Impact of Electricity Loss on Gross Domestic Product in Nigeria

David Adebisi Samuel
Department of Economics, Trinity University, Lagos, Nigeria

Abstract

This study investigated the impact of electricity loss both from the transmission and distribution channels that constituted the technical and non-technical losses of electricity on Gross Domestic Product in Nigeria between 1981 and 2020. The variables used in the work included electricity loss, electricity demand and electricity supplied from hydropower. Vector Autoregressive model was employed to estimate the parameters and it was revealed that electricity loss negatively impacted Gross Domestic Product in Nigeria. It was also discovered that electricity demand positively impacts GDP but electricity supply negatively impacts GDP in the country. It was however confirmed that there is no causal relationship between electricity loss, electricity demand and electricity supply and GDP in the country. It was therefore recommended that a deliberate policy that will stimulate investment in the transmission and distribution infrastructure be designed and implemented to reduce electricity losses to the barest minimum in the country.

Key Words: Electricity Loss, Electricity Demand, Gross Domestic Product, Hydropower

Introduction

Electricity production and supply has become a major hub around which virtually all economic activities revolve today. It is only with adequate supply of electricity that many sectors, such as industrial (for production), transport (train, air and road), services (telecommunication, entertainment, and so on), can be fully operational. Electricity enables the health sector and education sector to perform optimally and consequently building the sustainable human capital for development. Electricity has been rated as the major determinant of the productivity of all factors, especially labour and capital in an economy (IMF, 2015). It is a facilitator of the productivity of the factors of production in an economy. Both labour and capital are practically rendered inefficient and unproductive without it. Lack of sufficient electricity increases the cost of production in the production process and could also waste time in the optimal production of goods and services and eventually hurt factors' productivity. Inadequate supply of electrical power leads to low access to it, which in turn retards investment in a country and weakens competitiveness of an economy. Most firms would rather invest in countries where access to electricity is high and thereby reducing their cost of production (Payne, 2010).

Supply shortage of electricity has been partly due to electricity loss in transmission and distribution processes (NERC, 2019), which accounts for more than 50 percent of the inadequate quantity supplied. This position of electricity supply and losses in Nigeria calls for urgent policy actions that will address the ugly situation. It has been reported that more than 50 percent of businesses in Africa have attributed their poor performance to inadequate electricity supply and that implies explicitly that poor supply and access to electricity dampens productivity and GDP growth (Eberhard, et al, 2008 and Jones, 2011).

Electricity loss can take the form of either technical or/and non-technical. The technical losses result from the weakness of the electrical infrastructure used for transmission and distribution of electrical energy. These comprises of losses associated with generators or transformers in their windings, transmission and distribution lines due to the thermal effect of current flowing in the conductors as well as corona effect at high voltage. It also includes losses associated with cables that carry the energy (Ogujor, and Otasowie, 2010). This category of losses can only be reduced through the state of the art infrastructural equipment

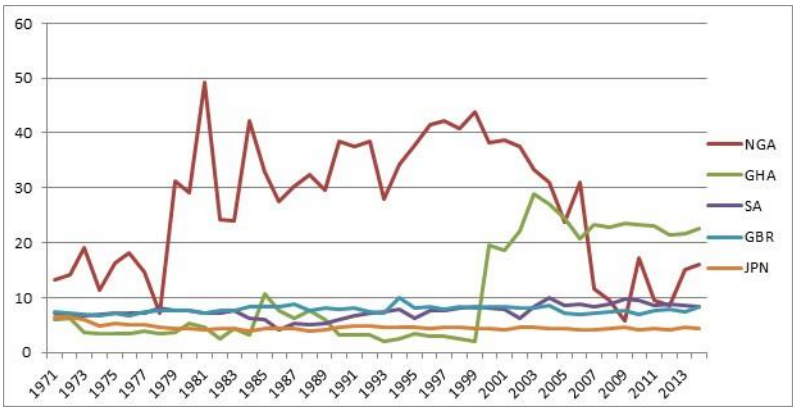
(Bandim, et al, 2003).

