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Forecasting Market Share on Laptop Brands for University Students Using Markov Chain

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ABSTRACT

Electrical devices market occupies a significantly position in Malaysia, especially the higher consumer's demand towards laptop market. In fact, laptop is an efficient and useful tool that contributes to students in university. Normally, students use laptop in communication, assessing information from the Internet and doing assignments. In order to grasp the business opportunities, it is important to the marketers to understand the market trend so as their marketing strategic can be planned. In this study, market share, which is a portion of targeted customers in using laptop, is identified and forecasted. The probabilities of the state of nature, which are belonging to the brands of laptop, are transformed into the transition matrix. This transition matrix presents the feature of the Markov chain, where the next state of the system depends only on the present state of the system. During the calculation procedure, the state probabilities are obtained and these probability values are changed over the time. When the steady state is achieved after a certain period, the state probabilities that are in steady state would show the chances of the customer loyalty and the market trend. In conclusion, the result of this study enables laptop marketers to make a more precise decision on improving their business.

Keywords: market share, laptop brands, Markov chain, forecasting, steady state probability

1. INTRODUCTION

Market supply and customer demand that are bidirectional interaction become the main source to the operation of a market. On supply side, firms and marketers provide or sell the products to consumers by accessing firms' capabilities to satisfy market needs and for firm profitability. While, demand can be defined as consumers' willing to give so that the desire can be satisfied by suppliers. Market competition is occurred among marketers and consumers for the respective benefits to access the needs. Firms are always chasing to play monopoly in the market, thus, they have a superiority authority to decide and this decision can left the impact on the market price and bring the highest profit indirectly. Besanko and Braeutigam [1] compared and showed quantitative methods that monopolist of market in a perfectly competition market could maximize firm profitability to achieve market equilibrium. On this point of view, market share becomes a key indicator for a firm to dominate whole market. Marketing strategy and planning stage play an important role in maintaining the market share. Different analysis methods and studies from consumer behavior and products positioning are included to provide a wider knowledge and information. In addition to this, the managers are enable to make an accurate decision for different role playing in market [2].

Strategic planning and management are important for traders to increase the profit or a company turnover. Application of econometric, game theory and Markov chain are normally utilized by a trader in doing market share analysis. From the history, a Russian mathematician named Andrey Andreyevich Markov had introduced a basic concept of Markov chain in 1907 [2]. After that an extensively use of Markov chain by many mathematicians and practitioners in research leading this method has been widely applied into variety fields, for instance, forecasting and analysis of experiment result of science, medical, finance, business and daily entertainment activities [3]. In marketing research, the properties of Markov chain that give the outcome only based on the present state but not on the previous states are concerned. The constant state probabilities that are achieved after a certain time calculation of transition matrix could be employed in forecasting market share competition among various brands of congeneric product within a long term behavior. Opportunity of customer switching from one brand to another brand of the product is simply defined as customer loyalty, which affects equilibrium of market direction for a manufacturing company. Management department that concerns on surveying customer opinion and decision making about merchandise produced enables the development of improving the company's market dynamics.

Market share is a percentage of sales of targeted products or services that is earned in particular firm over a specific period of time. Marketers are usually lack of knowledge to analyze future market share that lead to insufficient information to improve the business. Besides that, marketers are not realizing on the importance of forecasting future trend of market. A firm can grasp market competitive advantage through market share analysis. Cooper and Nakanishi [4] identified the related calculation and model for market share evaluation. By applying market share analysis, marketers may identify trends of total market rise or decline. These market trends help marketers to differentiate and to justify the revenue growth, and to understand the growth and loss which have resulted from changes in the market that were beyond control. Market potential and market opportunity could be justified by analysis of consumer behavior or loyalty towards the products in a long term period. By understanding the true market share, consumers are able to make a more rational purchase decision by comparing various aspects for a product when they investigate the market share analysis [5].

