ISSN: 2688-9323

Credit Decision of Small, Medium and Micro Enterprises

Longyun Wang, Yongteng Wen, Yudong Liang

Southwest Jiaotong University, Sichuan 610097, China

Abstract

Aiming at problem 1, select factor analysis method for research. The topic requires quantitative analysis of credit risk: This article summarizes the following six quantifiable indicators through the variables in Annex 1, namely, the total input of the enterprise, the total output of the enterprise, the influence of upstream and downstream enterprises, the credit rating, and whether or not they defaulted. The factor analysis method is selected to evaluate the credit risk. The above six indicators are used as the indicators of the factor analysis, and two public factors are obtained to obtain the final credit risk scores of 99 companies. The higher the final score, the higher the credibility. , That is, the lower the credit risk. Credit strategy: Through the analysis of the final score, companies with negative scores will not be loaned because their credit risk is too high. Calculate the proportion of credit of 36 companies that have passed the audit through the final score α_i ,So the credit limit for each company is represented by the following piecewise function. Annual interest rate: According to the customer churn rate under each annual interest rate, randomly selected lost customers through the C language, and each annual interest rate is sampled 10,000 times to meet the randomness, and the return rate after the randomly selected value is calculated, and each credit rating is under The largest rate of return is its optimal annual interest rate. When the credit rating is A, the optimal annual interest rate is 0.0745. When the credit rating is B, the optimal annual interest rate is 0.01425. When the credit rating is C, the optimal annual interest rate is 0.0585. For the second question, choose multiple linear regression, Bayes discriminant analysis and factor analysis method for research. The title requires a quantitative analysis of the credit risk of the 302 companies in Annex 2 on the basis of Question 1, and the credit strategy of the bank for these companies when the total annual credit is 100 million yuan. Comparing Attachment 2 with Attachment 1, the credit rating is missing. Based on the data in Annex 1, this question chooses multiple linear regression, taking the total input of the enterprise, the total output of the enterprise, the influence of upstream and downstream enterprises, and whether or not default as the independent variables, and the reputation rating as the dependent variable to obtain the linear regression equation. Bringing the corresponding indicators in Annex 2 into the regression equation can get the value of the reputation rating, and use the Bayes discriminant logarithmic analysis to determine the reputation rating. The subsequent quantitative analysis of credit risk and credit strategy are the same as the first question, using factor analysis, which is not too much to describe here. Annual interest rate: When the credit rating is A, the optimal annual interest rate is 0.0465. When the credit rating is B, the optimal annual interest rate is 0.0585. When the credit rating is C, the optimal annual interest rate is 0.0585. Aiming at problem three, choose coefficient modification and factor analysis method for research. Due to the excessive number of emergencies, this question only uses the new crown virus epidemic in the multiple-choice question as a representative of emergencies. The 302 companies in Annex 2 are classified into 16 groups including self-employed, construction, wholesale and retail. By searching for these 16 groups of big data during the epidemic on the National Bureau of Statistics, we can calculate the rate of change of the 16 groups of input and total output items, and substituting them into Annex 2 to obtain the new total input and output items. The

ISSN: 2688-9323

remaining indicators are assumed to be Not affected by the epidemic in the short term. The credit strategy method is the same as the first and second questions, and the factor analysis method is used, which is not too much to describe here. The credit limit is the same as the piecewise function of the second question, but the result is different. Annual interest rate: When the credit rating is A, the optimal annual interest rate is 0.0465. When the credit rating is B, the optimal annual interest rate is 0.0585. When the credit rating is C, the optimal annual interest rate is 0.0585.

Keywords

Factor Analysis Method; Multiple Linear Regression; Bayes Discriminant; Coefficient Correction.

1. Questions Raised

1.1. Problem Background

In actual credit, due to the relatively small scale of small and medium-sized and micro-enterprises and lack of mortgage assets, banks usually provide companies with strong strength and stable supply-demand relationship based on credit policies, corporate transaction bill information, and the influence of upstream and downstream companies. Loans, and can give preferential interest rates to companies with high reputation and low credit risk. Banks first evaluate the credit risk of small, medium and micro enterprises based on their strength and reputation, and then determine whether to lend and credit strategies such as loan limits, interest rates, and maturity based on factors such as credit risk.

A certain bank has a loan amount of 100,000 to 1 million yuan to an enterprise that is determined to lend; the annual interest rate is 4% to 15%; and the loan period is 1 year. Attachments 1 to 3 respectively give the relevant data of 123 companies with credit records, the relevant data of 302 companies without credit records, and the 2019 statistics on the relationship between loan interest rates and customer churn rates.

1.2. Questions Raised

(1) Quantify the credit risk of the 123 companies in Annex 1, and give the bank's credit strategy for these companies when the total annual credit is fixed.

(2) On the basis of question 1, conduct a quantitative analysis of the credit risk of the 302 companies in Annex 2, and give the bank's credit strategy for these companies when the total annual credit is 100 million yuan.

(3) The production and operation and economic benefits of enterprises may be affected by some sudden factors, and sudden factors often have different effects on different industries and different types of enterprises. Considering the credit risk of each company in Annex 2 and the impact of possible sudden factors (such as the new crown virus epidemic) on each company, the bank's credit adjustment strategy when the total annual credit is 100 million yuan is given.

