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Customer Retention Among Telecom Service Providers – A Markov Model Analysis

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***Abstract*: Customer retention is viewed as a major determinant of a firm's long term economic success. This is particularly true for the wireless telecom sector, where service quality is the prime defining factor of customer loyalty. With relaxed number portability norms, switching cellular network operators has become common among subscribers in India. In this paper, we have attempted to forecast the young subscriber's preference of network service providers in Pondicherry, India. Based on primary data we explored the consumer brand preferences while purchasing SIM cards from service providers, using the Markov Prediction Chain model. We found that the public sector players lose to the private sector players.**

***Keywords*: Customer retention, brand switching, markov chain, transition probability matrix.**

1. Introduction

With over 1.20 billion subscribers and growing, India is the world's second-largest telecommunications market in the world. Of the three components of the telecom market namely wireless, wireline and internet, the wireless market comprises of 98.17% subscriber base and boasts of CAGR of 19.61% in FY 18-19. With the Union Government launching number portability across service providers in February 2011, the completion has heated up among the top players in the Telecom sector. The sector is primed for a big leap after the launching of the National Digital Communications policy in 2018 by attracting large-scale Foreign Direct Investments (FDI).

The telecom network service providers are identified by the SIM (Service Identification Module) cards issued by them, to be inserted into a handset, to access the wireless network. The Indian teleservice providers market is dominated by private players like Reliance Jio, Barathi Airtel, Vodafone, Idea, and Tata. Public sector brands like BSNL and MNTL are also in the fray. The recent mergers between Vodafone and Idea and Tata and Airtel have helped them to consolidate market share. With the introduction of dual SIM, feature-rich smartphones, a single customer subscribing to multiple service providers is a common trend. As switching service providers became effortless, customer retention has become a tough task. According to the IBEF report 2018, 56.12% of India's wireless mobile service connections are urban of which a considerable portion is youth, particularly students attending college/university. We have used the data collected from college students in Pondicherry, a major town in South India, to predict the pattern of customer retention concerning the Network Service Provider brands, applying the Markov Chain concept.

A. Literature Review

Loyalty programmes are found to have a deep impact on customer retention (Magatef and Tomalieh 2015). Service Quality, Customer Satisfaction and Trust are the major associated variables influencing customer decision-making behaviour leading to retention in medical tourism (Han and Hyun 2015). Features that attract new customers may be different from those that retain customers and having too many features may decrease customer satisfaction. Additionally, different research methods are required to measure the effects of features on customer attraction and retention (Hamilton et al 2017). Customer retention is the customer continuing to transact with the firm (Ascerza et al 2017). There is a need to focus on the need to apply innovative data management and predictive tools in marketing for retention management.

Cohort-level retention rates typically increase over time, and the beta-geometric (BG) distribution has proven to be a robust model for capturing and projecting these patterns into the future. According to this model, the phenomenon of increasing cohort-level retention rates is purely due to cross-sectional heterogeneity; an individual customer's propensity to churn does not change over time. The beta-discrete- Weibull (BBW) distribution was presented (Fader et al 2018) as an extension to the BG model, one that allows individual-level churn probabilities to increase or decrease over time.

Predicting and measuring customer retention is of strategic significance in marketing as it is directly related to Customer Lifetime Value (CLV) and Customer Equity (CE). We employed the application of the Markov Chain Model, for this, which assumes that the future states depend only on the current state, not on the events that occurred before it.

B. Data and Methodology

Students pursuing higher education and owning mobile phones in Pondicherry District of Puducherry Union Territory, India were the target population of the study. Bailey (1987), suggests the correct sample size is dependent upon the nature

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of the population and the purpose of the study. There are several methods to determine the sample size, for instance: rules of thumb, average size samples from previous similar investigations, statistical method, or even the method where authors try to find all they can afford (Bryman and Bell, 2011). Accordingly, 430 questionnaires were distributed among the students randomly, of which 400 were returned with a conversion rate of 93.02%. A sample of this size is enough to maintain the error at an acceptable level (Roscoe 1975).

C. *Concept of Markov Chain*

Markov Chains serve as one of the most important methods in the application of applied probability theory to real-world models involving uncertainty. Medhi (2009), the simple models are often very useful in the analysis of practical problems in diverse fields such as geophysics, medicine, chemistry, physics, metrology, geography, education, economics, marketing, finance, management, etc. Markov analysis has been used widely in marketing research for nearly a decade. In this paper, we applied and examine the Markov chain to predict the behaviour of subscribers in terms of choosing one telecommunication service provider over another.

