Research on Simulation of Credit Risk of Credit Card Based on Multi-Agent

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Abstract

Banks are not able to identify every cardholder’s credit information in their credit card business, so they can’t control the credit risk effectively. To solve this problem, this paper establishes a complex credit risk system of credit card business based on multi-agent. Simulation of different initial state of cardholders and types of cardholder in the credit card market is carried out. Through the analysis of the simulation, we believe that more attention should be paid to the "overdrafts contingency" cardholders by banks, in order to control the credit risk better and develop the credit card business.

Keywords: Credit card business, Credit risk, Multi-agent, Simulation

1. Introduction

With the development of market economy, credit cards’ convenient payment and credit functions have gradually been accepted. Therefore, more and more consumers regard credit cards as necessities. No doubt that the credit card has become one of the fastest growing financial businesses in today's society. The rapid expansion of the credit card market not only makes us see its prosperity, however, the great potential credit risks it brings are quietly gathered as well. Therefore, without good risk control in the process of expansion, it is easy for banks to fall into the situations of bad rate increasing and huge amount of bad and doubtful debts.

Credit risk is the main risk that faced by the contemporary economy and society, while the credit risk of credit card is the most important source of credit card business loss\textsuperscript{1}. The credit risk of credit card can be defined as the risk that due to the cardholders "can’t afford" objectively or "do not want to" subjectively in payments, the card issuer will suffer a great loss. At present, the studies on the credit risk of credit card home

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and abroad are mainly carried out from the following aspects: the analysis of macro risk factors and the microscopic personal credit assessment methods. Justin W. Evans (2008) from the perspective of foreign banks, qualitatively analyzed the causes of the credit risk of credit card and the keys to strengthening the control of the risk. Sun Lei and Sun Yingjun (2012) made recommendations accordingly for the credit risk and the fraud risk in the credit card business of China. Chi Guotai et al (2006) established an evaluation index system of the credit risk of personal credit card, according to the actual situation in China. Deanna L. Sharpe (2012) further in-depth discussed the important factors affecting the credit risk of credit card of China's urban residents. In order to reduce the subjective factors in the evaluation process as far as possible and reflect the dynamic changes of the credit risk, regression analysis, neural network, support vector machines, the combination forecasting model and non-parametric random forest classification method, and other mathematical methods have been gradually applied into the field of credit risk evaluation. However, among those mathematical methods, the forecast capacity of the applicants’ future credit is limited, and most of them do not consider the association and interaction between the consumers, so it is difficult to dig out the complex behavior patterns of and internal evolution mechanism that the system generates. In order to solve those problems, the analysis and modeling of agent-based complex financial systems methods come into being.

The basic idea of modeling and simulating based on multi-agent is that the system is composed of the adaptable agents, and the interactions between agents. While the agents and environment will generate new structures and more complex behaviors. At present, the methods based on agent have been widely used in the complex system of the investment behavior in the financial markets, the credit risk contagion of inter-banks and the Enterprise Group credit risk management and control. Zhang Wei et al (2012) combined consumers’ behavior with the changes in willingness to repay and repayment behavior, and built a credit card prediction model. We also did some basic research work on the management and control of the credit risk of credit card through simulation methods. China's credit card business is on the stage of rapid development, in order to study the credit risk of credit card in our country, we took the behavior of the micro-credit card holders and card-issuing bank as the entry points. Through multi-agent simulation method, we did simulation about the credit card risk management of personal credit card consumer behavior and the issuing bank. Then we analyzed the impact of consumer behavior patterns in different types of credit card users on the credit risk of the bank credit card business. At the meantime, we also analyzed different expansion strategy that banks adopted. Finally, the findings of this paper provided a more reasonable choice for the issuing banks in credit policies for different types of applicants and the expansion strategies. In that case, it will effectively improve the level of risk management in the credit card market of China, so the problems that this paper studied have important theoretical and practical significance.

