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A 2^3 FACTORIAL DESIGN ON THE SUCCESS OF TELECOMMUNICATION SERVICE PROVIDERS AS A FUNCTION OF NETWORK POPULARITY, PERIOD OF THE DAY AND GENDER OF AGENT

[1]I.A.Iwok, [2]A.W.Akpan and [3]N.P.Akpan.

[1]Department of Mathematics/Statistics, University of Port-Harcourt,

P.M.B.5323, Port-Harcourt, Rivers State; Nigeria.

[2]Department of Mathematics/Statistics, University of Port-Harcourt,

[3]Department of Mathematics/Statistics, University of Port-Harcourt.

ABSTRACT

This study focused on the success of network service providers (MTN and AIRTEL) as a function of three factors: Network popularity, period of the day and Gender of Agent. High and low levels were assigned to the three factors based on data collected from two commercial telephone centres located at Ibom Plaza, Akwa Ibom State, Nigeria over a period of four days. The Analysis of Variance (ANOVA) technique was used to investigate the separate and combined effects of the three factors. The study revealed the existence of separate significant effects of the three factors. Also; except for Network popularity and Gender of Agent combined, there was no evidence of other interaction effects.

Keywords: 2^k factorial design, Contrast, Telecommunication and Analysis of variance.

INTRODUCTION/REVIEW

The word "success" according to Hawkins (2014) is a favourable outcome; attainment of one's aims, or of wealth, fame, or position. Success therefore, is synonymous with growth, increase or change in the positive direction. Telecommunication on the other hand can be defined as communication at a distance.

The first cell phone network with automatic roaming started in Saudi Arabia in September, 1981. In Nigeria, Econet wireless (now called Airtel) and MTN were the first mobile telecommunication operators licensed by Nigerian communications commission (NCC) to provide telecommunication services, and both networks rolled out their services in August 2001.

As soon as they started operation, the race for subscribers began with MTN announcing that it had 22,000 subscribers while Airtel was ahead by 8000 subscribers (Adam, 2005). This race continued and Airtel seemed to have higher figures all through the year 2001. Airtel was the first to reach 150,000 subscribers in December 2001. By March 2002, it hits 300,000 subscribers. Surprisingly, during the first anniversary in August 2002, MTN had a slight edge over Airtel (MTN – 505,000 ; Econet – 450,000 subscribers). The rapidity of telecommunication growth and intensity of development in different parts of the world are affected by a variety of factors, among which are: scientific, economic status, culture, degree of industrialization, size of market, linguistic and dialectic diversities, physiography, type of

ownership, managerial enterprise, political and military considerations. Although, the qualitative influence of these factors upon the development of the telecommunication industry can frequently be observed, no specific weight has so far been attached to them.

According to Farley (1975), telephone was initially developed using the technology designed for the telegraph. It started out as a manually switched network. Alexander Bell patented the telephone in 1976, though there remains some dispute about whether the inventor's glory should really go to Elisha Grey, whose similar patent was only filed an hour or so later (Northcott, 1983).

The first digital cellular phone call was made in the United States in 1990. In 1991, the first commercial GSM network opened in Europe.

The Global System of Mobile Communication (GSM) arrived Nigeria in 2001 with the successful conduct of the Digital Mobile License Auction held at the NICON Nuga Hilton Hotel, Abuja; where three companies: Communications Investment Limited (CIL), Econet Wireless Limited (now Airtel) and MTN Communications Nigeria Limited emerged as winners (Sun, 2006). However, by April 2001, the Nigerian Communication Commission, NCC cancelled the licensed issued to CIL for failing to pay the balance of it's license fee on the given date.

Over the past thirteen years, Airtel and MTN Nigeria has sustained its position in a telecoms behemoth with innovative products and marketing delivery resulting in a soaring subscriber base.

Because of the importance of communication to humanity, the study of the factors affecting the success of MTN and AIRTEL as the leading telecommunication operators in Nigeria becomes necessary. This work considers three factors: Popularity of Network, period of the day and gender of agent.

The popularity of network service providers evidenced in extensive coverage and good quality service delivery results in huge monthly turnover of profit to the providers. Subscribers are switching from one network to another, apparently, abandoning a bad network for a better one. This is a pointer to the fact that, the popularity of a network could affect the patronage it attracts and by implication, its success.

