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Modeling the Economic Determinants of Electricity Generation in Nigeria

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Abstract
Nigeria's poor electricity generation has been one of the main obstacles preventing the country from becoming an industrialized nation and experiencing economic growth. This study analyzed the factors affecting electricity generation in Nigeria focusing on electricity power loss, government funding for electricity, and electricity demand using annual time series data between 1981 and 2021. Energy Information Administration [EIA], (2022) database and the National Bureau of Statistics [NBS], (2022) were the sources of the data for this study. The study used the techniques of Impulse Response Functions (IRFs) and Variance Decomposition from the Vector Autoregressive Model (VAR). The results showed that Nigeria's electricity generation responds negatively to shocks in a considerable way and also accounts for more than 30% of the variation in its variable across the entire forecasting period. The findings also discovered that electricity generation in Nigeria responded negatively to shocks in both electricity power loss and electricity demand, with the economic implication that if these shocks are reduced, electricity generation will increase. On the other side, Nigerian electricity generation was found to have responded significantly to a shock in government funding for electricity. Several recommendations were made by the study, one of which is for the government to focus more on increasing electricity generation capacity in a manageable way, implement appropriate measures to lower the rate of electricity power loss during the transmission and distribution process, manage the allocation of funds to fund electricity generation, and also develop ways to meet more electricity demand.

Keywords: Electricity, Electricity Demand, Electricity Generation, Government Funding on Electricity
JEL Classification Codes: H53, Q4, Q40, Q41

1. Introduction

Electricity is an important ingredient to our modern economic growth and development. However, Nigeria's low level of electricity generation and production has impeded the country's attempts to industrialize and expand its economy. Numerous initiatives have been taken by the nation to address the electricity situation, but none have been effective because of inconsistent policies and a lack of sufficient commitment (Imo, Chukwu, & Abode 2017). Undoubtedly, electricity generation is crucial to the process of supplying Nigeria with a sufficient quantity of electricity, which has been a long-standing issue for the country's economy.

Nigeria's economy has grown commercially and industrially, but the nation continues to struggle with issues related to steadily rising consumption and rising electrical demand as a result of insufficient electricity-producing capacity. Therefore, it is important to study the factors responsible for low electricity generation to provide suggestions and recommendations to the government and policymakers for proper decisions in generating electricity in Nigeria (Imo *et al.,* 2017). It is common knowledge that having access to electricity enhances people's lives and the economy as a whole. Thus, every economy benefits from a steady supply of electricity. Electricity generation and supply are so essential to modern life and any industrial or commercial society (Nwalado, Obro, & Ofuasia, 2012).

For quick industrialization and overall economic growth, there must be sufficient electricity generation. Because of this, Nigeria should be a country where progress is driven by sufficient electrical generation. However, the country is grappling with the abysmal problem of shortages in electricity generation, supply, and distribution. From the extant literature reviewed, Emovon, Samuel, Mgbemena, and Adeyeri (2018) noted that although Nigeria is endowed with abundant potential for both renewable and non-renewable energy resources, certain economic factors work against the country's ability to generate electricity. Despite this, the country has the potential to address its electricity crisis. It is for this reason that this paper seeks to explore different factors responsible for the shortages of electricity with particular attention to its generation capacity. Several writers have examined the causes of Nigeria's appallingly low electricity production and generation in the literature. Ohajianya, AbumereOwate, and Osarolube (2014) identified several variables, including ineffective power reforms and incompetent workforce, that contribute to Nigeria's epileptic power supply. Sambo, Garba, Zarma, and Gaji (2016) stated that the reasons for Nigeria's electric power issue are poor private sector engagement and inadequate funding. Furthermore, Emovon *et al.,* (2018) argued that low power generation in Nigeria is caused, among other things, by a lack of energy mix and policy continuity.

However, unlike the previous studies, this paper considered other variables as important factors influencing electricity generation in Nigeria. These include electricity demand and government funding for electricity generation. The choice of these variables is informed by the fact that population increase has an impact on the consumption of electricity which in turn requires more electricity generation. Chukwueyem *et al.*, (2014) claimed that one of the main factors influencing Nigeria's demand for electricity is its population. Therefore, the electricity demand will increase as the population grows. Similarly, there is no doubt that generating electricity is a necessary step in the process of building infrastructure within the economy. The paper also differs from the previous studies in its methodological approach. The study will utilize the techniques of impulse response function and variance decomposition in analyzing the responses of electricity generation to shocks in the independent variables and to estimate how much variation in electricity generation is accounted for by the variables.

Therefore, the paper is segmented into five sections including the introduction as section one. Section 2 reviews the related literature while Section 3 examines the methodology employed in this study. Section 4 presents the discussion of results while section 5 concludes with recommendations.

