# A Markov Chain Model Analysis of GSM Network Service Providers Marketing Mix

By
Datong, G. Monday,
School of Arts and Sciences,
American University of Nigeria,
Yola, Nigeria.

## ABSTRACT

First order Markov Chain is used to find out the equilibrium market share of products in the present period as a basis for predicting future market shares.
The strength of subscribers' loyalty to selected network service providers over a period using variance analysis revealed that subscribers' loyalty is functionally not dependent on the subjective perception of subscribers, but on its five marketing mix determinants; network coverage, tariff, free sms, connectivity and customer services. By estimating the Transition Probability matrix (TPM), using the method of Unweighted Restricted Ordinary Least Squares; the scope of subscribers' loyalty, subscribers switching probabilities among service providers were calculated to suggest the probable marketing mix on equilibrium market share. From the results, it was suggested that the optimum marketing mix among the various service providers were as follows: MTN 52.5%, Globacom 27.5%, Zain 15.4% and etisalat 4.7%. These proportions can be used as a guiding principle on future allocation purposes (i.e. optimal policy that maximizes the expected revenue of the process over a finite number of stages). Other subsequent periods were predicted using the model.

From the study, it was concluded that for a profitable operation of any telecommunication network service provider, its marketing strategy must be designed to ensure that these variables; network coverage, tariff, free sms, connectivity and customer services interact optimally.

**Keywords**: Markov Chain Market Share Model, Market Share Determination, Subscribers' Switching Behaviour, Transition Probability Matrix

## INTRODUCTION

The deregulation of the telecommunication sector in Nigeria led to the introduction of major Global System of Mobile Communications (GSM) in the country. Network providers such as MTN Nigeria, Globacom, Zain and Etisalat came up with various network services in the country. After several years of the start of GSM in Nigeria, the focus is gradually shifting from providing coverage to providing quality service. Dissatisfaction by subscribers gives rise to high rate of subscribers churn and low revenue for the operator. The performance of the network has a direct impact on the revenues and ultimately the profit.

The realization of optimum profit and satisfaction of customers' needs and wants by any business organization depends on the successful production and availability of desired products and services wish meets certain needs and wants of a given market. Goods and services in any given market come in various forms and brands.

The provision of goods and services in sizes and brands lead to the existence of preferences among product buyers, resulting in certain brands attracting more or less percentage of the market share than the others. It is

therefore necessary to have a market share analysis of the brands and sizes of the various products so as to assist firms know their competitive advantages. This study is carried out to determine the market share of the mobile communications industry in Yola, North- western Nigeria. A market share needs to take into consideration, issues like; market size, market growth rate and market segmentation. This research examines market shares break-up in terms of identifying top players, the middle and minnows of the market place, based on the volume of business transactions. The study specifically evaluates market segmentation which identifies the main factors, such as network coverage, tariff, free sms, connectivity and customer services.

It has often been necessary that network service providers and marketers know what qualities or variables attract the customers most; as a way of finding out optimum marketing mix that will lead to profit optimization. In most cases, to increase the sales of any product, we must understand very clearly what buyers think of the company's product in comparison to competing products, considering the marketing mix packages of the different products, i.e. tariff, connectivity, customer services, coverage and free sms (Ailawadi and Neslin, 2001). Since these are within the company's control, they provide leverage for increasing total sales and, hence profitability. This understanding helps to plan for entry barriers; know who the top players are in each identifiable segment of the market – are they providing premium quality or premium price advantage? It is critical to identify the main strengths of the top players as well as weakness/ areas of improvement to combat the onslaught in the market warfare. The main objective of this study is aimed at obtaining optimal marketing mix policy which could be used as guiding principle for future allocation purposes (i.e. optimal policy that maximizes the expected revenue of the process over a finite number of stages).

## MATERIALS AND METHOD

In this research, pilot survey questionnaires were administered to 100 students, staff and faculty of the American University of Nigeria, Yola adopting the method of simple random sampling. The main study expanded the scope to cover Yola town, Numan, Mubi, Jimeta and Mayo-belwa. Selection of the respondents was based on stratified random sampling, the towns are the strata and in each stratum (town) simple random sampling was employed to select 100 samples. A total of 500 questionnaires were administered, with 472, representing 94.44% were completed and returned.