In this paper, a market share on laptop brands used among the university students is considered. There are 218 students who are from the Faculty of Science, Technology and Human Development, Universiti Tun Hussein Onn Malaysia, were involved in the online survey. They were asked to provide the current laptop brand, the next laptop brand if they want to buy a new laptop and some related information. From the information of the online survey, the state transition matrix is constructed. Also, the initial state probabilities are determined particularly. During the calculation procedure, the state probabilities are updated over a certain time period. Once the state probability values, which are in the steady state, are obtained, the market share forecasting on laptop brands among the university students would be achieved. Consequently, the market share and the customer loyalty on the laptop brands are presented.

The rest of the paper is organized as follow. In Section 2, the problem statement is described. In Section 3, the Markov chain approach is discussed, where the model description is made and the properties of Markov chain are given. In Section 4, the state transition matrix is constructed and the state probabilities are calculated. The results obtained, which are presented in table and graph forms, are further discussed. Finally, a concluding remark is made.

2. PROBLEM STATEMENT

Using the laptop for daily activities, include communication, assessing information from the Internet and doing assignments, is a normal task for the university students. The different brands of the laptop would be preferred by the university students upon the price of laptop, the performance of laptop and the durability of laptop. On this basis, the market share on the laptop brands used among the university students could be questioned and a proper information on laptop marketing strategy shall be provided for the university students. Hence, to understand the preferred brand of laptop used by the university students, the following brands of laptop are considered:

Acer, Asus, Dell, Lenovo, Sony, Others.

From the listed brands of laptop, the most preferred laptop used among the university students shall be known. Accordingly, the market share of the laptop shall be analyzed. Hence, the aim is to know the market share for each brand of the laptop used after a certain period and to provide laptop market information in the university usage. Since the current information on using laptop are used for determining the future laptop market share, the Markov chain approach is applied to forecast the market share and over the time period to reach the steady state of the market share would be provided in advance. As a result, the decisions on buying laptop by the university students and selling the laptop to the university students could be easily made.

3. MARKOV CHAIN APPROACH

In this section, the Markov chain approach is discussed. The model used in the Markov chain is described and the properties of the Markov chain are given.

3.2 Model description

Markov chain method is mainly used for analyzing the future development trend of random events [4]. Moreover, the current state and the trend of variable are used to predict the next state but not on the sequence of events. Generally, Markov chain can be defined as a stochastic process that involves with a set of random variables $\{X(t)\}$, where parameter t denotes time and ranges over an interval of interest, and $X(t)$ denote the random variable at time t, for $t \geq 0$. The values assumed by $X(t)$ is called states and the set of all possible states is called the state space. A

stochastic process is also known as a mathematical model that evolves over time in a probabilistic manner. Usually, a Markov chain is reserved for a process with a discrete time and states [6], that is, for $t = 0,1,\cdots,n-1$,

$$\pi_{t+1} = \pi_t P \qquad (1)$$

where π is the value of the state, which is also known as state probability, and P is the state transition matrix.
Equation of states, where the probability distribution of the state at time $t+1$ depends only on the state at time *t*, does not depend on the previous states, and the chain is passed through on the way to the previous state at time *t*. A further assumption mentioned that for all states *i* and *j* at all *t*, $P(X_{t+1} = j \mid X_t = i)$ is independent on *t* [6]. This assumption is applied whenever the system under study behaves consistently over time. Any stochastic process has this unchanged behavior, which is the steady state condition, is called the stationary behavior.

