive and negative effects of index, in this paper, the fuzzy membership method is used to standardize the index. Let y_{tj} be the tth index value of the jth evaluation object; w_{tj} be the standardized value of the tth index of the jth evaluation object and n be the number of objects to be evaluated. Then, the positive index standardization formula (6) and the negative index standardization formula (7) can be used to standardize the index [2]:

$$w_{tj} = \frac{y_{tj} - \min_{1\le j\le n} y_{tj}}{\max_{1\le j\le n} y_{tj} - \min_{1\le j\le n} y_{tj}}, \tag{6}$$

$$w_{tj} = \frac{\max_{1\le j\le n} y_{tj} - y_{tj}}{\max_{1\le j\le n} y_{tj} - \min_{1\le j\le n} y_{tj}}. \tag{7}$$

Among the 8 indicators of the quantitative index system affecting credit risk of SMMEs, the fourth indicator (negative invoice rate) and the sixth indicator (enterprise coefficient of variation) are both negative indicators, which need to be

Table 1: Asset flow data of enterprises.

Month	1	2	$\cdots$	12
Total of input price and tax	x_{i1}	x_{i2}	$\cdots$	$x_{i,12}$
Total of output price and tax	s_{i1}	s_{i2}	$\cdots$	$s_{i,12}$
Net income	$I_{i1} = s_{i1} - x_{i1}$	$I_{i2} = I_{i1} + s_{i2} - x_{i2}$	$\cdots$	$I_{i,12} = I_{i,11} + s_{i,12} - x_{i,12}$
EVA_{ij}	I_{i1}/x_{i1}	I_{i2}/x_{i2}	$\cdots$	I_{i12}/x_{i12}

processed with the help of formula (7), while other indicators are calculated with the help of formula (6).

The following uses the entropy weight TOPSIS method to evaluate the credit risk quantitative index system of SMMEs. On the one hand, the entropy weight method is used to determine the coefficient of the credit risk quantitative index system. On the other hand, the TOPSIS method, that is, the technology of approaching the ideal solution, is used to determine the ranking of the evaluated object n SMMEs. The core idea of the TOPSIS method is to define the positive ideal solution and negative ideal solution of the decision problem, and then compare and evaluate the distance between the solution and the positive ideal solution and negative ideal solution, and finally calculate the relative closeness degree between each solution and the ideal solution, and order the advantages and disadvantages of the solution.

3.1. Entropy Weight Method Being Used to Calculate the Objective Weight of Indexes. Set w_{ij} as the normalized value of the jth indicator in the ith system, where $i = 1, 2, \cdots, n$ and $j = 1, 2, \cdots, 8$. For a given index j, the larger the difference of w_{ij}, the larger the comparative effect of this index has on the system, that means the more information the index contains and transmits.

The specific steps of the entropy method to determine the index weight are as follows:

(i) Calculating the entropy value of 8 indicators such as effective invoice rate. Set e_j as the entropy value of the$j$th index, the solution process is as follows [3]:

$$\begin{aligned} p_{ij} &= \frac{w_{ij}}{\sum_{i=1}^{n} w_{ij}}, \\ e_j &= -\frac{1}{lnn} \sum_{i=1}^{n} p_{ij} \ln p_{ij}, \end{aligned} \tag{8}$$

where p_{ij} is the characteristic proportion of the jth index in the ith system, $i = 1, 2, \cdots, n$ and $j = 1, 2, \cdots, 8$. $\sum_{i=1}^{n} w_{ij}$ are the sum of all system observation data of the jth indicator

(ii) Calculation of the coefficient of variance g_j of the jth index $g_j = 1 - e_j$

(iii) Determine the weight coefficients of 8 indexes $s_j = (g_j / \sum_{j=1}^{8} g_j)$

3.2. Weighting of Standardized Data. Let y_{ij} be the weighted value of the jth index standardized data of the ith SMMEs, w_{ij} be the normalized value of the jth index observed value of the ith SMMEs, and s_j be the weight coefficient. According to the weighting method, it can be seen that

$$y_{ij} = w_{ij} s_j. \tag{9}$$

3.3. Determining the Positive and Negative Ideals of the Evaluation System. Set y_j^+ and y_j^- as the maximum and minimum value of the jth index observation data, respectively, $j = 1, 2, \cdots, 8$:

$$\begin{aligned} y_j^+ &= \max_{1 \le k \le n} y_{kj}, \\ y_j^- &= \min_{1 \le k \le n} y_{kj}. \end{aligned} \tag{10}$$

It is easy to know that the positive and negative ideal solutions of the evaluation system are, respectively, $y_j^+ = (y_1^+, y_2^+, \cdots, y_8^+)$ and $y_j^- = (y_1^-, y_2^-, \cdots, y_8^-)$.