A Markov process is one with the property that, given the value of X_t, the value of X_s, $s > t$, do not depend on the values of X_u, $u < t$; that is, the probability of any particular future behaviour of the process, when its present state is known exactly, is not altered by additional knowledge concerning its past behaviour. We should make it clear, however, that if our knowledge of the present state of the process is imprecise, then the probability of some future behaviour will in general be altered by additional information relating to the past behaviour of the system (Karlin et.al 1975).

In formal terms a process is said to be Markov if

$$\begin{aligned}&\Pr\{a < X_t \le b \mid X_{t_1} = x_1, X_{t_2} = x_2, \ldots, X_{t_n} = x_n\}\\ &= \Pr\{a < X_t \le b \mid X_{t_n} = x_n\}\end{aligned} \tag{1}$$

whenever $t_1 < t_2 < \ldots < t_n < t$.

Let $\{X_n, n \ge 0\}$ be a Markov chain. The probability distribution of $X_r, X_{r+1}, \ldots, X_{r+n}$ can is computed in terms of the initial distribution of X_r and the transition probabilities p_{jk}. If $r = 0$, then

$$\begin{aligned}&P\{X_0 = a, X_1 = b, \ldots, X_{n-2} = i, X_{n-1} = j, X_n = k\}\\ &= P\{X_n = k \mid X_{n-1} = j, \ldots, X_0 = a\} \times\\ &P\{X_{n-1} = j, \ldots, X_0 = a\}\\ &= P\{X_n = k \mid X_{n-1} = j\} \times P\{X_{n-1} = j \mid X_{n-2} = i\} \times\\ &\ldots \times P\{X_1 = b \mid X_0 = a\} \times P\{X_0 = a\}\\ &= \underbrace{p_{jk} \times p_{ij} \times \ldots \times p_{ab}}_{Transition\ probabilities} \times \underbrace{P\{X_0 = a\}}_{Initial\ probability}\end{aligned} \tag{2}$$

A discrete-time Markov Chain $\{X_n\}$ is a Markov stochastic process whose state space is a countable or finite set, and for which $T = (0,1,2,\ldots)$. The value of X_n is referred to the outcome of the n[th] trial. If $X_n = i$, it means that X_n being in state i and the state space of the process is specified by the non-negative integers such as $(0,1,2,\ldots)$. The probability of X_{n+1} being in state j given that X_n is in the state i is denoted by $P_{ij}^{n,n+1}$.

$$P_{ij}^{n,n+1} = \Pr\{X_{n+1} = j \mid X_n = i\} \tag{3}$$

The notation emphasizes that in general, the transition probabilities are functions not only of the initial and final state but also of the time of transition as well. When one-step transition probabilities are independent of the time variable, we say that the Markov process has *stationary transition probabilities*. Let $P_{ij}^{n,n+1} = P_{ij}$ is independent of n and P_{ij} is the probability that the state value undergoes a transition from i to j in one trail. Thus, $P = \left\| P_{ij} \right\|$ as the Markov matrix or transition probability matrix of the process is defined as,

$$\mathrm{P} = \begin{Vmatrix} P_{00} & P_{01} & P_{02} & P_{03} & \cdots \\ P_{10} & P_{11} & P_{12} & P_{13} & \cdots \\ P_{20} & P_{21} & P_{22} & P_{23} & \cdots \\ \cdots & \cdots & \cdots & \cdots & \\ P_{i0} & P_{i1} & P_{i2} & P_{i3} & \cdots \\ \cdots & \cdots & \cdots & \cdots & \end{Vmatrix}$$

If the number of states is finite then P is a finite square matrix whose order is equal to the number of states.

a) *Communicate State:* State j is said to be accessible from the state i if for some integer $n \ge 0$, $P_{ij}^{n} > 0$. That is, the state j is accessible from the state i if there is a positive probability that in a finite number of transitions state j can be reached starting from the state i. Two states i and j, each accessible to the other, are said to ***communicate*** and if two states i and j do not communicate, then either $P_{ij}^{n} = 0$ for all $n \ge 0$ or $P_{ji}^{n} = 0$ all $n \ge 0$ or both relations are true.

b) *Recurrence:* Consider an arbitrary state i and an integer $n \ge 1$, then f_{ii}^{n} is the probability that, starting from the state i, the first return to the state i occurs at the n^{th} transition.

