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The Effect of Energy Consumption and Losses on the Nigerian Manufacturing Sector: Evidence from the ARDL Approach

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Abstract**—**The bounds testing ARDL (2, 2, 2, 2, 0) technique to cointegration was used in this study to investigate the effect of energy consumption and energy loss on Nigeria's manufacturing sector from 1981 to 2020. The model was created to determine the relationship between these three variables while also accounting for interactions with control variables such as inflation and commercial bank loans to the manufacturing sector. When the dependent variables are energy consumption and energy loss, the bound tests show that the variables of interest are bound together in the long run. Because electricity consumption is a critical factor in determining manufacturing value-added in Nigeria, some intriguing observations were made. According to the findings, the relationship between log of electricity consumption (LELC) and log of manufacturing value added (LMVA) is statistically significant. According to the findings, electricity consumption reduces manufacturing value-added. The target variable (energy loss) is statistically significant and has a positive sign. In Nigeria, a 1% reduction in energy loss increases manufacturing value-added by 36% in the first lag and 35% in the second. According to the study, the government should speed up the ongoing renovation of existing power plants across the country, as well as the construction of new gas-fired power plants. This will address a number of issues, including overpricing of electricity as a result of grid failure.

Keywords**—**ARDL, cointegration, Nigeria's manufacturing, electricity.

I. Introduction

ENERGY is one of the most critical inputs that cannot be overlooked in manufacturing processes in both developed and developing countries worldwide [1]. It is one of the most challenging factors limiting the growth of the manufacturing sector in Nigeria. It lacks adequate development to channel manufacturing sector growth.

The manufacturing sector is known for generating income, jobs, and wealth, as well as improving citizens' standard of living through productivity and profitability. According to Beji & Belhadj (2014), as reported by [2], manufacturing has several long-run benefits such as economic diversification, technology transfer, unemployment reduction, and welfare improvement. As a result, manufacturing value added is the driving force behind economic growth. However, in order to do so, the manufacturing sector requires power, so it collaborates with the energy sector to ensure that its operations run smoothly.

Manufacturing Value Added (MVA) increased 39.2% from N33.3 billion in 1981 to N54.8 billion in 2020 during the study period (see Fig. 1). According to data from [3], the country's MVA in 2017 was $32.8 billion lower than it was in 1981. When MVA is expressed as a percentage of GDP, the picture becomes bleaker. The MVA contributed up to 20.3% of Nigeria's GDP in 1981. However, 39 years later, the sector's contribution has dropped to 12.7% (see Fig. 2). It began to rise steadily after reaching an all-time low of 6.55% in 2010, eventually reaching 9.6% in 2014. From 1981 to the present, this trend demonstrates that very little success has been recorded over the years.

Despite huge proven gas reserves estimated at 192 trillion cubic feet, Nigeria continues to lag in its electricity consumption. Unutilized power generation in Nigeria increased year on year to 3,008.18 Megawatts (MW) in 2021, up from 1,030.80 MW in 2013, representing a 291% increase in the last eight years, primarily due to a lack of infrastructure [4]. This demonstrates that, despite eight years of privatization, adequate investment has not been made to transmit and distribute electricity to consumers, including households and businesses. According to the most recent data from electricity generation companies, GENCOs, unutilized power fell from 2,734.94 MW in 2014 to 2,010.24 MW in 2015 before rising steadily to 22,827.98 MW and 3,311.92 MW in 2016 and 2017, respectively. It also increased to 3,698.51 MW in 2018, then slightly decreased to 3,599 MW in 2019, before remaining stable in 2020 and 2021 at 3,742.43 MW and 2,117.86 MW, respectively [3]. This has cost a significant amount of power that could have been used to increase the value of manufacturing in the country. It has also hampered GENCOs' ability to generate revenue from unutilized power over the years, particularly since data show that, despite having more than 5,000 MW of available generation capacity, it has not resulted in 100% invoice settlement [4]. Power remains a national issue, with consumers unable to access more than 40% of GENCOs' available capacity due to constraints. Due to system constraints, the generated power is either rejected or forced to be reduced in order to match the infrastructure that transmits and distributes this power to the customer.

