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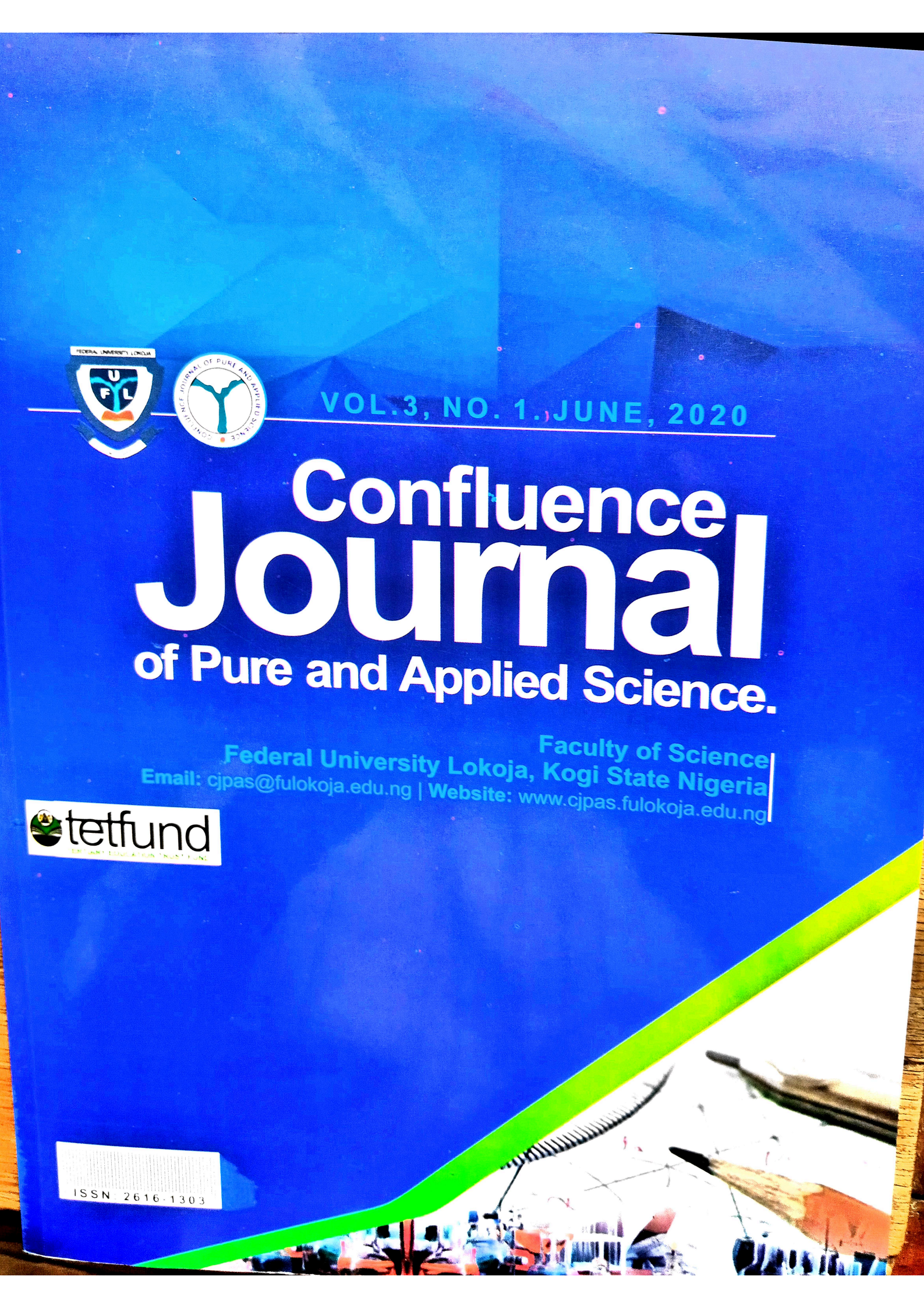

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APPLICATION OF MATRIX ALGEBRA IN MODELING CONSUMERS' PREFERENCE OF SATELLITE TELEVISIONS AMONG ACADEMIC STAFF OF A UNIVERSITY

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ABSTRACT
The work focused on the use of matrix operations in forecasting what consumers preference over Satellite Television Companies would be in time to come among the Academic Staff of the School of Physical Sciences in Federal University of Technology Minna. The formulated problem yielded results that shows preference for DStv, GOtv, StarTimes, Strong, and None Satellite TVs respectively to be 23.9%, 20.4%, 21.2%, 21.2% and 13.3%. Further analysis in the study can help the satellite companies see the population that is changing from one TV to another giving their various reasons such as subscription fee, better network, cost of purchase, available cost and prestige.