The gender of the agent attending to customers in a commercial mobile telephone call centre like in most other business may affect the success of the business. One school of thought argues that, women are better patronized than men, probably, because of the traditional female strengths such as creativity, organizational skills, attention to detail, patience and pleasure in exceeding the expectations of clients or may be for some other non-business related reasons. Yet others believe that gender does not matter in business success.

Period of the day (morning, afternoon, evening) may have effect on some business ventures with more clients turning up in certain periods than others. The number of calls made may vary between the different periods of the day but to what extent can we say that the period of day impacts on the success of a mobile telecommunication service provider?

These factors if properly understood could provide useful tools for the provision of better telecommunication services. This could be possible if there is sufficient research evidence regarding the popularity of the different mobile telecommunication networks and the influence exerted by the gender of the agent as well as the period of day on the overall success of the telecommunication industry.

In consideration of the great importance of communication to man, it is important that these factors be investigated on the basis of their separate and combined effects on the success of MTN and AIRTEL An appropriate tool that best fit such investigation is the design and analysis of experiment technique.

An experiment according to Adeola (2013) is a well defined action which leads to a well defined result. The action could be a process of observation or measurement, which for analytical purpose could lead to generating data under certain variables that are of interest to the researcher.

Experiments are carried out by investigators in all fields of study either to discover something about a particular process or to compare the effects of several conditions on some phenomena. It is a test or series of tests in which purposeful changes are made to an input variable of a system to examine and identify the reasons for the changes in the output variables (Montgomery, 2001). Thus, the design and analysis of experiment entail planning, conducting of experiment to generate data, and data analysis with a view to drawing conclusions from the analysis (Fisher, 1955). It is on this platform that this work is based.

METHODOLOGY

Definition of Relevant Terms

2^k Factorial Design

2^k factorial design is an experimental design method which involves two or more factors each varied at two levels. The k denotes the number of factors while, the base, 2 is the number of levels.This work intends to employ this method using analysis of variance (ANOVA) technique.

Factor

A factor refers to a general type or category of treatments under study. The three factors used in this work are:

Factor A = Mobile Network
Factor B = Period of the day and
Factor C = Gender of Agent.

Treatments

The levels of the factors under investigation are known as the treatments. The levels of the factors may be arbitrarily called "low" and "high". The low and high levels of the factors could as well be represented by negative (-) and positive (+) signs or "0" and "1" in some cases. The treatments combinations are represented by the lower case letters.

The eight (8) treatment combinations in the 2^3 factorial design considered in this work are: (1), a, b, ab, c, ac, bc, abc, where,

Experimental Units

Experimental units are those objects or elements on which the experiment is performed. Thus, as far as this work is concerned, the people who make calls at the two business centres constitute the experimental units.

Replication

Replication is the repetition of the basic experiment under identical experimental circumstances to improve the precision of an estimate and provide a proper estimate of the error variance, $V(e_{ijkm})$. The experiment in this research work is replicated over a period of four days.

Effect

An effect is a reflection of a difference amongst population means. Thus, we define the effect of treatment j (α_j) as the deviation of the mean of population j (μ_j) from the grand population mean μ. That is $\alpha_j = \mu_j - \mu$.

The Model

First we shall assume that the data for this research comes from this model.

$$y_{ijkm} = \mu + \alpha_i + \beta_j + \gamma_k + (\alpha\beta)_{ij} + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta\gamma)_{ijk} + \delta_m + \varepsilon_{ijkm}$$

$i = 1, 2, \dots, I;\ j = 1, 2, \dots, J;\ k = 1, 2, \dots, K;\ m = 1, 2, \dots, M$

Where,

α_i = the ith treatment effect corresponding to factor A.

β_j = the jth treatment effect corresponding to factor B

γ_k = the kth treatment effect corresponding to factor C

δ_m = the mth replicate effect

μ = the grand population mean

$(\alpha\beta)_{ij}$ = the ij^{th} effect of AB interaction

$(\alpha\gamma)_{ik}$ = the ik^{th} effect of AC interaction

$(\beta\gamma)_{jk}$ = the jk^{th} effect of BC interaction

$(\alpha\beta\gamma)_{ijk}$ = the ijk^{th} effect of ABC interaction

ε_{ijkm} = the normally and independently distributed random error component.

THEORETICAL BACKGROUND

We consider the three factors A, B and C of interest. Let the two levels be denoted by + and – or 1 and 0 ; where + or 1 represents high level and – or 0 represent low level.