According to [4], as a result of these power challenges, yearly "unutilized capacity" averaged about 27.1% of total generation. Reports from [43] suggest that approximately 85 million

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people, or 43% of Nigeria's population, lack access to grid electricity, making Nigeria the country with the world's largest energy access deficit. The power sector, particularly in relation to gas, is suffering from a severe infrastructure deficit. Even on transmission, the network of Electricity Distribution Companies (DISCOs) is only about 20% of what it should be. The Transmission Company of Nigeria, TCN, has a track record of 10% grid loss, while distribution has a track record of 50% grid loss [5]. This necessitates immediate action, which is nearly the same as declaring an emergency. Several authors have written on the subject of the energy and growth nexus [6]-[9], while others describe in detail the level of energy losses [10], [5], [11]. It is so important that the current study attempts to fill the gap by determining whether energy losses have the potential to improve Nigeria's economy through MVA.

The remainder of this paper is structured as follows: The theoretical framework and empirical literature on the energy-growth nexus are presented in Section II. Section III discusses the study's methodology as well as the empirical findings, while Section IV focuses on the study's conclusion and policy implications.

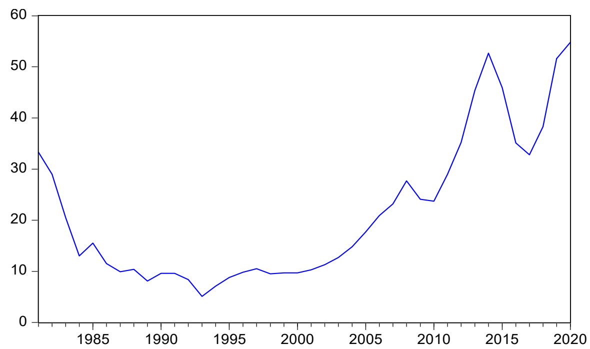


Fig. 1 Nigerian Manufacturing, Value Added (current US$) [3]

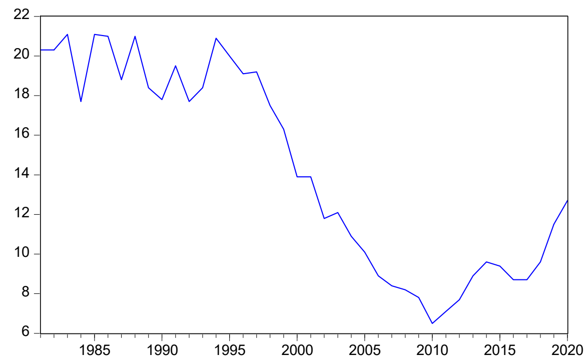


Fig. 2 MVA as a Percentage of the Gross Domestic Product (GDP) [43]

II. Theoretical Framework

The conventional economic growth theory pays little attention to the role of energy in economic growth. However, in order to comprehend the significance of energy in economic growth, it is necessary to first understand the role of energy in production. When it comes to production theories, the neoclassical economic theory describes the economy as a closed system in which output is produced by labor and capital inputs. As a result, economic growth is a result of increased inputs or their quality. Energy inputs are important in an indirect way, and they have been categorized as intermediate inputs. Mainstream economists, according to [12], have accepted the concept of primary and intermediate factors of production. Primary factors of production are inputs that already exist at the start of the period under study and are not directly used up in production (though they can be degraded and added to). Intermediate factors of production are those that are made during the period under study and are used up completely in production [13].

The primary factors of production are capital, labor, and land, while goods such as fuels and materials are intermediate inputs. This approach has resulted in a focus in mainstream growth theory on primary inputs, particularly capital and labor, with intermediate inputs such as energy playing a secondary role. Reference [14] was the first to emphasize the importance of energy in the economic system, arguing that the physical dimension of economic production required more explicit attention in growth theory. Following the first oil crisis in 1973-74, other economists began to develop energy-dependent production functions that included energy and materials in addition to traditional labor and capital inputs (for example, Tintner et al., 1974; Berndt and Wood, 1979), as reported by [13]. In general, the neoclassical production function explains economic growth by increasing labor, capital, and technology, with total factor productivity (TFP) being the portion of output that cannot be explained by the number of inputs used in production. Reference [15] also demonstrated that cross-country differences in technology can result in significant cross-country differences in income per capita. Although the model does not explain the sources of technological advancement, it is the only cause of continued economic growth [15].