The questionnaire administered for the research attempted to find out the decision of GSM subscribers preference for choosing a particular network provider in Yola-Nigeria. The study was limited in scope to just GSM network operators in Yola-Nigeria. The respondents ranked their provider preferences on a four point Likert scale ( rank 4 means the most preferred while rank 1 is for the least preferred provider), with respect to tariff, connectivity, customer services, coverage and free sms

First order Markov chain is used to analyse the data collected from the field study of the GSM subscribers' preference for choosing a network in Yola-Nigeria using market shares. The provider share data are static, because though they may indicate a changing picture over a time period and the exact nature of changes is known. There is a general model which assumes only a one-stage dependency of the events, with each event depending on time immediately preceding one, but independent of the other prior events i.e. provider choices made during the period determines the probability of choices in the forth coming period.

The events are the network services provided and the possible outcomes are the four network providers , and the outcomes $X_1, X_2, \ldots, X_n$, are called states and the number(s) $p_{ij}$ are called the transitional probabilities

For the use of Markov Chain analysis, the following assumptions were made: - a) subscribers do not shift from one provider (brand) in the future that reflect choices made in the past, b) the four network providers (brands) used in the research work are the only choices available for the subscribers, c) no subscriber left or entered Yola-Nigeria during the time period involved and iv) the switching probabilities remain constant over the period (stationary condition).

The records of the number of different network providers' selection made for the periods and their switching patterns to other providers in the preceding period will be presented as in the table below. The values are averages.

| Gains & Losses | MTN | Globacom | Zain | etisalat |
|---|---|---|---|---|
| MTN | $X_{11}$ | $X_{12}$ | $X_{13}$ | $X_{14}$ |
| Glo | $X_{21}$ | $X_{22}$ | $X_{23}$ | $X_{24}$ |
| Zain | $X_{31}$ | $X_{32}$ | $X_{33}$ | $X_{34}$ |
| Etisalat | $X_{41}$ | $X_{42}$ | $X_{43}$ | $X_{44}$ |
| | $T._1$ | $T._2$ | $T._3$ | $T._4$ |

The transition probabilities will then be

| | (A) MTN | (B) Globacom | (C) Zain | (D) etisalat |
|---|---|---|---|---|
| MTN | $p_{11}$ | $p_{12}$ | $p_{13}$ | $p_{14}$ |
| Glo | $p_{21}$ | $p_{22}$ | $p_{23}$ | $p_{24}$ |
| Zain | $p_{31}$ | $p_{32}$ | $p_{33}$ | $p_{34}$ |
| etisalat | $p_{41}$ | $p_{42}$ | $p_{43}$ | $p_{44}$ |
| | **1** | 1 | 1 | 1 |

## Markov Probability Model

The probability of provider switching from provider i to provider *j* is a conditional probability and can be represented by the transition matrix:

$P = p_{ij}$ *such that* $\sum_j^n p_{ij} = 1$, *i* refer to the number of provider. For instance*;* $p_{21}$ represents the probability of a change provider from Glocom (B) to MTN (A) in the next period of time. While $p_{ij}$ represents the probability of no change in provider for provider *i*. The matrix probability model used to explain the provider switching pattern is the Markov Chain with finite number of state {E}and a Markov process $\{x_i\}$with discrete time *t* such that $p_{ij}$ which represents the probability of the process moving from state *i* at time *t-1* to state *j* at time *t*. In this study, we assume that provider preference for type *i* in the next period *t* is only determined by the provider preference at the preceding period *t -1*. In other words, the history of provider preference before the time *t-1* does not influence the future provider preferences.

This is known as first order time dependency and statistically modelled as:

$$P(X_t = j/X_0, X_1, \ldots, X_{t-1} = i) = P(X_t = j/X_{t-1}) \text{ for } i,j \in E$$

Additionally, it is also assumed that the underlying variable that are responsible for the generation of provider preferences do not change overtime; such that the transition probability is stationary i.e.

$$P(X_t = i / X_{t-1} = i) = p_{ij}(t+1) = p_{ij}, \text{ for all } t.$$

Besides, the probability relation must also be satisfied, i.e.

$$\sum_{j=1}^{m} p_{ij} = 1, and\ 0 \leq p_{ij} \leq 1, \forall i.j \in E$$

The Markov process whose transition probabilities are not constant over time is said to be non-stationary or time-dependent and not applicable here.