2. Basic Assumptions

1. Choose the largest annual interest rate with the most frequency obtained by random sampling

2. Companies that have a negative final score on the factor are not allowed to lend due to low credibility

3. Industries that cannot find official data under emergencies (new crown pneumonia) conditions are deemed unchanged when lending

ISSN: 2688-9323

4. Sudden situation (new crown pneumonia) has no impact on the influence of upstream and downstream enterprises for the time being

3. Symbol Description

Table 1. Symbol Description

symbol	significance	units	Remarks
x	Fixed annual total credit	Ten thousand yuan	nothing
α_i	Credit ratio	nothing	$i=1、2、\cdots、36$
W	credit limit	nothing	nothing
$\bar{a}_{ij}$	Standardized index	nothing	nothing
F_i	Common factor	nothing	$i=1,2$
Y	Reputation rating	nothing	nothing
x_i	index	nothing	$i=1,2,\cdots,6$

4. Problem Analysis

The title requires a quantitative analysis of the credit risk of the 123 companies in Annex 1, and the credit strategy of whether the bank will lend to these companies when the total annual credit is fixed, and the loan limit, interest rate and term. The topic requires quantitative analysis of credit risk: This article summarizes the following six quantifiable indicators through the variables in Annex 1, namely, the total input of the enterprise, the total output of the enterprise, the influence of upstream and downstream enterprises, the credit rating, and whether or not they defaulted. This question selects the factor analysis method to evaluate the credit risk. First, the companies with a reputation rating of D are eliminated. The above six indicators are used as the index of the factor analysis to find the public factors, so as to find the final credit risk scores of 99 companies. The higher the score, the higher the credibility, that is, the lower the credit risk. Credit strategy: Credit strategy is divided into whether to lend, loan amount, interest rate, etc. Through the analysis of the final score, companies with negative scores will not be loaned because their credit risk is too highCalculate the credit ratio of the remaining companies through the final score.

α_i (Credit ratio$=\frac{\text{Final score of each company}}{\text{Sum of final scores}}$), Since the total annual credit of the bank in question 1 is a fixed value, we can assume that the total credit is x (Unit: ten thousand yuan), And the credit line is 100,000 to 1 million yuan, so the credit line for each company is represented by the following piecewise function:

1.if $\alpha_i x<100000$ yuan,credit limit =100000 yuan.
2.if $100000 yuan \leq \alpha i x \leq 1000000$yuan, credit limit = $\alpha_i x$;
3.if $\alpha_i x>1000000$ yuan,credit limit =1000000yuan.

ISSN: 2688-9323

Interest rate: Through Annex 3, the corresponding value of the annual loan interest rate and the customer churn rate under each credit rating can be obtained, and the return rate after losing customers is compared to select the best annual interest rate under each credit rating.

4.1. Analysis of Problem Two

The title requires a quantitative analysis of the credit risk of the 302 companies in Annex 2 on the basis of Question 1, and the credit strategy of the bank for these companies when the total annual credit is 100 million yuan. Comparing Attachment 2 with Attachment 1, the credit rating is missing. Based on the data in Annex 1, this question chooses multiple linear regression, taking the total input of the enterprise, the total output of the enterprise, the influence of upstream and downstream enterprises, and whether or not default as the independent variables, and the reputation rating as the dependent variable to obtain the linear regression equation. Bringing the corresponding indicators in Annex 2 into the regression equation can discriminate the credit ratings of 302 companies. The subsequent quantitative analysis of credit risk and credit strategy are the same as the first question, using factor analysis, which is not too much to describe here.

4.2. Analysis of Problem Three

The title requires consideration of the credit risk of each company in Annex 2 and the impact of possible sudden factors (new crown virus epidemic) on each company, and give the bank's credit adjustment strategy when the total annual credit is 100 million yuan. Because there are too many emergent factors here, only the new crown virus epidemic in the multiple-choice question is used as a representative of emergencies. Classify the 302 companies listed in Annex 2. The categories include self-employed, construction, wholesale and retail, health and social services, service industries, agriculture, forestry, animal husbandry and fishery, accommodation and catering, manufacturing, cultural and sports entertainment, transportation properties, and energy industries., Environment and public management, leasing and business, education, real estate, and finance. Find these 16 groups of economic changes during the epidemic on the National Bureau of Statistics, for example, manufacturing industry: manufacturing PMI= order× 30%+ production× 25%+ employee× 20%+ delivery ×15% +inventory×10% , Use PMI and the rate of change of orders and production values to represent the rate of change of the total input and output items. Calculate the change rate of the total input and output items of these 16 groups, and substitute it into Annex 2 to get the new total input and output items. The credit strategy method is the same as the first and second questions, and the factor analysis method is used, which is not too much to describe here.

5. Model Establishment and Solution

5.1. The Establishment and Solution of Problem One Model

5.1.1. Analysis of Problem One

The title requires a quantitative analysis of the credit risk of the 123 companies in Annex 1, and the credit strategy of whether the bank will lend to these companies when the total annual credit is fixed, and the loan limit, interest rate and term. The topic requires quantitative analysis of credit risk: This article summarizes the following six quantifiable indicators through the variables in Annex 1, namely, the total input of the enterprise, the total output of the enterprise, the influence of upstream and downstream enterprises, the credit rating, and whether or not they defaulted. This question selects the factor analysis method to evaluate the credit risk. First, the companies with a reputation rating of D are eliminated. The above six indicators are used as the index of the factor analysis to find the public factors, so as to find the final credit risk scores of 99 companies. The higher the score, the higher the credibility, that is, the lower the credit risk. Credit strategy: Credit strategy is divided into whether to lend, loan amount, interest

ISSN: 2688-9323

rate, etc. Through the analysis of the final scores, companies with negative scores will not be loaned because their credit risk is too high. Calculate the credit ratio of the remaining companies through the final score

α_i (Credit ratio= $\frac{\text{Final score of each company}}{\text{Sum of final scores}}$),Since the total annual credit of the bank in question 1 is a fixed value, we can assume that the total credit is (unit: 10,000) and the credit line is 100,000 to 1 million yuan, so the credit line for each company is represented by the following piecewise function:

$$1.\text{if } \alpha_i x < 100000 \text{ yuan,credit limit } = 100000 \text{yuan.}$$
$$2.\text{if} 100000\text{yuan} \le \alpha_i x \le 1000000\text{yuan} \text{ ,credit limit } = \alpha_i x .$$
$$3.\text{if } \alpha_i x > 1000000 \text{ yuan, credit limit } = 1000000\text{yuan} .$$

Interest rate: Through Annex 3, the corresponding value of the annual loan interest rate and the customer churn rate under each credit rating can be used to compare the return rate after losing customers to select the best annual interest rate under each credit rating. According to the customer churn rate at each annual interest rate, the churn customers are randomly selected through the C language, and each annual interest rate is sampled 10,000 times to meet the randomness. The yield rate is the sum of the credit ratio of the remaining customers × the annual interest rate, and the largest item corresponds to The annual interest rate is the optimal annual interest rate.

