

# Based on NetLogo Simulation for Credit Risk Management

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**Abstract.** With economic development, the credit card business has entered a stage of rapid development. Using quantitative methods of modeling to analyses and predicts the consumers use the credit card behaviors. It is one of hot project in the experimental economics, and it is important for avoiding credit risk. The essay based on a simple NetLogo simulation model to simulate individual consumers and economic activity, to observe the risk of credit card operation system. The experimental results is, in the different income levels, the cardholders' consuming and withdrawal behaviors would have no limits, then the issuing bank would be set line of credit is not higher twice than their income. In this situation, the cardholders could pay back the money on time. Otherwise, it will have risks for issuing bank. This method is common, so it can be used in many study areas.

**Keywords:** Credit, risk management, Netlogo, simulation.

## 1 Introduction

With the quick extension of the credit card business, it has brought huge business opportunities to China's banking industry. At the end of second quarter of 2011<sup>1</sup>, the whole country issued 2.674 billion bank cards, including 257 million credit cards, an increase of 24.3%. With improve the environment for accepting bank cards, the cards becoming the most widely non-cash payment instrument used in our life, and the number will keep growing. However, the risk of credit card management is an unprecedented challenge, how to improve the bank's ability to control the risk and make the industry healthy development are our important missions[1].

Experimental economics is a subject based on a certain amount of practical rules, using stimulation method to create a laboratory environment like the real's, through changing the parameters to analysis the experimental results, and it uses in verify the past economic theory or hypotheses. Maybe the subject will find new theory, or giving some decision-makings theoretical analysis. In 2002, the Nobel Prize of Economics was awarded to Vernon Smith, an experimental economist, the experimental economics get more and more attention[2][3].

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<sup>1</sup> [http://www.pbc.gov.cn/publish/goutongjiaoliu/524/2011/20110808155824275687112/20110808155824275687112\\_.html](http://www.pbc.gov.cn/publish/goutongjiaoliu/524/2011/20110808155824275687112/20110808155824275687112_.html), 2011-9-29.

For the risk of credit card management, some scholars use data mining to analyze one or more time sections, and find the potential risks[4]. Also the quantitative model uses in credit cards' approval, in this model, we could segment the card holders[5][6]. We could use experimental economics to build the credit card's data model and predicate risks, to find out strategy of avoiding risks[7]. Zeng Wei[8] has been built a model based on Netlogo, in China's backgrounds to set up some parameters, and discussed whether the cardholder behaviors should be controlled. Pietro Terna with his students uses simulation models for economics to explore the practical application of Netlogo[9]. These reports show that if we use some quantitative methods to analyze and simulate the complex credit card operation system, the loss will be reduced. But in the process of simulate, how to choose best parameters, how to explain the result, that is still a problem.

In view of these facts, this paper will use quantitative model to analyze the commercial bank risk of credit card management, also use Netlogo and data mining. According to Netlogo platform, we using simulation models for economics to observe bank's potential risk in different cardholder's consumptive behaviors, and doing comparative experiment.

## 2 Designing for Experiment Model

Our simulation experiment is based on Netlogo modeling platform[10][11][12].

Netlogo is developed by the Northwestern University Center for Connected Learning and Computer-Based Modeling, CCL. The purpose is providing a useful and powerful computer-aided tool in scientific research and education. In 1999, Uri Wilensky with the help of the United States National Science Foundation began developing Netlogo. The version 1.0 was released in 2002, the version 2.0 was released in 2003, and the version 3.0 was released in 2005, now the version is 4.1.3. Netlogo is free software based on Java, and can be run in many different platforms. Netlogo is a multi-agent based simulation environment, especially suitable for time-varying of complex cases for simulation. These features of Netlogo make the possibility of connection between microscopical behavior and macroscopical mode becoming real. These macroscopical modes are composed by many individual interactions. Netlogo is a programming environment, and we could create our own models. As a powerful tool, Netlogo application covers natural and sciences fields, such as biology, ecology, geography, chemistry, architecture, computer science and economics and social psychology and so on [13][14].

The simulation experiment observes the risk of credit card operation system in different situations, and adjusts the system immediately. The experiment is proposed to provide a reference for credit risk management of commercial banks.

### 2.1 Designing for Experiment

#### 2.1.1 The Agent of Experiment

The agent of experiment contains cardholder (consumer) and issuing bank. The numbers of cardholders set a constant number, and issuing bank's behavior as the whole financial system behavior.

According to the computer hardware setting the number of cardholders, but must be more than 100. This trial is 1000.