The second form of electricity losses is the non-technical losses which can be referred to as commercial losses. This results from theft of energy, when billing is poorly estimated, meters that are defective, which could have come from either deliberately tampering with it resulting in unpaid bills, by passing connections, illegal connections, illegal collusion with the meter readers to tamper with meter and give under estimated readings, and so on. These categories of losses are exogenous to the power operational systems and cannot be computed (Nagi, et al, 2010). These losses can be categorized into transmission loss and distribution loss. Electricity loss between the point of production and point of distribution is referred to as transmission loss while the loss between the distribution and the end users is called distribution loss (WDI, 2017). This definition was further expanded by Antmann (2009) by referring to electricity as all the electrical energy introduced into the transmission grid and distribution lines that are not eventually paid for by the customers. In other words, they are electricity that has been termed supplied but are not paid for by consumers.

There are different degrees of electricity loss along the transmission lines. Chint (2020) showed that as the electricity is being generated and stepped up by the transformer, about 1 to 2 percent of generated energy is lost. Another 2 to 4 percent is again lost in the transmission lines, while another 1 to 2 percent is lost during step down from the high tension wires. More importantly, about 4 to 6 percent is lost in the distribution process to the end users. On the whole, about 8 to 15 percent of electricity is lost between the power plants and the end users. This overall percentage loss implies a heavy dampening effect on Gross Domestic Product through firms' productivity. Dakpogan and Smit (2018) estimated the effect on GDP from 0.5 to 1.2 percent in some Sub-Saharan African countries.

A comparison of electricity loss in Nigeria with some other countries can be observed in figure one. The country with the highest volatility of losses is Nigeria followed by Ghana. The highest for electricity loss in Britain was 9.8 percent in 1994 while the highest loss in Nigeria was 49.27 percent in 1981. The lowest loss that Nigeria has ever had was 4.5 in 2009. This amount of electricity loss in Nigeria is quite worrisome and could be a factor responsible for the incessant power outages in the country and this has grave consequences on productivity in the country and attendant effect on GDP growth.

Figure 1: Electricity Loss in some selected countries



Source: Author generated using Excel 2010

Losses in electricity transmission and distribution in the Latin American and the Caribbean countries was estimated at between 0.19 and 0.3 of GDP for all the countries and the losses in terms of monetary value ranges between $11 to $17 billion (Jiménez, Serebrisky and Mercado, 2014). On a country by country analysis, electricity loss in Brazil cost about 0.26 of GDP, while that of Mexico is between 0.12 and 0.3 (Jiménez, et al, 2014). These authors estimated technical losses in Uruguay at $80 million as at 2010. The implication of these is that as the monetary losses increase, it finds its expression in reduction of productivity and consequently on economic growth.

A reduction in electric power losses leads to increase in GDP through increase in the revenue of the distribution companies, as a result of increase in the quantity of electricity that reaches the end users. This increase in electricity supply will increase its consumption and a reduction in the use of alternative sources of electricity, like generators, which in turn reduces the cost of production and raises profits of firms and expands investment potentials.

This work is particularly important because, to the best of the author's knowledge, most of the works done on electricity loss in Nigeria have only considered the effect of the loss on power outages in the country using descriptive analysis without a sound methodological approach. None of the works have investigated the impact of electricity loss on the Gross Domestic Product of the country. The remaining part of this work will be divided into six sections. The following section will handle the recent empirical literature, while the following section three will present the theoretical framework underpinning this study. Section four will show the methodology and the model specification while section five will show the sources of data for the work and section six will present the result and then analyze. Section seven will then summarize and give policy recommendations.

Literature Review

Das and McFarlane (2021) investigated the effect of remittances on electricity consumption and electricity losses in Jamaica between 1976 and 2014. The work employed Vector Error Correction model and Granger causality to analyze the work. The findings revealed that cointegration existed between remittances and electricity consumption and losses. It was also discovered that there was a bi-directional causality among the variables; however, the relationship between electricity losses and remittances was negative while that between energy consumption and remittances was positive. It was therefore recommended that social policies be designed to make use of remittances to reduce electricity theft in the country.

Adams, Atsu, Klobodu and Lamptey (2020) employed Autoregressive Distributed Lag model to evaluate the effect of transmission and distribution losses on the growth of South African economy using time series data between 1971 and 2014. Their findings showed that there existed a long run relationship among the variables by using Foreign Direct Investment as a control variable. By the time the robustness check was carried out it was found that 1 percent change in electricity loss in the country results in a decline in economic growth from about 3.8 percent to 2.2 percent. It was therefore recommended that policy makers should invest more in energy production and infrastructure to help reduce electricity loss due to technical factors.