We write, $P_{ii}^{n} = \sum_{k=0}^{n} f_{ii}^{k} P_{ii}^{n-k}, \ n \geq 1$ (4)

Clearly, $f_{ii}^{1} = P_{ii}$. A state i is recurrent if and only if, starting from the state i, the probability of returning to the state i after some finite length of time is one. i.e., $\sum_{n=1}^{\infty} f_{ii}^{n} = 1$. A non-recurrent state is said to be transient.

c) *Stationary Probability Distribution of the Markov Chain:*

If $\lim_{n\to\infty} P_{ii}^{n} = \pi_i > 0$ for one i in an aperiodic recurrent class, then $\pi_j > 0$ for all j in the class of i. It means that the class is positive recurrent or strongly ergodic. Any set $(\pi_i)_{i=0}^{\infty}$ is the stationary probability distribution of the Markov chain then π 's uniquely determined by the set of equations

$$\pi_i \geq 0,$$

$$\sum_{i=0}^{\infty} \pi_i = 1$$

$$\text{and } \pi_j = \sum_{i=0}^{\infty} \pi_i P_{ij} \qquad (5)$$

2. Statistical Analysis

The data from the Telecom Regulatory Authority of India (TRAI) report September 2019, indicates the proportionate number of wireless subscribers in Tamilnadu and Puducherry Telecom Circle as BSNL: 0.1486, Reliance Jio: 0.2648, Vodafone and Tata have taken together: 0.2808, and Airtel and Idea together: 0.3059. We consider the proportion of subscribers under each service network as an initial distribution.

$$X_0 = \begin{pmatrix} 0.1486 & 0.2648 & 0.2808 & 0.3059 \end{pmatrix}$$

According to our survey, 40.3% of college students are subscribers of Airtel and Idea in Puducherry; 38.8 % belongs to Vodafone and Tata; Reliance Jio and BSNL have 10.3% and 10.6 % customer base respectively.

Based on the survey findings the customer retention rate of the BSNL, Reliance Jio, Vodafone & Tata, and Airtel & Idea is 31.71%, 42.5%, 36.67%, and 69.87% respectively.

Therefore, the Transition Probability Matrix (TPM) is given by,

$$P = \begin{pmatrix} 0.3171 & 0.1463 & 0.1707 & 0.3659 \\ 0.0250 & 0.4250 & 0.2000 & 0.3500 \\ 0.0400 & 0.1733 & 0.3667 & 0.4200 \\ 0.0256 & 0.1474 & 0.1282 & 0.6987 \end{pmatrix}$$

The TPM indicates that Airtel &Tata brand induces maximum subscribers to switch from other service providers to their brand when purchasing an additional SIM card. They gain 36.59% customers from BSNL, 35.00% from Reliance Jio, and 42.00% from Vodafone & Idea.

Here, let us consider four states s as BSNL, Reliance Jio, Vodafone and Idea, and Airtel and Tata. When the college-going subscribers in Puducherry decide to switch the network service provider, their network preference will be indicated by the matrix,

$$p^1 = \pi_0 \times P = \begin{pmatrix} 0.1486 & 0.2648 & 0.2808 & 0.3059 \end{pmatrix} \times \begin{pmatrix} 0.3171 & 0.1463 & 0.1707 & 0.3659 \\ 0.0250 & 0.4250 & 0.2000 & 0.3500 \\ 0.0400 & 0.1733 & 0.3667 & 0.4200 \\ 0.0256 & 0.1474 & 0.1282 & 0.6987 \end{pmatrix}$$

Thus, the probability distribution for each state after the first step is

$$p^1 = \begin{pmatrix} 0.0728 & 0.2281 & 0.2205 & 0.4787 \end{pmatrix}$$

Comparing the results with the initial distribution, it may be concluded that when purchasing a second SIM, the college-going subscribers share would decline for BSNL from 14.86% to 7.28%, for Reliance Jio from 26.48% to 22.81%, for Vodafone and Idea from 28.08% to 22.05%. However, for Airtel and Tata, the customer base is observed to expand from 30.59% to 47.87%.

Furthermore, we may calculate the probability distribution for each subsequent change of network service providers by young college-going subscribers in Puducherry. In general, this approach can be used to obtain the probability of subscribers for each service provider for each time they change their network. Accordingly, the probability distribution for each state after subsequent steps commencing from the second step would be,

$$p^2 = p^1 \times P = \begin{pmatrix} 0..0728 & 0.2281 & 0.2205 & 0.4787 \end{pmatrix} \times \begin{pmatrix} 0.3171 & 0.1463 & 0.1707 & 0.3659 \\ 0.0250 & 0.4250 & 0.2000 & 0.3500 \\ 0.0400 & 0.1733 & 0.3667 & 0.4200 \\ 0.0256 & 0.1474 & 0.1282 & 0.6987 \end{pmatrix}$$