3.4. Calculating the Euclidean Distance between the Evaluation System and the Ideal Solution. Let d_i^+ be the Euclidean distance between the weighted value of the ith enterprise and the positive ideal solution and d_i^- be the Euclidean distance between the weighted value of the ith enterprise and the negative ideal solution. Then

$$\begin{aligned} d_i^+ &= \sqrt{(y_1^+ - y_{i1})^2 + (y_2^+ - y_{i2})^2 + \cdots + (y_8^+ - y_{i8})^2}, \\ d_i^- &= \sqrt{(y_1^- - y_{i1})^2 + (y_2^- - y_{i2})^2 + \cdots + (y_8^- - y_{i8})^2}. \end{aligned} \tag{11}$$

3.5. Calculating the Relative Closeness Evaluation Result. Set f_i as the relative closeness of all the indexes and the ideal solution of the ith enterprise, then

$$f_i = \frac{d_i^-}{d_i^- + d_i^+}, \tag{12}$$

where $i = 1, 2, \cdots, n$.

Determine the development status of the evaluated index by calculating the closeness. The greater the relative closeness f_i, the closer the evaluated index is to the ideal solution, and the better the development status.

4. Banks' Credit Strategies for SMMEs under Random Factors

Let x_i be the amount of the bank's loan to the ith SMMEs and l_i be the interest rate of the bank's loan to the ith SMMEs. Whether the bank gives loans to ith SMMEs, we use the 0-1 function

$$c_i = \begin{cases} 1, & \text{bank made a loan to the } i\text{th enterprise}, \\ 0, & \text{bank does not lend to the } i\text{th enterprise}. \end{cases} \quad (13)$$

The production, operation, and economic benefits of enterprises may be affected by some unexpected factors, and the size of the impact is related to different industries and different types of enterprises. For example, when COVID-19 became widespread, the demand for medical services and products produced by healthcare companies increased rapidly. With the help of relevant state policies, the total credit amount of banks to such healthcare companies and health enterprises will increase. At the same time, in order to avoid the rapid transmission of COVID-19, the state often needs to cut off some transmission routes. For example, during the outbreak of COVID-19, the state issued policies to close some self-employed small- and medium-sized enterprises, so as to reduce the movement of people and avoid cross-infection caused by too many people. In this regard, banks will reduce the total amount of credit to such self-employed SMMEs to avoid credit risk.

According to different industries, different categories, and the size of the impact, we classify enterprises as follows: self-employed enterprises, trade and transportation industry, literature and art advertising industry, manufacturing industry, service industry, financial investment industry, medical and health industry, high-tech enterprises, catering industry, and other industries.

In order to visually show the impact of credit risk and possible sudden factors on each enterprise, we carry out the numerical fluctuation of the total input price tax and the total output price tax of 10 types of enterprises. According to the actual impact of COVID-19 on society, the total input price and tax and the total output price and tax of the medical and health industry should be increased, while the total input price and tax and the total output price and tax of the individual business should be reduced. The concrete method is to add random numbers (Poisson random numbers) that are divided into three types for simulation.

The first category is to increase the total input and output tax of the medical and health industry, and the total input and output tax are, respectively, J_i and S_i. By adding random number α_i (0~100%), the total input price and tax and the total sales tax after the influence are, respectively $(1+\alpha_i)J_i$ and $(1+\alpha_i)S_i$. In MATLAB software, the function alpha1 = rand (length(location_a), 1) is used to achieve this [4, 5].

In the second category, for self-employed enterprises, the total input price and tax and the total output price and tax of the catering industry are reduced. The original total input price and tax and the total output price and tax are, respectively, J_i and S_i. By adding random number γ_i (-100%~0), the total input price and tax and the total output price and tax are $(1+\gamma_i)J_i$ and $(1+\gamma_i)S_i$. This is achieved with the help of the functiongamma1 = rand (length(location_g), 1).

In the third category, the influence of other industries is relatively small, and the random number φ_i (-50% ~50%) is added and fluctuates randomly, and the original total of the input price and tax and the total of the output price and tax are J_i and S_i, respectively. The total input price and tax and output price and tax are $(1+\varphi_i)J_i$ and $(1+\varphi_i)S_i$. This is achieved with the help of the function phi1 = rand (length(location_p), 1)/2.