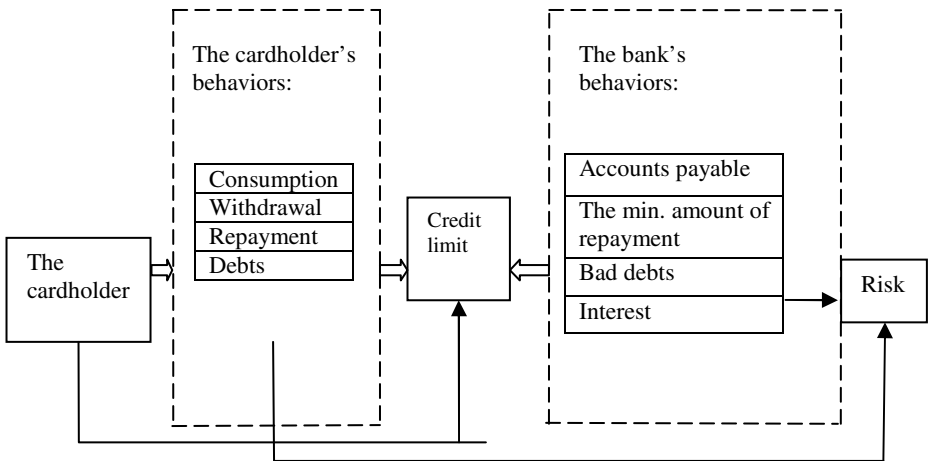
The cardholder’s behaviors include: income, pay by card, withdrawal, repayment. Now we give some assumption: 1) income, cardholder has a steady income. 2) Pay by card, only use in consumption. 3) Withdrawal, in a credit limit. 4) Repayment, cardholder repays monthly, and the amount of repayment should be greater than the minimum payments. Otherwise, the credit card would be freeze. 5) Last-term debt should be pay in next month, also must pay interest. 6) Cardholder’s other behaviors (e.g. saving, investment etc.) would exclude in this trail. Cardholder could use previous saving repay the debt.

We make market issuing banks as a whole, which is mean, the whole bank system face the risk from cardholder together. This setting considers that issuing credit card always bank own behavior in China’s commercial bank. Cardholders could borrow other bank to repay a given bank’s debt, so that their daily trading activities would be satisfied. If we take market issuing banks as a whole, this problem can adjust the total credit limit to be solved.

**2.1.2 Experiment Flow**

In this simulation experiment, each trail is based on real life credit card consumptive behaviors. Every month cardholder could get income, use credit card consumption, withdrawal and repayment. In use credit card consumption, we ignore the economic behavior between bank and seller. Withdraw is not a part of outflow of cash flow. In reality, the amount of minimum repayment should contain the money used in this month and last-term debt and its interest. When cardholder repays all the debt, these cash will return back to bank.

According to cardholder’s consumption and withdrawal, bank use these information to calculate interest, accounts payable, the minimum repayment. Cardholder is based on the bill and his condition to repay the bill, and bank could confirm the amount of bad debt. Figure 1 shows the experiment flow.



**Fig. 1.** The credit card’s working flow chart

**2.2 Assumption Condition**

- (1) The cardholder available money in each month must within the credit limit.
- (2) The cardholder could draw the amount money must within the limit in each month.

- (3) The daily interest is 0.5%, and it is compounded monthly. To ignored the credit card annual fee.
- (4) The cardholder has a stable income.
- (5) The cardholders keep their credit rating.

### 2.3 Building the Model

According to “Bank Card Business Management”<sup>2</sup>, and these experiment assumptions, setting these parameters. We use these parameters on the Netlogo platform to build the model. The table 1 shows the main parameters.

## 3 Simulation Experiment and Results

### 3.1 Building the Model

We use the Netlogo platform to build the model. In this experiment, the variables are 1)the number of experiment agent, 2)daily interest, 3)the repayment part of income, 4)the ratio of the amount of accumulative unconsumed money, 5)the ratio of withdrawal part, 6)the ratio of the minimum amount of repayment, 7)cardholders initial money, 8)cardholders credit limit. The figure 2 shows the model interface.

### 3.2 The Experiment

Shown in table 2, we do cross-over experiment in income ( $I_t$ ) and credit limit ( $V_t$ ), and observes the repayment risk ( $Y_t$ ). The figure 3 shows the risk curve.