## Estimating the Transition Probability Matrix (TPM) for the Provider Switching

The estimation of transition probability matrix (TPM) plays an important role in the study of Markov process (Thyagarjan and Bin Mohammed, 2005). If the distribution of a process is known, the estimation of the TPM

will be less difficult, otherwise the estimation procedure is quite tedious. For the data set that traces the movement from any given state to another state, then, the estimation procedure follows that of a multinomial distribution, that is $pij = \frac{n_{ij}}{n_i}$, where $n_{ij}$ is the number of times the process moves from state *i* to state *j* and $n_i$ is the number of time the process is in state *i.* Among the estimation techniques considered are Bayesian and non-Bayesian (maximum likelihood (MLE), weighted least squares, unweighted restricted least square, minimum absolute deviation and unrestricted least square estimator) but the estimation of TPM will be made using the unweighted restricted ordinary least square techniques (Catalina et al, 2009).

Following Catalina, Radu and Stuart, the first order conditional probability can be rewritten as:

$P(X_t = j) = \sum_{t=}^{m} P(X_t = j/X_{t-1})$

$= \sum P(X_{t-1} = i/\, X_t = j)P(X_{t-1} = i)$ or

$h_j(t) = \sum_{i=1}^{m} h_i(t-1)p_{i.j}$

where $h_j()$ and p() represent the probability.

If $h_j(t)$ is replaced by the observed proportion,$y_j(t)$, then the sample observation may be assumed to be generated by the following stochastic relation.

$y_j(t) = \sum_{i=1}^{m} y_i(t-1)p_{i.j} + u_j(t)$ or

$Y_j = X_j\, P_j + U_j$, and it is used to estimate the transition probability matrix with each relation giving the estimates of the probability of brand switching from type ***i*** to type ***j.***

$Y_j$ is a vector of proportion for provider j with (t – 1) components,

$X_j$ is a matrix of proportion with dimension of (t - 1) and m,

$P_j$ is a probability vector ($p_{ij}\ for\ all\ i \in E$, and

$U_i$ is a vector of random error.

Similarly, for all ***i*** and ***j*** the possible movement of the process are described in the following equation.

$$Y = XP + U$$

where $Y' = [Y_1', Y_2', \ldots, Y_m']$, $P' = [P_1', P_2', \ldots, P_m']$ $U' = [U_1', U_2', \ldots, U_m']$

and X is a block diagonal matrix with $X_1 = X_2 = \ldots = X_m$.

Thus, the above equation is used to estimate P by the ordinary least square (OLS) technique subject to the no negativity and equality constraints; i.e.,

$min[U'U = (Y - XP)'(Y - XP)]$, such that $GP = 1\ P \geq 1$

where $G = [I_1, I_2, \ldots, I_m]$ and $I_j$ is an identity matrix.

The optimization problem can be solved by the quadratic programming routine provided that $(X'X)$ is non singular. Under this formulation however, the error terms are uncorrected, thus $\boldsymbol{P}$ (the estimated $\boldsymbol{P}$) is an unbiased but consistent estimator of $\boldsymbol{P}$ (Mandansky , 1959).

The transition probabilities can be shown by a sequence for Markov process with states $X_1, X_2, X_3, X_4$ representing the probability variables with appropriate mapping and the matrix of transitional probabilities

$$P = \begin{pmatrix} P_{11} & P_{12} & P_{13} & P_{14} \\ P_{31} & P_{32} & P_{33} & P_{34} \\ P_{31} & P_{32} & P_{33} & P_{34} \\ P_{41} & P_{42} & P_{43} & P_{44} \end{pmatrix}$$

The matrix P is called a homogeneous transition or stochastic matrix because all the probabilities $P_{ij}$ are fixed and independent of time. The probabilities $P_{ij}$ must satisfy the condition for Markov chain;

$$P = \begin{cases} 1 & \text{for all i} \\ 0 & \text{for all i and j.} \end{cases}$$