5. Multiobjective Planning Strategy of SMME's Credit under Random Factors

When the COVID-19 outbreak occurred, the demand for services and products provided by medical and health enterprises also increased rapidly, and the resulting enterprise profits also increased, so the ability of enterprises to repay loans increased. It is a pity that the profit of the self-employed enterprise is reduced or stagnated, and the ability to repay the loan is weakened. Due to the impact of unexpected factors, the repayment ability is weakened and the bank's income is affected.

5.1. Determination of Objective Function. From the front, we can see that f_i means the comprehensive evaluation score of the ith enterprise out of n enterprises. Let

$$\begin{aligned} f_{\min} &= \min\{f_i\}, \quad i = 1, 2, \cdots n, \\ f_{\max} &= \max\{f_i\}, \quad i = 1, 2, \cdots n. \end{aligned} \quad (14)$$

Let the ith enterprise repayment for the bank loan ratio be τ_i. Taking it here

$$\tau_i = \frac{f_i - f_{\min}}{f_{\max} - f_{\min}}. \quad (15)$$

Thus, the amount of the loan that the ith enterprise can repay is $\tau_i x_i$. To establish the objective function

$$\max \sum_{i=1}^{n} c_i (1 - f_i) l_i \tau_i x_i. \quad (16)$$

On the other hand, the smaller the bank's lending risk, the better. f_i/J_i indicates the unit capital risk of the ith SMMEs, and $x_i(f_i/J_i)$ represents the investment risk brought by the capital flow x_i of the ith SMMEs, and establishes an objective function for this purpose:

$$\min \sum_{i=1}^{n} c_i x_i \frac{f_i}{J_i}. \quad (17)$$

On the other hand, the bank loan amount should take into account the business strength of the enterprise. This paper uses the sample variance index of loan amount and total input price and tax to describe the balance of credit amount, and establishes the objective function for this purpose:

$$\min s^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(\frac{x_i}{J_i} - \frac{1}{n}\sum_{i=1}^{n}\frac{x_i}{J_i}\right)^2. \quad (18)$$

5.2. Determination of Constraints

(i) The loan limit of the established bank to the enterprise determined to be loaned is 10-100 (ten thousand), so

$$10 \le x_{\mathrm{i}} \le 100, \quad i = 1, 2, \cdots, n. \quad (19)$$

(ii) The annual loan interest rate of the bank to the enterprise determined to lend is 4%~15%. Thus

$$4\% \le l_{\mathrm{i}} \le 15\%, \quad i = 1, 2, \cdots, n. \quad (20)$$

(iii) The balance of a bank's investment in enterprises. It's represented by x_i/J_i. The demand for services and products provided by medical and health enterprises is increasing rapidly. Therefore, the total input price and tax of such enterprises should also be increased, and the amount of bank loans to such enterprises should be increased. When the number of self-employed enterprises decreases or stagnates, the total input value and tax should also be reduced, and the amount of bank loans to such enterprises should be reduced. The upper and lower limits of the total balance of input price and tax for medical and health input are adjusted to 0.8 and 2. Considering that an individual business cannot be given a loan completely, the upper and lower limits of the total balance of input price and tax of an individual business are adjusted to 0.3 and 1, the upper and lower limits of other industries remain at 0.5 and 1.5. Set M = "medical enterprise code"; G = "individual enterprise code"; and Q = "all other enterprise codes". We agreed that

$$\begin{aligned} 0.8 &\le \frac{x_i}{J_i} \le 2, \quad i \in M, \\ 0.3 &\le \frac{x_i}{J_i} \le 1, \quad i \in G, \\ 0.5 &\le \frac{x_i}{J_i} \le 1.5, \quad i \in Q. \end{aligned} \quad (21)$$

(iv) Whether the bank loans to the enterprise and the loan amount is consistent, let δ be a very small positive number and M be a very large positive number. The values of 1 and 0 of c_i, respectively, indicate that the bank loans to the ith enterprise and does not lend to the ith enterprise. In order to ensure the consistency of bank loans to the enterprise and the loan amount, there are constraints

$$\delta c_i \le x_i \le M c_i. \quad (22)$$

(v) Total amount of loan. Assuming that the total amount of loan is 100 million when the bank loans to n enterprises, the unit here takes 10000 yuan. We have

$$\sum_{i=1}^{n} x_i = 10^4. \quad (23)$$

6. Example Checking

This paper verifies the multiobjective planning strategy of SMMEs under the influence of COVID-19 by using the related data. The original data of this paper comes from the data of competition question C for CUMCM-2020 (China University mathematical modeling competition), which can be downloaded publicly [6] (http://www.mcm.edu.cn/html_cn/node/10405905647c52abfd6377c0311632b5.html).