2. Literature Review

2.1 Clarification of Concepts

2.1.1 Concept of Electricity

Electricity is a controllable and convenient form of energy used in applications of heat, light, and power (Umar, Mathias, & Praisad, 2022). Electricity is also defined as a set of phenomena caused by the existence, interaction, and motion of electric charges derived from electric potential energy or kinetic energy (Oiol, 2019). Electrical energy and electrical current have a tight relationship with the concept of electricity. From a scientific perspective, these ideas differ in specific ways even if they are easily interchangeable in a common language. Energy can be stored in great quantities, but electricity cannot. This is so because the amount of energy that can be conducted depends on the type of conduction and the particle's capacity. For instance, there are restrictions on the quantity and capacity of the charges that permit their transfer via a conductor. That is why they will not allow the transfer of energy of over a certain amount (Aytekin & Kemal, 2009). Electricity is the most popular and commonly used energy source in the world today. One significant tendency that can be seen is that as the population of the nation grows, so does the electricity demand (Oyedepo, 2012).

2.1.2 Concept of Electricity Generation

The process through which electrical power is produced from different energy sources is called electricity generation (Iqbal, 2018). Electricity generation is the process of creating electricity from main energy sources. This stage precedes the supply (transmission, distribution) of electricity. (Alhashimi, Anooz, & Noori, 2020). Madueme (2002) noted that numerous development initiatives are causing Nigeria's peak demand for electric energy to rise. He continued by saying that despite this, the overall generation of electricity has not increased in line with this growth. It is a fact that most Nigerian communities view the building of town halls, access roads, pipe-borne water systems, and other infrastructure as necessary for their development, but electricity immediately enhances social and economic life by making a wide range of services and facilities easily accessible (Ogumodede, 2005).

Infrastructure for the production of electricity began to take shape in 1886 with the installation of two generating sets (Iyabo, 2021). Decades later, a large amount of investment in the value chain of generating electricity remains unrealized. The installed capacity for producing energy that is currently available is approximately 12,500 Megawatts (MW), or roughly 532 percent of the total from 1980 to 2017. The most populated nation in Africa's electrical demand cannot be met at the current rate of electricity generation. According to estimates, to generate a 7% economic growth in 2015, 2020, and 2025, respectively, 28,000MW, 51,000MW, and 77,000MW will be needed (Sambo, 2008).

2.1.3 Concept of Electricity Power Loss

Electric power losses are the terms used to describe the wasted energy that occurs in a system due to internal or external causes (Anumaka, 2012). Losses in electricity mostly happen during the distribution and transmission processes. These comprise miscalculations, resistance, atmospheric conditions, and losses that occur between supply sources and the load center (or consumers). The provision of electrical energy will inevitably result in losses; even technologically developed nations are unable to make all produced electricity available for consumer consumption; part of the electricity is lost merely as a result of the nature of the generating, transmitting, and distributing electricity industry. Technical and non-technical losses are the two main categories of electric energy losses.

Technical losses arise due to inherent losses in the electrical equipment employed in the power system, which cannot be completely removed. Generators and transformers have losses in both their core from hysteresis and eddy current, as well as in their windings from winding resistance. Non-technical losses, also known as commercial losses, are caused by things other than the power system and cannot be empirically computed like technical losses. Examples of non-technical losses include electricity theft, which involves things like tampering with meters to make them undercount, bypassing the meters, making illegal connections, or working with the billing department to alter the bill issued to the customer. These losses affect the profitability of the power venture and also impose undue strain on the paying customers whose tariff often includes factors that account for energy loss (Komolafe & Udofia, 2020).

2.1.4 Concept of Electricity Demand

Electricity demand is a derived demand by households for lighting, cooking, and heating and by firms to operate equipment to produce goods and services (Madhu & Narasimha, 2010). Nigeria's demand for electricity rises as the country's population grows. There are five groups of electricity consumers in Nigeria: residential, commercial, industrial, street light, and foreign clients. In Nigeria, the household sector is now the one that uses power the most. In Nigeria, over 59.5% of the populace has access to electricity in 2021 (Umar, *et al.*, 2022). Over the past decades, there has been an increase in electricity consumption in the country without a corresponding increase in supply.

2.2 Theoretical Review

2.2.1 Theory of Production

According to Paul (2004), Production theory had its first general application in economics by the French economist Jean-Babtiste Say in 1803. Production simply refers to the process of transforming inputs into outputs. Essentially, the production theory in economics deals with the description of the production technology which explains the economic behavior framework. This theory is very applicable to this study because electricity is not freely available in nature, so it must be "produced" that is transforming other forms of energy into electricity. It is generated by converting primary sources of energy like atomic, gasoline, coal, and other natural sources (Iqbal, 2018)**.** This theory is very relevant to justify the theoretical basis of this study. The process of transforming raw materials into finished or semi-finished goods for the satisfaction of human beings is the main subject matter of the theory of production which is equally what electricity generation is all about. The process of generating electric power from sources of primary energy which are from their natural form is the production itself. Production of quantities of goods and services from the economic viewpoint is influenced by certain factors perhaps, economic, social, technological, and political factors. Electricity production and generation is also influenced by major factors that have either positive or negative impact on the quantity of electricity generated on a timely basis. Thus, this theory of production is very relevant in studying factors that economically determine electricity generation in Nigeria.