Keywords: *Forecasting, Matrix Algebra, Consumer Preference, Satellite Television, Transition Probabilities*

1.0 INTRODUCTION
The success of any business venture depends largely on the attitude of customers towards the goods and services produced by the business organization since it is believed that most businesses are set up because of the costumers or consumers. Therefore it is of paramount importance for businesses and companies to be able to know or tell the preference and taste of their customers so as not to lose their valued customers but to stay in business and maximize profit. According to Schiffman and kanuk (2004, 2011),Salinget *al* (2016); consumers' behavior encompasses all of the behavior that consumers display in searching for, purchasing, using, evaluating and disposing of products and services that they expect will satisfy their needs.
On the basis of this definition, we can conclude that consumers' behavior is the study of consumers regarding what they buy, when they buy, from where they buy, how frequently they buy and how frequently they use a certain product.

Digital Satellite Companies have been around in Nigeria for quite a while now. Starting with the oldest of them - Strong decoder in 1988, to others such as DStv in 1996, StarTimes in 2010, GOtv in 2011 and other Satellite Televisions (TV). There is no doubt that digital satellite TV has brought a revolution in the television watching habits of Nigerian viewers, making most people switch from digital terrestrial TV to digital satellite TV. This is as a result of more interesting contents, clarity and other personal taste of the viewers (GOtv, 2011; StarTimes, 2011; Wikipedia, 2014).

Matrix algebra is a topic in linear algebra which has a quite number of applications in both sciences and engineering. In general, since it has a lot of applications in life both in modeling some real life problems and in other mathematical aspects of study, it will be the main focus of this research work.The workfocuses on the use of matrix operations in order to make forecasts of what consumers preference over satellite companies would be in time to come, taking the staff population of School of Physical Sciences (SPS), Federal University of Technology (FUT) Minna as a case study.
The people of Babylon were the earliest known people who knew how to solve a simple

2.0 MATERIALS AND METHOD
Our method of solution follows two models: Consumer Preference Prediction which is the forecasting model among the academic staff of

SPS, FUT Minna and an economic systemof the satellite Tvs.

2.1 The General Procedure of the Customer's Preference Model

Matrix algebra and its applications as earlier mentioned,can be employed in modeling certain kinds of situations, of which one of them is the consumers preference model or forecasting models. These models basically compare transitions probabilities over a given period of time, say a year and gives possible forecast of what consumer preference is likely to be in time to come, based on calculations using basic matrix algebra operations on the transition probabilities.

2.1.1 The General Schematic Diagram of the Transition Probabilities

The matrix of transition probabilities (transition matrix) is gotten from a general schematic diagram shown in Figure 1.