3.3 Properties of Markov chain

The steady state property of Markov chain is described here. As *n*-step is large, the transition matrix given by P^n approaches to a steady state with identical rows, which is written by

$$\lim_{n\to\infty} P^n = \begin{bmatrix} \pi_1 & \pi_2 & \ldots & \pi_s \\ \pi_1 & \pi_2 & \ldots & \pi_s \\ \vdots & \vdots & \ddots & \vdots \\ \pi_1 & \pi_2 & \ldots & \pi_s \end{bmatrix}. \qquad (2)$$

Taking the limit as *n* tends to ∞, the state probability (1) becomes

$$\pi = \pi P\,. \qquad (3)$$

The outcome of (3) can be shown as follows. From (1), let us consider at each time *t* for the state probability π_t, yielding

$$\begin{aligned}
&t = 0, && \pi_1 = \pi_0 \cdot P \\
&t = 1, && \pi_2 = \pi_1 \cdot P = \pi_0 P^2 \\
&t = 2, && \pi_3 = \pi_2 \cdot P = \pi_1 P^2 = \pi_0 P^3 \\
&t = 3, && \pi_4 = \pi_3 \cdot P = \pi_2 P^2 = \pi_1 P^3 = \pi_0 P^4 \\
&t = 4, && \pi_5 = \pi_4 \cdot P = \pi_3 P^2 = \pi_2 P^3 = \pi_1 P^4 = \pi_0 P^5 \\
&t = 5, && \pi_6 = \pi_5 \cdot P = \pi_4 P^2 = \pi_3 P^3 = \pi_2 P^4 = \pi_1 P^5 = \pi_0 P^6 \\
&\vdots && \vdots \\
&t = n-1, && \pi_n = \pi_{n-1} \cdot P = \pi_0 P^n
\end{aligned} \qquad (4)$$

As $n \to \infty$, $\pi_n = \pi_{n-1} = \pi$, which is a steady state of the state probability. Hence, (3) is satisfied to be an equilibrium state. The limiting steady state probabilities are therefore the solution of the system of linear equations given by (3) such that the row sum of the state probability is given by

$$\sum_{j=1}^{s} \pi_j = \pi_1 + \pi_2 + \cdots + \pi_s = 1\,. \qquad (5)$$

Remark: To obtain the steady state of the state probability π, (3) and (5) can be solved algebraically. While, the block diagram of the Markov chain approach is shown in Figure 1.

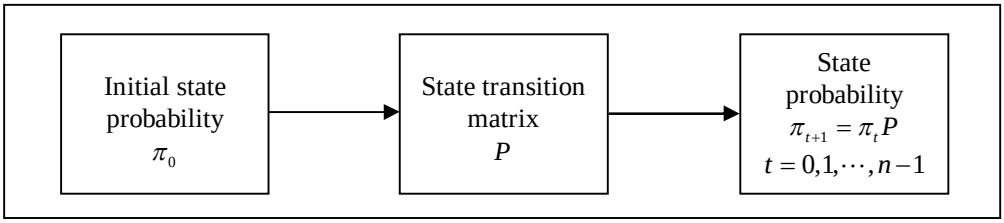

Figure 1 Block diagram for Markov chain approach

4. RESULTS AND DISCUSSIONS

There are six states in this study, which are the laptop brands given in the following state space form:

$$S = \{\text{Acer, Asus, Dell, Lenovo, Sony, Others}\}.$$

From the online survey data, the state transition matrix is obtained as follows:

$$P = \begin{pmatrix} 0.452 & 0.143 & 0.071 & 0.143 & 0.143 & 0.048 \\ 0.013 & 0.693 & 0.053 & 0.093 & 0.133 & 0.015 \\ 0.024 & 0.095 & 0.810 & 0.071 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.120 & 0.760 & 0.120 & 0.000 \\ 0.000 & 0.043 & 0.044 & 0.043 & 0.870 & 0.000 \\ 0.090 & 0.273 & 0.000 & 0.273 & 0.091 & 0.273 \end{pmatrix} \quad (6)$$

where P_{ij} is the probability of user laptop brand i chooses laptop brand j as future laptop brand with i and j represent Acer, Asus, Dell, Lenovo, Sony, Others. The initial state probability is given by

$$\pi_0 = [0.193, 0.344, 0.192, 0.115, 0.106, 0.050].$$

Let the time period be in a unit of year. Table 1 shows the state probabilities of the respective laptop brand used for 25 years. Notice that the result in Table 1 is obtained by using Markov chain process. The steady state occurs after 20 years.

