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Factors Affecting the Perception of Electricity Customers on the Problems of Electricity Distribution in Delta State, South-South Nigeria

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Abstract *– The perception of customers on the service delivery of electricity distribution companies (DISCOs) is a critical feedback mechanism in the evaluation of the services of DISCOs. Customers are at the receiving end of the DISCOs and should be able to say if a company is offering good and acceptable services or not. In this paper, we consider the factors that affect the perception of customers on the services of DISCOs, especially on the problems associated with electricity distribution in Delta State, South-South Nigeria. The methodology involves the use of correlation analysis and regression models. The results show that customers' perception on a particular performance metric can affect their views on the others. Also, the number of dependents in a household and average monthly bills of customers proved to be critical factors in the perception of electricity customers. The data analysis was done with IBM SPSS Version 23 and Microsoft Excel, 2016 Edition.*

Keywords — *Correlation Analysis, Regression Models, Electricity Customers' Perception, Electricity Distribution Problems*

I. INTRODUCTION

The problems of electricity distribution in Nigeria is multi-faceted and have defiled various endeavours and reforms over the years [1,2]. The facts on ground show that electricity customers are at the receiving end of the various problems bedeviling electricity distribution. A recent pilot survey[3.4] was conducted in Delta State, South-South Nigeria [5], on the problems of electricity distribution [6]. This pilot survey was part of a nationwide survey on the problems of electricity distribution and generation in Nigeria. In the pilot survey, electricity customers were asked to assign scores based on their perception on the severity of observed problems and performance metrics of their distribution company (DISCO).

Certain questions arise as to the factors that are likely to affect the perception of electricity customers in the survey. An analysis of the factors is likely to give more insight to the way customers view the performances of their DISCO and their perception of the severity of electricity distribution problems. This will aid users of the survey data to properly situate the problems of electricity distribution with a view of helping to proffer much needed solution.

The data for this inferential statistical analysis is available in the online repository [7]. The data for the analysis is described in [8]. The present endeavour of the inferential statistics was carried out with the aid of IBM SPSS Version 23[9] and Microsoft Excel 2016 Edition [10].

II. PERCEPTION SCORES ON PERFORMANCE OF DISTRIBUTION COMPANIES AND OBSERVED PROBLEMS

In order for electricity customers to give their assessment of the performance of their DISCO, they were asked to score on a five-point scale, by assigning scores to positive statements about the performance of their DISCO. Electricity customers were to assign the score 1 to "strongly disagree", two(2) to "disagree" and three(3) to "uncertain". Also, a score of 5 and 4 were assigned to "agree" and "strongly agree" respectively.

For the observed problems with electricity distribution, customers were to assigned scores between 0 and 10 inclusive depending on their perception of the severity of the observed problems, A score of 0 was assigned if in the customer's view the observed problem is of limited severity, while a score of 10 means the problems was of the highest level of severity. Other scores were assigned relatively depending on the electricity costumer's perception. More information about the performancd metrics and the observed problems can be found in [6,7,8]

III. CORRELATION ANALYSIS

In this section we describe the variables used and present both the autocorrelation and correlation matrices. The correlation matrices show the strength of the relationships among the various variables.

A. Variables for Analysis

The variables for analysis consist of both numeric and alphanumeric variables. The variables are further categorized into dependent variables, independent variables and observed problems. *Table 1a* gives the variable names and acronyms of the independent variables while *Table 1b* is for dependent variables, showing the names, acronyms and the number of positive statements in the questionnaire used in the collection of the data. *Table1c*. shows the names and acronyms of the observed problems during the pilot survey.

Table 1a: Independent Variables

S/N	Variable	Acronym
1	Number of Dependents	NOD
2	Highest Educational Qualification	HEQ
3	Average Monthly Income	AMI
4	Average Monthly Bill	AMB
5	Age Bracket	ABC

Table 1b: Dependent Variables

S/N	Variable	Number of Positive Statements	Acronym
1	Overall Satisfaction with DISCO	1	OSD
2	Quality and Reliability of Power from DISCO	2	QAR
3	Reasonableness of Bills	1	ROB
4	Billing System	4	BIS
5	Corporate Image of DISCO	6	CID
6	Effectiveness of Communication with Stakeholders	3	ECS
7	Customer Service	5	CUS

