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Modelling for optimizing service expenses when switching Between two consumer brands.

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ABSTRACT : Three statistical models are proposed in this study to examine à business that sells a single product unit of either 'A' or 'B' to every possible consumer. This organization permits a CRM team to monitor manufacturing expenses, service costs, predicted profit values, and switching probabilities between products A and B. There are three types of CRMs: Markov CRM, Perfect CRM, and No CRM. Using the theoretical foundation of transient and stationary features of Markov processes, closed-form formulations of probability distributions and their projected cumulative costs are produced for a given set of costs. Next, using numerical and graphical representations based on fictitious-input data sets, the profitability of the three CRMs is compared, and it is demonstrated that the Markov CRM technique outperforms both perfect CRM adaption and no CRM..

KEYWORDS : Transition Probability, Markov CRM, Right Product, Service cost, Expected Cost.

I. INTRODUCTION

Businesses such as restaurants offer different services, such as "A" or "B" or "C", to heterogeneous customers that try to learn their customers' preferences gradually over time using updated information.

Optimization Problem: This article examines a business that provides one product unit at a time to prospective customers with two different services, A and B. For each of the three categories of CRMs, an optimization problem is defined based on a given set of conditional costs. The principal aims are to (i) reduce service costs by matching the appropriate product to the appropriate customer and (ii) optimize long-term income by using up-to-date customer demands information. We derive analytical expressions to closed-form solutions for firms' matching, choice, and pricing strategies that are comparable between learning-prone and learning-unaware firms. Numerical illustrations are provided to support the results of the proposed method.

Literature Review: The answer to what is customer relationship management (CRM) plays the key role in this article.

[1], remarked that CRM is the key business strategy that integrates internal processes and external networks, to create value to targeted customers, at a profit.

[2] and

[3] described a CRM system as a technology-based business management tool for developing customer knowledge to nurture, maintain, and strengthen profitable relationship with customers.

[4] discussed several impacts for organizational of system quality, information quality, and service quality.

[5] discussed various countervailing effects of value and risk perceptions in manufacturers' adoption of expensive cases based on discontinuous innovations. For behavioural attributes in buyer supplier relationships, [6] derived number of performance outcomes. [7] published a book tilted as 'A primer on partial least squares structural equation modelling (PLS-SEM)' which accounted for novel applications SEM applications using PLS. [8] proposed a comparative case study of large enterprises and small and midsize enterprises (SMEs) in Germany employing differential cloud adoption methods.

[9] explained how to transform business principles using digital innovation with an application of AI, blockchain, cloud and data analytics. [10] implemented cloud ERP technology in the SME from UAE and obtained useful results. [11] investigated the role of customer trust through the relationship between CRM and customer loyalty.

Authors of [12] investigated how unpredictable consumers behave in their marketing of goods and thus looked at the significant consumer challenges that arise during times of crisis and the marketing strategies that managers prefer to counter the crisis. [13] proposed a frequency-based preference choice model to solve the optimal product design problem using the share of preference frequency criterion. Applying genetic algorithm, a software package for large-scale non-linear optimization is developed to achieve near-optimal solutions in reasonable computational time and significantly outperforms the runtime compared algorithm. [14] created a blockchain-based decision-making system by combining an expanding convolution neural network with federated learning which concentrated on creating and analysing a computer algorithm with the best policy.

An M/M/C/K queue was used in [15] to represent a dynamic virtual hub placement problem in the presence of capacity restrictions for both the original and virtual hubs, as well as uncertainty. Under three-level trade credit financing, [16] created a sustainable supply chain model for time-varying degrading products with customers' credit duration, credit amount, promotional activities, and selling price-dependent demand. The calculated findings show that the kind of degradation rates affects the ideal selling price. Prices are greater for constant functions than for linear and three-parameter Weibull functions.

Sectional organization : Section 2 deals with modelling consumer behaviour between two service types and discussed the analysis using three types of CRM: (i) no CRM, (ii) perfect CRM and Markov CRM. This section uses theoretical backgrounds of transient and stationary characteristics of Markov processes and obtained closed form expressions for probability functions and expected probability functions of profits. Section 3 provides both numerical and graphical illustrations for comparing the profits among the three CRM types of interest. Section 4 concludes the proposed analysis and its future scope.