George-Anokwuru and Ekpenyong (2020) did an empirical study on relationship between electricity and economic growth in Nigeria between 1971 and 2018 and using consumption of electricity, generation along with transmission and distribution losses. The work employed Autoregressive Distributed Lag model, the findings revealed that electricity generation and distribution losses have negative relationship with economic growth and electricity generation has a negative relationship with economic growth. It was therefore suggested that production and transmission infrastructure expenditure be encouraged to boost energy consumption and reduce the losses.

Dakpogan and Smit (2018) looked at the effect of electricity loss on Gross Domestic Product (GDP) in Benin Republic between 1980 and 2014 by employing the methodology of Autoregressive Distributed Lag model. The findings of the study showed that a 1 percent loss in electricity in the country would cost about 0.16 percent decline in GDP. It was therefore proposed that a financing mechanism on electricity infrastructure to reduce the losses from electricity in order to increase GDP be designed and implemented.

Adams, Klobodu and Lamptey (2017) carried out an examination of how electricity loss from transmission to distribution affects GDP growth in Ghana between 1971 and 2012. The work employed Autoregressive Distributed Lag model using Bounds test for cointegration and their findings revealed that there was a long run relationship between electricity loss and economic growth in the country. It was further discovered that electricity loss did not show any significant effect on economic growth but when the urban population growth was factored in, it was discovered that electricity loss became significant in affecting economic growth in Ghana.

Costa-Campi, Daví-Arderius and Trujillo-Baute (2016) carried out an analysis of the impact of consumption and generation on electricity losses in Spain. The study used a quantitative analysis of the marginal effect of losses in Mega Watts from an additional Mega Watts produced or consumed. It was found that there is a huge amount of saving that will be made when losses can be reduced by using smart meters. It was found out from the result that a 1 percent reduction in loss of electricity will lead to about 1.25 percent in saving. It was also discovered that in increase in solar and wind capacity would reduce energy losses. It was therefore recommended that a stronger coordination between the transmission and distribution system operators be encouraged.

Theoretical Framework

The work of Samuelson and Nordhaus (1989) on growth will be the framework on which this study will rest. The mainstream theory of economic growth claims that production plays the most important role of determining the growth of an economy, and every production process requires energy to be able to transform any matter into finished product. The theory classifies capital, labour and land into primary factors that must be obtained at the beginning of any production and they are not used up although they can be degraded or improved upon. But the theory asserts that energy resources or commodities like oil, gas fuels, electricity and coal are classified as intermediate inputs and can be completely used up in the production process. This theory helps us to explain that production can be influenced by the availability of electricity. The more the productive agents have access to electricity the more productivity can be enhanced. Increase in energy loss will imply shortage of electricity supply and consequently the negative implication on productivity and growth.

Methodology and Model Specification

This study employed an ex post facto research design by trying to interrogate the relationship between electricity loss and economic growth in Nigeria. An econometric method of Vector Autoregressive (VAR) model will be employed. The reason is that this method of estimation is to be used when all the variables are stationary at first difference or integrated at order one, I(1). The data were subjected to unit root test using Augmented Dickey Fuller test method and it was found that all variables were integrated at I(1). The first step after confirming the order of integration is to test for the long run relationship among the variables and this was done using Johansen cointegration test and it was found that there was no cointegration, and so the work has to employ Vector Autoregressive model.

The model for this work is hinged on the growth model proposed by Samuelson and Nordhaus (1989) where the Cobb-Douglas production function depends on labour and capital and energy as specified below:

Output = f (Labour, Capital, Energy) … (1)

$Q_t = wL^a C^B E^{1-a-B}$ … (2)

Where is the output, is the total factor productivity, L is the labour input, C is the capital input and E is the

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energy input, , and are the share of the factor inputs in income.

Adapting model (2) and incorporating the electricity components that is the focus of this study, we then have:

GDP=f(ELELOS,ELEDD,ELEHP)   … (3)

Expressing (3) econometrically, we have:

$RGDP_t = a + B_1 ELELOS_t + B_2 ELEDD_t + B_3 ELEHP_{t} + u_t$ … (4)

Where RGDP is the real Gross Domestic Product, ELELOS is the electricity loss both at the transmission and distribution lines, ELEDD is electricity demand in total and ELEHP is electricity supplied from hydropower source, is the error term.