Table 1c: Observed Problems

S/N	Variable	Acronym
1	Low Voltage	LOV
2	Incessant Power Outages	IPO
3	Load Shedding	LOS
4	Inadequate Number of Meters	INM
5	Inadequate Distribution Lines	IDL
6	Unreasonable Price of Power	UPP
7	Illegal Connections	ICO
8	Inadequate Number of Transformers	INT
9	Stealing of Distribution Facilities	SDF

B. Autocorrelation

Table 2a shows the autocorrelation of the independent variables among themselves. As can be seen from *Table 2a*, all the correlation coefficients (i.e.r values) are less than 0.5, indicating that there are no strong positive or negative relationships among the independent variables in our analysis that is likely to adversely affect our results. However, a statistically significant positive linear relationship is observed between NOD andABC ($r = 0.264, p = 0.000$), from 69.2% of the respondents. This is not unexpected, as one would expect the *number of dependents* and the *age bracket* of the respondents to be positively related. The positive linear relationship between the *number of dependents* and *average monthly income* was also statistically significant at 0.01 level of significance

Table 2a: Autocorrelation Matrix

		NOD	HEQ	ABC	AMI	AMB
NOD	r	1	.035	.264**	.248**	.111
	Sig.		.634	.000	.001	.150
	N	189	188	184	162	170
HEQ	r	.035	1	.140*	.120	.067
	Sig.	.634		.025	.088	.343
	N	188	263	255	204	200
ABC	r	.264**	.140*	1	.382**	.024
	Sig.	.000	.025		.000	.733
	N	184	255	257	203	196
AMI	r	.248**	.120	.382**	1	.329**
	Sig.	.001	.088	.000		.000
	N	162	204	203	205	180
AMB	r	.111	.067	.024	.329**	1
	Sig.	.150	.343	.733	.000	
	N	170	200	196	180	201

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

There is a statistically significant positive linear relationship between *highest educational qualification* and *age bracket*($r = 0.140, p = 0.025$) at 0.05 level of significance. Also is the statistically significant positive relationship between *age bracket* and *number of dependents*, with parameters as ($r = 0.248, p = 0.001$) at 0.01 level of significance. There is also a statistically significant positive linear relationship between *average monthly bill* and *average monthly income* with parameters ($r = 0.329, p = 0.001$) at 0.01 level of significance.

The non-parametric autocorrelation matrix is presented in *Table 2b* for the dependent variables.

All the correlation coefficients are less than 0.5 except for the case of the relationship between *average monthly income* and *age bracket*. The parameters for the relationship between *average monthly income* and *age bracket* are respectively ($r = 0.549, p = 0.000$) and ($r = 0.586, p = 0.000$) for Kendall's tau-b and Spearman's rho correlation coefficients. Interestingly, the same low values of the correlation coefficients are observed.

Table 2b: Non-parametric Autocorrelations

			NOD	HEQ	ABC	AMI	AMB
Kendall's tau_b	NOD	Correlation Coefficient	1.000	.054	.306**	.330**	.023
		Sig. (2-tailed)		.368	.000	.000	.692
		N	189	188	184	162	170
	HEQ	Correlation Coefficient	.054	1.000	.143*	.216**	.138*
		Sig. (2-tailed)	.368		.011	.001	.014
		N	188	263	255	204	200
	ABC	Correlation Coefficient	.306**	.143*	1.000	.549**	.007
		Sig. (2-tailed)	.000	.011		.000	.909
		N	184	255	257	203	196
	AMI	Correlation Coefficient	.330**	.216**	.549**	1.000	.071
		Sig. (2-tailed)	.000	.001	.000		.247
		N	162	204	203	205	180

	AMB	Correlation Coefficient	.023	.138*	.007	.071	1.000
		Sig. (2-tailed)	.692	.014	.909	.247	
		N	170	200	196	180	201
Spearman's rho	NOD	Correlation Coefficient	1.000	.065	.363**	.386**	.025
		Sig. (2-tailed)		.373	.000	.000	.742
		N	189	188	184	162	170
	HEQ	Correlation Coefficient	.065	1.000	.159*	.236**	.178*
		Sig. (2-tailed)	.373		.011	.001	.012
		N	188	263	255	204	200
	ABC	Correlation Coefficient	.363**	.159*	1.000	.586**	.009
		Sig. (2-tailed)	.000	.011		.000	.905
		N	184	255	257	203	196
	AMI	Correlation Coefficient	.386**	.236**	.586**	1.000	.086
		Sig. (2-tailed)	.000	.001	.000		.251
		N	162	204	203	205	180
	AMB	Correlation Coefficient	.025	.178*	.009	.086	1.000
		Sig. (2-tailed)	.742	.012	.905	.251	
		N	170	200	196	180	201