Since we are operating on a 2^3 factorial design, it follows that, we have three factors at two levels each and hence, there are $2^3 = 8$ treatment combinations. The treatment combinations are: (1), a, b, c, ab, ac, bc, abc where the presence of each small alphabet represents the high level of the factor and the absence of any small alphabet represents the low level of the factor. (1) represents all three factors at low level.

The effect of a factor refers to a reflection of the difference amongst population means. Thus, for the 2^3 design we have $2^3 - 1 = 7$ effects which include A, B, C, AB, AC, BC, ABC.

Contrasts

The treatment combinations for each of the effects are referred to as contrasts. Thus,

A – Contrast = a + ab + ac + abc – (1) – b – c – bc
B – Contrast = b + ab + bc + abc – (1) – a – c – ac
C – Contrast = c + ac + bc + abc – (1) – a – b – ab
AB – Contrast = (1) + ab + c + abc – a – b – ac – bc
AC – Contrast = (1) + ac + b + abc – a – c – ab – bc
BC – Contrast = (1) + bc + a + abc – b – c – ab – ac
ABC – Contrast = a + b + c + abc – (1) – ab – ac – bc

Sum of Squares

Total sum of squares (SS_T) = $\sum\sum\sum\sum y^2_{ijkm} - T^2/N$; where $T = \sum\sum\sum\sum y_{ijkm}$
and N = Total number of observations.

In the 2^3 design with n replicates, the sum of squares (SS) for any effect (Q, say) is

$$SS_Q = \frac{[\text{contrast}(Q)]^2}{IJKn}$$

The error sum of squares (SS_E) is obtained by subtraction. That is,

$$SS_E = SS_T - SS_A - SS_B - SS_C - SS_{AB} - SS_{AC} - SS_{BC} - SS_{ABC}$$

Assumptions

The following assumptions are used in this study:

(i) The random error term e_{ijk} is normally and independently distributed with zero mean and constant variance.
(ii) All the populations involved are normal
(iii) All the populations have the same variances
(iv) The samples are independently chosen.

Means Squares

The Mean Squares (MS) for the effects and Error is obtained by dividing the sum of squares by the corresponding degrees of freedom.

DATA ANALYSIS, RESULTS AND INTERPRETATION

Data Preparation

The data collected from the two commercial telephone centres for four days is tabulated on the basis of two levels of each of the three factors as shown in table 3 and summarized in tables 4, 5 and 6.

The data consist of number of telephone calls made to MTN and AIRTEL Networks by male and female agents during the morning and afternoon periods, taken over a period of four days. These data were summarized in three tables on the basis of two levels of the three factors (see tables 4, 5and 6).

Having assigned suitable levels to the three factors, the original data (see appendix: table 3) was transformed to allow for the application of 2^3 factorial design technique, as presented in table 1 below.

Table 1 Low and High Levels of the Three Factors (Network, Period of The Day and Gender of Agent).

	PERIOD OF THE DAY (B)			
	MORNING (-)		AFTERNOON (+)	
	GENDER (C)		GENDER (C)	
NETWORK (A)	MALE (-)	FEMALE (+)	MALE (-)	FEMALE (+)
MTN (-)	21 15 18 17 (1) = 71	24 28 27 40 c = 119	29 29 25 23 b = 106	49 42 42 48 bc 106
CELTEL (+)	26 23 34 25 a = 108	35 64 72 50 ac = 221	30 34 34 35 ab = 133	102 82 100 51 abc = 335

Based on the methodology described above, the following computations are obtained:

Treatment Combinations:

(1) = 71, a = 108, b = 106, c = 119, ab = 133, ac = 221, bc = 181 and abc = 335.

A – contrast = 240, B – Contrast = 236, C – contrast = 438, AB – contrast = 42,

AC – contrast = 192, BC – contrast = 116, ABC – contrast = 62

The sum of squares for the three factors and their interactions are displayed in the ANOVA table (table 2) below.

