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THE USE OF MARKOV ANALYSIS IN MARKETING OF SOFT DRINKS PRODUCTS

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Abstract

This paper examined the application of Markov chain in marketing three competitive soft drink products in Nigeria. Markov analysis has been used in the last few years mainly in marketing, examining and predicting the behavior of customers in terms of their loyality and switching from one product to another. The three soft drinks companies Coca-Cola, Pepsi and Bigi-Cola were used as a case study. Information on daily sales was extracted from the records of sampled distributors in Oyo metropolis when we assume the same pattern of gain and losses. It was observed that, Bigi-Cola Company has the highest probability of retaining their customers followed by Coca-Cola company and Pepsi in that order.

Keywords: Markov Chain, Soft Drinks, Customers.

Introduction

Soft drinks are one of the majorly consume snacks among the Nigerians especially those in the cities and towns. Consumption of soft drinks is very high in the country. Soft drinks like Pepsi, Bigicola, Coca cola make a growing contribution to the diet of children and the adolescent. The quality of soft drinks consumed especially carbonated soft drinks like Pepsi, Bigicola, Cocacola,etc increased with age and account for the largest single food contribution to non milk extrinsic sugar drink intake among young people.

Sweetened soft drinks are those least recommended for beverages intake because they add to the high energy burden, have a low nutrients values can

be positively over consume and may contributes to other deleterious health concerns. Soft drinks manufacturer including cocacola and pepsicola are aware that this is a diminishing overall market. At least 50% of their total markets now come from the low energy drinks or water growth in these products for exceed that of sweetened beverage

As many of soft drinks are a source of energy there is concern that children may obtain a significant proportion of their total level daily energy requirement from the sugar contained within soft drinks. However there is a little published evidence to support this. In the scientific literature soft drinks have been reported to provide between 0.7% and 4.8%of total energy intake. With the increasing in popularity of soft drinks, the wider variety of those available and powerfully advertising this makes them to be competitive.

The increased competition resulted in the deployment of various strategies which include the sale of the soft drinks in plastic bottles making it possible for their drinks to be sold in traffic jams, and other "on the go" market points. The number of sales that occurs at this time could have been influenced by the number of sales one time before, and the amount of sales in the future can be affected by the current sales etc. This phenomenon is a real-life example of the markov chain event which is a method for modeling in stochastic process. Markov chain model used to assist in estimating the changes that may occur in the future, where the changes are represented in dynamic variables at certain times. The markov chain was first coined by Andrew Andreyev markov(1856-1922). It had been observed that there is an inequality in the consumption of soft drinks. Some customers shift back and forth from particular product to another due to the quality of the product and the nutritional facts, availability of the product or information about the product. This research aim to shed more light on the movement of customers from one brand to another.

Methodology

Data Sources

In line with the aim of this research work which to determine the biased movement of customer of soft drink from one brand to another. Some wholesalers of soft drink majorly Coca cola, Pepsi, Bigicola was selected on convenience sampling in oyo metropolis in which ADEFAMS trading store in Ajegunle, Ajetunmobi super mart Sabo area, and Mummy ola softdrink store was selected purposively due to the orderliness and completeness of their sales record. Documentation method of data collection was adopted to explored data from the records of the wholesalers on daily bases from October 2019- August 2020. The data was obtained on the record of sales on Coca cola, Pepsi and Bigicola.

Analytical Procedure

The statistical used for this study is the Markov chain in determining the transition probability or matrix of the process and the equilibrium state of the Markov chain wil be determine.

The sequence of number of customer that consume a particular soft drinks is considered to be a realization of a stochastic process. If Xt denotes the number of customer that maintain the consumption of a soft drink for a given period Xt is the random variable describing the outcome of the soft drink consumption on the t^{th} period and the "state" of the process.

Markov Chain Model

The model is based on the theory of Markov Chains, which we now review. To create a model, we have to simulate seemingly random events. We call these events random variables. A random variable denoted X, is a variable that is subject to variations due to chance. It is defined on a set **Ω** of possible outcomes and has a probability distribution which assigns likelihood of happening to each outcome. Thus for a Markov chain the state of the model at a given period or time contains all the information about the past evolution which is use in predicting its future behavior. We can only say that the given present state, the past and the future are independent.

$$mathematical\ representation\ of\ the\ Markov\ chain$$

$$P\left(\frac{X}{t_{n+1}}\right) = j|(X_{t1}) = 1, X(t_2) = 2 \ldots X(t_s) = i = P(X(t_{n-1}) = j \ \backslash X(t_s) = i$$
$$= P_{ij}(t-s)$$

This means the past information is fully sum up by the mere knowledge of the present state. This property is called "Markov property"

A Markov chain is called "Homogeneous" if the transition probabilities : $Pi, j(t, t\ +\ s)$ depends only on s. we can then note :

$$Pi, j(t, t\ +\ s) =\ Pi, j$$

Transition Matrix

From one level of change to another in a system, a measure is attached. This measure is probabilistic in nature. The collection of all such measured arranged in rows and columns cumulate to the transition matrix of the system.

