A Bank Credit Decision Model Based on Bi-Objective Planning

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Abstract. Since the implementation of market economy, credit business of commercial banks has been the main source of their revenue and credit risk is also the main risk they face. MSMEs are the main customers of commercial banks, and at the same time, MSMEs are characterized by small scale and lack of collateral assets. Therefore, it is of great significance to reasonably quantify the credit risks of MSMEs and formulate credit strategies to improve banks' returns. The problem of how commercial banks adjust their credit strategies for enterprises under the influence of unexpected factors. We select 10 representative manufacturing companies on the Shenzhen Stock Exchange to form manufacturing industry stocks to predict the impact of the new crown pneumonia on manufacturing returns.

Keywords: Credit model; Risk assessment model, Multiple logistic regression objective planning.

1. Introduction

MSMEs are an important part of the national economy. MSMEs in China manufacture 50% of the total national tax revenue in taxes, create 70% of invention patents and 80% of new products, and absorb more than 80% of the employed population [1]. However, banks in our country have been in the primary stage of development in credit management of MSMEs for a long time, and compared to large enterprises, MSMEs lack perfect management structures, have relatively low profits, and face greater market risks, therefore the requirements of credit for MSMEs are more stringent, and banks mainly base their credit strategies on credit policies [2].

Banks consider providing loans to enterprises with strong strength and stable supply and demand relationships [3]. The final credit plan is determined based on the credit risk of the enterprise and other factors, such as the amount of the loan granted, the annual interest rate and the loan term.

Bank credit decisions without contingency factors： When banks make credit strategies for MSMEs, they first assess their credit risk based on their strength and reputation, and then determine whether to lend and credit strategies such as loan amount, interest rate and maturity based on credit risk and other factors [4]. First, we use the strength and creditworthiness of the enterprise as the main factors affecting credit risk, using the average annual return and net cash flow stability as indicators of the enterprise's strength, and the credit rating and default status as indicators of the enterprise's creditworthiness. The credit risk assessment model is constructed using entropy weighting method and TOPSIS comprehensive evaluation method to determine the weight of each indicator and calculate the credit risk degree of each enterprise [5]. Next, the long-term and short-term earnings of the enterprise are used as the dual objectives, and the annual interest rate and loan amount are used as the decision variables to construct a sustainable earnings maximization model, and the optimal loan strategy is solved through dual-objective planning.

Contingency factors： The main consideration is the impact of the unexpected factor, the new crown pneumonia, on corporate credit. New crown pneumonia causes most of the enterprises to fail to carry out production activities on time, which seriously affects the enterprise's profitability, and then affects the debt-servicing ability, and finally causes the default of enterprise credit. For banks, it is to consider the extent of the impact of New Crown pneumonia on the credit riskiness of enterprises

in different industries in a comprehensive manner. Since the existing data time span cannot reflect the impact of New Crown pneumonia on enterprises, we need to additionally find relevant data reflecting the impact of New Crown pneumonia. And the impact of 2019-nCoV on the manufacturing industry is studied by building a CAPM model (asset pricing model) with dummy variables.

2. Implement

As a capital raising institution, commercial banks, while absorbing funds from all parties in debt, are bound to use the funds raised in the higher yielding credit market to gain revenue from them. Therefore, one of the main objectives of commercial banks in providing loans to enterprises is to obtain the highest possible return from them without losing money. In this paper we mainly consider the impact of the unexpected factor, New Crown Pneumonia, on corporate credit. New crown pneumonia causes most of the companies to fail to carry out their production activities on time, which seriously affects the profitability of the companies, which in turn affects the solvency and finally causes the default of corporate credit. For banks, it is to consider the extent of the impact of New Crown pneumonia on the credit riskiness of enterprises in different industries in a comprehensive manner.

Since the existing data time span cannot reflect the impact of NCCP on enterprises, we need to additionally find relevant data reflecting the impact of NCCP. And the CAPM model (asset pricing model) with dummy variables [6] is established to study the impact of 2019-nCoV on manufacturing industry.

2.1 Model analysis

One of the main purposes of commercial banks to provide loans to enterprises is to obtain the highest possible income from them without losing money. In formulating credit strategies for MSMEs, banks first assess the credit risk of MSMEs based on their strength and creditworthiness, and then determine whether to lend and the credit strategy in terms of loan amount, interest rate and maturity based on credit risk and other factors.