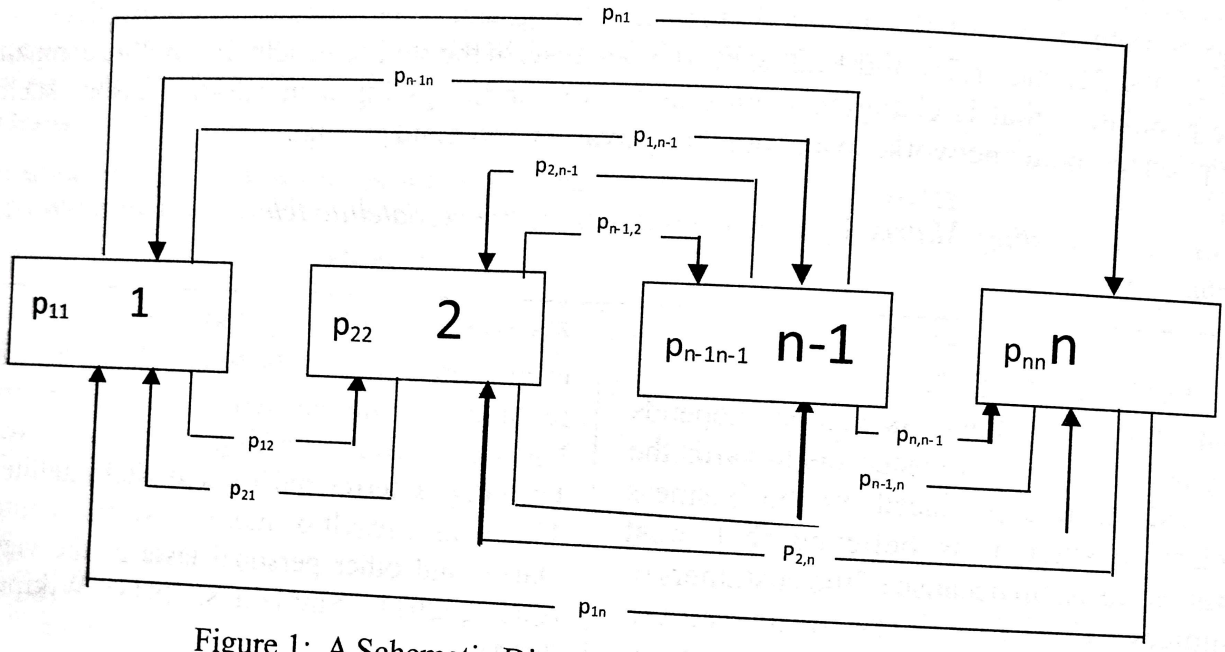

Figure 1: A Schematic Diagram of the Transition Probabilities

The above schematic diagram, takes into account n number of companies rendering a good or a service to a given set of people (population), say, a city. In the case of n companies, it implies that every individual in a given population or a sample is a consumer to at least one of the companies at a given point in time, which may not always be the case, hence we consider n - 1 companies, where either an individual is a customer to either 1, 2, ..., n - 1, n which in this case will signify "none". We can say in a general case, that n represents n states of customers' patronage.

The schematic diagram in Figure 1 is gotten from a given set of data, which will be tabulated and put into a schematic diagram, before representing it in a transition matrix.The arrow from *1*to*2*and *2*to*1* represent the transition of customers preference from state 1to state 2 over the period of time, so also does the arrows from 2 to 3, 3 to 4,... n-1 to n, and other arrows shown in the diagram. The values in the rectangles 1, 2, ..., n - 1, n represent the transition probabilities that have remained constant over the period of time being considered.

2.1.2Representing Transition Probabilities Data (Transition matrix)

Let T represent the transition matrix. Then the general matrix representing the transition probabilities gotten from the schematic diagram above will be represented thus.

$$T = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1n-1} & p_{1n} \\ p_{21} & p_{22} & \cdots & p_{2n-1} & p_{2n} \\ \cdots & \cdots & \ddots & \cdots & \cdots \\ p_{n-1,1} & p_{n-1,2} & \cdots & p_{n-1n-1} & p_{n-1n} \\ p_{n,1} & p_{n,2} & \cdots & p_{n,n-1} & p_{nn} \end{bmatrix}$$

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The above matrix is an $n \times n$ matrix. This is because we are considering n number of states of customer's preference. Generally speaking, as the states gets higher in number, that is, $m > n$, so also does the transition matrix. The matrix as seen above and from the schematic

diagram, the entries represent the transition probabilities, of which the diagonal entries $p_{11}, p_{22}, p_{33}, \ldots, p_{n-1n-1}, p_{nn}$ are the transition probabilities of customers that remained unchanged over the period of time being considered.

2.1.3 Customer Vector

The customer vector representing the current customers' population of the n states of customers' preference is given as:

$$X = \begin{bmatrix} x_{11} \\ x_{22} \\ \vdots \\ x_{n-1n-1} \\ x_{nn} \end{bmatrix}$$

2.2 DataCollection

The data for this research was obtained in November 2018. A questionnaire was designed as an instrument of data collection (see appendix) for the digital satellite television preference among the selected sample. Data on staff population was obtained by personal interview with the Head of Departments.