2.2.2 Theory of Supply

It is well known that, under the classical theory of supply, producers will typically provide less for sale at a lower price and more at a higher price (Smith, 1776). On the other hand, there might be a visual disparity in the generation and distribution of electricity. According to this theory of supply, a product's maximum amount that can be sold at a particular price depends on several factors. These factors include, but are not limited to, the commodity's price, production costs, advances in technology, weather patterns, and governmental regulations. It is clear from the literature analysis that several factors, including cost, government funding, power outages, technology, and rainfall, affect the production and delivery of energy in Nigeria. It should be noted that these factors influence the quantity (and maybe quality) and consistency of the electrical power that Nigeria's electricity organizations supply. This theory is pertinent to our research because it clarifies how the previously described economic factors affect the generation of electricity.

2.3 Empirical Review

Some empirical studies have identified some key determinants of electricity generation both in Nigeria and in other countries as follows:

Imo, Chukwu, and Abode (2017) used the box-Jenkins autoregressive model of order 1 and the multiple linear regression model to examine the factors that influence the generation of electricity in Nigeria. Temperature and rainfall were used as explanatory variables in the study. The study's conclusions showed that rainfall and power generation in Nigeria had a strong and significant relationship. Temperature has a positive correlation but has little effect on the generation of electricity. The study suggested that the government build more dams so that more electricity might be generated through harnessing rainfall.

Ubi, Effiom, Okon, and Oduneka (2012) conducted a study to analyse the determinants of electricity supply in Nigeria (from 1970-2009).

The study of ordinary least squares. The findings of indicated that government funding, technology, and electricity loss were the statistically significant determinants of electricity supply in Nigeria. The study found that an average of 40% of electricity is lost during the transmission process. Thus, the study recommended that the government should inject more funds into the power sector to complete electricity projects to enhance electricity supply.

Peprah (2015) investigated the determinants of electricity generation in 25 sub-Saharan African nations using the Ordinary Least Square method. The study discovered that factors including labor, GDP per capita, privatization, and others had a positive correlation with electricity generation in those nations but it turned out that the production of electricity was not significantly impacted by regulatory quality.

Similarly, Lean and Symth (2010) studied the influence of CO2 emissions on electricity generation in Malaysia. The study established that electricity generation is determined by national income in Malaysia. The study made some recommendations which include that the Malaysian government should enhance its national revenue sources for a steady electricity generation in the country.

The study by Cerra, Alfredo, and Svetlana (2017) analysed the determinants of electricity infrastructure and its financing in Latin America using the ARDL model. The study found that factors, such as level of income, rising financial depth, private investment, degree of urbanization, population density, fertility, and higher debt burden all were found to affect electricity generation capacity in Latin America and hence recommended that the government should take proper decisions in ensuring private investment, national income among others.

Okon and Oduneka (2012) employed a parametric econometric methodology of ordinary least squares to investigate the factors influencing the availability of power in Nigeria between 1970 and 2009. The results indicated that funding from the government, technology, and power loss levels were found to be the statistically important factors influencing Nigeria's electricity supply.

Akinbola, Zekeri, and Idowu (2017) investigated how Nigerian government policies affected the country's industrial growth and power supply with yearly time series data spanning 1980–2010. The study used the co-integration technique to determine the long-term link between a few macroeconomic variables, such as the real gross domestic product's industrial compound. Kilowatt-hours (KWH) of electricity generation, consumption, real gross fixed capital formation, labor force growth rate, and phone lines per hundred people were among the independent variables. The study concluded that long-term government policy regarding power had a detrimental effect on industrial output.

Iyabo (2021) also examined the factors that affected Nigeria's infrastructure for producing power from 1980 to 2016. An Autoregressive Distributed Lag model was employed in the investigation. Electricity generation capacity was employed as a gauge for the growth of the electrical infrastructure. To predict the amount of electricity generated in Nigeria, various factors were considered, including total government spending, interest rates, inflation, private sector credit, exchange rates, real GDP per capita, real gross fixed capital creation, and the pace of urbanization. Based on their estimate, every one million population requires 1000MW of electricity to function in modern-day society implying that Nigeria needs 180,000MW of electricity capacity. The realization of this is hinged on a large scale.

Yoo and Kim (2005) used time-series approaches to establish a causal association between Indonesia's economic growth and energy generation during the years 1971–2002. The findings showed that there is unidirectional causality devoid of any feedback effect, between economic growth and electricity generation. Therefore, measures aimed at decreasing electricity generation can be implemented without negatively impacting Indonesia's economy, as economic expansion leads to a rise in electricity generation.