## RESULTS AND DISCUSSION

Provider Total Rating in Terms of Marketing Mix Determinants

**Table 1**: Summary Scores of the Respondents' ranking of Providers

| | MTN | Globacom | Zain | etisalat |
|---|---|---|---|---|
| Tariff | 371 | 276 | 341 | 419 |
| Connectivity | 501 | 405 | 250 | 377 |
| Customer Services | 530 | 218 | 225 | 405 |
| Coverage | 545 | 278 | 225 | 405 |
| Free sms | 453 | 381 | 264 | 395 |

Number of useful Responses 141 *Source*: Field study

**Table 2**: Marketing Mix Determinant Index (Averages of Table 1 values ÷ 141)

| | MTN | Globacom | Zain | Etisalat |
|---|---|---|---|---|
| Tariff | 2.631 | 1.957 | 2.418 | 2.972 |
| Connectivity | 3.553 | 2.872 | 1.773 | 2.674 |
| Customer Services | 3.759 | 1.546 | 1.546 | 3.000 |
| Coverage | 3.865 | 1.972 | 1.596 | 2.872 |
| Free sms | 3.213 | 2.702 | 1.872 | 2.801 |

*Source*: Field study

Table2above shows the average summary of scores of the marketing variables. In terms of tariff, etisalat is the most preferred, connectivity is Globacom, customer services is MTN, which is also the most preferred network provider in terms of coverage and free sms.

Analysis of Variance was carried out on the values in Table 2 and the result is presented below:

**Table 3**: Analysis of Variance (ANOVA)

| Source of variation | Sum of Squares | Degrees of Freedom | Mean Squares | F-Ratio |
|---|---|---|---|---|
| Between Row Means | 0.178 | 4 | 0.0445 | 0.204 |
| Between Column Means | 7.214 | 3 | 2.405 | 11.032 |
| Error | 2.615 | 12 | 0.218 | |
| Total | 10.007 | 19 | | |

From the statistical table, we have:

$$F_{0.95,4,12} = 3.26 > F_{computed} = 0.204$$

$$F_{0.95,3,12} = 3.49 < F_{computed} = 11.032.$$

The result shows that the brand share of the network providers depends on the five marketing mix:- tariff, connectivity, customer services, coverage and free sms. This is consistent with what was observed earlier.

## Calculations of present and prediction of future equilibrium market share

**Table 4**: Brand Switching Tables (Gain and Losses

| Brand | No. of Subscribers in period one | Gains from A B C D | Losses from A B C D | No. of Subscribers in period one |
|---|---|---|---|---|
| A (MTN) | 198 | 0 4 3 5 | 0 1 0 1 | 208 |
| B (Globacom) | 97 | 3 0 10 5 | 1 0 3 2 | 110 |
| C (Zain) | 102 | 1 0 0 6 | 12 3 9 5 | 84 |
| D (etisalat) | 75 | 1 2 2 1 | 7 1 2 0 | 70 |
| Total | 472 | | | 472 |

*Source*: Field study

**Table 5: Matrix Probabilities of Gains and Losses recorded within the period**

| | A | B | C | D |
|---|---|---|---|---|
| A | $\frac{196}{198}$ | $\frac{4}{97}$ | $\frac{3}{102}$ | $\frac{5}{75}$ |
| B | $\frac{3}{198}$ | $\frac{91}{97}$ | $\frac{10}{102}$ | $\frac{6}{75}$ |
| C | $\frac{1}{198}$ | $\frac{0}{97}$ | $\frac{82}{102}$ | $\frac{1}{75}$ |
| D | $\frac{1}{198}$ | $\frac{7}{97}$ | $\frac{2}{102}$ | $\frac{65}{75}$ |

**Table 6: Transition Probability Matrix (TPM)**

| | A | B | C | D |
|---|---|---|---|---|
| A | 0.996 | 0.041 | 0.029 | 0.067 |
| B | 0.015 | 0.938 | 0.098 | 0.080 |
| C | 0.005 | 0.000 | 0.804 | 0.013 |
| D | 0.005 | 0.021 | 0.020 | 0.860 |

The transition probability matrix for the market share is given in Table 6.
It shows that the probability of a subscriber switching from Zain to Globacom cannot be made in one time period because of its zero probability. Probability of no subscriber switching is quite high for MTN (0,996), it is 0.938 for Globacom, for etisalat (0.860) and Zain (0.804).
The probability value of 0.996 signifies no network switching, 0.041 of switching to Globacom and 0.067 of switching to etisalat from MTN. Other transition probabilities are interpreted accordingly.