Therefore, we consider the following two steps to determine the credit strategy for a group of enterprises.

1.Credit risk assessment model

The strength of a firm is closely related to multiple factors such as the adequacy of its capital and the stability of its net cash flow. With limited data, we obtain information from the firms' invoices and use the average yield of each firm for 2018-2019 and the stability of net cash flow between each quarter of 2018-2019 as indicators to assess the strength of the firm. Since the firms' credit ratings and default status are known, we used them directly as indicators to assess the firms' creditworthiness. Combining the average yield of each enterprise in 2018-2019, the stability of net cash flow between each quarter in 2018-2019, the creditworthiness rating and default status, the weights of each indicator were determined using the entropy weighting method, and the measure of enterprise credit risk was derived by the TOPSIS comprehensive evaluation method.

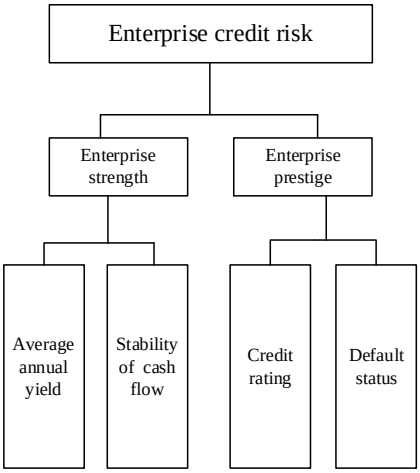

Figure 1 Credit risk assessment model indicator system

2.Sustainable Return Maximization Model

The core objective of banks in determining lending strategies such as whether to lend, loan amount, interest rate and loan term is to maximize returns. The bank wants to maximize the profit within a loan term, but does not want to lose customers due to higher interest rates. Therefore, we construct a sustainable revenue maximization model with the dual objectives of maximizing the bank's profit within a loan term and minimizing customer churn, and construct a dual objective planning model with interest rate and loan amount as decision variables to solve the lending strategy.

2.2 Industry Segmentation

By consulting the main divisions of industries [7], we can match the enterprises with the industries they belong to by keyword matching from the partial names of 302 enterprises. And the statistics of the divided industries are obtained, and the industry division of 302 enterprises is shown in Figure2.

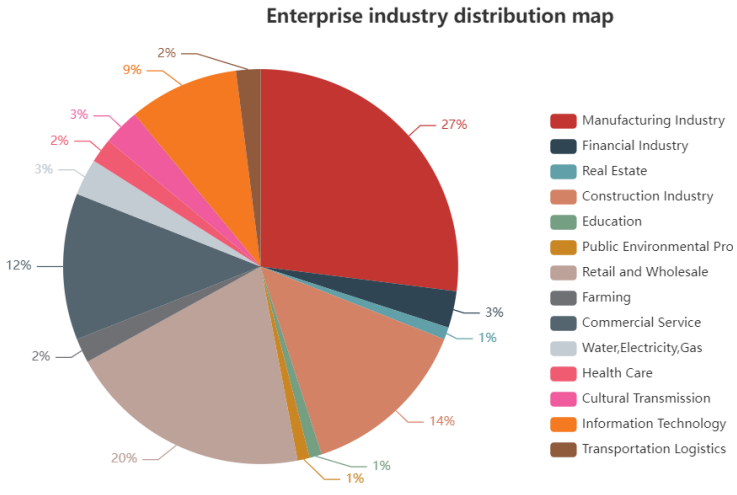

Figure 2. Enterprise industry distribution map

2.3 Data Selection

We selected 10 listed companies belonging to the manufacturing sector in the segmentation of SZSE, and downloaded the daily closing prices of 10 listed companies, daily short-term treasury rates, and the SZSI from Yingwei Caijing (https://cn.investing.com) and Juchao Information Website (http://www.cninfo.com.cn). The daily closing prices of the 10 listed companies were used to form the Changsha manufacturing industry stocks.

In particular, to visualize the impact caused by 2019-nCoV on the manufacturing industry, we introduce dummy variables (0-1 variables) as indicators to determine whether there is an impact, and predict whether the new crown pneumonia epidemic has an impact on manufacturing returns by testing the regression coefficients.