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

C. Correlation Matrix for Performance Metrics

Table 3 shows the correlation matrix for the scores assigned by the respondents in the survey for the performance metrics for the DISCO. There appears to be a strong positive linear relationship between the scores assigned in all cases. The lowest positive linear relationship is that between the *overall satisfaction with the DISCO* and *the reasonableness of bills/rates*, where $r = 0.512$. The highest value of r is observed for the positive relationship between the scores for effectiveness of *communication with stakeholders* and *corporate image of DISCO* with the parameters ($r = 0.776, p = 0.000$)

Table 3: Correlation Coefficients Among Performance Metrics

		QAR	BIS	CID	ECS	CUS	OSD	ROB
QAR	Pearson Correlation	1	.714**	.753**	.620**	.707**	.730**	.609**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000
	N	266	266	266	266	266	265	266
BIS	Pearson Correlation	.714**	1	.727**	.669**	.659**	.580**	.715**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000
	N	266	266	266	266	266	265	266

CID	Pearson Correlation	.753**	.727**	1	.776**	.769**	.617**	.627**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000
	N	266	266	266	266	266	265	266
ECS	Pearson Correlation	.620**	.669**	.776**	1	.753**	.561**	.580**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000
	N	266	266	266	266	266	265	266
CUS	Pearson Correlation	.707**	.659**	.769**	.753**	1	.598**	.538**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000
	N	266	266	266	266	266	265	266
OSD	Pearson Correlation	.730**	.580**	.617**	.561**	.598**	1	.512**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000
	N	265	265	265	265	265	265	265
ROB	Pearson Correlation	.609**	.715**	.627**	.580**	.538**	.512**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	
	N	266	266	266	266	266	265	266

**. Correlation is significant at the 0.01 level (2-tailed).

D. Correlation Matrix for Observed Problems

Table 4 shows the correlation among the scores assigned by the respondents to the observed problems during the pilot survey. Virtually all the correlation coefficients were statistically significant at the 0.01 α level of significance for the two-tailed test, except for the correlation between the scores for *unreasonable price of power* and *load shedding* with parameters ($r = 0.101, p = 0.102$). The pairs of variables; UPP & IPO, IDL & IPO, IMN & LOS, UPP & IDL, and ICO & INT had correlation coefficients greater than 0.5. Thus exhibiting a relatively strong positive linear relationship among those pairs of variables.

Table 4: Correlation matrix for observed problems

		LOV	IPO	LOS	INM	IDL	UPP	ICO	INT	SDF
LOV	Pearson Correlation	1	.496**	.302**	.308**	.367**	.282**	.250**	.219**	.163**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000	.000	.008
	N	266	266	264	266	266	266	266	266	265
IPO	Pearson Correlation	.496**	1	.148*	.183**	.528**	.555**	.278**	.404**	.233**
	Sig. (2-tailed)	.000		.016	.003	.000	.000	.000	.000	.000
	N	266	266	264	266	266	266	266	266	265
LOS	Pearson Correlation	.302**	.148*	1	.623**	.219**	.101	.304**	.303**	.271**
	Sig. (2-	.000	.016		.000	.000	.102	.000	.000	.000

	tailed)									
	N	264	264	264	264	264	264	264	264	263
INM	Pearson Correlation	.308**	.183**	.623**	1	.253**	.186**	.360**	.352**	.342**
	Sig. (2-tailed)	.000	.003	.000		.000	.002	.000	.000	.000
	N	266	266	264	266	266	266	266	266	265
IDL	Pearson Correlation	.367**	.528**	.219**	.253**	1	.554**	.334**	.346**	.291**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000	.000	.000
	N	266	266	264	266	266	266	266	266	265
UPP	Pearson Correlation	.282**	.555**	.101	.186**	.554**	1	.455**	.499**	.324**
	Sig. (2-tailed)	.000	.000	.102	.002	.000		.000	.000	.000
	N	266	266	264	266	266	266	266	266	265
ICO	Pearson Correlation	.250**	.278**	.304**	.360**	.334**	.455**	1	.566**	.428**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000		.000	.000
	N	266	266	264	266	266	266	266	266	265
INT	Pearson Correlation	.219**	.404**	.303**	.352**	.346**	.499**	.566**	1	.533**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000		.000
	N	266	266	264	266	266	266	266	266	265
SDF	Pearson Correlation	.163**	.233**	.271**	.342**	.291**	.324**	.428**	.533**	1
	Sig. (2-tailed)	.008	.000	.000	.000	.000	.000	.000	.000	
	N	265	265	263	265	265	265	265	265	265