Table 1: Staff Population by Departments

Department	Academic Staff Population
Mathematics	25
Statistics	18
Physics	26
Chemistry	28
Geology	24
Geography	27
Total	**148**

2.3 Sample Size for the Research

Using the table of sample size by krejcie& Morgan (1970), a sample of 113 academic staff were served with questionnaire out of the population of 148 academic staff of SPS, FUT Minna to collect data on the state of preference.

Table 2: Raw Data from Questionnaire

Question Number	Yes	No	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] Fee	[illegible] Network	[illegible] Number	[illegible] Channels	[illegible]	[illegible]
Q1.No. that owns satellite television	46	17										
Q2. No. that subscribes to cognizo satellite television			46	10	30	29						
Q3. No. that first acquired a particular satellite television			21	22	28	16						
Q4. No. that frequently use a particular television			27	23	26	29						
Q5. No. that switched/changed complaints from a particular satellite television to another	56	40										
Q6. a. No. that changed from a particular satellite television			13	12	18	17						
b. No. that changed to a particular satellite television			9	18	15	14						
Q7. Reason for change from one satellite television to another							21	13	18	22	5	3

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Table 3:Movement from one State of Preference to another.

CHANGE FROM	CHANGE TO				
	DStv	GOtv	StarTimes	Strong	None
DStv	83	6	3	4	17
GOtv	3	73	4	7	26
StarTimes	3	6	74	5	25
Strong	3	6	8	66	30
None	21	22	24	31	15

The diagonal elements in table 3 were obtained by subtracting the sum of all other column elements from 113 (sample size) since the column total must add up to 113. Take DStv for example, 3+3+3+21=30; 113-30=83, which is the number that did not change from DStv to another TV. Table 4 shows the change in customers' preference in percentages.

Table 4: Percentage Representation of Table 2.

CHANGE FROM	CHANGE TO				
	DStv	GOtv	StarTimes	Strong	None
DStv	73.75%	5.31%	2.65%	3.54%	15.04%
GOtv	2.65%	64.60%	3.54%	6.19%	23.01%
StarTimes	2.65%	5.13%	56.49%	4.45%	22.12%
Strong	2.65%	5.13%	7.08%	58.40%	26.54%
None	18.58%	19.47%	21.24%	27.43%	13.27%

3.0 RESULTS AND DISCUSSIONS.

3.1 Presentation of Results

The matrix formulation follows the schematic diagram in figure 2. The results from computations are presented in this section.

