Computers & Operations Research 48 (2014) 81–88

Contents lists available at ScienceDirect

Computers & Operations Research

journal homepage: www.elsevier.com/locate/caor

Optimization strategy of credit line management for credit card business

So Young Sohn *, Kyong Taek Lim, Yonghan Ju

Department of Information and Industrial Engineering, Yonsei University, 134 Shinchon-dong, Seoul 120-749, Republic of Korea

ARTICLE INFO

Available online 26 March 2014

Keywords:
Credit line
Credit card
Optimization

ABSTRACT

Adjusting the credit lines of card users is an important issue. It is essential to establish an optimized approach for credit card companies to identify the proper amount of credit to offer for their customers. Most of the related research concentrated on the prediction of credit card users' default. Our contribution is a consideration of a holistic and heuristic approach that looks at the credit line that maximizes the net profits of the credit card companies. We first apply regression models to find the probability of default of customer and customer's current balance as a function of credit line. Next we use a regression tree to identify groups of customers assigned with the same credit line. The results are then used to formulate the net profit and genetic algorithm is used to find optimally adjusted credit line for each group of customers. It is expected that our study can contribute to present strategic guidelines for the management of credit lines for card companies.

1. Introduction

Assigning proper credit limits is one of the most critical tasks of credit card companies [35,9]. Credit card companies usually assign an initial credit line based on the customer credit score. The initial credit line can be adjusted when required by a customer. It is essential to establish proper credit lines that can maximize the net profit of the credit card company. However, the existing methods that are used by credit card companies to adjust credit lines are not very systematic [36]. Adjusting a credit line without proper reason or basis may put the credit card company at risk of losing business and at the very least decrease their profit.

There has been some effort to find the relationship between credit limit and the response of the credit card users. Dey and Mumy [17] have examined the determinants of credit limits on credit cards. The authors have found evidence that suggests a positive relationship between the proxies (LOGINCOME, SELF-EMPLOYED, AGE, and CREDITRATE) of borrower quality and the approved borrowing limits on credit cards. Gross and Souleles [22] investigated consumer response to changes in credit supply using the data set collected on credit card accounts from user in the U.S. Based on the results of their study, increases in credit limits seem to generate an immediate and significant increase in debt. This response is especially true for people who used near their credit limit. However, people who used well below their credit limit also experienced a significant increase in debt. Song [41] has shown that the credit levels and needs of customers are reflected in the credit line, and that these factors can effectively increase credit card usage. By determining the limit value at which profit can be maximized by taking into account the response to the limit exhibited by both good and bad customers, the author provided the appropriate credit limits for different customer groups. Nonetheless, data is still lacking in regard to developing an optimized strategy for credit card businesses to manage lines of credit.

Most of the related research concentrated on the prediction of credit card users' default. Our contribution is a consideration of a holistic and heuristic approach that looks at the credit line that maximizes the net profits of the credit card companies. The purpose of this study is to develop a strategy that will maximize the net profit of credit card companies by adjusting the credit lines of credit card customers. In order to determine an appropriate credit line, we assessed the expected profit as a function of the credit line for customer groups and applied data mining algorithms to find the probability of default (PD). Using this information and the current balance, we grouped customers by their initial credit line. The PD was estimated using a logistic regression in which the credit line was used as one of the predictor variables. We estimated the current balance using the multiple regression model and used a regression tree to identify homogeneous groups assigned with the same credit line. The expected net profit was then obtained as a function of the initial credit line of the individual group, as well as the current balance and PD. Finally,

* Corresponding author. Tel.: +82 2 2123 4014; fax: +82 2 364 7807.
E-mail address: sohns@yonsei.ac.kr (S.Y. Sohn).

http://dx.doi.org/10.1016/j.cor.2014.03.013
0305-0548/

we utilized a genetic algorithm (GA) to find the optimal credit line that maximizes the net profit of the credit card company. It is expected that an optimal strategy derived from adjusting lines of credit can help credit card companies better manage their consumers and costs.

This paper is organized as follows. In Section 2, we review the current literature related to our study. In Section 3, we introduce the data and variables used in our study. In Section 4, optimization models are proposed for a case with empirical data. In Section 5, we discuss our study results as well as suggestions for further research.

2. Literature review

In this section, we review the current literature on credit lines and financial optimization models that have been used in previous research studies. We review the role of credit lines and examine how the characteristics of optimal finance methods have evolved over time.

2.1. Credit line

Credit card companies provide convenient payment options to their customers and allow postponement of payment by granting a line of credit. This is why the credit card business has similar credit risks to that of companies in the mortgage business.