In [16], these new growth theories have successfully addressed the problem of endogenizing growth by linking growth performance to profit incentives, but they continue to ignore the fact that equally endogenous energy-saving technical change will be required to make these growth paths sustainable in practice. They used energy as an explicit factor of production in an endogenous growth model and discovered that the rate of growth is negatively related to the rate of growth in real energy prices. This conclusion implies that rising real energy prices will tend to stifle economic growth. The reason for this is that rising real energy prices make it less profitable to use new intermediate goods and, as a result, less profitable to do research, which hurts growth.

In the period 1970–1990, [17] discovered empirical evidence for a negative relationship between natural resource intensity and subsequent growth. Even after controlling for a large number of additional variables that other studies have claimed are important in explaining cross-country growth; their findings remain significant. One of the most frequently cited reasons for the hypothesis that natural resources may be a curse to long-term development is the quality of institutions and governance. In recent years there has been a significant increase in research on "good governance" and the quality of government institutions. This evolution has resulted from empirical findings among economists that such institutions can be regarded as the key to understanding economic growth in developing countries [18]-[20].

Access to energy and economic development in developing countries is heavily reliant on state support and commitment. It is the government's responsibility to establish a clear institutional framework and to decide what role state-owned enterprises, private national capital, and international investors should play. As a result, the type of political governance in place has a significant impact on the relationship between energy resources, energy policy, and economic development [21]. Institutional economists have made significant contributions to our understanding of energy's role in economic development by introducing the impact of economic, social, and political institutions on energy efficiency [22]. However, while new institutional economics has focused on industrial organization and public choice, it has not demonstrated how environmental governance institutions are likely to be effective under what conditions. This raises the possibility of changing institutional structures, such as changing financial incentives or establishing communication networks, to facilitate individual and collective behavior in order to achieve a low-carbon economy [23]. During this time, new perspectives on economic growth have emerged. Outside of the mainstream, there is a large body of literature known as "ecological economics" that emphasizes the importance of energy in production and growth. Furthermore, some of them regard energy as the sole primary factor of production, whereas capital and labor are viewed as flows of capital consumption and labor services, rather than stocks [24].

According to ecological economists, energy is not only a critical production factor, but some [25] even conclude that energy availability drives economic growth, as opposed to economic growth that results from increased energy use. Ecological economists, as previously mentioned, focus on the material foundations of the economy and see the economy as an open subsystem of the global ecosystem. Although there are various schools of thought in the field, they all stem from the same fundamental principles – the laws of thermodynamics. According to the first law of thermodynamics, energy cannot be created or destroyed, but only transformed. This means that the only available energy source is solar energy, which can be used directly or indirectly, as in the case of fossil fuels. According to the second law, the entropy of an isolated system that is not in equilibrium tends to increase over time. It implies that energy can be reused, but that it will eventually become less useful, necessitating the use of additional energy. Reference [23] also said that there are limits on how much energy can be replaced by other things in the manufacturing process.

III. Empirical Literature

A significant amount of research using various time periods, variables, countries, and models emphasizes the importance of energy in the growth process. Reference [10] used Canonical Cointegrating Regression to examine the long-run impact of electricity consumption on manufacturing sector performance as measured by output, employment, and capital from 1981 to 2019. The output equation results show that electricity consumption and credit to the manufacturing sector have a negative relationship with output. Electricity consumption and interest rates have a negative impact on employment in the employment equation. Electricity consumption is not statistically significant in the capital equation. To summarize, the effects of electricity consumption as an input in the manufacturing sector have not improved the sector's performance. Reference [26] studied the energy consumption of industrial output from 1980 to 2013. The results, using an error correction mechanism, show that all variables in the study have a positive trend, indicating a long-run relationship between energy consumption and industrial output in Nigeria. Reference [27] found that electricity supply and trade openness have no effect on Nigerian industrial output. Reference [6] used the autoregressive distributed lag technique to examine manufacturing productivity and electricity consumption in Nigeria from 1980 to 2013. They discovered evidence of cointegration between electricity consumption, capital, and manufacturing productivity. The results revealed a bidirectional causal relationship between manufacturing productivity and energy consumption. People in Nigeria studied the relationship between electricity use and industrial growth from 1980 to 2012. Reference [28] looked into this relationship between those years.