Table 1: State probabilities

Year	**State Probability**					
(n)	**$\pi_1(n)$**	**$\pi_2(n)$**	**$\pi_3(n)$**	**$\pi_4(n)$**	**$\pi_5(n)$**	**$\pi_6(n)$**
0	0.193	0.344	0.192	0.115	0.106	0.050
1	0.101	0.302	0.206	0.179	0.184	0.028
2	0.057	0.259	0.220	0.209	0.239	0.017
3	0.036	0.224	0.231	0.221	0.277	0.011
4	0.026	0.197	0.240	0.226	0.303	0.008
5	0.021	0.178	0.247	0.226	0.322	0.006
6	0.018	0.166	0.253	0.224	0.334	0.005
7	0.017	0.157	0.256	0.222	0.343	0.005
8	0.016	0.152	0.259	0.220	0.349	0.004
9	0.016	0.148	0.261	0.218	0.353	0.004
10	0.016	0.146	0.262	0.217	0.355	0.004
11	0.016	0.145	0.262	0.216	0.357	0.004
12	0.016	0.144	0.263	0.215	0.358	0.004
13	0.016	0.144	0.263	0.214	0.359	0.004
14	0.016	0.143	0.264	0.213	0.360	0.004

15	0.016	0.143	0.264	0.213	0.360	0.004
16	0.016	0.143	0.264	0.213	0.360	0.004
17	0.016	0.143	0.264	0.213	0.360	0.004
18	0.016	0.143	0.264	0.212	0.361	0.004
19	0.016	0.143	0.264	0.212	0.361	0.004
20	0.016	0.143	0.263	0.212	0.362	0.004
21	0.016	0.143	0.263	0.212	0.362	0.004
22	0.016	0.143	0.263	0.212	0.362	0.004
23	0.016	0.143	0.263	0.212	0.362	0.004
24	0.016	0.143	0.263	0.212	0.362	0.004
25	0.016	0.143	0.263	0.212	0.362	0.004

Figure 2 shows the steady state graphically for the brands of laptop that are used by the university students after 20 years. Forecasting market share of the laptop brands after this year (*x*-axis) is represented by the stationary probabilities (*y*-axis), where the probability of each state is remained unchanged after 20 years. The percentage of stationary probabilities for states π_1 to π_6 are, respectively, 1.60%, 14.30%, 26.30%, 21.20%, 36.20% and 0.40%.