2. Simulation model of the credit risk of credit card based on multi-agent

2.1. Basic assumption of the system environment of the credit card market

Nowadays, the vast majority of cardholders in the market will take active steps to maintain its credit status, and return at least the minimum amount of the bank repayment in whatever circumstances, in order to maintain the use of credit cards. In that case, we make the following basic assumptions:

1. Cardholders actively maintain their credit status, on the conditions that” can afford”, the current return of bank amount not less than the minimum amount (Minimum-Repayment, abbreviated as min-R).
2. Cardholder with a stable income (Income, abbreviated as I), and may own some savings (Wealth, abbreviated as W).
3. Cardholders credit card spending and cash withdrawal with daily interest rate of five ten thousandths (r = 0.05%) remain unchanged, and charge monthly with compounding interest. According to "the bank card business management approach" Article 23, credit card overdrafts charge monthly with compounding interest,
quasi-credit card overdrafts charge monthly with simple interest, overdraft interest rate with daily interest rate of five ten thousandths, and in accordance with the interest rate adjustment provision of China People's Bank if need adjustment.

4. Cardholders’ cash withdrawal is related to the credit line, it is assumed that the cash withdrawal (Withdrawal Cash, abbreviated as WC) is 50% of its credit line (Credit Line, abbreviated as CL). The cash withdrawal proportions in different banks are different, ranging from 30% to 100%, in order to facilitate the simulation, we take 50%.

5. Credit card annual fee is negligible. In China, many credit cards carry no annual fee or no annual fee with fixed number of consuming, generally, it is the easy for the cardholders to achieve, so we take the credit card annual fee with 0.

2.2. Properties and behavior of intelligent economic agents in the credit card market

The credit card market contains two types of intelligent economic agents: cardholder (individual consumers) and the issuing bank.

2.2.1. Cardholder settings

(1) Cardholders’ property setting
The cardholder's properties include: consumer types, income levels, the initial savings, and credit line. Consumer type (B): we divide credit card consumers into three types according to the literature [17]: "overdraft Preferences "," overdrafts contingency "and "overdrafts averse ".

(2) Cardholders’ behavior setting
Cardholders’ behavior includes: credit to income, credit card spending, cash withdrawals, and current repayment four.

2.2.2. Issuing bank setting

(1) Issuing banks’ properties setting
The issuing bank's properties include: the cumulative amount of bad debts, the number of disabled credit card.

The cumulative amount of bad debts (Debts): the accumulated bad debts of bank because of the credit card owners losing the ability to repay, this indicator can reflect the size of the credit risk of credit card faced by the bank. The number of disabled credit card (Number): the number of the cardholders that can’t repay the current specified minimum repayment amount and are stopped using the card by the card issuing bank, this is another indicator to reflect the credit risk of bank credit card.

(2) Issuing banks’ behavior settings
Issuing banks’ behavior includes: issuing credit cards, determining credit line, disabling credit card

Issuing credit cards: banks market credit cards to consumers in order to expand its business. Determining credit line: banks determine the credit line with a certain method, according to the consumers’ application. Disabling credit card: by setting the minimum repayment amount, monitoring cardholder repayment, banks disable the cardholder's credit card when the cardholder can’t repay the current minimum repayment amount.

2.3. Simulation model of the credit risk of credit card

The cardholder’s current spending should be reflected the two aspects of the current consumption frequency and each consuming amount, because each consumption frequency and consuming amount will affect the
calculation of interest, the current consuming amount is the total each consuming amount. If cardholder’s consuming number is a random number, and each consuming amount is random number as well, then the total monthly consuming amount we obtain will also be a random number, which is equivalent with that we directly set the total monthly consuming amount a random number. So we set that consuming many times per month for consuming once per month, and consuming amount is the adding liabilities of this month.

According to the basic assumptions as well as the descriptions of the properties and behavior of intelligent economic agents in the credit card market, we have developed the following interaction rules:

\[
C_i = b_1 \times CL_i
\]  
(1)

\[
b_1 \in [0.10\%], \text{ is the proportion of credit card random consuming within the credit line.}
\]

\[
T_i = \begin{cases} 
  b_2 \times r_i \times CL_i & b_i \leq 1-r_i \\
  b_2 \times (CL_i - C_i) & b_i > 1-r_i 
\end{cases}
\]  
(2)

Because the actual cash withdrawal is affected by both bank regulations and credit card consumption. \(b_2 \in [0.10\%]\), represents the proportion of random cash withdraw within the, cash withdrawal; \(r_i \in [0.10\%]\), means the proportion the bank sets about that the cash withdrawal accounts for the overall credit line.

\[
P_i = 0.05\% \times (C_i \times d_1 + T_i \times d_2 + Y_{i-1} \times d_3)
\]  
(3)

\(Y_{i,1}\) represents that the repay amount in the previous period; \(d_1, d_2 \text{ and } d_3\) respectively represents consumption, cash, and the random days with interest that is generated from the cardholder overdue in the previous period.