Iqbal (2018) examined electricity generation using footsteps in Nigeria. The study focused on designing a setup that leads to the generation of electrical energy which is going to waste when humans are walking. The study found that electrical energy can be produced by converting mechanical energy using footsteps and this type of process will reduce global warming and load shedding in a much cleaner cost-effective way.

Emovon, Samuel, Mgbemena, and Adeyeri (2018) conducted a study on the electric power generation crisis in Nigeria and discovered that the main obstacles to power generation in the country are vandalism of gas pipelines, old or obsolete equipment, and poor plant maintenance. These obstacles can be reduced or eliminated, among other things, with the use of structured maintenance methodology and adequate funding.

Onisanwa and Adaji (2020) used an Autoregressive Distributed Lag (ARDL) technique to analyze the energy consumption and its determinants in Nigeria between 1981 and 2017, with a focus on income per capita, the number of electricity consumers, and shortages in electricity distribution. The study's conclusions show that per capita income, population density per square kilometer, the number of power users, and electricity shortages are the main factors driving Nigeria's long-term electricity consumption. The distribution of electricity shortages has various short- and long-run effects, whereas the amount of electricity consumed rose as the population and number of consumers in a given area increased.

Sule (2010) conducted a study on the primary factors influencing the generation, transmission, and distribution of electricity in Nigeria. The study discovered that issues such as a lack of diversification in the energy sources utilized to generate electricity, a culture of bad maintenance, losses in electrical power transmission lines due to distances between generating stations and load centers, etc. are responsible for the low generation of electricity.

It is important to point out that all the above studies have tried to figure out different factors responsible for the abysmal low power generation in one way or the other. However, the studies did not take into consideration the response of electricity generation to the shocks caused by the adopted variables based on time horizon and how much variations in these shocks are explained by the variables. This study utilises the techniques of impulse response functions and variance decomposition to fill this vacuum.

3. Methodology

3.1 Data Description

Data for this study was obtained from a secondary source. The data for electricity generation, electricity power loss, and electricity demand per Billion Kilowatt-hours (BKWH) was obtained from the Energy Information Administration [EIA], (2022). The data for government funding on electricity was obtained from the National Bureau of Statistics [NBS], 2022). The analysis is to cover the period spanning from 1981 to 2021. The choice of the period is intended due to the unstable increase of electricity generation in Nigeria in the period which makes it very interesting to examine the factors responsible for the upstream and downstream trends in the electricity generation. This is evident from the World Bank (2018) World Development Index (WDI) report which showed that 32%, 38%, 26%, and 13% of electricity power losses were recorded in Nigeria between 1980-1989, 1990-1999, 2000-2009, and 2010-2016 respectively. Additionally, WDI in 2018 recorded that Nigeria could not meet the electricity demand of its teeming population, as it recorded a lower than 50 percent average generation capacity between 1990 to 2016 (Iyabo, 2021). The variables are expected to have a significant relationship with electricity generation in Nigeria.

3.2 Variables Description

Electricity Generation (EGT): This refers to the amount of electricity generated annually in Nigeria. It is measured in billion kilowatt hours quantity and it is the dependent variable in this study.

Electricity Power Losses (EPL): This refers to the amount of electricity lost annually during the transmission and distribution process. It is also measured in a billion-kilowatt-hour quantity.

Government Funding on Electricity (GFE): This refers to the annual government allocation for electricity generation purposes in Nigeria. This is measured in billions of Naira allocated to electricity generation.

Electricity Demand (ELD): This refers to the annual electricity consumption rate by the individuals with electricity access in Nigeria. It is also measured in a billion-kilowatt-hour quantity.

Several studies such as Okon *et al.*, (2012); Iyabo (2021); Lean and Symth (2010) Ubi *et al.* (2021); Sule (2010); and Iqbal (2018) attempted to identify the variables that determine the quantity of electricity generation such as: economic growth, GDP per capita, electricity power loses inflation and technology. However, this paper considered other variables such as electricity demand and government funding for electricity. The choice of these variables has been explained in the introduction section of this paper

Unlike the previous studies, techniques of the Vector Autoregressive Model (VAR) including impulse response functions (IRFs) and variance decomposition are adopted in this study. The VAR model is an extension of the univariate autoregressive model to dynamic multivariate time series analysis (Chukwuma *et al.*, 2019). Biljanovska and Meyer-Cirkel (2016) believe that VAR has become a solid and dependable technique in terms of forecasting the economic behavior of variables over some time. Impulse response functions (IRFs) and variance decomposition will be utilized to achieve the objectives of this study. Impulse response functions are used to explain the effects of shocks on a variable to itself and the other variables based on time horizon. Variance decomposition is used to analyze how much variation is explained by a variable on itself and by other variables due to a one-standard-deviation shock in the system during a specific time horizon.