5.1.2. Question One Model Preparation

1. Explanation of Factor Analysis

The factor analysis method explores the basic structure of the observed data by studying the internal dependence relationship among many variables, and uses a few hypothetical variables to express its basic data structure. These few hypothetical variables can reflect the main information of the original many variables.

2. data processing

Please refer to the problem data processing table in the attachment for the specific handling situation

1) Delete the company with a reputation rating of D

2) The sum of the prices and taxes of all upstream companies corresponding to each company is summed to get the total input of each company.

3) The sum of the prices and taxes of all downstream companies corresponding to each company is summed to get the total output of each company.

4) The influence of upstream and downstream enterprises is the total input/total output divided by the corresponding invoice quantity.

5) Void invoices are represented by 0, and valid invoices are represented by 1.

6) The treatment of non-quantitative data is as follows: Default: Default is represented by 0, non-default is represented by 1. Reputation rating: A is represented by 1, B is represented by 0.5, and C is represented by 0.

7) All data are converted into standardized data (0~1)

ISSN: 2688-9323

Table 2. Problem one data processing

enterprise	Total enterprise input	Total enterprise output	Upstream corporate influence	Downstream corporate influence	Reputation rating	Breach of contract
E1	1	1	1	0.601841288	1	1
E2	0.07622725	0.13325573	0.00803021	0.050469086	1	1
E3	0.00816203	0.14065706	0.00603069	0.027765789	0	1
E4	0.03835284	0.45682015	0.23641181	1	0	1
E5	0.03424732	0.04960973	0.05421063	0.228129315	0.5	1
E6	0.04838522	0.08421846	0.01455986	0.390649441	1	1
E7	0.00956496	0.1268568	0.00238547	0.075307121	1	1
E8	0.02567338	0.08100387	0.00379267	0.041227203	1	1
E9	0.00396708	0.07858139	0.00305232	0.064263026	1	1
E10	0.00081617	0.07476086	0.00055773	0.64283191	0.5	1
⋮	⋮	⋮	⋮	⋮	⋮	⋮
E92	0.00002397	0.00044121	0.00026008	0.059900807	0	1
E93	0.00004559	0.00028041	0.00060942	0.00988669	0.5	1
E94	0.00000242	0.00018772	0.00199076	0.004958463	0	1
E95	0.00000013	0.0004634	0.00001961	0.001910073	0.5	1
E96	0.00036686	0.00027212	0.11466021	0.080299627	0	1
E97	0.00000295	0.00016978	0.00101731	0.003143628	0.5	1
E98	0.00003149	0.0002644	0.00195871	0.00902607	0.5	1
E104	0	0.00001441	0.00001728	0.012601379	0	1
E105	0.00000124	0.00015957	0.00060486	0.007323022	0	1
E106	0.00000786	0.00008532	0.00062763	0.003305554	0.5	1
E110	0.00000011	0	0.00005184	0.00174331	0	1

5.1.3. The Establishment and Solution of Problem One Model

1. Standardize raw data

There are 6 indicator variables for factor analysis. The total enterprise output, the influence of upstream enterprises, the total input of enterprises, the influence of downstream enterprises, whether or not a contract is defaulted, and the reputation rating are respectively regarded as 6 indicator variables, which are respectively x_1、x_2、$\cdots$、x_6 ,There are a total of 99 groups of evaluation objects, and the value of the j-th index of the i-th evaluation object is a_{ij} , $i=1,2,\cdots,99; j=1,2,\cdots,6$. Transform various indicators into standardized indicators $\overline{a_{ij}}$, Available:

$$\overline{a_{ij}} = \frac{a_{ij} - \overline{\mu_j}}{s_j}$$

Table 3. Standardization

	Mean	Standard deviation	Analysis N
Total enterprise input	0.01644	0.10057	99
Total enterprise output	0.03192	0.11147	99
Upstream corporate influence	0.02546	0.10371	99
Downstream corporate influence	0.09464	0.16419	99
Reputation rating	0.46464	0.39287	99
Breach of contract	0.96970	0.17229	99

ISSN: 2688-9323

2. Calculate the elementary load matrix

Calculate the eigenvalues of the correlation coefficient matrix R $\lambda_1 \geq \lambda_2 \geq \lambda_3 \geq \lambda \geq 0$,And the corresponding feature vector $u_1,\ldots,u_4$,Elementary load matrix

$$\Lambda_1 = \left[\sqrt{\lambda_1} u_1 \quad \sqrt{\lambda_2} u_2 \quad \sqrt{\lambda_3} u_3 \quad \sqrt{\lambda_4} u_4 \right]$$

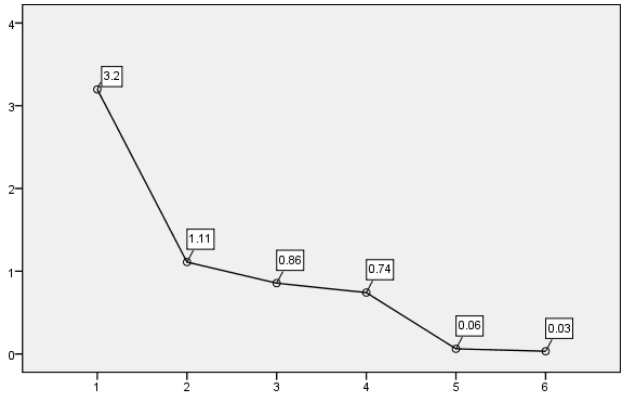

Figure 1. Gravel map of characteristic roots

3. Select the main factor

According to the elementary load matrix, the contribution rate of each common factor is calculated. According to Table 4, because the contribution of the common factor needs to exceed 1, and only the contribution of the first two factors exceeds 1, the components 1 and 2 are selected as the main factors. Table 4 shows the contribution rate data.