\[
\min R = P_i + T_i + Y_i \times 10\%
\]  
(4)

According to the "bank card business management approach ", the overdrafts period of credit card is up to 60 days, and in the first month, the minimum payment of the credit card shall not be less than 10\% of its overdraft balance for the month.

\[
R_i = \begin{cases} 
  \min R + b_3 \times (S_i - \min R) & I_i \leq \min R \\
  I_i & \min R < I_i \leq S_i \\
  S_i & I_i > S_i
\end{cases}
\]  
(5)

\(S_i = Y_{i-1} + C_i + T_i + P_i\), \(S_i\) is the amount ought to repay currently; \(Y_i = S_i - R_i\), \(Y_i\) is the amount unpaid off currently; \(W_i = W_{i-1} + I_i + T_i - R_i\), \(W_i\) is the savings of cardholder currently.

According to the above interaction rules, we built the basic simulation model based on the NetLogo simulation platform, through adjusting the corresponding parameters. Due to the fact that the model contains a lot of random variables, we need to repeat the experiment many times. Through removing the minimum and maximum values and averaging, we got the final results of the statistics.
3. Simulation experiment and results analysis

According to literature [17], the cardholders are divided into three types, their specific features are as follows: 1. overdraft preferences, it owns the highest consuming willingness, the highest overdraft emotion, the highest repayment ability, the lowest financial pressure, the most perfect social security, the lowest self-controlling, the lowest interest rate sensitivity, the lowest herd environment; 2. overdraft contingency, it owns the average consuming willingness, the highest overdraft emotion, the average repayment ability, the average financial pressure, the average perfect social security, the average self-controlling, the average interest rate sensitivity, the average herd environment; 3 overdrafts averse, it owns the lowest consuming willingness, the lowest overdraft emotion, the lowest repayment ability, the highest financial pressure, the worst social security, the highest self-controlling, the highest interest rate sensitivity, the average herd environment. According to the survey of literature [17], these three types of cardholders respectively account for 21.9% 38.5% and 39.6%, and the statistics provide us the corresponding interval of the income.

Accordingly, our simulation experiments determined different initial parameters for the different three types of consumers: overdraft preferences, income [5000,8000], the credit consumption interval [0.5,0.8]; 2 overdraft contingency, income [2000, 5000], credit consumption interval [0.25,0.55]; 3 overdrafts averse, income [1000,2000 ],credit consuming interval [0.1,0.4]. When the credit line reaches 8000, that is the conditions meet the application requirements of all consumers. When we faced the independent and the adjusted mixed consumers after the actual investigation, we did specific simulation about the credit risk of banks in the 36 months, and the results are as follows:

![Credit line with 10000, figure of changes in the number of the disabled credit cards](image)

Fig. 1. Changes in the number of different types of defaulted cardholders in the credit card market

From the Figure 1, we can see the initial parameters setting for the three types of cardholders are realistic, the "overdraft preferences" has the strongest solvency; the "overdrafts averse" has the weakest solvency; while the "overdrafts contingency" in the middle. From Figure 1, the actual default of various types of cardholders existed with certain proportions is closest to the "overdrafts contingency" consumers’. The issuing bank should focus on the "overdrafts contingency" consumers’ information and data. Therefore, the default of the credit card market can be predicted through analyzing its rules and trends.

4. Conclusion

This paper studied it based on multi-agent simulation method: firstly, we did simulation of the changes of the bank's credit risk in the case of that the homogeneous cardholders are different in credit line and initial savings. The findings show that the banks should credit to the applicants in the appropriate range; the banks also should consider whether the applicants have applied for credit and take the applicants’ savings condition into account when doing credit assessment. Secondly, we further divided the cardholders into three types, and constructed the actual situation of the market according to the proportion of the three types; and then the
simulation was carried out, the results suggested that all banks should concern about the "overdrafts contingency" consumers, in order to strengthen the monitoring of credit risk.

The model in this paper does not take the banks' profitability into account, if we combine the profitability and risk studies, the study will be more meaningful. As for the cardholders' heterogeneous discussion, we only consider the factors of consuming willingness and income difference, there still exists a huge gap with the actual situation. Additional, this paper did not consider the interaction between the consumption concepts of the consumers, these deficiencies will become the problems that need to be focused on in further research.

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