3.3 Model Specification

Following the model of Imo *et al.*, (2021) which was specified as follows:

$$\mathrm{G_t} = \beta_0 + \beta_1 \mathrm{R_t} + \beta_2 \mathrm{T_t} + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where $\mathrm{G_t} = Elec\ tricity\ generation$

$R_t = Annual\ Rainfall$
$T_t = Temperature$
The functional specification of our model is expressed as follows:

$$LEGT = f\ (LEPL\ ,\ LGFE,\ LELD) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where:
LEGT = Log of Electricity Generation in Megawatt Hours
LEPL = Log of Electric Power Losses
LGFE = Log of Government Funding on Electricity
LELD = Log of Electricity Demand
Transforming Equation (1) to an econometric equation we obtained the following:

$$LEGT_t = \beta_0 + \beta_1 LEPL_t + \beta_2 LGFE_t + \beta_3 LELD_t + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where: LEGT, LEPL, LGFE, and LELD are defined earlier in Equation (1).
β_0 = Constant
β_{1-3} = Estimation parameters
μ = Stochastic variable
$\beta 0 > 0, \beta 1 > 0, \beta 2 > 0, \beta 3 > 0$
The Vector Autoregressive Regressive form of the model based on the notations of the variables in equation (1) is specified as follows:

$$\Delta legt_t = \beta_0 + \sum_{i=1}^{k} \beta_i \Delta legt_{t-i} + \sum_{j=1}^{k} \Phi_j \Delta lepl_{t-j} + \sum_{n=1}^{k} \gamma_i \Delta lgfe_{t-m} + \sum_{m=1}^{k} \varphi_m \Delta leld_{t-n} + \lambda_1 ECT_{t-1} + u_{1t}$$

$$\Delta lepl_t = \beta_0 + \sum_{i=1}^{k} \beta_i l\Delta egt_{t-i} + \sum_{j=1}^{k} \Phi_j \Delta lepl_{t-j} + \sum_{n=1}^{k} \gamma_i \Delta lgfe_{t-m} + \sum_{m=1}^{k} \varphi_m \Delta leld_{t-n} + \lambda_2 ECT_{t-1} + u_{2t}$$

$$\Delta lgfe_t = \beta_0 + \sum_{i=1}^{k} \beta_i \Delta legt_{t-i} + \sum_{j=1}^{k} \Phi_j \Delta lepl_{t-j} + \sum_{n=1}^{k} \gamma_i \Delta gfe_{t-m} + \sum_{m=1}^{k} \varphi_m \Delta leld_{t-n} + \lambda_4 ECT_{t-1} + u_{4t}$$

$$\Delta leld_t = \beta_0 + \sum_{i=1}^{k} \beta_i \Delta legt_{t-i} + \sum_{j=1}^{k-1} \Phi_j \Delta lepl_{t-j} + \sum_{n=1}^{k} \gamma_i \Delta lgfe_{t-m} + \sum_{m=1}^{k} \varphi_m \Delta leld_{t-n} + \lambda_3 ECT_{t-1} + u_{3t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where:
K = Implies the lag length
β_i, Φ_j, φ_m and γ_i = Implies short-run dynamic coefficient of the model's adjustment long-run equilibrium
$\lambda_1, \lambda 2, \lambda_3$, and λ_4 = Implies the speed of the parameter with a negative sign
ECT_{t-1} = Is the error correction term which is the lagged value of the residuals obtained from a cointegrating regression of the dependent variable on the regressors.
u_{it} = Is the stochastic error term

Following Koop, Pesaran, and Potter (1996), the forecast error impulse response of Φi for the ith period after the shock is obtained by:

$$\Phi i = \sum_{j=1}^{i} \Phi i - j\, Aj,\ \ i = 1{,}2, \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . \ldots .. (5)$$

Where, $\Phi_O = I_K$ and $A_J = 0$ for j > p $A_J = 0$ for j > p, where K is the number of endogenous variables and p is the lag order of the VAR model.

The impact of a single shock to one of the innovations on the present and future values of the endogenous variables is represented by an impulse response function.

The generalized forecast error variance decomposition is given by:

$$\Phi_{ii}(\mathrm{h}) = \frac{\sigma_{ii}^{-1}\ \sum_{i=0}^{h}\left(e_i^{'} A_l \sum ej\right)^2}{\sigma_i^2(h)} \qquad i, j = 1, \ldots \ldots \ldots\ldots \ldots \ldots \ldots \ldots \ldots . \ldots .. (6)$$

Where $i, j = 1$

The variation in an endogenous variable is divided into the component shocks to the VAR using variance decomposition, as shown in equation 6. The relative significance of each random innovation is thus shown by the variance decomposition.

