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A Dynamic Model for Valuing Customers: A Case Study

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Abstract. To support personalized marketing, it is necessary to identify an individual customer's true value. Various researches on customer value have conducted under the name of Customer Lifetime Value (CLV), Customer Equity, Customer Profitability, and Lifetime Value. In this paper we present issues of calculating individual customer's lifetime value to deploy more personalized CRM activities. We propose a new method to calculate individual customer's lifetime value dynamically. The feasibility of the suggested model is illustrated through a case study of the wireless telecommunication industry in Korea. Data mining techniques are used to predict lifetime value of a customer. Marketing implications will be discussed based on the result of individual CLV.

Keywords: Customer lifetime value, Customer relationship management, Dynamic model, Data mining

1 Introduction

The more a marketing paradigm evolves, the more a long-term relationship with customers gains its importance. When evaluating customer lifetime value, marketers are often reminded of the 80/20 rule (80% of the profits are produced by top 20% of profitable customers and 80% of the costs, by top 20% of unprofitable customers, vice versa) [1].

It is required to know individual customer's value to a firm since a firm has to foster profitable customers to optimize marketing efforts. Therefore we need a research foundation for the recent but growing interests in Customer Lifetime Value and its marketing applications.

This paper aims at proposing a new model for measuring customer lifetime value considering both customer relationship dynamics with a firm and marketing potential. Customer relationship dynamics denotes the change of customer relationships with a firm such as customer retention, customer churn, customer winback, and customer loss.

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2 Related Works

CLV can be defined as the sum of the revenues gained from a company's customers over the lifetime of transaction after the deduction of the total cost of attracting, selling, and servicing customers, taking into account of the time value of money [2]. The literatures in customer lifetime value research have taken multiple directions. However, the main directions of previous studies in CLV research are classified into four categories. The first one is developing structural models to calculate CLV for a customer or customer group. The second direction focuses on the strategic use of CLV in customer management [3-7]. The third direction is normative models used mainly to understand the issues concerning CLV [8]. The last area has been devoted to developing analytical models which help decision making relevant to marketing management, such as promotion, campaign, pricing, and budget allocation. If classified in detail, the structural model can be divided into eight sub-models according to the classification criteria shown in Table 1.

Table 1. Classification of the CLV researches

Focus	Category	Model
Structural Model	Customer Unit	Individual model
		Segment (Customer base) model
	Prediction data	Retrospective model
		Prospective model
	Transaction	Contractual model
		Non-Contractual model
	Purchase cycle	Discrete model
		Continuous model
Strategic Model	Strategic use of CLV in management	
Normative Model	Relationship between Duration and cost	
Analytic Model	Resource allocation (Budget allocation) / Pricing	

3 A Dynamic Model for Measuring Customer Lifetime Value

To regard the time variant characteristics of customer relationship with a firm, we adopt the Markov chain model to express the customer relationship dynamics. Before expressing the customer relationship in terms of the Markov chain model, we should define the states of the Markov chain. The relationship with a customer can be classified into three states, P (potential customer state), D (defected customer state), and A (active customer state). Figure 1 shows the Customer Relationship Dynamics (CRD) using the Markov chain.

CRD represents the changing relationship of a customer with a firm during a customer's lifetime. Customers are acquired from the potential customer (P) state and defect from the active customer (A) state and become the defecting customer (D) state. Some of defected customers are wonback to an original firm and move to the active customer state but the others are lost and move to the potential customer state. Each

state change is represented by the probability of movement from one state to the other. Within the active customer state, there are many substates representing possible states while a customer served by a firm.

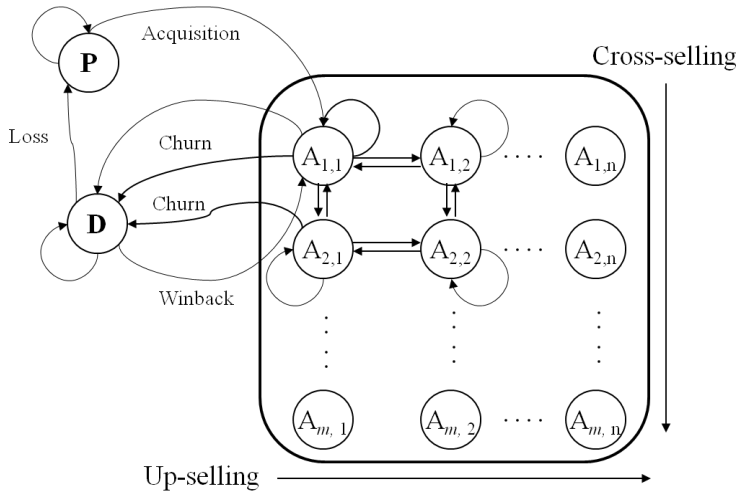

Fig. 1. Customer Relationship Dynamics

3.1 Individual CLV equation

The suggested individual CLV model based on the Markov chain is as follows:

$$CLV_i = \lim_{N \to \infty} \sum_{t=0}^{N} \frac{\mathbf{T}^t \mathbf{R}}{(1+d)^t} \tag{1}$$

T is the one-step transition matrix of customer *i*. **R** is the reward vector of customer *i*. The reward vector is a $(mn+2)\times(mn+2)$ square matrix whose i^{th} *column element* represents the profitability of a customer while he or she remains at i^{th} *rows state* for one time period. To consider time value of money, discount rate *d*, converts future profits into present one. All future profits changed into Net Present Value (NPV) and then added. The suggested model, therefore, converts the future profit potentials composed of the probability of customer staying at a state and profit contribution to net present value.