Table 4. Contribution rate data

factor	contribution	Contribution rate	Cumulative contribution rate
1	3.198	53.297%	53.297%
2	1.111	18.509%	71.805%
3	0.856	14.261%	86.067%
4	0.742	12.359%	98.426%
5	0.062	1.034%	99.460%

Rotate the extracted factor loading matrix to obtain the rotating component matrix $\Lambda_2 = \Lambda_1^{(m)} T$ (among them $\Lambda_1^{(m)}$ is Λ_1 The first m columns of, T is an orthogonal matrix), Construct a factor model.

Table 5. Rotation component matrix

	Ingredients	
	1	2
Total enterprise output	0.974	0.073
Upstream corporate influence	0.965	0.041
Business total	0.940	0.073
Downstream corporate influence	0.616	0.032
Breach of contract	-0.041	0.788
Reputation rating	0.133	0.714

4. The indicators are classified into public factors, and the names of the public factors are obtained

ISSN: 2688-9323

Table 6. Component score coefficient matrix

	Ingredients	
	1	2
Total enterprise input	0.297	-0.004
Total enterprise output	0.308	-0.007
Upstream corporate influence	0.308	-0.035
Downstream corporate influence	0.196	-0.017
Reputation rating	-0.010	0.626
Breach of contract	-0.071	0.705

According to the component score coefficient matrix in Table 6, the six indicators can be classified into two common factors. The score coefficient of component 1 of the first four items is obviously greater than that of component 2, and the score coefficient of component 1 of the latter two items is significantly smaller than that of component 2. Therefore, the first four indicators are included in the public factor F1, and the last two indicators are included in the public factor F2. Based on the characteristics of the four indicators included in F1, they are named as corporate influence factors. Based on the characteristics of the two indicators included in F2, they are named reputation factors.

5. Corporate influence factor

Use regression method to find the score function of a single factor

$$F_j = \beta_{j1}x_1 + \beta_{j2}x_2 + \beta_{j3}x_3 + \cdots + \beta_{j6}x_6$$

Record the estimated value of the i-th sample point to the j-th factor F score

$$F_{ij} = \beta_{j1}a_{i\ldots1} + \beta_{j2}a_{i2} + \beta_{j3}a_{i3} + \cdots \beta_{j6}a_{i6}, i = 1,2,\ldots,99; j = 1,2$$

Finally, the score function of each factor can be obtained

$$F = \left(F_{ij}\right)_{99\times2} = X_0 R^{-1}\Lambda_2$$

Calculate the score function of each factor:

$$\begin{cases} F_1 = 0.308x_1 + 0.308x_2 + 0.297x_3 + 0.196x_4 - 0.071x_5 - 0.01x_6 \\ F_2 = -0.007x_1 - 0.035x_2 - 0.004x_3 - 0.017x_4 + 0.705x_5 + 0.626x_6 \end{cases}$$

Factor final score function:

$$E = 3.198F_1 + 1.111F_2$$

6. Credit strategy (credit line)

Through the statistics of the final factor scores of 99 companies, it is found that 36 groups are positive and 63 groups are negative. Since the credit risk of companies with negative factor scores is too high, it is judged not to lend, so the remaining 36 groups are analyzed.

Calculate the credit ratio of the remaining companies through the final score α_i, $\alpha_i = \frac{E}{\sum E}$, Since the total annual credit of the bank in question 1 is a fixed value, we can assume that the total credit is (unit: 10,000) and the credit limit is 100,000 to 1 million yuan. So credit line W= $\alpha_i x$. However, since the fixed value cannot be determined exactly how much, it may appear $\alpha_i x < 100000$, $100000 \le \alpha_i x \le 1000000$ and $\alpha_i x > 1000000$ There are three situations. For these three situations, this article adopts a piecewise function to solve the problem. Figure 2 shows the credit line of E1 (for statistical data, please refer to the problem result table in the attachment.)

ISSN: 2688-9323

$$\begin{cases} W = 100000(\alpha_i x < 100000) \\ W = \alpha_i x(100000 \le \alpha_i x \le 1000000) \\ W = 1000000(\alpha_i x > 100000) \end{cases}$$

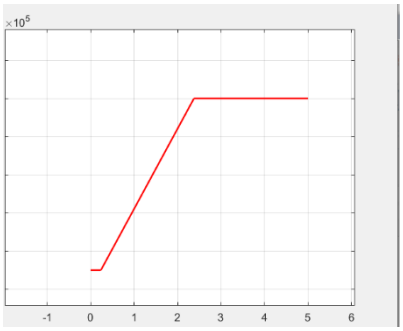

Figure 2. Credit limit function diagram of enterprise E1

Table 7. Credit Line

Enterprise	Credit ratio	credit limit(Assuming that the total amount of credit for a fixed year is x)
E1	0.420496	0.420496x
E2	0.030364	0.030364x
E4	0.121458	0.121458x
⋮	⋮	⋮
E88	0.000392	0.000392x
E89	0.003336	0.003336x
E91	0.001534	0.001534x
The rest of the companies do not grant loans		

7. Credit strategy (annual interest rate)

Derive the optimal annual interest rate by comparing the yield rate, rate of return=$\sum \alpha_i \times$ Annual interest rate.