**Table 1.** Netlogo parameters and formulas

Symbols	Parameter names	Formulas
$V_t$	Credit Limit	$V_t = V$ , $V$ is constant
$C_t$	Pay by Card	$C_t = b_1 \times V_t$
$b_1, b_2, b_3$	Random Number	(0, 100%)
$d_1, d_2$	Interest days	Range from 0 to 60
$r_1$	Cash rate	$r_1 = (V_t - C_t) / V_t$
$r_2$	The minimum repayment rate	$r_2 = 10\%$
$r_3$	Day rate	$r_3 = 0.05\%$
$M_t$	The amount of withdrawal	$M_t = b_2 \times r_1 \times V_t$ , ( $b_2 \leq 1 - r_1$ ) $M_t = b_2 \times (V_t - C_t)$ , ( $b_2 > 1 - r_1$ )
$I_t$	The holder’s income	$I_t = I$ , $I$ is constant
$P_t$	Interest	$I_t = r_3 \times (C_t \times d_1 + M_t \times d_2)$
minR	The minimum amount of repayment	$\text{minR} = I_t + M_t + Y_t \times r_2$
$R_t$	The total amount of repayment	$R_t = I_t$ , ( $\text{minR} < I_t \leq T_t$ ); $R_t = T_t$ , ( $I_t > T_t$ ) $R_t = \text{minR} + b_3 \times (T_t - \text{minR})$ , ( $\text{minR} \geq I_t$ )
$Y_t$	Bad debts	$D_t = T_t - R_t$
$T_t$	Current accounts payable	$T_t = Y_{t-1} + C_t + M_t + P_t$
$W_t$	Available currency in short-term	$W_t = W_{t-1} + I_t + M_t - R_t$

<sup>2</sup> Bank Card Business Management, People’s Bank of China [1999] 17.

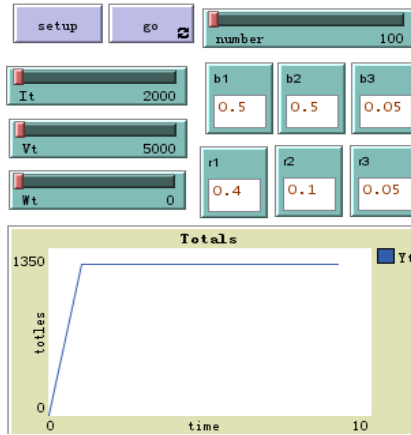
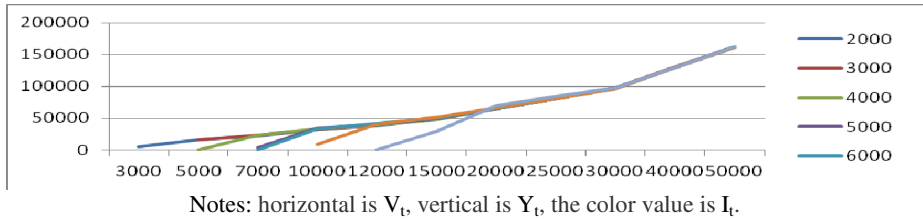


Fig. 2. Netlogo model interface

Table 2. Setting the parameters

Variables	Number of cardholders	$b_3$	$r_1$	$r_2$	$r_3$	$W_t$
Values	100	0.05	0.05	0.1	0.4	0



Notes: horizontal is  $V_t$ , vertical is  $Y_t$ , the color value is  $I_t$ .

Fig. 3. The relation map of  $I_t$ ,  $V_t$ ,  $Y_t$

Through figure 3, when the credit limit gets a certain line, the potential risk curve in different income levels almost overlap. That is means the income has little negative influence for the bank potential risk curve. Then we concluded that between credit limit and cardholder’s income has a special relationship. To observe this relationship, we use the model to find the relationship between  $I_t$  and  $V_t$ .

(1) It selected a set of  $I_t$  values, taking  $V_t = 2I_t$ , and doing separate trails.

(2) we set  $(I_t, V_t)$  model, use  $(2000,4100)$ ,  $(2000,4200)$ ,  $(2000,4300)$ , .....,  $(2000,4800)$  to do trails.

Then we get the regression coefficient is 2.012067. The result shows that when the credit limit less than twice the cardholder’s income, the bank has little risk.

## 4 Conclusion

This paper builds a simple simulation model of credit risk management, simulates individual behaviors influence credit card risk. This model will provide a reference to commercial banks to make their issuing card rules.

Through experiments, we observed that, if the repayment of credit is not higher than 2 times the income, cardholder's wealth can be the stability in the long-term, and be able to guarantee repayment, otherwise will bring risks for the issuer. We also found that when the credit line was some level, the cardholder's potential risks for banks and the cardholder's income do not matter.

Credit risk management based on research NetLogo is an effective method of experimental economics. This method can provide a decision-making reference and is suitable for further similar studies.

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