4.1 Specification of Vector Autoregressive Model

The basic form of a VAR model consists of a set of M variables that are endogenous:

$g_t = g_{1t}, .., g_{mt}$, For m = 1, …M. When the lags p of the endogenous variables is included, we have VAR(p) expresses as:

$g_t = B_1 g_{t-1} + \dots + B_p g_{t-p} + EF_t + E_t$ … (5)

Where are (M x M) coefficient matrices for i =1, …., p, is an M-dimensional white noise with time invariant positive definite covariant matrix , where

$E[_{Et}] = 0$

$E[\varepsilon_t \varepsilon_t'] = \sum \varepsilon$ whose value is positive and definite

The matrix E is the matrix of coefficients of possible deterministic regressors having dimension (M x N), while F is a column vector containing deterministic regressors like constant, trend, dummy and seasonal variables.

Equation (5) can be expressed VAR with the variables of interest in this work as:

$$RGDP_t = \sum_{i=1}^{k} \beta_i \, RGDP_{t-1} + \sum_{j=1}^{k} \beta_j \, ELELOS_{t-1} + \sum_{n=1}^{k} \beta_n \, ELEDD_{t-1} + \sum_{m=1}^{k} \beta_m \, ELEHP_{t-1} + u_{1t} \quad \dots \quad (6)$$

$$ELELOS_t = \sum_{i=1}^{k} \beta_i \, RGDP_{t-1} + \sum_{j=1}^{k} \beta_j \, ELELOS_{t-1} + \sum_{n=1}^{k} \beta_n \, ELEDD_{t-1} + \sum_{m=1}^{k} \beta_m \, ELEHP_{t-1} + u_{2t} \quad \dots \quad (7)$$

$$ELEDD_t = \sum_{i=1}^{k} \beta_i \, RGDP_{t-1} + \sum_{j=1}^{k} \beta_j \, ELELOS_{t-1} + \sum_{n=1}^{k} \beta_n \, ELEDD_{t-1} + \sum_{m=1}^{k} \beta_m \, ELEHP_{t-1} + u_{3t} \quad \dots \quad (8)$$

$$ELEHP_t = \sum_{i=1}^{k} \beta_i \, RGDP_{t-1} + \sum_{j=1}^{k} \beta_j \, ELELOS_{t-1} + \sum_{n=1}^{k} \beta_n \, ELEDD_{t-1} + \sum_{m=1}^{k} \beta_m \, ELEHP_{t-1} + u_{4t} \quad \dots \quad (9)$$

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where the variables remained as defined earlier.

Data and Sources

Annual time series data will be used for this study and it will cover the period between 1981 and 2014. Real Gross Domestic Product data is obtained from the National Bureau of Statistics of the country while data for Electricity Loss, Electricity demand, and Electricity from hydropower are all sourced from the World Bank Development Indicator. Electricity loss, electricity demand and supply are expressed as percentage of output.

Table 1: Variables, Definition and Source

No	Variable	Definition	Source
1	RGDP	Real Gross Domestic product	National Bureau of Statistics
2	ELELOS	Electricity Loss	WDI
3	ELEDD	Elecricity Demand	WDI
4	ELEHP	Elecridity supply from Hydropower	WDI
Note: WDI is World Development Indicator Data base of World Bank			

Results and Discussion

6.1 Unit Root Test

The variables were tested for the presence of unit root, because time series are assumed to be stationary.

Table 2: Stationarity Test (Augmented Dickey Fuller)

	At Level			**At First Difference**			
Variable	**ADF Stat**	**5 % Level**	**Prob. Value**	**ADF Stat**	**5 % Level**	**Prob. Value**	**Order of Integration**
RGDP	0.650415	-2.92245	0.9898	-5.95836	-2.92378	0.0000	I(1)
ELELOS	-1.45922	-2.92517	0.5453	-6.54566	-2.92517	0.0000	I(1)
ELEDD	-1.48747	-2.92245	0.5316	-9.39097	-2.92378	0.0000	I(1)
ELEHP	-2.70943	-2.92245	0.0797	-8.98493	-2.92378	0.0000	I(1)

Source: Author generated using Eviews 10

The result of the test is in table 1. It showed that all the variables are stationary at first difference with all the probability values less than 5 percent.

6.2 Optimum Lag Selection

The lag selection criteria were used and all the criteria selected lag length one as indicated in table 3.

Table 3: Optimum lag length selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1080.21	NA	4.89e+14	45.17536	45.33129	45.23428
1	-908.892	306.9428*	7.59e+11*	38.70382*	39.48348*	38.99845*
2	-895.812	21.25386	8.70e+11	38.82551	40.22891	39.35586

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*Lag length selected.