Attachment 3 is the corresponding value of the annual loan interest rate and the customer churn rate under each credit rating. The 36 groups of companies mentioned above are classified according to the credit rating, and the maximum yield is calculated according to the credit rating. According to the customer churn rate under each year's interest rate, randomly select churn customers through the C language, and each annual interest rate is sampled 10,000 times to meet the randomness, and calculate the rate of return after randomly selected values, and the largest return under each credit rating The rate is its optimal annual interest rate. For the credit rating C, there is only one company, so there is no need to use random sampling to lose customers, and directly calculate the interest rate expectation. The results are as follows:

Table 8. Optimal annual interest rate

Reputation rating	Maximum rate of return	Corresponding annual interest rate
A	0.034243	0.0745
B	0.005196	0.01425
C	0.005043	0.0585

ISSN: 2688-9323

5.1.4. Analysis and Verification of the Result of Question One

1. Result analysis

Lending situation: The factor scores of 99 groups of companies obtained through factor analysis, a total of 36 groups are positive numbers, and 63 groups are negative numbers. Because the credit risk of companies with negative factor scores is too high, this question only lends to the remaining 36 groups of companies.

Loan limit: Since the credit limit is 100,000 to 1 million, the credit limit for each company is represented by the following piecewise function:

$$\begin{aligned} &1.\text{if } \alpha_i x < 100000 \text{ yuan,credit limit } = 100000\text{yuan.} \\ &2.\text{if} 100000 yuan \le \alpha ix \le 1000000\text{yuan,credit limit } = \alpha_i x \\ &3.\text{if } \alpha_i x > 1000000 \text{ yuan,credit limit } = 1000000\text{yuan.} \end{aligned}$$

Annual interest rate: According to the customer churn rate under each annual interest rate, randomly selected lost customers through the C language, and each annual interest rate is sampled 10,000 times to meet the randomness, and the return rate after the randomly selected value is calculated, and each credit rating is under The largest rate of return is its optimal annual interest rate. When the credit rating is A, the optimal annual interest rate is 0.0745. When the credit rating is B, the optimal annual interest rate is 0.01425. When the credit rating is C, the optimal annual interest rate is 0.0585.

2. Model test (KMO and Bartlett sphericity test)

When KMO is greater than 0.6, it is suitable for factor analysis, and when the concomitant probability given by Bartlett's sphericity test is less than the significance level of 0.05, it is suitable for factor analysis. From Table 8, the KMO metric is 0.707, which is greater than 0.6 and meets the standard. The sphericity test Sig is 0, which is less than the significance level of 0.05, which meets the standard.

Table 9. KMO and Bartlett sphericity test

Sample enough KMO metrics	0.707
Bartlett's sphericity detection approximate chi-square	513.569
df	15
sig	0

5.2. The Establishment and Solution of Problem Two Model

5.2.1. Analysis of Problem Two

The title requires a quantitative analysis of the credit risk of the 302 companies in Annex 2 on the basis of Question 1, and the credit strategy of the bank for these companies when the total annual credit is 100 million yuan. Comparing Attachment 2 with Attachment 1, the credit rating is missing. Based on the data in Annex 1, this question chooses multiple linear regression, taking the total input of the enterprise, the total output of the enterprise, the influence of upstream and downstream enterprises, and whether or not default as the independent variables, and the reputation rating as the dependent variable to obtain the linear regression equation. Bringing the corresponding indicators in Annex 2 into the regression equation can discriminate the credit ratings of 302 companies. The subsequent quantitative analysis of credit risk and credit

ISSN: 2688-9323

strategy are the same as the first question, using factor analysis, which is not too much to describe here.

5.2.2. Preparation of the Second Model

1. Explanation of Multiple Linear Regression

Multiple linear regression analysis is a regression analysis in which the dependent variable is linearly correlated with two or more independent variables. It is an extension of unary linear regression. Its basic idea is to make the sum of squares of residuals reach the minimum. Its general model is:

$$y=b_0+b_1x_1+\cdots+b_nx_n$$

2. Bayes discriminant

It is assumed that there is a certain understanding of the research object, which is often described by a priori probability. When a sample is obtained, the sample can be used to modify the existing prior probability distribution and obtain the posterior probability distribution for various statistical inferences.

3. Screening of independent variables

The total input of the enterprise, the total output of the enterprise, the influence of upstream and downstream enterprises, and whether or not the contract is defaulted are used as independent variables, and the reputation rating is used as the dependent variable.

Table 10. Selection of independent variables

Dependent variable	Independent variable
Reputation rating	Breach of contract
	Total enterprise input
	Total enterprise output
	Upstream corporate influence
	Downstream corporate influence

5.2.3. The Establishment and Solution of Problem Two Model

1. Establish a linear regression equation

1) data processing

Enter the selected 5 indicators and all the data of the reputation rating into SPSS, select multiple linear regression, enter the total input of the enterprise, the total output of the enterprise, the influence of the upstream and downstream enterprises, and whether or not default is entered into the independent variables, and enter the dependent variable into the reputation rating.

2) The first model test (fitness and significance)

This question is multiple linear regression, so the coefficient of determination is used to test the goodness of fit. Fitness test: Table 11 is a fitness test table, the judgment coefficient is 0.545, and the correction judgment coefficient is 0.526. Therefore, 52.6% of the information in the change of the dependent variable can be explained by the independent variable, indicating a good degree of fit.

ISSN: 2688-9323

Table 11. Test table of goodness of fit

Model 1	R	R^2	Correction R^2	Standard estimation error
1	0.738^a	0.545	0.526	0.7174

Analysis of variance: Table 12 shows the results of the significance test of variance. It can be seen that the F statistic is 28.050, and the significance probability Sig is 0, which is less than 0.05. Therefore, it can be considered that there is a good linear relationship between the independent variable and the dependent variable, and the reliability is high.