II. MODELLING CONSUMER BEHAVIOUR BETWEEN TWO SERVICE TYPES

Suppose a firm has a customer relationship management (CRM) that provides two types of services A and B, in a market where each potential customer demands one unit of either A or B service in each period (t, t+1), t ∈ {0,1, 2, . . ., ∞}. Customer types are assumed to change over the first two periods (t, t+1), t ∈ {0,1} according to a Markov Chain (MC) process {X(t); t ∈ {0, 1}} with unit transition probability matrix (TPM) P=(Pij) on the state space {A, B}

Definition 1.

$$X(t) = \begin{cases} \text{A if the customer demands service A at time t} \\ \text{B if the customer demands service B at time t} \end{cases} \tag{1}$$

$$\boldsymbol{P} = \begin{matrix} & A & B \\ A & P_{AA} & P_{AB} \\ B & P_{BA} & P_{BB} \end{matrix}$$

Notice that the events relating to customer types are independent and identically distributed (i.i.d) random variables.

$$\lambda_t = \textit{proportion of type A at the beginning of period } (t, t+1) \textit{ for } t \in \{0, 1\} \tag{2}$$

Assume that, initially, the firm gains knowledge over the proportion of type 'A' customers i.e., λ_0, through implementing a few strategies of the CRM and hence the MC is not completely known as the values of transition probabilities are yet to be estimated. If the TPM of the underlying MC of is determined then,

$$(\boldsymbol{\lambda_0}, (\mathbf{1} - \boldsymbol{\lambda_0}))\,\boldsymbol{P} = (\boldsymbol{\lambda_1}, (\mathbf{1} - \boldsymbol{\lambda_1})) \tag{3}$$

For this strategy to be profitable, the condition λ1> λ0 >0.5 needs to be met in the second period under Markov CRM. Since PAA+PAB=1 and PBA+PBB=1, we observe that the following conditions must also be satisfied

$$\lambda_0 > \frac{|0.5 - P_{BA}|}{|P_{AA} - P_{BA}|} = \frac{|P_{BB} - 0.5|}{|P_{BB} - P_{AB}|} \quad (4)$$

Since, λ1 = λ0PAA + (1- λ0) PBA > λ0, or (1- λ0) PBA > λ0PAB which implies that

$$\frac{\lambda_0}{1 - \lambda_0} < \frac{P_{BA}}{P_{AB}} \quad (5)$$

Thus, the condition λ1> λ0> 0.5 holds hood as long as PBA>PAB. Further, assume that the CRM updates data to the firm over the switching pattern of customers from product A to B and vice versa at the end of the second period so that the MC is completely known as the values of transition probabilities are known.

Definition 2. Conditional Service cost: Let the optimal matching strategy is to provide service A for a customer with $\lambda_t \geq 0.5$ and provide service B for a customer with $\lambda_t < 0.5$.

$$S(\lambda_t) = \begin{cases} A & \text{for } \lambda_t > 0.5 \\ B & \text{for } \lambda_t < 0.5 \end{cases} \quad (6)$$

Expected Service Cost: Let the sale price of each unit of service be ‘v’ for these customers. Also, let C[Si(λt)] denote the service cost if customer i is provided with service Si at time ‘t’. It is assumed that the service cost is low, say Lc, if the service for one unit provided match the customer type of A or B, and the service cost becomes high, say Hc, otherwise. It is remarked that Hc > v > Lc.

Definition 3. The the expected service cost, say Ct, is given by,

$$C(\lambda_t) = \begin{cases} \lambda_t L_c + (1-\lambda_t)H_c & \text{for } \lambda_t > 0.5 \\ (1-\lambda_t)L_c + \lambda_t H_c & \text{for } \lambda_t < 0.5 \end{cases}$$
$$= (0.5 + |\lambda_t - 0.5|)\, L_c + (0.5 - |\lambda_t - 0.5|)\, H_c \quad (7)$$