Source: Author generated using Eviews 10

6.3 Cointegration test

From the result of the unit root test results, the test for the existence of long run relationship among the variables was carried out using Johansen cointegration test method as shown in table 3.

Table 4: Cointegration (Johansen)

	Trace Test			**Max-Eigen Test**		
Null: No of Coint.	**Trace Statistic**	**5 % Level**	**Prob. Value**	**Max-Eigen Statistic**	**5 % Level**	**Prob. Value**
None	32.62383 0.7906	47.85613	0.5777	14.44681	27.58434	
At most 1	18.17702 0.6907	29.79707	0.5530	10.56215	21.13162	
At most 2	7.614869 0.4207	15.49471	0.5074	7.600756	14.26460	

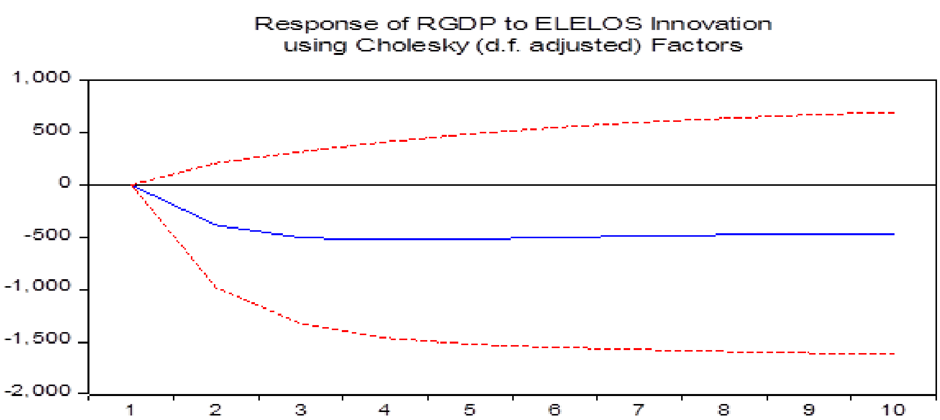
Source: Author generated using Eviews 10

The condition for accepting the null hypothesis is that if the probability value of the first null hypothesis is greater than 5 percent critical value, we accept the null hypothesis that there is no cointegration. The probability is 79 percent, so we conclude that there is no cointegration among the variables and we can only run the VAR at level.

6.4 VAR Impulse Response Function

The VAR models (6) to (9) were estimated and the impulse response functions were generated as shown in figure 2 to 4.

Figure 2: Response of RGDP to electricity loss



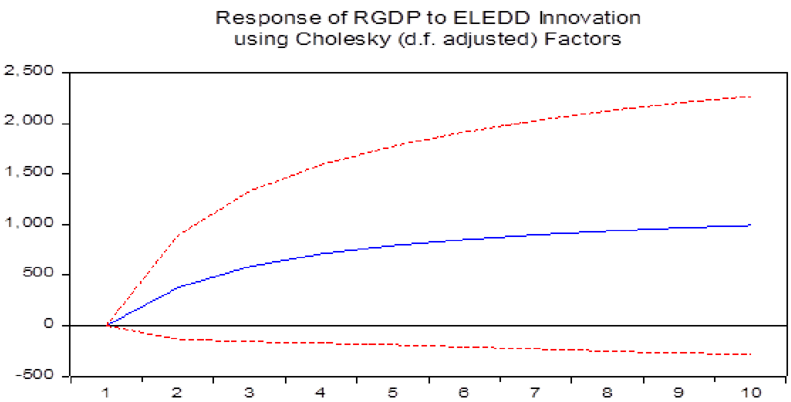
Source: Author generated using Eviews 10

The response of GDP to a shock in electricity loss as shown in figure 2 assumes a negative dimension from period one to period 10 of the horizon. This implies that GDP and electricity loss are negatively related and significant. It also means that as more electricity is lost through the technical and non-technical channels, it is manifesting a dampening effect on the nation's productivity. This finding is in support of most of the works from other countires, such as Dakpogan and Smit (2018) and George-Anokwuru and Ekpenyong (2020).

Figure 3 on the other hand showed the response of GDP to a shock in electricity demand. It showed that GDP is positively responding to electricity demand. This implied that if more electricity is available for consumption it has a positively strong impact on GDP. It is obvious that the more the available electricity for consumption, the more positive ripple effect it will have on GDP of the country.