Table 12. Analysis of variance

Model	sum of squares	df	Mean square	F	Sig
return	72.187	5	14.437	28.050	0^a
Residual	60.219	117	0.515		
Expected	132.407	122			

3)Derive linear regression equation

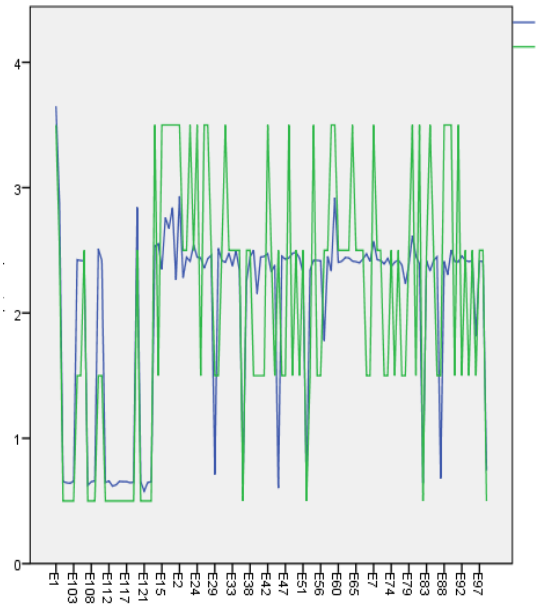

Figure 3. Regression curve fitting diagram

Table 13. Linear regression equation coefficients

	Non-standardized coefficient	Sig
	B	
constant	0.651	0
Total enterprise input	9.204×10^{-10}	0.036
Upstream corporate influence	-2.973×10^{-6}	0.053
Downstream corporate influence	6.69×10^{-7}	0.301
Breach of contract	1.766	0
Total enterprise output	1.004×10^{-10}	0.829

ISSN: 2688-9323

The linear regression equation can be derived from Table 13:

$$Y = 1.004\times10^{-10}x_1 - 2.973\times10^{-6}x_2 + 9.204\times10^{-10}x_3 + 6.69\times10^{-7}x_4 + 1.766x_5 + 0.651$$

2. Establish Bayes discriminant model

Bring the corresponding indicators in Annex 2 into the linear regression equation to get the credit rating value. We then use the Bayes discriminant analysis in SPSS to obtain the credit ratings of the companies in Annex 2.

1) Eigenvalues

It can be concluded from Table 14 that there are 3 common factors and the information carried is 97.7%.

Table 14. Characteristic values

function	Eigenvalues	% Of variance	Grand total%	Formal correlation
1	6.443[a]	97.7	97.7	0.930
2	0.122[a]	1.8	99.6	0.329
3	0.029[a]	0.4	100	0.167

2)Significance test

It can be found from Table 15 that only the sig of function 3 exceeds 0.05, so the significance except 3 meets the requirements, indicating that it is acceptable.

Table 15. Significance test

function	Eigenvalues	Bangla	df	sig
1~3	0.116	252.704	15	0
2~3	0.866	16.842	8	0.032
3	0.972	3.343	3	0.342

3)Reputation rating

According to the operation diagram of the Bayes discriminant model, it can be concluded that there are 38 companies rated as A, 189 companies rated as B, and 75 companies rated as C.

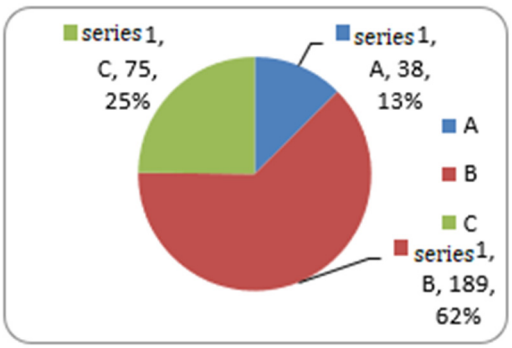

Figure 4. Reputation rating

3. factor analysis

1)Credit strategy (credit line)

Calculate the score function of each factor:

ISSN: 2688-9323

$$\begin{cases} F_1 = 0.308x_1 + 0.308x_2 + 0.297x_3 + 0.196x_4 - 0.071x_5 - 0.01x_6 \\ F_2 = -0.007x_1 - 0.035x_2 - 0.004x_3 - 0.017x_4 + 0.705x_5 + 0.626x_6 \end{cases}$$

Factor final score function:

$$E = 3.198F_1 + 1.111F_2$$

Calculate the credit ratio of the remaining companies through the final score α_i, $\alpha_i = \frac{E}{\sum E}$, Due to problem two, the total annual credit of the bank is 100 million yuan, and the credit line is 100,000 to 1 million yuan. So credit line

$$W = \alpha_i \times 10^8 \text{ (yuan)}$$

may appear $\alpha_i \times 10^8 < 100000$, $100000 \le \alpha_i \times 10^8 \le 1000000$, $\alpha_i \times 10^8 > 1000000$ There are three cases. For these three cases, this article adopts a piecewise function to solve them (for statistical data, please refer to the problem result table in the attachment.)

$$W = \begin{cases} 100000 (\alpha_i \times 10^8 < 100000) \\ \alpha_i \times 10^8 (100000 \le \alpha_i \times 10^8 \le 1000000) \\ 1000000 (\alpha_i \times 10^8 > 100000) \end{cases}$$

Table 16. Credit Line

Enterprise code	Loan line (total of 100 million yuan) (yuan)	Final loan (yuan)
E124	1036766.934	1000000
E125	1148590.153	1000000
E126	755474.7911	755474.7911
⋮	⋮	⋮
E422	267615.5847	267615.5847
E423	272650.1098	272650.1098
E424	277061.6946	277061.6946
E425	268810.2639	268810.2639

2)Credit strategy (annual interest rate)

Derive the optimal annual interest rate by comparing the income:

$$\text{income} = \sum \alpha_i x \cdot \text{Annual interest rate}$$

Attachment 3 is the corresponding value of the annual loan interest rate and the customer churn rate under each credit rating. The 302 groups of companies mentioned above are classified according to the credit rating, and the maximum yield is calculated according to the credit rating.