A. Effect of Charging price ‘v’ USD to all Customers with Service A when $\lambda \geq 0.5$ and B when $\lambda < 0.5$

Suppose a ‘Restaurant’ which is familiar with mass production of low-cost products A and B, serves one of the two types A and B as lunch packages every day to its customers who expect a high level of quality in their packages, both in taste and presentation (both flavors are totally customer-driven). Increasingly, most customers prefer several pre-defined options into the configuration of products and services before they make purchases. Meeting this demand is quite a challenge for the restaurant management. If the current type of service in a day is ‘A’ and if it provides a customer with a personal touch suited specifically to his/her tastes, it is called matching; otherwise, it is called mismatching. In the case of matching, the restaurant sells the product A for \$v while the cost of service is 0 < \$ Lc < \$v. This transaction leads to a positive profit of \$ (v- Lc). With the case of mismatching, if the restaurant decides to satisfy the customer’s demand, it must prepare product B (when the current service is on ‘A’ only) by investing extra amount in material and labor. This would lead to a higher service cost \$ch than the price of the product \$v and hence this transaction would yield a loss of \$ (Hc - v). As a result of ‘Match and Go’ process, one can expect higher sales on the spot, as well as increased loyalty and improved business. Let the sale price of each unit of service be ‘v’ for these customers. This means that the sale price is v USD to provide all customers with service A when $\lambda_1 \geq 0.5$ and B when $\lambda_1 < 0.5$. We, now consider three cases, (i) no CRM, (ii) perfect CRM and (iii) Markov CRM for the firm to maximize the profits of the first two periods. It should be noted that the expected cost remains c(λ0) for the first period under (i) no CRM, (ii) perfect CRM and (iii) Markov CRM situations. In cases without CRM, it is evident that λ1=λ_0, and the expected profits remain the same in both periods as the firm cannot identify whether customer i will be of type A or type B

Definition 4. The total expected cumulative profits, say Π= Π (λ0), of (i) no CRM case is given by

$$\Pi = 2[v - C(\lambda_0)] \tag{8}$$

Since Hc > v > Lc and the revenue from sales is v and the expected service cost is C(λ0), profits Π of can take on both positive and negative value.

Definition 5. The total expected cumulative profits, say ψ, of (ii) perfect CRM isgiven:

$$\psi = \psi(\lambda_0) = (v - C(\lambda_0)) + (v - L_c) \tag{9}$$

The proposed Markov Chain approach deals with product-switching and repeat purchase of products by customers. The restaurant could develop a new product 'B' for an existing product 'A' or the enhancement as 'B' of an existing product 'A' since the harsh reality is that product 'A' will never be the best fit for everyone forever. The cumulative total probit of this business is found to be increasing with the number of matches of customers with the right products like lunch packages served by a restaurant.

Definition 6. The total expected cumulative profits, say β, of (iii) Markov CRM is given:

$$\beta = \beta(\lambda_0) = (v - C(\lambda_0)) + (v - C(\lambda_1)) \tag{10}$$

Let the breakeven points of (8) , (9) and (10) be denoted respectively by λ_n, λ_p, and λ_m so that $\Pi(\lambda_n)=0$, $\psi(\lambda_p)=0$ and $\beta(\lambda_m)=0$. Then it can be verified that,

$$\lambda_n = \frac{H_c - v}{H_c - L_c},\ \lambda_p = \frac{H_c + L_c - 2v}{H_c - L_c} \text{ and } \lambda_m = \frac{2H_c - 2v - P_{BA}(H_c - L_c)}{(1 + P_{AA} - P_{BA})(H_c - L_c)} \tag{11}$$

Inspecting (11) we observe that $\lambda_p < \lambda_n$ and $\lambda_p < \lambda_m$ as expected

B. CRM with an irreducible MC

Let the Markov Chain defined by **Error! Reference source not found.** be irreducible, aperiodic and positive recurrent (i.e. $0< P_{AA}, P_{BA} < 1$), and let (θ_A, θ_B) denote it's the stationary distribution so that (θ_A, θ_B) **P**= (θ_A, θ_B) and $\theta_A+\theta_B=1$ (i.e. $0< \theta_A< 1$), and thus

$$\theta_A = \frac{P_{BA}}{P_{AB}+P_{BA}} > 0 \text{ and } \theta_B = 1-\theta_A = \frac{P_{AB}}{P_{AB}+P_{BA}} > 0 \tag{12}$$

For this stationary Markov CRM, it can be shown that,

$$\lambda_n = \lambda_m = \theta_A = \frac{P_{BA}}{P_{AB}+P_{BA}} = \frac{H_c - v}{H_c - L_c} \tag{13}$$

From (13), we notice that,

$$P_{BA} = H_c - v \text{ and } P_{AB} = v - L_c \tag{14}$$

C. Profitable Market

A sufficient condition for the strategy of charging the price '*v*' by providing all customers with service *A* when $\lambda_0 \geq 0.5$ and *B* when $\lambda_0 < 0.5$ to be profitable is associated with conditional CRM's type:

Case (i) no CRM:

$$\Pi(\lambda_0) > 0 \rightarrow v > C(\lambda_0) \rightarrow \frac{v - H_c}{H_c - L_c} = \lambda_n < \lambda_0 \qquad (15)$$

Equation **Error! Reference source not found.** states that the firm will make a profit if the value v of the service is larger than the expected cost $C(\lambda_0)$. If this condition is satisfied, the firm will provide service *A*. The number λ_n is the minimum perceived percentage of type A customers for the firm to provide service *A* with no CRM. The firm's profit in this market is the positive part $\Pi^+(\lambda_0)$ of $\Pi(\lambda_0)$, when $\lambda_0 > \lambda_n$ because it will only enter the market when $\Pi(\lambda_0)$ is positive.