A transition matrix $P(t-1; t)$ of dimension m timesm, is the one that summarizes the probabilities $pi, j(t)$, corresponding to the different possible states of i and j is :

$$P_{m,m} = (\begin{bmatrix} P_{1,1}(t) & \cdots & P_{1,m}(t) \\ \vdots & \ddots & \vdots \\ P_{m.1}(t) & \cdots & P_{m,m}(t) \end{bmatrix})$$

All the lines of this matrix are probability distributions; (i.e) the sum of the coefficients of each line is equal to 1. (i.e):

$$i.Pi,j \geq 0.$$
$$ii.P\ i \in E\ p\ j,i\ (t-1;t) = 1$$

Equilibrium State of Markov Model

A Markov chain with transition matrix P, then $Xt \sim \pi^t \Rightarrow X_{t+1} \sim \pi^t P$

$$This\ raises\ the\ question: is\ there\ any\ distribution\ \pi\ such\ that\ \pi^t P = \pi^t$$

If π^tP $= \pi^t$, then

$$X_t \sim \pi^t \Rightarrow X_{t+1} \sim \pi^t P = \pi^t$$
$$\Rightarrow X_{t+2} \sim \pi^t P = \pi^t$$
$$\Rightarrow X_{t+3} \sim \pi^t P = \pi^t$$
$$\Rightarrow \ldots$$
$$In\ other\ words, if\ \pi^t P = \pi^t, and\ X_t \sim \pi^t, then$$

$X_t \sim X_{t+1} \sim X_{t+2} \sim X_{t+3} \sim$ .. Thus, once a Markov chain has reached a distribution πT such that $\pi^t P = \pi^t$, it will stay there. If $\pi^t P = \pi^t$,we say that the distribution $\pi^t$is an equilibrium distribution.

Equilibrium means a level position: there is no more change in the distribution of X_t as we wander through the Markov chain.

Note: Equilibrium does not mean that the value of X_{t+1} equals the value of X_t It means that the distribution of X_{t+1} is the same as the distribution of X_t.

Let $\{X_o, X_1,...\}$ be a Markov chain with transition matrix P and state space S, where |S| = N (possibly infinite). Let π^t be a row vector denoting a probability distribution on S: so each element π_i denotes the probability of being in state i, $and \sum \pi_i = 1\ where\ \pi_i \geq 0, for\ all\ i = 1,\ldots,N.$ The probability distribution π^t is an equilibrium distribution for the Markov chain if π^tP = π^t. That is, π^t is an equilibrium distribution if

$$(\pi^t \mathrm{P})\ \mathrm{j} = \sum \pi_i p_{ij} = \pi_j for\ all\ j = 1,\ldots,N.$$

Let $\{X_o, X_1,...\}$ be a Markov chain with transition matrix P. Suppose that π^t. is an equilibrium distribution for the chain. If $X_t \sim \pi^t$. for any t, then $X_{t+r} \sim \pi^t$. for all r ≥ 0.

Once a chain has hit an equilibrium distribution, it stays there for ever. Note: There are several other names for an equilibrium distribution. If π^t is an equilibrium distribution, it is also called:

• invariant: It doesn't change; π^tP = π^t

• stationary: The chain 'stops' here.

Markov Chain Analysis

Based on daily records, the sales was summarized below

Table 1

Product	1st quarter (oct-dec 2022)	2nd quarter (Jan-March 2023)	3rd quarter (April-June 2023)	Total
Coca cola	5957	4437	4270	14664
Pepsi	5977	4181	4706	14864
Bigi cola	5843	4347	4781	14971
Total	17777	12965	13757	44499

Source: Market survey

Estimation of Transition Probability

Using the data presented in table 1 above, the transition probability is displayed the table below

Table 2

	Coca-Cola	Pepsi	Bigi-Cola
Coca-Cola	0.838	0.003	0.159
Pepsi	0.071	0.917	0.013
Bigi-Cola	0.035	0.023	0.942

The transition matrix is given thus:

$$p_{ij} = \begin{matrix} 0.838 & 0.003 & 0.159 \\ 0.070 & 0.917 & 0.013 \\ 0.035 & 0.023 & 0.942 \end{matrix}$$

Determination of Equilibrium State 0f the Process

Equilibrium means a level position: there is no more change in the distribution of X_t as we wander through the markov chain. Equilibrium does not mean that the value of X_{t+1} $equals\ the\ value\ \ of\ X_t$. It means that the distribution of X_t is the same as distribution of X_{t+1}.