Firstly, the Poisson random number is considered, and with the help of the TOPSIS evaluation method, the scores and ranking comparison table of 302 enterprises before and after the introduction of random distribution are obtained [7–17]. The scores and ranking of the top 20 enterprises with enterprise number before and after the introduction of random distribution are shown in Table 2.

It can be seen from Table 2 that, after the introduction of random distribution, the ranking of enterprises with enterprise labels ranging from 1 to 20 changed correspondingly—-some changed greatly, while some changed less—indicating that our model has good practicability.

After the introduction of random distribution, the changes in scores and rankings.

of the top 20 enterprises among the 302 enterprises are shown in Table 3.

As can be seen from Table 3, after the introduction of random distribution, the number of the top 20 enterprises is basically still in the top 20, indicating that our comprehensive evaluation method is relatively good and the ranking distribution is relatively stable.

From Table 4, we can see the ranking changes of enterprises in the case of occurrence of emergent factors and absence of emergent factors. It can be found that under the influence of COVID-19, the rating and ranking of enterprises in the medical and health industry have increased, indicating that under the influence of COVID-19, such enterprises have a good credit situation and a low credit risk. However, the decline in the score and ranking of self-employed enterprises indicates that under the influence of COVID-19, the credit situation of such enterprises is poor and the credit risk is high, which is in line with the actual situation. It indicates that our TOPSIS evaluation method is effective and can be better applied to the situation when random factors occur.

When the total annual credit of the bank is 100 million yuan, we use the data given in the attached table of question C to establish the multiobjective programming model of 302 enterprises.

Table 2: Comparison of scores and rankings of the top 20 enterprises with enterprise numbers before and after the introduction of random distribution.

The score results of entropy weight method before introducing a random distribution			The score results of entropy weight method after introducing a random distribution		
Enterprise numbers	Score f_i	Ranking	Enterprise numbers	Score f_i	Ranking
1	0.03470546	133	1	0.01051545	258
2	0.03473871	132	2	0.01009714	271
3	0.26589653	77	3	0.2664342	52
4	0.29959602	8	4	0.36079418	3
5	0.26882309	21	5	0.31805003	22
6	0.2663194	61	6	0.04038756	92
7	0.26669382	46	7	0.01158391	189
8	0.26632932	59	8	0.0171994	112
9	0.26681615	40	9	0.01643889	114
10	0.26611135	72	10	0.11524284	72
11	0.26909606	19	11	0.32030139	17
12	0.2667195	44	12	0.31590827	32
13	0.26702299	31	13	0.01160196	187
14	0.26627581	63	14	0.11280042	75
15	0.26699131	33	15	0.31609219	31
16	0.27680573	15	16	0.32686684	12
17	0.2469376	90	17	0.29235498	47
18	0.26674657	42	18	0.31711769	26
19	0.26660041	50	19	0.31528929	40
20	0.24583911	93	20	0.24091041	58

Table 3: Changes in scores and rankings of the top 20 companies after the introduction of random distribution.

The score results of entropy weight method before introducing a random distribution			The score results of entropy weight method after introducing a random distribution		
Enterprise numbers	Score f_i	Ranking	Enterprise numbers	Score f_i	Ranking
206	0.65353762	1	206	0.74570025	1
30	0.51530701	2	30	0.55732306	2
4	0.36079418	3	237	0.33358854	3
107	0.34892084	4	235	0.31445308	4
92	0.34436155	5	89	0.31144136	5
89	0.34363768	6	107	0.30352414	6
76	0.34281575	7	220	0.30110706	7
220	0.34233996	8	4	0.29959602	8
122	0.33108545	9	92	0.2928879	9
26	0.32893502	10	76	0.29120591	10
62	0.32855488	11	122	0.28217424	11
16	0.32686684	12	26	0.28128101	12
38	0.32600357	13	38	0.28008684	13
45	0.32299682	14	62	0.27817557	14
110	0.32166147	15	16	0.27680573	15
33	0.32044747	16	45	0.27234886	16
11	0.32030139	17	33	0.27128483	17
53	0.3194912	18	110	0.27112156	18
111	0.31946501	19	11	0.26909606	19
63	0.31856213	20	63	0.26895159	20

Table 4: Changes in medical and individual business scores and rankings after the introduction of random distribution.