3.4 Unit Root Test

This study adopts the Augmented Dickey fuller (ADF) unit root test to confirm the unit property of the series. In conducting the unit root test, the study makes use of Augmented Dickey-Fuller (ADF). This test is used to check the problem of a non-stationary or unit root in the series variables (Hassan, Maman, & Farouk, 2013). Similarly, the ADF test is frequently used in stationary tests. The model is given as

$$\Delta_{yt} = \alpha_0 + \alpha_1 y_{t-1} + \sum \alpha_i \Delta y_{t-1} + \mu_i \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (7)$$

Where: $\Delta\, y_t$ is the variation in y at period t, α_o represents constant, y_{t-1} is the past value of y, α_1 is the estimated lag coefficients and μ_t is the error terms.

4. Results and Discussion

4.1 Descriptive Statistics

Table 1: Descriptive Statistics of the Variables

	LEGT	LEPL	LGFE	LELD
Mean	2.838664	1.418405	6.132683	2.519231
Median	2.708050	1.458615	5.910926	2.441401
Maximum	3.496508	1.960095	6.940706	3.332205
Minimum	1.931521	0.741937	5.431974	1.547563
Std. Dev.	0.457170	0.337550	0.534471	0.565005
Skewness	-0.170383	-0.507612	0.306008	0.077239
Kurtosis	1.944767	2.547346	1.510179	1.502860
Jarque-Bera	2.151869	2.162259	4.539729	3.964261
Probability	0.340979	0.339212	0.103326	0.137775
Sum	119.2239	59.57301	257.5727	105.8077
Sum Sq. Dev.	8.569181	4.671529	11.71204	13.08845
Observations	41	41	41	41

Source: Author's computation using E-Views version 10.

The descriptive statistics summary of all our variables is shown below (see Table 1). According to the table, the average value of the log of electricity generation (LEGT), log of electricity power loss (LEPL), log of government funding on electricity (LGFE), and log of electricity demand (LELD) over the period covered by this study is 2.838664BKW, 1.418405BKW, ₦6.132683b and 2.519231BKW respectively. Furthermore, the maximum values associated with the log of electricity generation (LEGT), log of electricity power loss (LEPL), log of government funding on electricity (LGFE), and log of electricity demand (LELD) is 3.496508BKW; 1.960095BKW, ₦6.940706b and 3.332205BKW respectively. On the other hand, the minimum values associated with the log of electricity generation (LEGT), log of electricity power loss (LEPL), log of government funding on electricity (LGFE), and log of electricity demand (LELD) is 1.931521BKW; 0.741937BKW, ₦5.431974b and 1.547563BKW respectively. The implication is that all the variables had been increasing throughout the study period. The dispersion around the mean is measured by the standard deviation. According to the findings, LELD has the most variance from the mean while LEPL has the least variation. The period of analysis for the variables covers from 1981 to 2021 making 41 observations for all the variables. The Jarque-Bera along with the probability values indicated that the variables are normally distributed. This is because all the values of Jarque-Bera are greater than 0.05 for all the variables.

The table shows that the probability values are low for all the variables, and the means are nearly equal to the medians, hence we conclude that the residuals for the distribution are normally distributed.

4.2 Stationary Test

Table 2: Unit Root Test (ADF) Result

Variable	ADF test statistic	Critical value	P-values	Order
LEGT	-3.805825	-2.938987	0.0060	1(1)
LEPL	-8.759497	-2.938987	0.0000	1(1)
LGFE	-6.862631	-2.938987	0.0000	1(1)
LAPG	3.436397	-2.945842	0.0000	1(1)

Source: Author's computation using E-Views version 10

In this study, the augmented Dickey-Fuller test was computed to test the stationary level of our series. The null hypothesis for this test says that there is a unit root (non-stationary) against the alternative which says that there isn't a unit root at a 5% level of significance. It is indicated that all our variables (LEGT, LEPL, LGFE, and LELD,) are stationary at the first difference 1(1). As a result, we have completely rejected the null hypothesis for all of these variables.

4.3 Optimal Lag Selection

Table 3: Lag length Selection Criteria Table

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-295.1921	NA	124.1001	16.17254	16.34670	16.23394
1	-165.5369	224.2684	0.268251	10.02902	10.89979	10.33601
2	-117.3124	72.98845	0.048580	8.287155	9.854535	8.839730
3	-76.79834	52.55875	0.014061	6.962072	9.226065	7.760236
4	-45.61179	33.71519*	0.007350*	6.141178*	9.101784*	7.184930*

Source: Author's computation using E-Views version 10.
* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 3 shows different criteria from which a lag length of our model variables can be selected. All four criteria: FPE, AIC, HQIC, and SBIC indicate the selection of a maximum of four (4) lags in our model as shown by the asterisk (*) along the fourth lag.