The equilibrium state can be determine as follows

$$let\ \pi^t\ .P = \ \pi^t$$

$Where\ P\ is\ the\ transition\ matrix,$ $\pi^t = \pi 1 + \pi 2 + \pi 3 + \cdots = 1$ and $\sum_0^i \pi_i = 1$

$$This\ is\ the\ distribution\ of\ chain\ converge\ to\ P_{ij}\ \ i.e\ \ P$$

Long Term Behavior

This will always happen for this markov chain. In fact the distribution it converge to π^t = (0.209 0.178 0.613) does not depend upon starting condition for any value

X_o.we have $X_t \sim (0.209 \quad 0.178 \quad 0.613)\ as\ t{\sim}\infty$. This will reveal that each row of the transition matrix $P^t\ converge\ to\ the\ equilibrium\ distribution\ (0.209 \quad 0.178 \quad 0.613) as\ t{\sim}\infty$

$$if\ p = \begin{pmatrix} 0.838 & 0.003 & 0.159 \\ 0.070 & 0.917 & 0.013 \\ 0.035 & 0.023 & 0.942 \end{pmatrix}$$

$$\rightarrow P^t = \begin{pmatrix} 0.209 & 0.178 & 0.613 \\ 0.209 & 0.178 & 0.613 \\ 0.209 & 0.178 & 0.613 \end{pmatrix} at\ t \rightarrow \infty$$

This converge of P^t means that for large t no matter what which "state" we start in we always have the probability of about

0.209 of being in state 1 i.e Coca cola after t -steps
0.178 of being in state 2 i.e Pepsi after t –steps
0.613 of being in state 3 i.e Bigi cola after t-step

Discussions

The results of the analysis from the transition matrix reveals that Coca cola products retains 83.8% of its customer while the remaining two products i.e Pepsi and Bigi cola retains 91.7% and 94.2% respectively during the period. Also it was reveals that as Coca cola retains 83.8%of its customer it gains about 7% from Pepsi and about 3.5% from Bigi cola while its losses about 0.3% of customer to Pepsi and about 15.9% to Bigi cola products. Moreover the reveals that Pepsi also gain about 0.3% from Coca cola and about 2.3% from Bigi cola during the period. However as Pepsi cola gain from both Coca cola and Bigi cola, it also losses some customer to them in the period as it loss about 7% and 1.3% to Coca cola and Bigi cola respectively. Furthermore the transition probability reveal that Bigi cola product gain about 15.9% from Coca cola and 1.3% from Pepsi during the period in which it losses about 3.5% to Coca cola and about 2.3% to Pepsi co during the period of the study. It was also discovered that at the state of equilibrium, the demand of the products will drop to a minimum level. At this level Coca cola will be at a stable value of 20.9% while Pepsi and bigi cola will be 17.8% and 61.3% respectively.

Conclusion

Based on the findings, the three products are majorly consumed with slight variation in the consumption of the products. The three companies have potentials of retaining their customers but when market is steady, bigi cola companies has the highest potential of retaining their customers. The demand of the three products may drop at a certain level as a result of change in size, taste, price, availability, health effect or the due to the fact that it is a Nigeria made product and other factor that may affect the

consumption . During this period, Bigi cola will be the most demanded of the three products while Coca cola will follow and Pepsi will be the least consumed of the three products.

REFERENCES

Anderson w (1991) *Contionous time Markov chains:an application oriented approach*, springer, New York.

Baum, L. E. and Eagon, J. A. (1967). *An inequality with applications to statistical estimation for probabilistic functions of Markov processes and to* a model for ecology. *Bulletin of the American Mathematical Society 73*(3), 360– 363.

Baum, L. E. and Petrie, T. (1966). Statistical inference for probabilistic functions of finite-state Markov chains. *Annals of Mathematical Statistics 37*(6), 1554–1563.

Dempster, A. P., Laird, N. M., and Rubin, D. B. (1977). Maximum likelihood from incomplete data via the *EM* algorithm. *Journal of the Royal Statistical Society 39*(1), 1– 21.

Eisner, J. (2002). An interactive spreadsheet for teaching the forward-backward algorithm. *Proceedings of the ACL Workshop on Effective Tools and Methodologies for Teaching NLP and CL*.

Feller w (1968): *An introduction to Probability Theory and its Applications*, vol 1, 3rd edition Wiley NewYork

Forney, Jr., G. D. (1973). The Viterbi algorithm. *Proceedings of the IEEE 61*(3), 268–278.

Gilks W, Richalison S, Spiegeihalter D (eds) (1995*) Markov Chain Monte Carlo in Practice* Chapman & Hall, London.

Haeggstroem O(2002) *Finite Markov Chains and Algorithmic applications*, London Mathematical Society Student Texts (no.52)

Jelinek, F. (1997). *Statistical Methods for Speech Recognition*. MIT Press

Kemeny J, Snell , (1960): *Finite Markov Chains by* Van Nostrand Publishing Company Springer Verlag, 3rd Printing.

Kruskal, J. B. (1983). An overview of sequence comparison.

Meyn S, Tweedie R (1993*) Markov chains and Stochastic Stability*. Springer, London

Sankoff, D. and Kruskal, J. B. (Eds.), *Time Warps, String Edits, and Macromolecules: The Theory and Practice of Sequence Comparison*, 1–44. Addison-Wesley.