The current balance of a credit card user directly affects the profit of a credit card company. Generally, credit card companies generate more profit when their card users have a high current balance. However, card users with a large current balance and poor credit scores increase the costs of the credit card company. In this regard, the credit line assigned to a customer, which is closely related to the current balance of the card user, is very important. Therefore, two important factors to consider when increasing or lowering the credit lines of customers are the current balance and credit score.

Soman and Cheema [39] manipulated credit limits and the credibility of card users. They posed hypothetical purchase opportunities to their test subjects. The authors mentioned that when user's credibility is high, the effects of credit limit on spending will be strong while if the credibility is low then the effects of credit limit will be attenuated.

Ko et al. [25] analyzed how changes in credit limit affect household consumption and default patterns using data of Korean credit card users. Through empirical analysis, the authors have shown that changes in credit limits can critically affect how people with low credit ratings make purchases. In addition, the time period between the change to the credit limits and the time in which their effects are realized is short.

Norden and Weber [33] investigated the link between account activity and information production in regard to borrower risk. In their study, it was found that credit line usage, limit violation, and cash flow all exhibited abnormal patterns approximately 12 months prior to a default event. This observation shows that account activity provides a real-time window into the borrower's cash flow and thus explains why banks have an advantage in allowing certain types of customers to go into debt.

Using trended Brownian motion to characterize the cash needs of a borrower over time, Stanhouse and Ingram [40] derived a probability density function to determine the time to depletion of a bank credit line as well as the time to exhaust the sources of liquidity that fund the loan. Armed with these analytic results, the authors calculated the credit line mark-up rate and identified the configuration of stored liquidity that maximizes the bank's intertemporal expected profits from the loan. The optimal conditions produce a system of integral differential equations whose solutions are able to be simulated over a host of scenarios.

2.2. Financial optimization models

Genetic algorithms have been frequently applied to financial optimization models [45]. Korhonen [28] presented a two-stage genetic programming (GP) approach that can be applied to the management of a bank's assets and liabilities. The model included three one-year planning periods with multiple scenarios to describe uncertainty, changing priorities, and multiple goals in terms of expected profit, risk, liquidity, capital adequacy, growth, customer relationships, and other aspects of a bank's operation.

Zopounidis and Doumpos [50] proposed a methodology that combines the preference disaggregation approach (a multicriteria decision aid method) with a decision support system. This system incorporates a plethora of financial modeling tools, along with powerful preference disaggregation methods that lead to the development of additive utility models for the classification of alternatives that could be considered as predefined classes.

Saunders et al. [37] presented portfolio credit risk management using factor models, with a focus on the optimal portfolio selection based on the tradeoff between expected return and credit risk. By using the Central Limit Theorem for the large portfolio approximation, the authors show how the results on the large portfolio approximation can be used to reduce significantly the computational effort required for credit risk optimization.

Using the consequences of extremal dependence on the risk of large heterogeneous credit portfolios, Bassamboo et al. [1] built algorithms to efficiently estimate the risk of credit portfolios via Monte Carlo simulation. Killough and Souders [27] developed a GP model for public accounting firms, and Lawrence and Reeves [30] developed a zero–one GP model for capital budgeting in a property and liability insurance company. Bhaskar and McNamee [11] discussed the nature of multiple objectives in accounting, and Farn and Waung [21] presented a multiple criteria Markovian process system for pension funds and manpower planning. In this category, for example, Ashton and Atkins [7] introduced a multicriteria model to take advantage of both simulation models as financial statement generators and mathematical programming as a flexible search tool. Vinso [44] presented a stochastic GP model to deal with uncertain exchange rates and other barriers to free capital flows, and Eom et al. [18] introduced a GP model-based multiple criteria decision support system for global financial planning in a multinational corporation in order to allow managers to satisfy the multiple financing goals and to effectively analyze the trade-offs among costs, foreign exchange risks, and political risks.

3. Proposed model

In this section, we propose an optimization model to find the credit line that can maximize the total net profit of a credit card company. *Total Net Profit* (X_i) is represented by the sum of *Net Profit* (X_i) as follows:

$$Total\ Net\ Profit\ (X_i) = \sum Net\ Profit\ (X_i) \tag{1}$$

where X_i represents individual characteristics including credit line x of credit card user i. *Net profit* (X_i) can be obtained as follows:

$$Net\ Profit\ (X_i) = Revenue\ (X_i) - Cost\ (X_i) \tag{2}$$

where the cost due to credit card user i can be calculated as follows:

$$Cost\ (X_i) = Current\ Balance\ (X_i)\ \mathrm{PD}_i \tag{3}$$

with the probability of default of card user i, PD_i, whereas the