Table 2 Anova Table

Source of Variation	Sum Of Square	Degrees of Freedom	Mean Squares	F-Value
A	1800	1	1800	10.31
B	1740.5	1	1740.5	9.97
C	5995.125	1	5995.125	34.34
AB	55.125	1	55.125	0.32
AC	1152	1	1152	6.60
BC	420.5	1	420.5	2.41
ABC	120.125	1	120.125	0.69
Error	4189.5	24	174.5625	
Total	15472.875	31		

Hypothesis and Results

Since the calculated F's of the factors A, B and C in the ANOVA table are greater than their critical values at 5% level of significance; we conclude that Network (A), period of the day (B) and Gender of Agent (C) have separate effects on the success of MTN and AIRTEL. Except for AC, the two factor interaction effects AB and BC were found to be insignificant. Also, the calculated F-value of the three factor interaction, $F_{ABC} = 0.69$ was found to fall below the critical F-value, $F_{0.05,\ 1,\ 24} = 4.26$ (that, is $F_{ABC} < F_{0.05,\ 1,\ 24}$). Hence, we cannot reject the null hypothesis, at 5% level of significance. Thus, there is not enough evidence to infer that, the interaction of Network(A), period of the day(B) and Gender of Agent(C) has effect on the success of MTN and AIRTEL.

Summary

This work is an attempt to investigate the separate and interaction effects of the popularity of network, period of the day and Gender of agent on the success of MTN and AIRTEL with particular reference to Uyo metropolis, Akwa Ibom State, Nigeria.

The opinions of other writers were reviewed while data were collected from two commercial telephone centres in Ibom Plaza, Uyo, Akwa Ibom State. The data comprised the number of calls made to MTN and AIRTEL networks in the morning (7am to 12pm) and afternoon (12pm to 5pm) periods by the male and the female agent.

The experiment was replicated over a period of four days to improve the precision of our estimates and minimize the error variance.

The Analysis of Variance (ANOVA) technique was used to test the seven hypotheses developed in line with the objective of the research. The test resulted in the rejection of the hypotheses of no separate effect of the three factors and the hypothesis of no interaction effect of Network popularity and Gender of Agent and confirmed that, the three factors separately affect the success of MTN and AIRTEL whereas, only the interaction of network and Gender of agent had a combined effect. All other interactions of the factors were found to have no effect on the success of MTN and AIRTEL.

Conclusion

From the findings of this study, we conclude that, the three factors – Network popularity, period of the day and gender of agent separately affect the success of MTN and AIRTEL and by extension, the success of other mobile telecommunication service providers. That is, the success of a mobile telecommunication operator in a given community at any given time depends on the extent of its network coverage and quality of service at that time, period of the day and gender of the agent.

We further conclude that, the interaction of network popularity with Gender of agent has effect on the success of the two mobile telecommunication operators. This implies that, by using an agent with good customer relation, a mobile operator with wide network coverage and quality service delivery is bound to be successful.

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Author Profile

DR. IBEREDEM ANIEFIOK IWOK(I.A.Iwok) He is a Ph.D holder in Statistics.He is a Senior Lecturer, Department of Mathematics/Statistics, University of Port Harcourt,Nigeria.

DR. NSIKAN PAUL AKPAN (N.S. Akpan) He is a Ph.D holder in Statistics.He is Lecturer , Department of Mathematics/Statistics, University of Port Harcourt, Nigeria.

ABRAHAM W. AKPAN(A.W.Akpan) He is a Masters Degree student in Statistics; University of Port Harcourt.He is a Lecturer, Heritage Polytechnique, Akwa Ibom State.

APPENDIX

Table 3 Number of phone calls made to MTN and AIRTEL Networks in the Morning and Afternoon periods by Male and Female Agents for Four Days.

DAY	MTN NETWORK				CELTEL NETWORK				TOTAL
	MORNING		AFTERNOON		MORNING		AFTERNOON		
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	
1	21	24	29	49	26	35	30	102	316
2	15	28	29	42	23	64	34	82	317
3	18	27	25	42	34	72	34	100	352
4	17	40	23	48	25	50	35	51	289
TOTAL	71	119	106	181	108	221	133	335	1274

Table 4 Number of Calls Made To MTN and AIRTEL Networks For 4 Days.

	NETWORK		
DAY	MTN	CELTEL	TOTAL
1	123	193	316
2	114	203	317
3	112	240	352
4	128	161	289
TOTAL	477	797	1274

Table 5 Number of Calls Made During The Morning and Afternoon Period For 4 Days.

	PERIOD OF DAY		
DAY	**MORNING**	**AFTERNOON**	**TOTAL**
1	106	210	316
2	130	187	317
3	151	201	352
4	132	157	289
TOTAL	519	755	1274

Table 6 Number of Calls Made By Male and Female Agents For 4 Days

	GENDER OF AGENT		
DAY	**MALE**	**FEMALE**	**TOTAL**
1	106	210	316
2	101	216	317
3	111	241	352
4	100	189	289
TOTAL	418	856	1274