According to the customer churn rate under each year's interest rate, randomly select churn customers through the C language, and each annual interest rate is sampled 10,000 times to meet the randomness, and calculate the rate of return after randomly selected values, and the largest return under each credit rating The rate is its optimal annual interest rate. The results are as follows:

ISSN: 2688-9323

Table 17. Optimal Annual Interest Rate

Reputation rating	Maximum profit (yuan)	Corresponding annual interest rate
A	647296.2403	0.046500
B	2679070.916	0.058500
C	1240559.236	0.058500

5.2.4. Analysis of the Results of the Second Question

Attachment 2 Credit rating of the enterprise: Calculate the total input of the enterprise, the total output of the enterprise, the influence of upstream and downstream enterprises, and the linear regression equation of the credit rating through Annex 1, and bring the corresponding indicators in Annex 2 into the regression equation to obtain The credit ratings of 302 companies were released. Linear regression equation:

$$Y = 1.004\times10^{-10}x_1 - 2.973\times10^{-6}x_2 + 9.204\times10^{-10}x_3 + 6.69\times10^{-7}x_4 + 1.766x_5 + 0.651$$

Limit: Since the credit limit is 100,000 to 1 million, the credit limit for each company is represented by the following piecewise function: Loan

$$\begin{aligned} &1.\text{if}\ \alpha_i\times10^8 < 100000\ \text{yuan,credit limit} = 100000\text{yuan.} \\ &2.\text{if}100000yuan \le \alpha i \times 10^8 \le 1000000\text{yuan,credit limit} = \text{yuan} \\ &3.\text{if}\ \alpha_i\times10^8 > 1000000\ \text{yuan,credit limit} = 1000000\text{yuan.} \end{aligned}$$

Annual interest rate: According to the customer churn rate under each annual interest rate, randomly selected lost customers through the C language, and each annual interest rate is sampled 10,000 times to meet the randomness, and the return rate after the randomly selected value is calculated, and each credit rating is under The highest rate of return is its best annual interest rate. When the credit rating is A, the best annual interest rate is 0.0585. When the credit rating is B, the best annual interest rate is 0.0585. When the credit rating is C, the best annual interest rate is 0.0745 .

5.3. Establishment and Solution of Problem Three Model

5.3.1. Analysis of Problem Three

The title requires consideration of the credit risk of each company in Annex 2 and the impact of possible sudden factors (new crown virus epidemic) on each company, and give the bank's credit adjustment strategy when the total annual credit is 100 million yuan. Because there are too many emergent factors here, only the new crown virus epidemic in the multiple-choice question is used as a representative of emergencies. Classify the 302 companies listed in Annex 2. The categories include self-employed, construction, wholesale and retail, health and social services, service industries, agriculture, forestry, animal husbandry and fishery, accommodation and catering, manufacturing, cultural and sports entertainment, transportation properties, and energy industries., Environment and public management, leasing and business, education, real estate, and finance. Find these 16 groups of economic changes during the epidemic on the National Bureau of Statistics, for example, manufacturing industry: manufacturing PMI= order× 30%+ production× 25%+ employee × 20% + delivery × 15%+inventory×10% , Use PMI and the rate of change of orders and production values to

ISSN: 2688-9323

represent the rate of change of the total input and output items. Calculate the change rate of the total input and output items of these 16 groups, and substitute it into Annex 2 to get the new total input and output items. The credit strategy method is the same as the first and second questions. The factor analysis method is used to obtain the proportion of credit, and thus the credit limit and the optimal annual interest rate are obtained. I will not elaborate here.

5.3.2. Preparation of Problem Three Model

1. Explanation of factor analysis

The factor analysis method explores the basic structure of the observed data by studying the internal dependence relationship among many variables, and uses a few hypothetical variables to express its basic data structure. These few hypothetical variables can reflect the main information of the original many variables.

5.3.3. Establishment and Solution of Problem Three Model

1. Classification

Table 18. Enterprise classification and changes

type of enterprise	Self-employed	Construction	Wholesale and retail	Health and social work
Total input decline	0.397	0.037	0.189	0.330
Total output decreased	0.249	0.558	0.189	0.310
Number	56	41	13	8
type of enterprise	Culture, Sports and Entertainment Industry	Transportation and logistics industry	Energy production industry	Environment and Public Management Industry
Total input decline	\	0.098	-0.137	\
Total output decreased	\	0.600	0.028	\
Number	13	14	6	6
type of enterprise	Service industry	Agriculture, forestry, animal husbandry and fishery	Accommodation and Catering Industry	manufacturing
type of enterprise	0.075	0.256	0.098	0.458
Total input decline	0.460	0.241	0.600	0.430
Number	72	4	3	38
type of enterprise	Leasing and Commercial Industry	Education	Real estate industry	Financial industry
type of enterprise	0.024	\	0.293	\
Total input decline	0.159	\	0.362	\
Number	23	1	3	1

In order to consider the impact of the epidemic on the companies listed in Annex 2, it is necessary to classify and count these 302 companies. Categories include self-employed, construction, wholesale and retail, health and social services, service industries, agriculture, forestry, animal husbandry and fishery, accommodation and catering, manufacturing, cultural,

ISSN: 2688-9323

sports and entertainment, transportation and property, energy industry, environment and public management, rental and business Industry, education, real estate, finance. Find these 16 groups of economic changes during the epidemic on the National Bureau of Statistics. For example, manufacturing industry: manufacturing PMI= order× 30%+ production ×25%+ employee×20%+delivery×15%+inventory×10% , Use PMI and the rate of change of orders and production values to represent the rate of change of the total input and output items. Calculate the change rate of the total input and output items of these 16 groups, and substitute it into Annex 2 to get the new total input and output items.