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

IV. REGRESSION MODELS

A. Regression Models

In this section, we present the regression models for the various performance metrics. The results show the contributions to the variations in the performance metrics. It was observed that in all the models, the contributions to the variations were positive in all cases for the number of dependents (NOD). The highest coefficient for the performance metric arising from the number of dependents is 0.050.The regression models for the performance metrics are presented in the subsections that follow.

B. Overall Satisfaction with DISCO (OSD)

The variables HEQ, ABC, AMI and AMB all contributed negative coefficients to the regression equation for OSD with the exception of NOD. NOD has a coefficient of 0.025 which shows that compared to other variables the scores for the overall satisfaction with DISCO are more likely to be affected positively by the number of dependents of the respondents. In effect the respondents with more dependents are likely to give high scores for OSD in their evaluation of the DISCO. With a coefficient of -4.663×10^{-6}, the highest negative coefficient for the regression equation for OSD is from AMB, this is closely followed by HEQ and ABC in decreasing values of negative coefficients. Respondents with high values for HEQ, ABC, AMI and AMB are likely to score the performance measure OSD low.

$$OSD = 2.833 + 0.025NOD - 0.116HEQ - 0.052ABC - 0.186AMI - 4.663 \times 10^{-6}AMB \quad (1)$$

C. Quality and Reliability of Power from DISCO (QAR)

The highest single contribution in QAR is ABC, with a coefficient of 0.046, NOD has a positive coefficient of 0.014, while AMI, HEQ and AMB have negative coefficients with the highest negative contribution to the independent variable QAR being -4.363×10^{-6}, arising from AMB. The greatest factor that affect the scores for QAR is the age bracket. This gives the impression that the older folks are more likely to give a high score for the *quality and reliability of power* from the DISCO. In effect, on the average, the older respondents are more likely to "strongly agree" and "agree" with the positive statements used to evaluate *the quality and reliability of power* from DISCO.

$$QAR = 2.795 + 0.014NOD - 0{,}008HEQ + 0{,}045ABC - 0.247AMI - 4.363 \times 10^{-6}AMB \quad (2)$$

D. Reasonableness of Bills (ROB)

Just like in the case of all other performance metrics, the variable NOD has a positive coefficient in the regression model for ROB. The other variables namely HEQ, ABC, AMI and AMB have negative coefficients in the regression model with the highest negative contribution coming from AMB, while the lowest is from HEQ. For the variables HEQ, ABC, AMI and AMB higher values are likely to go with lower scores for Reasonableness of Bills as a performance metric. Conversely respondents with more number of dependents are likely to score the performance measure higher. In effect those with more number of dependents in their household are more likely to disagree that the DISCO is performing well in the reasonableness of their bills.

$$ROB = 3.111 + 0.030NOD - 0.161HEQ - 0.053ABC - 0.136AMI - 4.473 \times 10^{-6}AMB \quad (3)$$

E. Billing System (BIS)

The variables HEQ, ABC, AMI and AMB all have negative coefficients in the regression model for BIS. The highest negative coefficient is -2.253×10^{-6} contributed to the regression model by AMB. In contrast NOD has a positive coefficient. Respondents with high values for NOD are more likely to score the variable BIS high, while those with lower values for HEQ, ABC, AMI and AMB are likely to score the variable higher. In effect the more the number of dependents of a respondents the higher the score higher the score assigned to the *effectiveness of the billing systems* of the DISCO.

$$BIS = 2.988 + 0.019NOD - 0.044HEQ - 0.029ABC - 0.201AMI - 2.253 \times 10^{-6}AMB \quad (4)$$

