Forecasting the market share of an auto insurance company: A literature review

Assignment for Probabilistic Operations Research course (OR 7230)

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1. Introduction

Companies attract customers by their competitive advantage. They need to put in place clear and competent strategies to attract customers and win the market share. Basic inputs for decision makers to develop their strategy should be collected and carefully assessed; for example, they have to assess potential short term and long term market share. In this report, I reviewed the literature on forecasting the market share of companies using Markov chain.

The report is organized as follows. Section 2 reviewed literatures conducted related to forecasting market share, and section 3 summarized problem formulation of forecasting market share for the case of auto insurance industry.

2. Literature Review

Markov chain is a special type of stochastic process that has Markovian property. A stochastic process is said to have Markovian property if probabilities involving how the process will evolve in the future depend only on the present states of the process and independent of events in the past. Markov chain is widely used in forecasting the market share of companies and brand loyalty of consumers. For example, Andrei (2012) used Markov chain to forecast the market share of Furniture Company. Datong (2011), and Oseni and Ayoola (2013) analyzed the market share of companies in telecommunication sector. Umoh, Awa and Ebitu (2013) analyzed brand switching and brand loyalty of toothpaste users. Prinzie and Van den Poel (2006) investigated purchasing sequence pattern for financial services using Markov, Mixture Transition Distribution (MTD) and similar model and then compared the results of each model.

Though Markov chain is used in marketing to forecast the market share, it has its own limitation as pointed by Ehrenberg (1965), Dura (2006) and Prinzie and Van den Poel (2006). The authors questioned the type of input data used, the assumptions and solutions procedure of Markov model. The later problem is addressed by researchers to make the solution procedure simple. For example, Schwarzblat and Arellano (1987) developed a new method to calculate the steady state solution of complex problem by solving it as optimization problem. Raftery (1985) reduces the number of parameters to be estimated by using lambda that weights the effect of each time step. Similar approach is used by Prinzie and Van den Poel (2006).

Unlike the Markov chain approach, other methods that account explanatory variables have been used in literature to forecast market share. Babic et al. (2014) identified explanatory variables and estimated the future market share of airlines using Fuzzy logic and other traditional methods. Shafiei et al. (2012) modeled the market share evolution of electric vehicles using agent based modeling. They incorporated consumer behavior and different car attributes in the model to predict future market share of electric vehicle.

3. Problem formulation

Auto insurance is the most common type of insurance in the United States as it is required by most states. Consumers spend their time by searching and quoting to choose the right auto insurance provider. According to the report by Agency Revolution (2014), 38.8million online quotes were submitted in 2010. The data taken in the earlier years (2006 to 2007) shows most consumers filled two to three quotes (Honka, 2014). The consumers' effort indicates that there may be a potential switch to other provider when their criteria are met. Individual insurers need to know the proportion of loyal and switching customers and their future market share in advance. This is an important input to review their marketing strategies. Thus, companies may act strategically to keep their existing customers loyal and to attract new customers.

The problem under study is forecasting the market share of an auto insurance company. Markov chain approach is used to forecast the market share. Customers' choice of auto insurance is assumed to have the following properties: 1) their preference evolves over time in a probabilistic manner; 2) probability of customers' choice in the future depends only on their current choice and independent of the past. Due to this, the process is assumed to be Markov chain.

Let the evolution of customers choice of auto insurance from time to time is represented by X_t (t(time)= 0, 1, 2,…n). The possible states are A_0, A_1, A_2,…,A_m. Where A_0 is an auto insurance company under study (for which the market share will be forecasted); and A_1, A_2,…,A_m are other auto insurance companies. The state represents auto insurance companies that the customers choose from time to time. For simplicity, the states are represented by their indexes 0, 1, 2,…, m.

$$X_t = \begin{cases} 0 & if\ customers\ choose\ \ A_o \\ 1 & if\ customers\ choose\ \ A_1 \\ 2 & if\ customers\ choose\ \ A_2 \\ & \qquad . \\ & \qquad . \\ & \qquad . \\ m & if\ customers\ choose\ \ A_m \end{cases}$$

Customers' choice of auto insurance is modeled using transition probability matrix. Equation(1) shows a one-step transition probability matrix of customers' choice. The probabilities in each row are the probability of customers' loyalty to their current auto insurance provider or the probability of switching to other provider. These transition probabilities are assumed stationary (do not change over time).

$$P = \begin{array}{c} \\ 0 \\ 1 \\ 2 \\ \vdots \\ m \end{array}\begin{array}{c} \begin{array}{ccccc} State\ 0 & 1 & 2 & \cdots & m \end{array} \\ \begin{bmatrix} p_{00} & p_{01} & p_{02} & \cdots & p_{0m} \\ p_{10} & p_{11} & p_{12} & \cdots & p_{1m} \\ p_{20} & p_{21} & p_{22} & \cdots & p_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ p_{m0} & p_{m1} & p_{m2} & \cdots & p_{mm} \end{bmatrix} \end{array} \quad \textbf{(1)}$$

In the transition matrix, each p_{ij} is the probability that the system is in state j for next time given that it was in state i. In other words, it is the conditional probability that customers currently choose A_i chooses A_j for the next time for all i,j ={0,1,2,…,m}. The state transition diagram is shown in Fig 1. Note that the transition to or from unlisted states is not shown in the diagram.