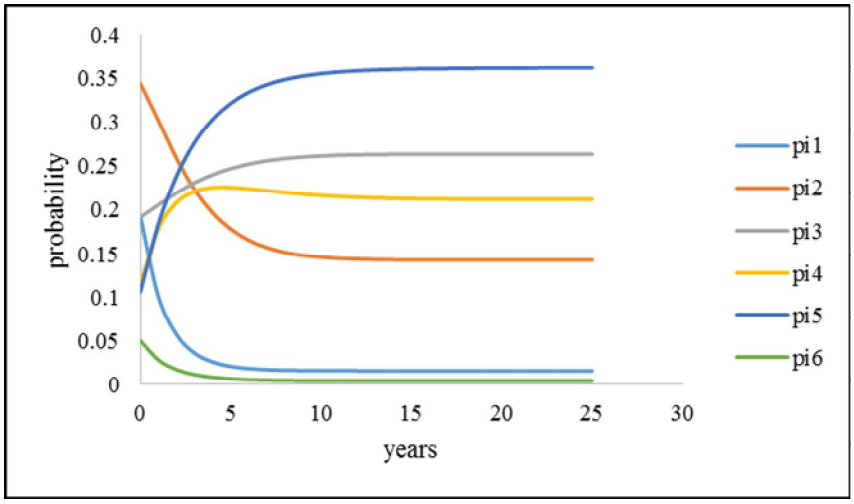

Figure 2 Markov chain steady state

A comparison between the initial market share and the forecast market share of laptop brands is shown in Table 2. It is concluded that all brands of laptop experience an increasingly trend in market share except Acer and Asus. Note that Acer is suffering seriously which declines of market share from 19.30% to 1.60%. It can be observed that Asus as the main producer initially on the market undergoes an extremely decreasing in market from 34.4% to 14.3% after 20 years, which indicates Asus lost the market leader position in future. On the other hand, there is a growing market share of Dell from 19.20% to 26.30% threshold. Therefore, Dell consolidates its position in market at the second higher percentage of holding on laptop market share, while the highest percentage of market share belongs to Sony with 36.20%. During this 20-year period considered, Lenovo is the most probably competitor to grasp market advantage with new strategic in future market trend. The percentages for Lenovo grows incrementally from 11.50% to 21.20%. Market share of other brands is decreased from 5.00% to 0.04% after 20 years.

Table 2: Comparison between initial market and forecasting market

Brand	Initial Market (%)	Forecast Market (%)	Variation
Acer	19.30	1.60	–17.70
Asus	34.40	14.30	–20.10
Dell	19.20	26.30	+ 7.10

Lenovo	11.50	21.20	+ 9.70
Sony	10.60	36.20	+25.60
Others	5.00	0.40	– 4.60
TOTAL	**100.00**	**100.00**	

Moreover, customer loyalty has been a major focus on strategic management that a firm could sustain its competitive advantage. As seen from the Markov transition matrix in Table 3, the probability of staying with same brand is higher than probability of switching to other brands. In other words, the university students will loyal towards their current using brand of laptop. In addition to this, the students' purchasing power on 20-year period could be reviewed. The highest probability of 0.87 indicates the most of Sony's current users will consistently purchase the same product. The amount of the university students that has the repeating purchasing behavior towards the same laptop products is followed by Dell, Lenovo, Asus and Acer. From the other side, this trend can be explained as product satisfaction for those same brands is higher than other brand because of the university students most probably keep purchasing the same brand. Other brands like Compaq, Toshiba and HP have the least probability that a university student will buy the same brand again, given a number of past purchased brands. Nevertheless, the university students switch to the other brands of laptop that could satisfy their needs and demands. The university students are likely to try a new brand of laptop most of the time. Lenovo, which has the highest variation in Table 2, is one of the preferences laptop brand for future purchase due to none of probabilities are zero in the column four in Table 3. Lenovo which is a market fresh entry brand normally would attract population of purchasing power most probably of the promotion, product's appearance and price.

Table 3: Transition matrix for probabilities of laptop's brand

From \ To	Acer	Asus	Dell	Lenovo	Sony	Others
Acer	0.452	0.143	0.071	0.143	0.143	0.048
Asus	0.013	0.693	0.053	0.093	0.133	0.015
Dell	0.024	0.095	0.810	0.071	0.000	0.000
Lenovo	0.000	0.000	0.120	0.760	0.120	0.000
Sony	0.000	0.043	0.044	0.043	0.870	0.000
Others	0.090	0.273	0.000	0.273	0.091	0.273

5. CONCLUDING REMARKS

This paper has presented the use of Markov chain prediction method to overcome the deficiency of the traditional prediction methods. This method provides a more effective method for the product market sales forecast. Based on the results of Markov chain prediction model, the laptop market was classified into six different states. Then, the steady state transition model was established. In the forecast, the percentage of market share is changing depend on the current user feedback and individual brand preferences in future. The results from the forecasting model reflect that the trends of the market allow the marketers to take an action accordance with the electricity market economic conditions in different period. Thus, a visually map would provide marketers a long-term planning and ascending income in whole market. The result of forecasting also reflects that the preference trends of laptop brand still occupying a huge market advantage and purchasing power among the university students. In conclusion, this study contributes a precise quantitative decision making for management to both marketers and consumers.

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