F. Corporate Image of DISCO (CID)

The variables NOD and HEQ both have positive coefficients in the regression model for the corporate image of DISCO (CID). The respective coefficients for NOD and HEQ are 0.017 and 0.013. Respondents with high values of NOD and HEQ are likely to score CID high. On the other hand ABC, AMI and AMB have negative coefficients in the regression equation for CID, the respective values of -0.023, -0.177 and -3.248×10^{-6}. Respondents with higher values for ABC, AMI and AMB are likely to score the Corporate Image of DISCO (CID) low.

$$CID = 2.722 + 0.017NOD + 0.013HEQ - 0.023ABC - 0.177AMI - 3.248 \times 10^{-6}AMB \quad (5)$$

G. Customer Service (CUS)

The regression model for the Customer Service of the DISCO is presented in Equation 6. From Equation 6, we can see that, both NOD and ABC have positive coefficients. This is an indication that respondents in the survey with high values in NOD and ABC are likely to have high scores for CUS. The coefficient contributed by NOD in the regression model is 0.050, which is greater than that of ABC which is 0.012. The remaining three variables namely; HEQ, AMI and AMB all have negative coefficients. For these variables with negative contributions to the regression model, respondents with high scores are likely to assign low scores to the performance measure CUS. In effect, such respondents are likely to be of the opinion that the DISCO being evaluated is not performing well in the area of customer service.

$$CUS = 2.984 + 0.050NOD - 0{,}037HEQ + 0.012ABC - 0.316AMI - 9.346 \times 10^{-7}AMB \quad (6)$$

H. Effectiveness of Communication with Stakeholders (ECO)

In the regression model for ECO shown in equation 7, the variables HEQ, AMI and AMB have negative coefficients. While the variables NOD and ABC have respective positive coefficients in the regression model as 0.023 and 0.010. In this model we see the number of dependents and age bracket of the customers having the same kind of effect on their score on the

effectiveness of the communication system of the DISCO, even though the positive contribution to the model is slightly more from NOD.

$$ECO = 3.038 + 0.023NOD - 0.102HEQ + 0.010ABC - 1.190AMI - 4.706 \times 10^{-6}AMB \qquad (7)$$

V. DISCUSSION OF RESULTS

In the correlation analysis for the performance metrics, there appear to be a strong positive relationship among all the performance metrics. A customers'view of the performance of a DISCO on a specific aspect is likely to affect the others, This suggest that in decision making not all the metrics are needed to draw conclusion. In this case the customer's few in a key area is enough to enable the DISCO and other stakeholders take corrective steps and/or actions to meet the needs of the customers.

The highest correlation among the performance metrics is that between the *effectiveness of communicaton* and the *corporate image of DISCO*, While the lowest correlation is that between *overall satisfaction with the DISCO* and *reasonableness of bills*. This result suggests that in the electricity customers'point of view high importance is attached to effective communication and that corporate image of the DISCO. It is possible for DISCO to get better ratings from customers by working on the effectiveness of their communication. DISCOs can also get better ratings by image lundering. It thus appears that customers are as interested in communication and the status of the distribution company as in the utility derived from the services.

From the correlation analysis there is a stong positive linear relationship between the ratings of electricity customers on the problems of inadequate number of transformers and illegal connections. In the view of electricity customers inadequate number of transformers may be the cause of illegal connections by customers. This suggests that increasing the number of transformers might help reduce the problems of illegal connections by electricity customers.

The regression models show that the highest positive contribution to the variations in the scores by the respondents is from the *number of dependents*, The number of dependents per household cannot be taken for granted by the DISCOs in their area of operation. Demographic changes should be monitored as part their decision making process.

The highest negative contribution in the regression models analysed in this study come from the *average monthly bills*. This factor was consistently negative in all the regression models. The likely implication of this is that customers are more likely to rates DISCOs low in the performance metrics if their average monthly bills are very high.

VI. CONCLUSION

In this paper we have elected to use correlation analysis and regression models to provide some inferential insight into the data on customer's perception on the performance of DISCOs in Delta State, South-South Nigeria. The results show that effectiveness of communication and corporate image of DISCO, and overall satisfaction and reasonableness of bills are critical factors to be taken into consideration in the decision making process of the DISCOs. Also the number of dependents in an electricity customer have been shown to impact on the perception of customers as to the performance of their DISCO. The pilot survey on problems with electricity distribution in Delta State is part of a nationwide survey on problems with electricity generation and distribution in Nigeria. Further work is still being done on the data from some other geopolitical zones in Nigeria.

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