2.4 Model building

From the above analysis we build the modified CAPM model [8], i.e. expected return = benchmark interest rate + risk premium + impact of the new crown pneumonia epidemic. The mathematical expression is.

$$E\left(r_{it}\right)-r_f=\varsigma+\beta_{im}\times(E(r_{mt})-r_f)+\pi\times\omega_t$$

Where

p_{it} is the closing price of the company i ' s shares on the t day of trading.

p_{mt} is the SZSI for the t day.

r_{mt} are market index daily returns ($E(r_{mt})=\ln(\frac{p_{mt}}{p_{mt}-1})$);

r_{it} is daily return of manufacturing stocks ($r_{it}=\frac{\sum_{i=1}^{10}p_{it}}{10}$, $E(r_{it})=\ln(\frac{r_{it}}{r_{it}-1})$);

r_f is the risk-free rate (replaced by the 5-year Treasury rate).

β_{im} is the systematic risk factor in the CAPM model.

ω_t=1 Indicates that the manufacturing industry is affected by the new crown pneumonia.

ω_t=0 Indicates that manufacturing is not affected by new crown pneumonia.

In solving this problem, we need to process the original data to obtain the credit risk rate and the APR-customer churn rate function relationship.

(1) Credit risk rate

In the credit risk assessment model, we obtain the credit risk degree $D_i(0\le D_i\le 1)$ of each firm using the TOPSIS integrated evaluation method. Since there are always enterprises in default, we can assume that the negative ideal solution is in default, i.e., the risk degree of the negative ideal solution is 1 and the probability of default is 100%. In addition, the results of TOPSIS are the relative proximity to the negative ideal solution, i.e., the degree of difference in the probability of default of the firm relative to the negative ideal solution. Therefore, with limited data, we approximate the credit riskiness as the probability of default of the firm, i.e., the credit risk ratio.

(2) Annual interest rate-customer churn rate function relationship

Since the annual interest rate and customer churn rate of bank loans are discrete values, to obtain a continuous functional relationship between each annual interest rate and customer churn rate between 4% and 15%, we fit it polynomials using MATLAB. Since in the credit risk assessment model, we have already considered firms with a creditworthiness rating of D and a credit risk degree higher than 0.5 as firms that are not associated with loans [9]. Therefore, it is only necessary to fit the relationship between interest rate and customer churn rate function for enterprises with creditworthiness ratings of A, B and C grades.

The results of the three curve fits were obtained as follows.

$$P_{1i}=m_{11}\times r_{1i}^3+m_{12}\times r_{1i}^2+m_{13}\times r_{1i}+m_{14}$$

$$P_{2i}=m_{21}\times r_{2i}^3+m_{22}\times r_{2i}^2+m_{23}\times r_{2i}+m_{24}$$

$$P_{3i}=m_{31}\times r_{3i}^3+m_{32}\times r_{3i}^2+m_{33}\times r_{3i}+m_{34}$$

where P_{1i},P_{2i},P_{3i} is the annual interest rate (r_i) of the firm corresponding to the turnover rate of A, B, and C-rated firms, respectively. are parameters whose fitted values are

$m_{11}=640.94, m_{12}=-258.57, m_{13}=37.97, m_{14}=-1.1215$

$m_{21}=552.83, m_{12}=-225.05, m_{13}=33.99, m_{14}=-1.0165$

$m_{31}=504.72, m_{32}=-207.39, m_{33}=32.16, m_{34}=-0.9735$

We use MATLAB to solve the entropy weight method and TOPSIS integrated evaluation method to obtain the weights of each indicator and the credit risk intensity [10].

Entropy method assignment results

Table 1 Table of credit risk indicator weights

Indicators	Average annual return (α)	Net Cash Flow Stability (β)	Credit rating	Default status
Weight	0.0165	0.1104	0.4792	0.3939

Through the above analysis, we quantified the impact of the new crown pneumonia on the manufacturing rate of return, the following we just need to substitute this impact into the credit assessment model risk ---- credit assessment model in the average annual rate of return α_i , and then risk assessment to obtain the credit risk rate D_i . We construct a sustainable revenue maximization model, with the dual objectives of maximizing the bank's revenue and minimizing customer churn within a loan term, and constructing a dual objective planning model to solve the lending strategy with interest rate and loan amount as decision variables.