The score results of entropy weight method before introducing a random distribution			The score results of entropy weight method after introducing a random distribution		
Enterprise numbers	Score f_i	Ranking	Enterprise numbers	Score f_i	Ranking
E195 (medical)	0.266610	48	E195 (medical)	0.314380	44
E398 (medical)	0.014558	189	E398 (medical)	0.012037	166
E420 (medical)	0.014021	227	E420 (medical)	0.013773	184
E373 (individual)	0.014911	162	E373 (individual)	0.009712	279
E124 (individual)	0.034705	133	E124 (individual)	0.010516	258
E125 (individual)	0.034739	132	E125 (individual)	0.010516	271

Table 5: Analysis of different results obtained by different scale coefficients of the three objective functions.

Plan	1	2	3	4	5	6	7	8
$u(1)$	0.7	0.6	0.6	0.5	0.6	0.5	0.4	0.3
$u(2)$	0.2	0.2	0.1	0.25	0.15	0.15	0.15	0.15
$u(3)$	0.1	0.2	0.3	0.25	0.25	0.35	0.45	0.55
The number of different values of the loan amount	7	9	9	8	11	17	19	20

The multiobjective function includes the following: max $\sum_{i=1}^{302} c_i(1-f_i)l_i\tau_i x_i$, min $\sum_{i=1}^{302} c_i x_i(f_i/J_i)$, and

$$\min\ s^2 = \frac{1}{301}\sum_{i=1}^{302}\left(\tau_i\frac{x_i}{J_i} - \frac{1}{302}\sum_{i=1}^{302}\tau_i\frac{x_i}{J_i}\right)^2. \tag{24}$$

The constraint conditions are as follows:

$$\begin{cases} 10 \le x_i \le 100, \\ 4\% \le l_i \le 15\%, \\ \tau_i = \dfrac{f_i - f_{\min}}{f_{\max} - f_{\min}}, \\ 0.8 \le \dfrac{x_i}{J_i} \le 2, \quad i \in M, \\ \delta c_i \le x_i \le M c_i, \\ \displaystyle\sum_{k=1}^{302} x_i = 10^4. \end{cases} \tag{25}$$

The software programming of Lingo is used to solve the above multiobjective function programming model [18]. In the three target functions, let $u(j), (j = 1, 2, 3)$ be the scale coefficient of the jth objective function, which satisfies

$$u(1) + u(2) + u(3) = 1. \tag{26}$$

Set three different proportional coefficients and get different results of different loan amounts, which are analyzed in the following list (see Table 5).

According to the analysis in Table 5, the balance of credit amount is important for banks. Finally, the eighth plan is selected to obtain the specific credit plan for 302 SMMEs, as shown in Table 6 below. The loan amount of enterprises not listed in Table 6 is 100,000 yuan.

It can be found that during the COVID-19 epidemic, due to the rapid increase in the demand for the services and products provided by the medical and health enterprises, the investment of the finally obtained bank in this industry also increased, the sales of the self-employed industry decreased or stagnated, and the investment of the finally obtained bank in this industry also decreased or stagnated. The investment of banks in other industries is also adjusted accordingly to maintain the survival and operation of the industry, which is more consistent with the actual situation and demonstrates the effectiveness and practicability of our model.

7. Sensitivity Analysis of the Model

The sensitivity of the model is used to analyze the sensitivity and stability of the model. In order to test the stability and effectiveness of the multiobjective programming strategy model, sensitivity analysis is carried out.

In the case of COVID-19, 3 random Poisson numbers were added to simulate the total value of the total tax and total sales tax in each industry. In order to fully demonstrate the sensitivity of the model, we changed the number of algorithm runs and record the average scores of the 302 comprehensive evaluation scores obtained by each algorithm; then, the average score of the comprehensive evaluation of the 20 algorithms was obtained and drawn. The results are shown in Figure 1.

By checking whether the average value of the comprehensive evaluation score is stable and centralized when the algorithm runs for 20 times, we can verify whether the model is stable. One can find that the average value of the comprehensive evaluation score of 20 times is relatively centralized and stable, floating in a certain range. It can be seen that our model is stable and practical.

