A Dynamic Interest Rate Adjusting Mechanism for Online Social Lending

(Extended Abstract)

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ABSTRACT

Social lending is a dynamic trading mechanism that can directly match one consumer with another consumer. Most manual transaction processes conducted by traditional financial institutions can be done automatically and tailored to each consumer in social lending. In this paper, we focus on an automatic interest adjustment and incentive mechanism for borrowers because they are crucial for dynamic social lending since they could help increase worth and reduce payment delays. First, we propose a Bayesian updating method for interest rate adjustment that considers the influence of their social groups on borrowers. Our method determines an accurate rate because the borrower's delay history is dynamically reflected in the rate decision. Second, we propose an incentive mechanism that improves a borrower's payment delay score. The mechanism offers incentives for payment with rewards (penalties) to borrowers. We demonstrate the efficiency on our proposed methods by conducting agent simulations.

Categories and Subject Descriptors

I.2.11 [Artificial Intelligence]: Distributed Artificial Intelligence-Multi-agent System

General Terms

Algorithm, Design, Experimentation

Keywords

Social Lending, Interest Rate Adjustment, Bayesian Estimation, and Incentive Mechanisms

1. INTRODUCTION

In social lending, most manual transaction processes done by traditional financial institutions can be automatically conducted and tailored to consumers so that all players can maximize their own values. The processes that could be automated include adjusting interest rates, making incentives to borrowers for returning money, recommending lenders and borrowers, creating portfolios, etc. In this paper we focus on automatic interest adjustment and an incentive mechanism for borrowers because they are crucial for dynamic social lending and might help increase the value of players and reduce payment delays.

The related literature on offline group lending is plentiful. It is well-known that physical group lending mechanisms in rural areas have shown high repayment rates. For example, [2] explained how joint-liability credit contracts used by group lending schemes can achieve high repayment rates even if borrowers have no collateral.

2. RATE ADJUSTMENT MECHANISM WITH GROUP HISTORIES

In this section, we propose a method for updating interest rates by forecasting delay probability using Bayesian estimation to exploit the group histories to which a borrower belongs. This method enables group histories to be substituted for individual histories to estimate the rate when the individual history is scant.

The following expression that adds distribution Pr_{group} to $p(\boldsymbol{x}|\pi)$ is defined as our likelihood: $l(\pi|\boldsymbol{x}) = p(\boldsymbol{x}|\pi) \cdot Pr_{group}$, where $\boldsymbol{x}$ shows the history of a borrower, π is deley probability. Since prior distribution should not be affected much by group probability, the prior distribution used at the nth term is defined as follows: $p^*_{n-1}(\pi) = p(\boldsymbol{x_{n-1}}|\pi) \times p(\boldsymbol{x_{n-2}}|\pi) \times \cdots \times p(\boldsymbol{x_1}|\pi)p_0(\pi)$. Therefore, the following are the nth period post distributions: $p_n(\pi|\boldsymbol{x_n}) = p(\boldsymbol{x_n}|\pi) \cdot Pr_{group} \times p^*_{n-1}(\pi)$. At period n, the influence of groups will be $1/n$ for the borrower's repayment history.

The procedure for updating the interest rate of borrowers with the likelihood consists of the following four steps:

[Step 1] Calculate of posterior distribution $p(\pi|\boldsymbol{x})$ using the likelihood mentioned above. The calculating formula is as follows: $p(\pi|\boldsymbol{x}) = K \cdot l(\pi|\boldsymbol{x})p(\pi)$, where $p(\pi)$ is prior distribution, and K is a standardization fixed number to satisfy following expression: $\int_0^1 K \cdot l(\pi|\boldsymbol{x})p(\pi)d\pi = 1$.

[Step 2] Calculate of predictive delay probability $Prob$.

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$Prob$ is defined as follows: $Prob = \int_0^1 \pi p(\pi|\boldsymbol{x})d\pi$.

[Step 3] Calculate of a proper rate based on the predictive delay probability.

[Step 4] Adjust the rate. When the interest rate calculated in Step 3 is greatly different from the present interest rate, the interest rate is adjusted.