Solving the resulting homogeneous, we obtain the various equilibrium market shares as A (MTN) = 52.5%, B (Globacom) = 27.5%, C (Zain) = 15.3% and D (etisalat) = 4.7%.

## CALCULATION OF FUTURE PROBABLE MARKET SHARE AFTER PERIOD 1

| Transition Probabilities | | | | | | Period One Market Share | | Period Two Probable Market Share |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | | | | |
| A | 0.996 | 0.041 | 0.029 | 0.067 | | 0.53 | | 0.54 |
| B | 0.015 | 0.938 | 0.098 | 0.080 | X | 0.27 | = | 0.28 |
| C | 0.005 | 0.000 | 0.804 | 0.013 | | 0.15 | | 0.12 |
| D | 0.005 | 0.021 | 0.020 | 0.860 | | 0.05 | | 0.06 |

The above table shows that in period two ( one year after) the equilibrium market share of MTN, Globacom, Zain and etisalat networks will be 54%, 28%, 6% and 12% respectively.

Similarly, period three equilibrium market share are calculated using transition probabilities to multiply (X) period two probable market shares to obtain the following result.

| Transition Probabilities | Period Two Market Share | Period Three Probable Market Share |
|---|---|---|

$$\begin{array}{c} \\ A \\ B \\ C \\ D \end{array} \begin{array}{c} \begin{array}{cccc} A & B & C & D \end{array} \\ \begin{pmatrix} 0.996 & 0.041 & 0.029 & 0.067 \\ 0.015 & 0.938 & 0.098 & 0.080 \\ 0.005 & 0.000 & 0.804 & 0.013 \\ 0.005 & 0.021 & 0.020 & 0.860 \end{pmatrix} \end{array} X \begin{pmatrix} 0.54 \\ 0.28 \\ 0.12 \\ 0.06 \end{pmatrix} = \begin{pmatrix} 0.55 \\ 0.29 \\ 0.10 \\ 0.06 \end{pmatrix}$$

It then be seen from the table that in period two (one year later) the equilibrium market share of MTN, Globacom, Zain and etisalat networks will be 55%, 29%, 6% and 10% respectively.

Thus the model can predict the probable market share of the service providers at any given point in time for appropriate decision action. Any future value can always be forecasted provided that the transitional probabilities remain unchanged.

Often advertising campaign is designed to lure additional customers away from competitors; however some attempt to reduce customers is utilized in the Markov analysis of the first order as presented in this study. From such provider switching behaviour over time period of one year, a matrix of transition probabilities were calculated (a transitional probability being the probability that a subscriber would change from one service provider to another in the given period). With the aid of these transitional probabilities and this period , brand share predicted the future market share as follows:

| | MTN | Globacom | Zain | etisalat |
|---|---|---|---|---|
| Period 1 | 52.5% | 27.5% | 15.3% | 4.7% |
| Period 2 | 54% | 28% | 12% | 6% |
| Period3 | 55% | 29% | 10% | 6% |

The major upshot of this work is the simple analysis of the net gains and losses of customers to other competitors by the various service providers. With these types of information, the management can attempt to:

1. predict the share of the total market a provider will gain or loss his share of the market in future;
2. predict the rate at which a given provider will gain or loss his share of the market in future, and
3. analyze a provider's promotional effort in terms of what they are having on his gain and losses of his market share.

Optimum marketing mix can be reached and maintained only if no provider takes action which alters the matrix of transition probabilities. However, the optimum marketing mix or the equilibrium market shares of the providers so far are MTN 52.5%, Globacom 27.5%, Zain 15.4% and etisalat 4.7%

From the hypothesis tested, the following conclusions are reached; preference for any service provider is dependent on the five marketing mix variables: Tariff, connectivity, customer services, coverage and free sms.

It follows therefore that for effective market strategy, great care should be taken by companies in striking an optimum marketing mix. While a service provider that is high in the determinants is likely to capture the majority of subscribers, unfortunately such a provider is likely to spend more resources if the company is to break-even.

Conclusively, there is the need for companies to determine their product market share at fairly intervals to take cognisance of their competitive position and satisfying their customers marketing needs and wants.

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