$$p^2 = \begin{pmatrix} 0.0499 & 0.2281 & 0.2205 & 0.4787 \end{pmatrix}$$

$$p^3 = \begin{pmatrix} 0.0429 & 0.2126 & 0.1936 & 0.5509 \end{pmatrix}$$

$$p^4 = \begin{pmatrix} 0.0408 & 0.2114 & 0.1915 & 0.5564 \end{pmatrix}$$

$$p^5 = \begin{pmatrix} 0.0401 & 0.2111 & 0.1908 & 0.5581 \end{pmatrix}$$
$$p^6 = \begin{pmatrix} 0.0399 & 0.2109 & 0.1905 & 0.5586 \end{pmatrix}$$
$$p^7 = \begin{pmatrix} 0.0399 & 0.2109 & 0.1905 & 0.5588 \end{pmatrix}$$
$$p^8 = \begin{pmatrix} 0.0399 & 0.2109 & 0.1905 & 0.5588 \end{pmatrix}$$

Alternatively, we can find the probability of long-run subscribers by using the stationary probability distribution of the Markov chain, from equation (5) $i = 0,1,2,3$ we may write,

$$\sum_{i=0}^{\infty} \pi_i = 1 \Rightarrow \pi_0 + \pi_1 + \pi_2 + \pi_3 = 1 \quad (6)$$

$$\pi_j = \sum_{i=0}^{\infty} \pi_i P_{ij} \Rightarrow$$

$$\pi_0 = \sum_{i=0}^{3} \pi_i P_{i0} = \pi_0 P_{00} + \pi_1 P_{10} + \pi_2 P_{20} + \pi_3 P_{30}$$

$$\pi_1 = \sum_{i=0}^{3} \pi_i P_{i1} = \pi_0 P_{01} + \pi_1 P_{11} + \pi_2 P_{21} + \pi_3 P_{31}$$

$$\pi_2 = \sum_{i=0}^{3} \pi_i P_{i2} = \pi_0 P_{02} + \pi_1 P_{12} + \pi_2 P_{22} + \pi_3 P_{32}$$

$$\pi_3 = \sum_{i=0}^{3} \pi_i P_{i3} = \pi_0 P_{03} + \pi_1 P_{13} + \pi_2 P_{22} + \pi_3 P_{33}$$

$$\Rightarrow$$

$$\pi_0 = \pi_0 0.3171 + \pi_1 0.0250 + \pi_2 0.0400 + \pi_3 0.0256 \quad (7)$$
$$\pi_1 = \pi_0 0.1463 + \pi_1 0.4250 + \pi_2 0.1733 + \pi_3 0.1474 \quad (8)$$
$$\pi_2 = \pi_0 0.1707 + \pi_1 0.2000 + \pi_2 0.3667 + \pi_3 0.1282 \quad (9)$$
$$\pi_3 = \pi_0 0.3659 + \pi_1 0.3500 + \pi_2 0.4200 + \pi_3 0.6987 \quad (10)$$

To solve π_0, π_1, π_2, and π_3 we consider the equation (6) and omit anyone equation from the equations (7), (8), (9) and (10) then by solving the system linear equations, we get,

π_0 = 0.0398, π_1 =0.2108, π_2 = 0.1905 and π_3 = 0.5589.

A. Findings

The survey indicates the customer retention rates of telecom network service providers such as BSNL, Reliance Jio, Vodafone & Tata, and Airtel & Idea as 31.71%, 42.5%, 36.67%, and 69.87% respectively among college-goers in Puducherry.

When the young subscribers purchase a new SIM, the number of customers preferring to buy BSNL would decrease from 7.23% to 4.62%. Concerning Reliance Jio the customer's preference falls from 23.27% to 21.94% and for Vodafone & Idea from 29.13% to 22.06%. However, in the case of Airtel & Tata, the young customer's preference to buy the brand increases from 32.98% to 48.77%.

Finally, if the given situational parameters continue to operate in the youth market, the stationary probability distribution of young customers of BSNL will be 3.98%, Reliance Jio will be 21.08%, Vodafone & Idea will be 19.05%, and Airtel & Tata will be 55.89% concerning telecommunication service providers in Puducherry. There is a clear indication that the public sector undertaking BSNL and private sector player Vodafone and Idea will lose ground to Airtel & Tata due to brand switching among youngsters in the near future.

3. Conclusion

Easing the number of portability norms by the telecom regulator has opened up choices for the customers and challenges for the network service providers in India. The task of subscriber retention, especially of young customers could be a daunting task for the telecom network operators. Prediction of brand switch over among the telecom network service providers would help them to devise appropriate marketing strategies for customer retention. Markov, being a robust prediction platform, since it operates on the theory of probability, factors in the uncertainties appear to be a reliable measure of prediction. We have demonstrated in this paper that through the Markov prediction chain, the future trend of brand switching by the young subscribers between the private and public telecom service providers to make aware the service providers about the future trends in brand switching.

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