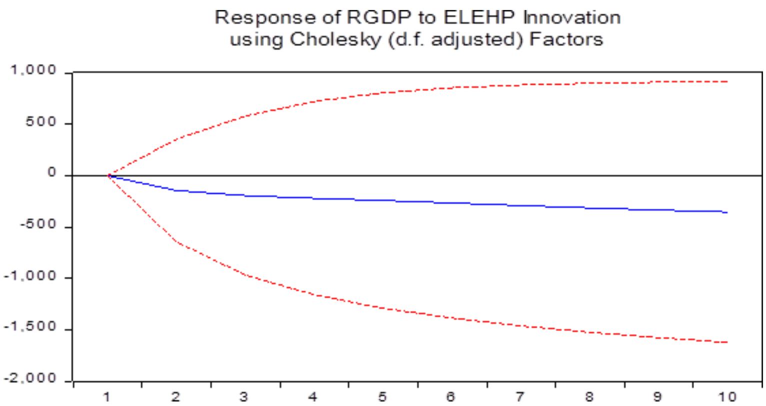
The response of GDP to a shock in electricity supply from hydropower is shown in figure 4 and it revealed that GDP is negatively related to electricity supply from hydropower. It is expected however, since electricity loss is huge, it means the available electricity supplied will not be able to influence GDP significantly.

Figure 3: Response of RGDP to electricity demand



Source: Author generated using Eviews 10

Figure 4: Response of RGDP to electricity supplied from hydropower



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6.5 Residual Diagnostics

The VAR model was checked if the assumptions of Ordinary Least Squares are satisfied. Table 4 showed that the model is free from serial correlation among the residuals and that is makes the model suitable for policy prescription and forecast. But the errors in the model are not free from heteroscedasticity and they are not normally distributed.

Table 5: Residual Diagnostic tests

VAR Residual Serial Correlation LM Tests						
Lag	LRE stat	df	Prob.	Rao F-stat	df	Prob. value
1	21.23046	16	0.1698	1.366627	(16, 13.7)	0.1711
VAR Residual Heteroskedasticity Tests (Levels and Squares)						
Joint test:						
Chi-sq	df	Prob.				
139.5899	80	0.0000				
VAR Residual Normality Tests						
Component	Jarque-Bera	df	Prob.			
RGDP	701.0944	2	0.0000			
ELELOS	3.775582	2	0.1514			
ELEDD	3.806633	2	0.1491			
ELEHP	33.81916	2	0.0000			
Joint	742.4958	8	0.0000			

Source: Author generated using Eviews 10

6.6 Granger Causality test

It was shown in table 5 that none of the independent variables could cause GDP with all their probability values more than 5 percent significant level. This implies that even though electricity loss is negatively impacting GDP, there is no causality running from electricity loss to GDP. Similarly, electricity demand and supplied from hydropower could not Granger cause GDP.

Table 6: VAR Granger Causality test

Dependent variable: RGDP			
Excluded	Chi-sq	df	Prob.
ELELOS	0.238600	1	0.6252
ELEDD	1.609738	1	0.2045
ELEHP	0.335856	1	0.5622
All	3.975535	3	0.2641

Source: Author generated using Eviews 10

Conclusion and Policy Implications

This study investigated the impact of electricity loss on Real Gross Domestic Product in Nigeria along with electricity demand and supplied from hydroelectric power. It was found that there was no long run relationship among the variables, Vector Autoregressive impulse response analysis was employed to check the how the independent variables stimulate the response of RGDP and it was revealed that GDP responds negatively to electricity loss significantly through the period under consideration. Although the period covered was limited due to availability of data on electricity loss, the situation described in this work has not changed, but rather grown worse. Similarly, electricity demand impacted GDP positively and electricity supplied from hydropower impacted GDP negatively. This negative relationship between electricity demand and GDP shows that if only more electricity could be supplied, it would boost GDP. It was also shown that electricity supply showed a negative impact on GDP simply due to the huge loss of electricity through transmission and distribution channels.

The major recommendation therefore is that there should be a sound energy policy that would be designed to encourage investment in the transmission and distribution lines to upgrade the infrastructure with the purpose of reducing electricity loss. It is certain that if the losses can be reduced, it will increase the quantity being supplied and consequently increase the quantity demanded and eventually translate to higher productivity and GDP.

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