4.4 Impulse Response Functions (IRF)

Response to Cholesky One S.D Innovations ± 2 S.E

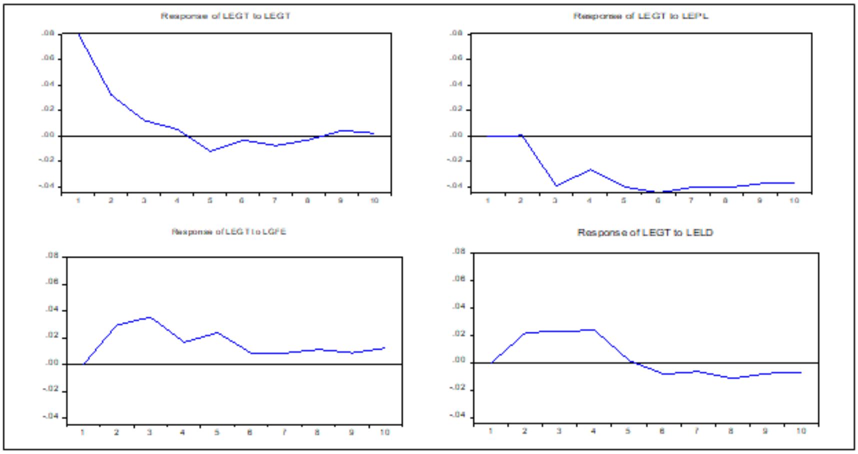

Figure 1: Impulse Response Functions
Source: Author's computation using E-Views version 10.

The impulse-response function framework is used in this study to evaluate and interpret the short-term and long-term interactions between the variables under investigation. The VAR system's impulse-response function displays how the dependent variables respond to sudden shocks in the independent variables. This study applies the Cholesky decomposition to the VAR Equation and investigates how Nigerian electricity generation responds to shocks from electricity demand, government funding for electricity, and power loss. Figure 1 shows the results of impulse-response functions for the responses of electricity generation to key variables' shocks in Nigeria.

The Figure 1 indicated that electricity generation responded negatively to a shock from itself from the first to the fifth periods, after that, it continued to respond positively as well as negatively until the end of the forecasting period. The overall response of electricity generation to a shock from its own is negative. The second diagram in Figure 1 shows the response of electricity generation (LEGT) to shocks from electricity power loss (LEPL). The effect started with a sharp negative response from 1st period to the 3rd period. Afterward, it responded positively to the 4th period.

It later on responded negatively from the 4th period to the 6th period. Thereafter, the system continued to slightly respond until the end of the forecasting period. The overall short-run effect of LEPL shock on LEGT in Nigeria appears to be negative. The third diagram in Figure 1 illustrates the response of electricity generation (LEGT) to short-term shocks from government funding (LGFE). The effect started to respond positively from the 1st period to the 3rd period.

After that, the response zigzagged from the 3rd period to the 6th period. However, from the 6th period, the system slightly responded positively until the end of the forecasting period. The overall response of electricity generation to government funding on electricity shocks in Nigeria is positive. The fourth diagram in Figure 1 shows the response of electricity generation (LEGT) to short-term shocks from electricity demand (LELD). The initial response of LEGT is positive from 1st period to the 2nd period. After that, the response became flattened up to the 4th period. It later on responded negatively to the 6th period. The system then slightly responded positively to the 7th period and negatively to the 8th period. From the 8th to the end of the forecasting period, the effect was found to have slightly responded positively. The overall response of electricity generation to electricity demand shocks in Nigeria is negative.

4.5 Variance Decomposition of Electricity Generation (LEGT)

Table 4: Variance Decomposition of LEGT

Variance Decomposition of LEGT: Period	S.E.	LEGT	LEPL	LGFE	LELD
1	0.080468	100.0000	0.000000	0.000000	0.000000
2	0.094362	84.60092	0.004048	9.807227	5.587807
3	0.111260	62.10228	12.28338	17.23075	8.383589
4	0.118150	55.29333	15.87373	17.29298	11.53996
5	0.127488	48.32355	23.39472	18.34756	9.934161
6	0.135534	42.80936	31.39863	16.64453	9.147477
7	0.141941	39.29751	36.63215	15.54316	8.527178
8	0.148510	35.93393	40.92152	14.77574	8.368804
9	0.153629	33.66206	44.13970	14.13436	8.063875
10	0.158664	31.58303	46.83233	13.85714	7.727490

Source: Author's computation using E-Views version 10

The results of the variance decomposition of LEGT in Table 6 revealed that in the 1st period, 100% variation in LEGT is due to its shocks. This implies that 0% variation in LEGT is accounted for by all other endogenous variables of the VAR model in the 1st period. On the other hand, from the 2nd period to the end of the entire forecasting period, 84.6%, 62.1%, 55.2%, 48.3%, 42.8%, 39.2%, 35.9%, 33.6%, and 31.5% variations in LEGT is due to its shocks respectively. Similarly, from the 2nd to the end of the entire forecasting period, 0.004%, 12.2%, 15.8%, 23.3%, 31.3%, 36.6%, 40.9%, 44.1%, and 46.8% variations are explained and accounted for by LEPL respectively. Moreover, from the 2nd to the end of the entire forecasting period, 9.8%, 17.2%, 17.2%, 18.3%, 16.6%, 15.5%, 14.7%, 14.1%, and 13.8% variations are explained and accounted for by LGFE respectively. Similarly, from 2nd to the end of the entire forecasting period, 5.5%, 8.3%, 11.5%, 9.9%, 9.1%, 8.5%, 8.3%, 8.0%, and 7.7% variations is explained and accounted for by LELD respectively.