$$CLV_i = \left\{ \frac{\mathbf{T}^0}{(1+d)^0} + \frac{\mathbf{T}^1}{(1+d)^1} + \cdots\cdots + \frac{\mathbf{T}^N}{(1+d)^N} + \cdots\cdots \right\} \mathbf{R} \tag{2}$$

$$CLV_i = \left\{ \mathbf{I} - \frac{\mathbf{T}}{(1+d)} \right\}^{-1} \mathbf{R} \tag{3}$$

3.2 Limiting probability of CRD

Generally speaking, the one-step transition matrix has the limiting probability on condition that the Markov chain is irreducible and *ergodic*, i.e., *positive recurrent* and *aperiodic*. The CLV transition matrix, **T**, communicates among all states and the expected time, starting at state *i,* until the process returns to state *i* is finite. Furthermore, all states have the period 1. Therefore the matrix **T** has the limiting probability.

$$\pi_j = \sum_i \pi_i P_{ij}, \quad \sum_j \pi_j \qquad (4)$$

where P_{ij} is the transition probability from state i to state j

4 A Case Study of a Wireless Telecommunication Company

Churn is the one of the most serious problems in the wireless telecommunication industry where customers join a cellular service for an introductory offer and then join a different company when the introductory offer of the original firm expires. To decide several probabilities for the one-step transition matrix of a customer, the probabilities of the customer denoted in Figure 3 should be calculated. We use data mining techniques to predict these probabilities.

4.1. One-step transition matrix of customer i

The one-step transition matrix consists of the probabilities listed in Table 2. Figure 8 represents the one-step transition probabilities of customer *i* after normalizing the probabilities.

$$\mathbf{T} = \begin{array}{c} \\ \mathbf{A_1} \\ \mathbf{A_2} \\ \mathbf{A_3} \\ \mathbf{A_4} \\ \mathbf{D} \\ \mathbf{P} \end{array} \begin{array}{c} \begin{array}{cccccc} \mathbf{A_1} & \mathbf{A_2} & \mathbf{A_3} & \mathbf{A_4} & \mathbf{D} & \mathbf{P} \end{array} \\ \begin{pmatrix} 0.909 & 0.071 & 0 & 0 & 0.021 & 0 \\ 0.045 & 0.868 & 0.067 & 0 & 0.020 & 0 \\ 0 & 0.045 & 0.868 & 0.067 & 0.020 & 0 \\ 0 & 0 & 0.048 & 0.931 & 0.021 & 0 \\ 0.234 & 0 & 0 & 0 & 0.745 & 0.021 \\ 0.006 & 0 & 0 & 0 & 0 & 0.994 \end{pmatrix} \end{array}$$

Fig. 2. One-step transition matrix of customer *i*

4.2 Reward vector of customer i

The reward vector of customer i, the contributed profit while he or she stays at a certain state, is derived from an interview as shown in table 3.

Table 2. Cost drivers of a telecommunication company

ID	Profit/Cost Drivers	Profit/cost (KRW)
D1	Monthly Profit from Charge without optional service	(+)15,000
D2	Profit from a cross-selling service	(+)1,000
D3	Marketing cost for a cross-selling promotion	(-)3,000
D4	Marketing cost for a defected customer	(-)2,000
D5	Subsidy for a wonback customer	(-)20,000
D6	Marketing cost for acquiring a potential customer	(-)2,000
D7	Subsidy for an acquired customer	(-)20,000

4.3 Lifetime value of customer i

Lifetime value of customer i can be derived through Equation 4 as shown above. Monthly interest rate are used for the discount rate, d, and it is set as 0.3 (%/month). The result of Equation 3 is shown in Figure 10. As mentioned before, the diagonal elements are the lifetime value and, therefore, Figure 10 can be summarized as Figure 11.

$CLV_i =$

	A_1	A_2	A_3	A_4	D	P
A_1	**2,244,096**	2,244,096	2,244,096	3,247,096	-1,436,533	-1,436,533
A_2	2,262,946	**2,262,946**	2,262,946	3,265,946	-1,420,173	-1,420,173
A_3	2,282,095	2,282,095	**2,282,095**	3,285,095	-1,400,335	-1,400,335
A_4	2,293,046	2,293,046	2,293,046	**3,296,046**	-1,386,319	-1,386,319
D	1,928,705	1,928,705	1,928,705	2,931,705	**-1,361,950**	-1,361,950
P	1,161,731	1,161,731	1,161,731	2,164,731	-1,180,577	**-1,180,577**

Fig. 3. CLV matrix of customer *i*

6 Conclusion and Further Research Directions

This paper focused on the implementation of an individualized Customer Lifetime Value model. Customer relationship with a firm is embodied by a state of the Markov chain. The suggested CLV model provides not only the lifetime value of a customer but the fractionized lifetime value of a customer according to the state. The model also covers the long-run proportion of time for a state where he or she stays. The suggested model is illustrated by an industrial case study on the wireless telecommunication industry in Korea.

In future, we expect this work to spur further research on personalized stochastic CLV model, which includes the Markov chain model and other structural CLV models based on probabilistic revenue estimation. Another further research issue is to develop a personalized marketing strategy based on individual CLV. Individual CLV is expected to vary with changes of business environment. Therefore, marketing strategies should be built based on the result of sensitivity analysis. A sensitivity analysis can help the strategy development by deciding optimal budget allocation, forecasting profitability change, and measuring marketing effectiveness.

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