2. Factor analysis

1)Function formula

Calculate the score function of each factor:

$$\begin{cases} F_1 = 0.308x_1 + 0.308x_2 + 0.297x_3 + 0.196x_4 - 0.071x_5 - 0.01x_6 \\ F_2 = -0.007x_1 - 0.035x_2 - 0.004x_3 - 0.017x_4 + 0.705x_5 + 0.626x_6 \end{cases}$$

Factor final score function:

$$E = 3.198F_1 + 1.111F_2$$

2)Credit strategy (credit line)

Calculate the credit ratio of the remaining companies through the final score α_i , $\alpha_i = \frac{E}{\sum E}$, Due to problem two, the total annual credit of the bank is 100 million yuan, and the credit line is 100,000 to 1 million yuan. So, credit line W= $\alpha_i \times 10^8$ yuan may appear $\alpha_i \times 10^8 < 100000$, $100000 \le \alpha_i \times 10^8 \le 1000000$, $\alpha_i \times 10^8 > 1000000$ There are three cases. For these three cases, this article adopts a piecewise function to solve them (for statistical data, please refer to the problem result table in the attachment.)

$$W = \begin{cases} 100000 (\alpha_i \times 10^8 < 100000) \\ \alpha_i \times 10^8 (100000 \le \alpha_i \times 10^8 \le 1000000) \\ 1000000 (\alpha_i \times 10^8 > 100000) \end{cases}$$

Table 19. Credit Line

Enterprise code	Loan line (total of 100 million yuan) (yuan)	Final loan (yuan)
E124	997989.8047	997989.8047
E125	1108740.748	1000000
E126	733464.6944	733464.6944
⋮	⋮	⋮
E422	267615.624	267615.624
E423	272642.242	272642.242
E424	277111.5623	277111.5623
E425	268823.5052	268823.5052

3)Credit strategy (annual interest rate)

ISSN: 2688-9323

Derive the optimal annual interest rate by comparing the income,

$$\text{income}=\sum \alpha_i x \cdot \text{Annual interest rate}$$

Attachment 3 is the corresponding value of the annual loan interest rate and the customer churn rate under each credit rating. The 36 groups of companies mentioned above are classified according to the credit rating, and the maximum yield is calculated according to the credit rating. According to the customer churn rate under each year's interest rate, randomly select churn customers through the C language, and each annual interest rate is sampled 10,000 times to meet the randomness, and calculate the rate of return after randomly selected values, and the largest return under each credit rating The rate is its optimal annual interest rate. The results are as follows:

Table 20. Optimal annual interest rate

Reputation rating	Maximum profit (yuan)	Corresponding annual interest rate
A	651867.325	0.046500
B	2710587.691	0.058500
C	1258693.919	0.058500

5.3.4. Analysis of the Results of Question Three

Enterprise classification and changes: the categories include self-employed, construction, wholesale and retail, health and social services, service industry, agriculture, forestry, animal husbandry and fishery, accommodation and catering, manufacturing, cultural and sports entertainment, transportation property, energy industry, environment and public management , Leasing and business, education, real estate, and financial industries. Calculate the change rate of the total input and output items of these 16 groups, and substitute it into Annex 2 to get the new total input and output items. Please refer to Table 18 for the change data.

Loan limit: Since the credit limit is 100,000 to 1 million, the credit limit for each company is represented by the following piecewise function:

1. If $\alpha_i \times 10^8 < 100000$ yuan,Credit line = 100,000 yuan.
2. If$100000\ yuan \leq \alpha i \times 10^8 \leq 1000000\ yuan$, Credit line = $\alpha_i \times 10^8$
3. If $\alpha_i \times 10^8 > 1000000$ Yuan,Credit line =1000000yuan.

Annual interest rate: According to the customer churn rate under each annual interest rate, randomly selected lost customers through the C language, and each annual interest rate is sampled 10,000 times to meet the randomness, and the return rate after the randomly selected value is calculated, and each credit rating is under The largest rate of return is its optimal annual interest rate. When the credit rating is A, the optimal annual interest rate is 0.046500. When the credit rating is B, the optimal annual interest rate is 0.0585. When the credit rating is C, the optimal annual interest rate is 0.058500.

ISSN: 2688-9323

6. Model Evaluation

6.1. Evaluation of the Model

Advantage:

1) When excluding lost customers, considering the definition of churn rate, according to the churn rate corresponding to each annual interest rate, 10,000 random samples of churn customers using the C language have been randomly sampled, which has high stability.

2) In the factor analysis method, the factor is more interpretable through rotation.

Disadvantages:

1) When dealing with emergencies, this article only addresses the new crown epidemic mentioned in the topic, and cannot be widely applied to various emergencies.

2) In multiple linear regression, it is 0.526, which is acceptable for fitting, but the effect is average.

References

[1] Baidu Library, PMI, https://baike.baidu.com/item/PMI/958800?fr=aladdin, September 13, 2020.

[2] Du Yafei, Research on the Impact of New Coronary Pneumonia on Manufacturing Industry and Countermeasures, "Journal of Jingdezhen University", Issue 2, Pages 11-16, 2020.

[3] Frank R. Giordano, "A First Course in Mathematical Modeling" Fifth Edition.

[4] Yang Xiaoming, "The Application of SPSS in Education Statistics" 2nd Edition.

[5] Si Shoukui, "Mathematical Modeling Algorithms and Applications" 2nd Edition.

[6] National Bureau of Statistics, China Purchasing Managers Index Operation in February 2020, February 29, 2020.

[7] Zhao Qinghe, Senior Statistician, Service Industry Survey Center, National Bureau of Statistics, Interpretation of China Purchasing Managers Index in February 2020, February 29, 2020.

[8] National Bureau of Statistics, National Real Estate Development Investment and Sales from January to February 2020, March 16, 2020.