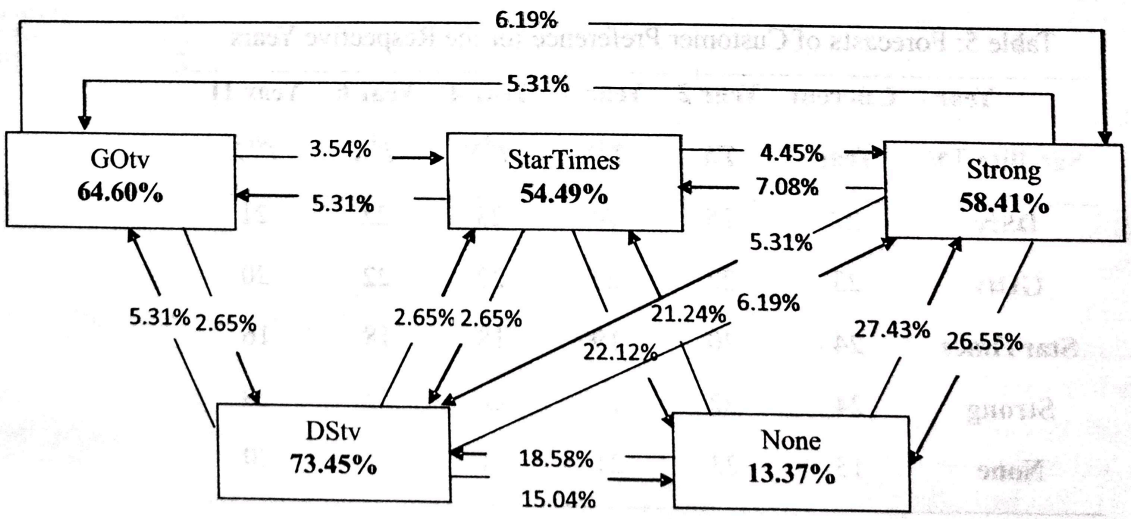

Figure 2: Schematic Diagram of the Problem

The matrix representing Figure 2is shown below:

$$T = \begin{bmatrix} 73.45\% & 2.65\% & 2.65\% & 2.65\% & 18.58\% \\ 5.31\% & 64.60\% & 5.31\% & 5.31\% & 19.47\% \\ 2.65\% & 3.54\% & 56.49\% & 7.08\% & 21.24\% \\ 3.54\% & 6.19\% & 4.45\% & 58.41\% & 27.43\% \\ 15.04\% & 23.01\% & 22.12\% & 26.55\% & 13.27\% \end{bmatrix}$$

Converting the percentages to probabilities yields

$$T = \begin{bmatrix} 0.7345 & 0.0265 & 0.0265 & 0.0265 & 0.1858 \\ 0.0265 & 0.6460 & 0.0531 & 0.0531 & 0.1947 \\ 0.0265 & 0.0354 & 0.5649 & 0.0708 & 0.2124 \\ 0.0354 & 0.0620 & 0.0445 & 0.5841 & 0.2743 \\ 0.1504 & 0.2301 & 0.2212 & 0.2655 & 0.1337 \end{bmatrix}$$

The vector representing the current state of customers' preference is given below

$$X = \begin{bmatrix} 27 \\ 23 \\ 24 \\ 24 \\ 15 \end{bmatrix}$$

In order to get the customer's projection in the next one year, we find the matrix TX which is given as

$$TX = \begin{bmatrix} 0.7345 & 0.0265 & 0.0265 & 0.0265 & 0.1858 \\ 0.0265 & 0.6460 & 0.0531 & 0.0531 & 0.1947 \\ 0.0265 & 0.0354 & 0.5649 & 0.0708 & 0.2124 \\ 0.0354 & 0.0620 & 0.0445 & 0.5841 & 0.2743 \\ 0.1504 & 0.2301 & 0.2212 & 0.2655 & 0.1337 \end{bmatrix} \begin{bmatrix} 27 \\ 23 \\ 24 \\ 24 \\ 15 \end{bmatrix} = \begin{bmatrix} 25 \\ 22 \\ 20 \\ 22 \\ 23 \end{bmatrix}$$

The result of TX computation above indicates that, on the basis ofthe current transition probability matrix T, the expected customers' projections for next year will be 25persons subscribing to DStv, 22 to GOtv,20 to StarTimes, 22 to Strong and 23 to None.

Assuming the transition matrix remains unchanged; the customers' projections in the next third and subsequent years would similarly be computed by obtaining T^2X, T^3X, ... T^nX. where n is the $n^{th}+1$ year of projection. Table 5 shows the numerical projections for the respective years.

Table 5: Forecasts of Customer Preference for the Respective Years

Year	Current	Year 2	Year 3	Year 4	Year 6	Year 11
Satellite TV	Year	TX	T^2X	T^3X	T^5X	$T^{10}X$
DStv	27	25	24	23	22	21
GOtv	23	22	22	22	22	20
StarTimes	24	20	19	18	18	16
Strong	24	22	22	22	22	20
None	15	23	21	21	21	20

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Table 6: Analysis on Reasons for Changing from one Satellite TV to Another.