4.6 Diagnostic Tests of the VAR Model

Table 5 presents some diagnostics tests conducted to ensure the robustness and validity of our model as well as the variables employed in this study.

Table 5: Results of the Diagnostic Tests

Heteroskedasticity Test			
F-statistics	31.84	P-value	0.132
Serial Correlation LM test			
F-statistics (lag order 1)	33.133	P-value	0.307
Normality test			
F-statistics	87.735	P-value	0.231

Source: Author's computation using E-Views version 10

To confirm the reliability of the estimation analysis, this study conducted some major post-estimation tests to identify the result fitness and appropriate decisions. These tests include heteroscedasticity, autocorrelation, and normality test. Looking at the above values of p-values along with the corresponding F-statistics, it is concluded that our model is free from the heteroskedasticity problem since the p-value is 0.132 which is greater than 0.05. Our model is also free from serial correlation since the p-value is 0.121 and finally the p-value of 0.595 in the normality test shows that there is a normal distribution of our residual value because this value is greater than 0.5%

4.7 Discussion of Findings

The factors included in this study are found to be appropriate predictors of electricity generation in Nigeria based on the impulse response function and the variance decomposition performed in this study. It is shown from the result that electricity generation responds significantly and negatively to its shock and it also accounts for higher variation by itself throughout the forecasting period. This confirms the findings of Iyabo (2021) which indicated that in the short run, there exists a negative link between the lag values of electricity generation and its current values unlike in the long run where the positive link is associated between the lag values of electricity generation and its current values.

Moreover, the negative response was obtained in the electricity generation due to a one standard deviation shock in electricity power loss. This economically implies that a negative correlation exists between electricity power loss and electricity generation in Nigeria. This is obvious from the result of the variance decomposition which indicated that a significant percentage of variation in electricity generation is explained by electricity power loss throughout the forecasting period. This is in line with the empirical evidence found by Ubi *et al.,* (2012); and Onisanwa *et al.,* (2020) who found a negative association between electricity generation and electricity power loss in their studies.

Therefore, electricity power is a major factor influencing the quantity of electricity generation in Nigeria as also indicated by Okon *et al.,* (2012). This electricity power loss takes different forms such as vandalism of oil/gas pipelines, old or obsolete equipment, and poor plant maintenance which jointly caused a negative impact on electricity generation in Nigeria as pointed out by Emovon *et al.,* (2018).

However, a positive response in electricity generation was found due to shocks in government funding for electricity and more interestingly a significant variation in electricity generation is accounted for by government funding for electricity throughout the entire forecasting period. This positive impact is in line with the empirical evidence from the studies of Iyabo (2021); Ubi *et al.,* (2012); and Emovon *et al.,* (2017). Okon *et al.,* (2012) even pointed out that in Nigeria, government funding and electricity loss are the major factors influencing electricity generation.

This study also found that electricity generation responds negatively to shocks in electricity demand in Nigeria and also a moderate variation in electricity generation is accounted for by electricity demand on electricity generation in Nigeria throughout the forecasting period. This indicates that electricity demand is an important variable in forecasting electricity generation in Nigeria, especially in the urban areas where electricity demand is higher due to population density demanding for availability of electricity supply. This corroborates with the findings of some previous researchers like Cerra *et al.,* (2017) who stated that electricity demand due to population density is among the factors affecting electricity generation in Latin America. There this could also be the case with Nigeria as portrayed in this study.

5. Conclusions and Recommendations

This study analyzed the joint interaction of the determinants of electricity generation in Nigeria. The study applied the Impulse Response Function (IRF) and Variance Decomposition of the VAR model. One strong outcome of the study is that the Impulse Response Function (IRF) and Variance Decomposition results indicated that all the variables used in this study are very significant in predicting electricity generation in Nigeria. However, electricity generation is the main influencer of its variable. Interestingly, all the variables: the Log of Electricity Power Loss (LELP), the Log of Government Funding on Electricity (LGFE), and the Log of Electricity Demand (LELD) were significant in causing responses to electricity generation in Nigeria.

It is advised that the government should focus more on increasing electricity generation capacity in a manageable way, implement appropriate measures to lower the rate of electricity power loss during the transmission and distribution process, manage the allocation of funds to fund electricity generation, and also develop ways to meet more electricity demand.

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