3. INCENTIVE MECHANISM FOR IMPROVING DELAY SCORE

We design a mechanism that encourages borrowers to repay. It creates several groups of borrowers and gives a reward (penalty) to them. Consider an economy of n individuals. Let $k = 1, ..., m$ be the groups in the economy, and let I_k be the set of individuals in group k. The mechanism owner makes individual i belong to group k. When the delay rate of i is g_i, reward (penalty) r_i of i is as follows:

$$r_i = P_G(g_i - \frac{1}{n_k - 1}G^k_{-i}) \qquad (1)$$

where $G^k_{-i} \equiv \sum_{j \in I_k - \{i\}}^{n_k} g_j$, $n_k \leq n$ is the number of people belonging to group k, and G^k_{-i} is the sum of the total delay rate of the members of this group except the contribution of individual i. This general reward function is known as the Falkinger mechanism [1]. In this mechanism, the reward is dependent on the results of others: G^k_{-i}. Thus, borrowers don't have an incentive to intentionally deteriorate the repayment results. Also, the mechanism owner doesn't need a large budget, despite the value of P_G.

Our mechanism has one problem. The amount of penalty can't be increased, even if the entire repayment score falls. Thus we expects a (one-step) future loss each time and gets it as a tax from borrowers by including one agent without any delays in each group. About the expected loss, when x_t becomes the ratio of the 0-delay borrowers at period t, M is the average commission, and N is the number of lenders, R is the investment participation rate, the following are expected losses E: $E = -M \times N \times (R(x_t) - R(x_{t-1}))$. As one example, R can be defined as follows:$R(x_t) = {x_t}^2 \quad (0 \leq x_t \leq 1)$.

The following is the reward (penalty) that the borrower receives: $P_G(x) = \frac{E}{\sum_{k=1}^m v_k} x$, where v_k is the distance of a tax agent from the average rate in group k. The total tax is $\sum_{l=1}^m P_G(v_l) = \sum_{l=1}^m \frac{E}{\sum_{k=1}^m v_k} v_l = \frac{E}{\sum_{k=1}^m v_k} \sum_{l=1}^m v_l = E$.

4. EXPERIMENTS

In the field of financial engineering, a good or a service is described as high-risk if it has a large dispersion on its attributes such as profit dispersion. Therefore, dispersion should be minimized because it is considered a risk.

In this experiment, we confirmed the effectiveness of our adjustment method. Borrowers are generated with delay probability based on the group probability to which they belong and generate payment history. The system adjust rate of the borrowers after repayment.

Figure 1 shows a comparison of the sum of dispersions for every interest rate. The horizontal axis is the frequency of the transactions. Graph (a) is the result affected by the groups, and graph (b) is not affected by the groups. In both graphs, the sum of the dispersions decreased as the number of transactions increased because Bayesian estimation decides the proper interest rate with the increasing loan histories. The dispersion of graph (a) is smaller than (b) in the

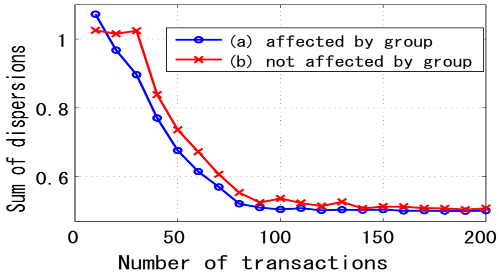

Figure 1: Comparison of sum of dispersions every interest

early stages because group histories are substituted for the borrower history to estimate the rate in the early stages.

Next, we observe the transition of owner earnings. Assume about 1000 lenders are in the system. The lender finances an average of $10,000, and the commission is 1%. The lender judges whether to invest based on the proportion of no-delay borrowers.

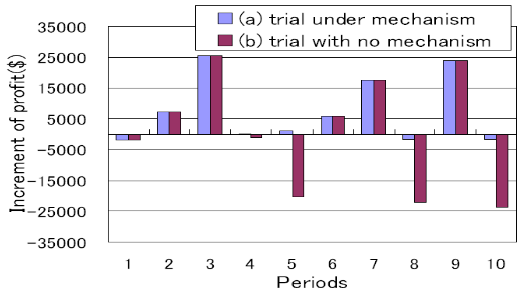

Figure 2: Comparison of profit increment

Figure 2 shows the transition of the profit increment. The horizontal axis shows the number of periods. (b) shows profit increment without compensation, and (a) shows profit increment to which the compensation was applied. Graph (b) fluctuates and the profit decreases, but graph (a) is not less than zero very much. The reason is that the difference of earnings is suppressed using the compensation mechanism.

5. CONCLUSION AND FUTURE WORK

In this paper, we proposed an automated interest rate adjustment mechanism and incentive mechanisms. With the former method, small interest rate dispersion is attained with the increasing loan histories of borrowers. Our method can increase the transactions of risk-averse lenders. With the latter method, borrowers are encouraged to repay. In addition, by setting the expected loss collection agents into groups, the mechanism owner can avoid profit loss.

6. REFERENCES

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