Mode of change		Reason for Change						
From	To	Subscription Fee	Better Network	Cost of Purchase	Available Channels	Prestige	Others	Unspecified
DStv	GOtv	4	1	-	-	-	-	1
	StarTimes	1	-	1	-	-	-	1
	Strong	-	-	1	-	-	-	3
GOtv	DStv	-	-	-	-	1	-	1
	StarTimes	1	-	-	-	-	-	3
	Strong	3	-	-	-	-	-	5
StarTimes	DStv	-	3	-	2	-	-	-
	GOtv	2	1	-	3	-	-	1
	Strong	-	-	-	-	-	-	5
Strong	DStv	-	1	-	1	1	-	1
	GOtv	1	2	-	2	-	1	1
	StarTimes	1	-	3	3	-	-	3

Table 7: Analysis on Reasons for Maintaining Choice of Satellite TV.

	Subscription Fee	Better Network	Cost of Purchase	Available Channels	Prestige	Others	Un specified
DStv	-	3	-	6	2	-	6
GOtv	5	2	3	4	-	-	3
StarTimes	4	-	2	-	-	1	5
Strong	3	-	-	1	-	-	6

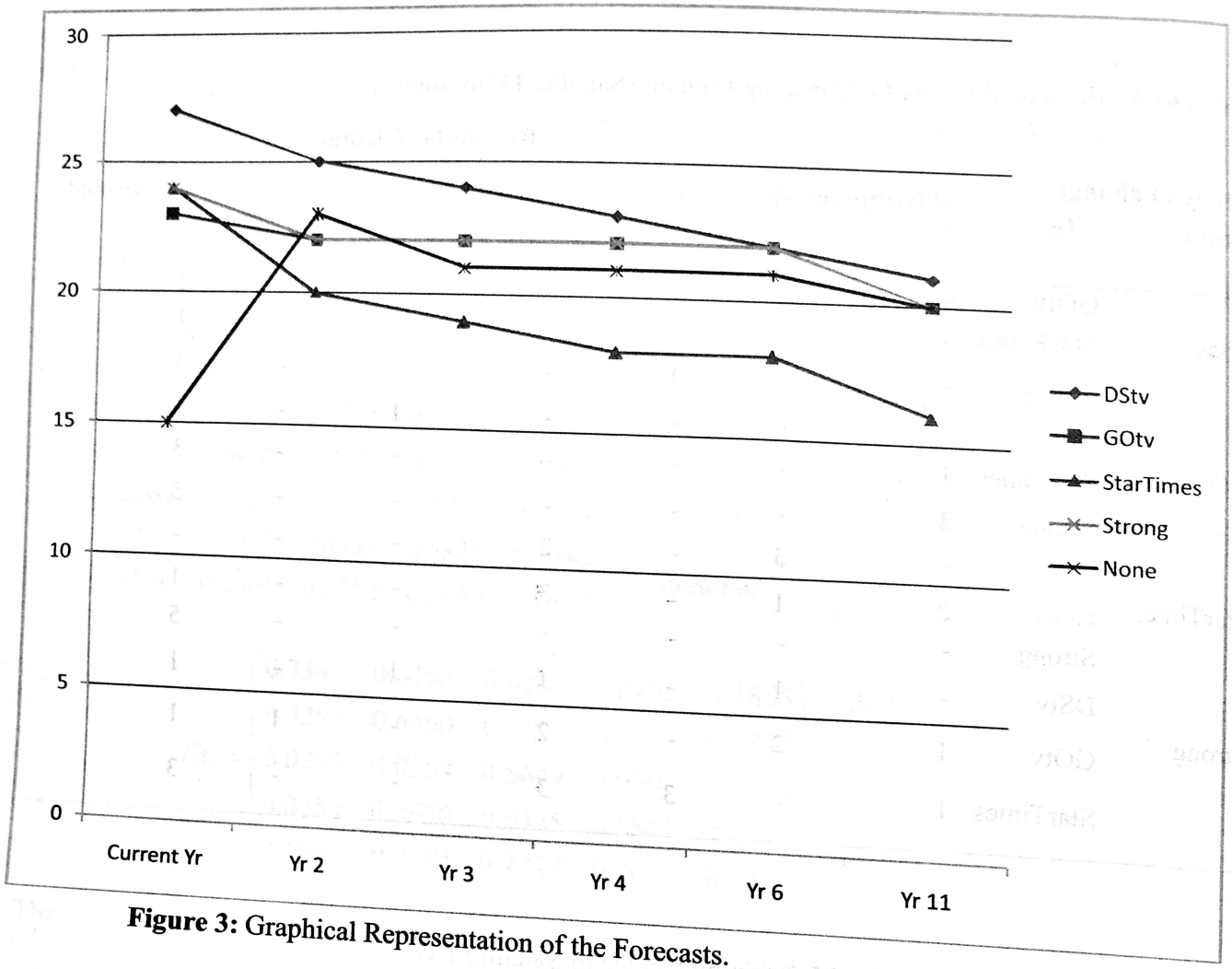

Figure 3: Graphical Representation of the Forecasts.