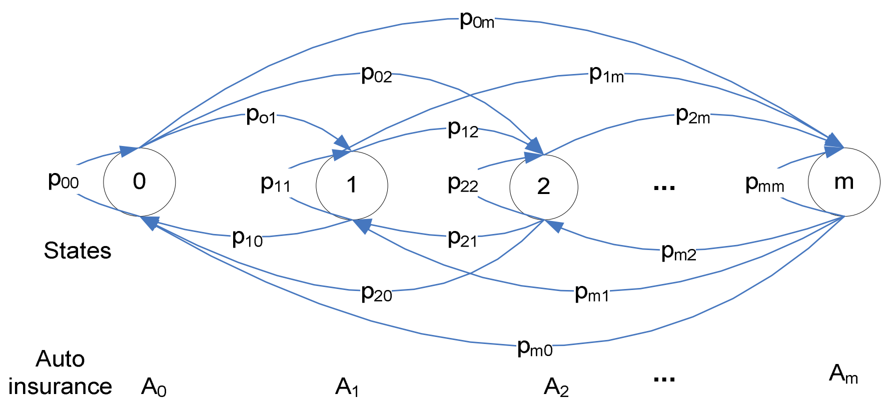

Fig. 1 The state transition diagram of service shift from one auto insurance to another

We are interested to know the market share of A_0 after some discrete time n (for example years) and in the long run. The market share after some time n can be predicted after calculating the n-step transition probability matrix. The n-step transition probability matrix shown in equation (3) can be calculated from the one-step probability matrix (see equation 2). The n-step transition matrix is the nth power of the one-step transition matrix.

$$P^{(n)} = P.P^{(n-1)} = P^n \quad \textbf{(2)}$$

$$P^{(n)} = \begin{array}{c} \\ 0 \\ 1 \\ 2 \\ \vdots \\ m \end{array}\begin{array}{c} \begin{array}{ccccc} State\ 0 & 1 & 2 & \cdots & m \end{array} \\ \begin{bmatrix} p_{00}^{(n)} & p_{01}^{(n)} & p_{02}^{(n)} & \cdots & p_{0m}^{(n)} \\ p_{10}^{(n)} & p_{11}^{(n)} & p_{12}^{(n)} & \cdots & p_{1m}^{(n)} \\ p_{20}^{(n)} & p_{21}^{(n)} & p_{22}^{(n)} & \cdots & p_{2m}^{(n)} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ p_{m0}^{(n)} & p_{m1}^{(n)} & p_{m2}^{(n)} & \cdots & p_{mm}^{(n)} \end{bmatrix} \end{array} \quad \textbf{(3)}$$

$p_{ij}^{(n)}$ is the conditional probability that the customers choose auto insurance A_j after n time steps given that they choose A_i at first.

The unconditional probability that the customers choose auto insurance A_0 after some years later is our interest. It can be calculated as:

$$P\{X_n = 0\} = P\{X_0 = 0\}p_{00}^{(n)} + P\{X_0 = 1\}p_{10}^{(n)} + P\{X_0 = 2\}p_{20}^{(n)} + \cdots + P\{X_0 = m\}p_{m0}^{(n)} \quad \textbf{(4)}$$

Where: P{X_0 =0 X_0 =1 X_0 =1 X_0 =2 … X_0 =m} is the probability vector of the initial states. In other words, it is the current market share of auto insurances.

In the long run, the market share of A_0 doesn't depend on the current state. This is called the steady state(equilibrium). The steady state is calculated as:

$$t * P = t \quad \textbf{(5)}$$

$$t = [c_0 \quad c_1 \quad c_2 \quad \cdots \quad c_m] \quad \textbf{(6)}$$

Where: P is the one-step transition probability matrix; t is the unique fixed probability vector and $c_{0,}$ c_1, c_2,…,c_m are the steady state probabilities of customers choice of A_0, $A_{1,}$ $A_{2,\ldots,}$ A_m respectively. These probabilities are the market share of the corresponding auto insurance.

In conclusion, the market share of an auto insurance company after some time in the future can be forecasted using equation (4) and its market share in the long run by computing t from equation(5). Some input parameters have to be determined first to perform the analysis. The transition probabilities in the one-step transition matrix are usually obtained by customer survey and similar market research as done in similar studies by Datong (2011) and Umoh et al. (2013). The current market share should also be known to forecast future market share. The advance in computers software can help to go through the solution procedure in a short time. For simplicity, the number of states can also be reduced by merging some states that have low market share as a single state as a representative of these states.

4. Reference

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