Table 6: List of the specific amount of 100 million yuan loan from the bank to 302 SMMEs (yuan).

Enterprise number	Loan amount
133	880344.8
147	548104
149	864340.1
166	532681.5
167	867680.4
171	150709.4
173	726597.9
178	836082.4
179	646818.7
182	425921
187	402967.4
190	414155.8
191	735308.3
193	338920
198	732913.7
205	313454.6
211	798931.5
242	184068.4
1	1000000
2	1000000
212	1000000
296	1000000
39	1000000
58	1000000
100	1000000
101	1000000
103	1000000
109	1000000
124	1000000
125	1000000
126	1000000
127	1000000
128	1000000
129	1000000
130	1000000
131	1000000
132	1000000
134	1000000
135	1000000
136	1000000
137	1000000
138	1000000
229	1000000
3	1000000
139	1000000
140	1000000
141	1000000
142	1000000

Table 6: Continued.

Enterprise number	Loan amount
145	1000000
148	1000000
150	1000000
153	1000000
154	1000000
155	1000000
156	1000000
157	1000000
158	1000000
159	1000000
160	1000000
161	1000000
162	1000000
163	1000000
164	1000000
165	1000000
250	1000000
4	100000
169	1000000
170	1000000
174	1000000
175	1000000
176	1000000
177	1000000
181	1000000
183	1000000
184	1000000
185	1000000
186	1000000
189	1000000
196	1000000
197	1000000
199	1000000
200	1000000
201	1000000
202	1000000
203	1000000
204	1000000
258	1000000
5	100000

In this paper, the TOPSIS evaluation method is firstly used to get the score and ranking comparison of 302 enterprises before and after the introduction of a random number, and the ranking results are analyzed. Then, considering that different industries each have a different ability to repay loans when affected by COVID-19, the ratio factor that can repay bank loans is introduced, and considering the floating

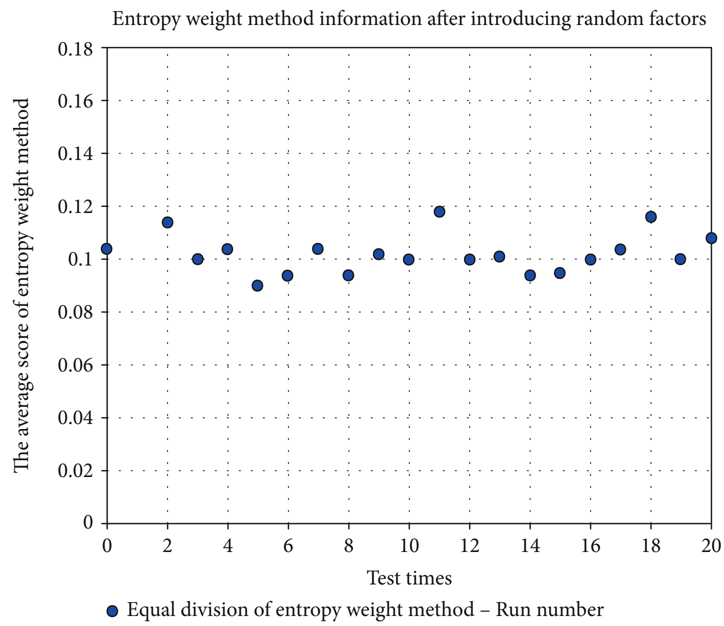

Figure 1: Sensitivity inspection chart.

amount of loans in different industries under national conditions and policies, the objective function and constraints of the multiobjective credit optimization model are modified, and the multiobjective credit optimization model of enterprises influenced by COVID-19 is established. When the total amount is 100 million, the corresponding credit decision is made. Finally, sensitivity analysis is carried out to test the stability and effectiveness of the multiobjective programming strategy model.

Data Availability

The original data of this paper comes from the data of competition question C for CUMCM-2020 (China University mathematical modeling competition), which can be downloaded publicly. Download from the following website: http://www.mcm.edu.cn/html_cn/node/10405905647c52abfd6377c0311632b5.html. The later data used to support the findings of this study are included within the supplementary information file(s).

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Supplementary Materials

We have uploaded three attachments. Annex 1.1: raw data on 302 enterprises without credit records which comes from the data of competition question C for CUMCM-2020. Annex 2: in this paper, we get the relevant data of 302 enterprises before and after the introduction of random distribution. Annex 3: Ligon Program Source Code. *(Supplementary Materials)*

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