3.2 Discussion of Results

The result presented in table 5 is the projected number of persons who prefer DStv, GOtv, StarTimes, Strong, and None Satellite TVs in the respective years. It will be observed that, in the current year, *27, 23, 24, 24 and 15* persons from the sample of 113 persons respectively preferred DStv, GOtv, StarTimes, Strong, and None Satellite TVs. These represent 23.9%, 20.4%, 21.2%, 21.2% and 13.3% of the total population of the academic staff of SPS respectively for DStv, GOtv, StarTimes, Strong, and None Satellite TVs. It can be observed from the graphical illustration in figure 2 that, except for "None"which increased sharply in the current year and began to decrease in the second year, all other TVs are experiencing a downward turn right from the current year. DStv in particular is showing that, if measures are not quickly taken, the downward trend may continue without any slight upward movement until after the tenth year. There are indications in the trend of preference for GOtv, StarTimes and Strong that, although they may try to gain stability, after the sixth year the downward trend may be faster except if there are interventions. The population of those using none of the DStv, GOtv, StarTimes and Strong will increase sharply from the current year till the second year when it will begin to decrease. There are indications that this decrease of the "None" category will continue especially with the migration to the digital TV by Nigeria Television Authority (NTA).

Table 6 shows the analysis for various reasons people prefer/change from one TV to another. These reasons range from subscription fee, better network, cost of purchase, available cost to prestige and so on. It can be seen that 3.5% and 0.9%of the population changed from DStv to GOtv and StarTimes respectively because of

subscription fee. Also, 0.9% and 2.7% of the population changed from GOtv to StarTimes and Strong respectively because of subscription fee. 2.7% and 0.9%of population changed from StarTimes to DStv and GOtv respectively because of Better network. 1.8% and 2.7%of population changed from StarTimes to DStv and GOtv respectively because of available channels. There were unspecified reasons also for changing from one TV to another.

It can be observed from table 7 that while nobody maintained or preferred the use of DStv because of subscription fee; 4.4%, 3.5% and 2.7% of the population maintained the use of GOtv, StarTimes and Strong respectively for the reason of subscription fee. 2.7% and 1.8% maintained the use of DStv and GOtv respectively because of better network. 5.3% and 3.5% maintained the use of DStv and GOtv respectively because of available channels while 1.8% maintained DStv for the reason of prestige.

4.0 CONCLUSION

The percentages of the populations changing/preferring one satellite TV to another because of several reasons ranging from subscription fee, better network, cost of purchase, available cost to prestige must be a serious point of concern to the satellite TVs that operate in the country. Measures must be taken by all the studied TVs to avoid the downward movement of trend as can be observed from the graphical illustration in figure 2 that, except for "None Satellite TV" which increased sharply in the current year and began to decrease in the second year, all other TVs are experiencing a downward turn right from the current year. DStv in particular is showing that, if measures are not quickly taken, the downward trend may continue without any slight upward movement until after the tenth year. There are indications in the trend of preference for GOtv, StarTimes and Strong that, although they may try to gain stability, after the sixth year the downward trend may be faster except if there are interventions. The population of those using none of the DStv, GOtv, StarTimes and Strong will increase sharply from the current year till the second year when it will begin to decrease. There are indications that this decrease of the "None" category will continue especially with the migration to the digital TV by Nigeria Television Authority (NTA).

It is recommended that, DStv in particular should revisit its subscription fee to attract more customers. Furthermore, a larger population should be considered for this research to have a more generalization and to cover other Satellite Tvs.

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