Case (ii) under perfect CRM is $\psi(\lambda_0) > 0$:

$$(v - C(\lambda_0)) + (v - L_c) > 0 \rightarrow \lambda_0 > \frac{H_c + L_c - 2V}{H_c - L_c} \qquad (16)$$

At the end of first period, information on λ_0 can be updated to λ_1 and using this information the firm will be able match the right customer with the right service on the average 100 λ_1 % during the second period under Markov CRM.

Case (iii) under Markov CRM is $\beta(\lambda_0) > 0$:

$$(v - C(\lambda_0)) + (v - C(\lambda_1)) > 0 \rightarrow \lambda_0 > \frac{2H_c - 2v - P_{BA}(H_c - L_c)}{(1 + P_{AA} - P_{BA})(H_c - L_c)} \qquad (17)$$

Based on similar arguments, the numbers λ_p and λ_m respectively represent the minimum proportions of type 'A' customers for whom the firm provides product A under perfect and Markov CRM policies during the second period. Thus, the firm's total profit is the positive part $\psi^+(\lambda_0)$ of $\psi(\lambda_0)$ when $\lambda_0 > \lambda_p$ under perfect CRM and is the positive part $\beta^+(\lambda_0)$ of $\beta(\lambda_0)$ when $\lambda_0 > \lambda_m$ under Markov CRM.

II. NUMERICAL ILLUSTRATION

These facts that are derived using **Error! Reference source not found.** through **Error! Reference source not found.** are illustrated by assigning $L_c=1$, $H_c=10$ and $v=3$, $P_{AB}=0.15$ and $P_{BA}=0.19$. It turns up that,

$$\theta_A = \frac{P_{BA}}{P_{AB}+P_{BA}} = 0.5588 \text{ and } \theta_B = 1 - \theta_A = \frac{P_{AB}}{P_{AB}+P_{BA}} = 0.4412$$

Table 1 records the numerical values correspondent to the cumulative profit functions $\Pi(\lambda_0)$, $\psi(\lambda_0)$ and $\beta(\lambda_0)$ of (8), (9) , and (10) respectively as a function of λ_0.