$$\min S=\sum_{i\in E_1}P_{1i}+\sum_{i\in E_2}P_{2i}+\sum_{i\in E_3}P_{3i} \tag{1}$$

$$\max w=\sum_{i=1}^{m}(a_i\times r_i\times(1-D_i)-a_i\times D_i) \tag{2}$$

$$s.t.\begin{cases} 10\le a_i\le 100 & i\in E \quad ① \\ 4\%\le r_i\le 15\% & i\in E \quad ② \\ \sum_{i\in E}a_i\le 10^5 & \quad ③ \\ P_{1i}=m_{11}\times r_{1i}^3+m_{12}\times r_{1i}^2+m_{13}\times r_{1i}+m_{14} & i\in E_1 \quad ④ \\ P_{2i}=m_{21}\times r_{2i}^3+m_{22}\times r_{2i}^2+m_{23}\times r_{2i}+m_{24} & i\in E_2 \quad ⑤ \\ P_{3i}=m_{31}\times r_{3i}^3+m_{32}\times r_{3i}^2+m_{33}\times r_{3i}+m_{34} & i\in E_3 \quad ⑥ \end{cases} \tag{3}$$

Where, r_{1i}, r_{2i}, r_{3i} denotes the annual interest rate for customers of grades A, B and C, respectively; a_i denotes the loan amount; D_i denotes the credit risk level; P_{1i}, P_{2i}, P_{3i} denotes the annual interest rate of enterprises (r_i) corresponding to the churn rate of enterprises of grades A, B and C, respectively; m is the parameter of the bank's loan annual interest rate-customer churn rate fitting curve.

Eq. (1) indicates that the first objective is to minimize the annual customer churn rate of the bank.

Eq. (2) indicates that the second objective is the maximum annual average rate of return for the bank.

The ① in Eq. (3) denotes the loan amount limit; ② tabular annual interest rate limit; ③ denotes the total loan amount limit; ④ ⑤ ⑥ denotes the annual loan interest rate as a function of customer churn rate under the credit rating classification of the enterprise.

The risk rate obtained in model II is brought into model III to obtain the loan interest rate and loan amount under the influence of the new crown epidemic

3. Results

In the following, we will use the data from November 21, 2019 - March 31, 2020 to fit the parameter (ς、β_{im}、π). The results of the multiple regression using SPSS are solved as follows.

Table 1 Multiple regression solution results

Model		Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
	Regression	0.001	2	0	15.666	0.000
	Residuals	0.001	84	0		
	Total	0.002	86			

From the F-test of the model, it is known that, p is less than α=0.05 ,to reject the original hypothesis, the model is considered to be valid. After the model test is established, the test of the regression coefficient of this question will be conducted.

Table 2 Regression coefficient test

	Coefficient	Standard error	Standardized coefficient	t	Significance	Covariance statistical	
			Beta			tolerance	VIF
(Constant)	0.083	0.009		8.815	0		
Industry Benefits	1.423	0.364	0.826	3.908	0	0.194	5.148
Impact of New Crown Pneumonia	-0.004	0.002	-0.368	-1.742	0.005	0.194	5.148

The test from the coefficient t of the regression system shows that, p is less than α=0.05, to reject the original hypothesis, the regression coefficient is significantly non-zero, while the VIF (variance inflation factor) is less than 10, and it can be considered that there is no covariance between the variables.

The value of the coefficient ω_t of the impact factor π of neocon pneumonia is -0.004, which means that neocon pneumonia reduces the daily rate of return of the manufacturing industry by 0.4%. From the projected daily rate of return, we can obtain the annual rate of return Through the above analysis, we quantified the impact of the new crown pneumonia on the manufacturing rate of return, the following we just need to substitute this impact into the credit assessment model risk. From the projected daily rate of return, we can obtain the annual rate of return, and then risk assessment to obtain the credit risk rate D_i. Once the risk rate is obtained, the credit strategy can be obtained by using the sustainable return maximization model.

4. Conclusion

Evaluation of the model

Advantages

(1) The default risk of each firm is obtained through the entropy-based TOPSIS risk assessment model, which is entirely based on objective data and avoids subjectivity.

(2) It is innovative to introduce dummy variables on CAPM model (asset pricing model) to quantify the impact of new coronary pneumonia.

Disadvantages

(1) There is some concern about the setting of the first and second objectives of the planning model when deciding the credit strategy using the sustainability benefit maximization model.

(2) When building the model, only profit maximization was considered, and there were no special preferences given to some key national enterprises and industries.

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