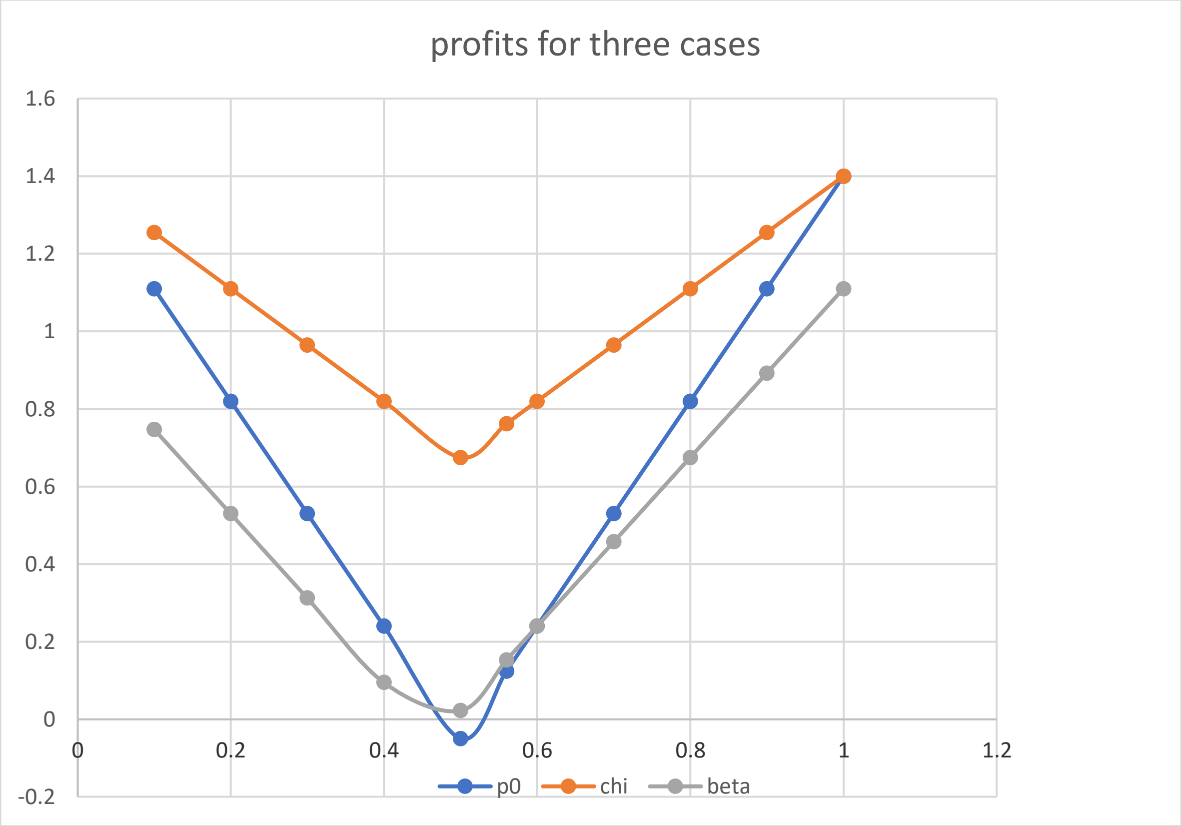
Table 1: Expected profits for $L_c=1$, $H_c=10$ and $v=3$, $P_{AB}=0.15$ and $P_{BA}=0.19$.

λ_0	$\Pi(\lambda_0)$	$\psi(\lambda_0)$	$\beta(\lambda_0)$
0.1	2.2	3.1	0.796
0.2	0.4	2.2	-0.698
0.3	-1.4	1.3	-2.192
0.4	-3.2	0.4	-3.686
0.5	-5	-0.5	-4.82
0.558824	-3.94118	0.029412	-3.94118
0.6	-3.2	0.4	-3.326
0.7	-1.4	1.3	-1.832
0.8	0.4	2.2	-0.338
0.9	2.2	3.1	1.156
1	4	4	2.65

It is noticed that the profit function is symmetric around 0.5, and further focus may be made with those $\lambda_0 > 0.5$. In addition, it is observed that the firm incurs a negative total profit (i) under no CRM during the first period for those λ_0 values for which $1 - \lambda_n < \lambda_0 < \lambda_n$, and $\lambda_n > 0.5$, and (ii) under perfect CRM during the second period for those λ_0 values for which $1 - \lambda_p < \lambda_0 < \lambda_p$ if $\lambda_p > 0.5$. Note that when $\lambda_p < \lambda_0 < \lambda_n$, the firm incurs a negative first period profit. This suggests that the firm may have to face some losses in the first period till it can find out the identity of customers completely or partially in the subsequent period. If the firm can perfectly match the product with the right customer by implementing CRM, it can improve its profit in the second period and the increase of profit offsets the loss of profit in the previous period.

For another visual illustration, we feed the input parameters as L_c=1.8, H_c =3.25 and v=2.5, P_{AB}=0.2 and P_{BA}=0.3. Figure 1 is drawn to show the graph of the cumulative profit functions $\Pi(\lambda_0)$, $\psi(\lambda_0)$ and $\beta(\lambda_0)$ as a function of λ_0.

Figure 1 : Graphs showing the expected profits of three CRM types p0=$\Pi(\lambda_0)$, chi=$\psi(\lambda_0)$ and beta=$\beta(\lambda_0)$ for L_c=1.8, H_c =3.25 and v=2.5, P_{AB}=0.2 and P_{BA}=0.3, and 0< λ_0<1.



A simple inspection of the Figure 1, it is observed that the firm incurs no negative total profit for each of the three cases, i.e., no CRM, perfect CRM, and Markov CRM for all possible λ_0 values.

Value of Information (VoI) : The main purpose of a CRM is to enhance firm profitability by focusing on customers. Availing updated data and knowledge between first and second periods on individual customers generated by the CRM, the profit loss incurred in the first period can be made up during the second period. Since the profit functions are symmetric around λ_0 = 0.5, in both Table 1 and Figure 1, we now further focus is on the case in which λ_0 > 0.5 only. One can measure the Value of Information (VoI) to discuss the profit implication of learning; VoI of implementing perfect CRM over no CRM is defined as the firms 'net expected profit gain.

$$\text{VoI}= \psi^{+}(\lambda_0) - \Pi^{+}(\lambda_0) = \begin{cases} \mathbf{0} & \mathbf{0.5} \leq \boldsymbol{\lambda_0} < \boldsymbol{\lambda_p} \\ \text{v-}\boldsymbol{L_c} + (\boldsymbol{\lambda_0} - \boldsymbol{\lambda_n})(\boldsymbol{H_c} - \boldsymbol{L_c}) & \boldsymbol{\lambda_p} < \boldsymbol{\lambda_0} < \boldsymbol{\lambda_n}, \\ (\mathbf{1} - \boldsymbol{\lambda_0})(\boldsymbol{H_c} - \boldsymbol{L_c}) & \boldsymbol{\lambda_n} < \boldsymbol{\lambda_0} < \mathbf{1} \end{cases} \quad (18)$$

If $0.5 \leq \lambda_0 < \lambda_p$ the firm will not provide service with or without learning and thus the value of information is zero. When $\lambda_p \leq \lambda_0 \leq \lambda_n$, the firm will provide service only with learning and thus the value of information is simply the profit under learning $\Pi(\lambda_0$). When $\lambda_n < \lambda_0 < 1$, the firm will provide services with or without learning and the added value of learning comes from the reduction of service cost through customized service in the second period. The value of information is positive as long as $\lambda_p < \lambda_0 < 1$. Furthermore, the value of information increases with λ_0 when $\lambda_0 < \lambda_n$ and decreases with λ_0 when $\lambda_0 \geq \lambda_n$. As λ_0 approaches 1, most of the customers are likely to be of type A, the value of customer information goes to zero.

$$VoI = \psi^{+}(\lambda_0) - \Pi^{+}(\lambda_0) = \begin{cases} 0 & 0.5 \leq \lambda_0 < \lambda_p \\ 2v - H_c - L_c + \lambda_0(H_c - L_c) & \lambda_p < \lambda_0 < \lambda_m, \\ (1 - \lambda_0)(H_c - L_c) & \lambda_m < \lambda_0 < 1 \end{cases} \quad (19)$$

When $\lambda_p \leq \lambda_0 \leq \lambda_m$, the firm can provide service only with perfect CRM and thus the value of information is simply the profit $\Pi(\lambda_0)$. When $\lambda_m < \lambda_0 < 1$, the firm will provide services with perfect CRM or with Markov CRM. The value of information is positive as long as $\lambda_p < \lambda_0 < 1$. Furthermore, the value of information increases with λ_0 when $\lambda_0 < \lambda_m$ and decreases with λ_0 when $\lambda_0 \geq \lambda_m$. As λ_0 approaches 1, many of the customers are likely to be of type A, the value of customer information goes to zero.

III. CONCLUSION

The present study underscored the significance of "customer service (CS)" as a critical operating variable within the CRM domain. Any company's CRM department often updates data on every aspect of customer service, including retention, happiness, length of stay, repeat business, and word-of-mouth marketing. Today's businesses are more prepared than ever to build lasting relationships with their clients because to advancements in digital technology. The primary concern of any firm producing consumer goods is to attract most customers to buy and use a particular brand of its own products. Nevertheless, complete switching from ‘A’ product to ‘X’ or complete repurchasing of ‘A’ product only by customers would be seldom found in any fair market. Hence it is vital for the firm to avail (updated) data on matching and mismatching of services. If the firm aims further to estimate the future market scenarios and total profit of the business over short or long runs, it is experienced that ‘Markov Chains’ are the appropriate predictive tools. The proposed ‘Markov Chain’ model approach has been used for a market with two kinds of customers and two kinds of products. Matching the right product with the right customer, the firm can reduce its service costs. To do so the firm needs to learn about the heterogeneity type of customers; it should take into account short term cost of learning and long-term gain in profit based on better knowledge of individual customers, the goal being maximizing long run profit from each customer. Analytically derived and numerically illustrated result of this paper is the closed form solution for the firm’s matching, selection and pricing strategies which is comparable between firms that prefer learning and those that ignore it.Future research can be directed to study many other forms of customer heterogeneity. For example, customers may switch back and forth between the firm and its competitor. Consequently, the customer’s future switching behavior needs to be modeled in a forward-looking analysis.

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