Reference [29] used the ARDL bounds testing approach to examine the relationship between electricity supply and manufacturing sector output in Nigeria from 1971 to 2010. The findings revealed a long-term relationship between the variables. Manufacturing production was discovered to be positively dependent on electricity in both the short and long run. Reference [30] investigated the impact of electricity supply on manufacturing industry productivity in Nigeria. They used ordinary least square multiple regression to analyze the data from 1980 to 2012. According to the findings of the study, electricity generation and supply have a positive impact on manufacturing productivity growth. As a result, investigations into other countries' research have also been conducted.

Using cointegration and error correction techniques, [44] discovered a long-run significant positive relationship between industrial growth and electricity consumption, labor employment, electricity generation, and foreign exchange rate, as well as a negative relationship between capital input and industrial growth. Reference [31] conducted multiple regression analyses and discovered that national energy supply has no effect on industrial productivity in Nigeria. Reference [32] investigated the impact of aggregate energy consumption on Nigerian sectoral output. The study discovered bidirectional causality between total energy consumption and agricultural production and unidirectional causality from service output to total energy consumption using a bivariate Vector Autoregressive (VAR) model.

Reference [33] conducted a study that focused solely on the Ghanaian economy and discovered that electricity consumption has a negative impact on industrial growth in both the long and short run. The findings support the growth hypothesis in Ghana by demonstrating co-integration and unidirectional causality from electricity consumption to industrial growth. Reference [34] conducted another study that looked at the causal relationship between energy consumption and industrial production in Tunisia from 1980 to 2007. The Granger causality test results show that industrial output causes gas consumption, but there is no causality between oil consumption and industrial GDP. In the short run, however, Granger causality runs from industry GDP to total energy consumption and from electricity consumption to industry GDP, with no causality on both sides in the long run. From 2005 to 2015, [35] investigated the relationship between electricity consumption and sectoral output growth in Uganda. At the macro level, the result indicates the presence of a causality running from electricity consumption to GDP. Long-run causality runs from electricity consumption to industry, indicating that the sector is growing. There is no short-term causality from the service sector to electricity use in agriculture.

III. Methodology

A. Data Sources

The data employed in this study are yearly time series data of MVA, energy loss (ENGL), electricity consumption (ELC), inflation rates (INF) and loan to the manufacturing sector (ML). All data were sourced from the Nigerian Central Bank's and World Bank's statistical database. All of the data were converted to log form so that they were all of the same magnitude and could be analyzed more effectively.

TABLE I
Measurement of Variables and Data Sources

S/No	Variables	Measurement	Expected sign	Sources of Data
1.	Manufacturing (MVA)	MVA of an economy is the total estimate of net-output of all resident manufacturing activity units obtained by adding up outputs and subtracting intermediate consumption.	Negative	[45]
2.	Energy loss (ENGL)	Losses in electric power transmission and distribution include transmission losses between sources of supply and points of distribution, as well as distribution losses to consumers, including pilferage.	Negative	[46]
3.	Electricity power consumption (ELC). A proxy foe energy consumption.	Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants.	Positive	[47]
4.	Inflation rate (INF)	Annual percentages of average consumer prices a year-on-year changes.	Negative	[48]
5.	Manufacturing sector loan	Total amount of loanable fund granted to the manufacturer sector.	Positive	[48]

B. Method of Data Analysis

This study employs the autoregressive distributed lag (ARDL) estimation technique proposed by [36]-[38], also known as the bounds testing cointegration technique, to determine the long-run relationship between energy consumption, manufacturing sector value added, energy loss, inflation, and commercial bank loans to the manufacturing sector. The selection of this technique became critical and most appropriate because it offers three advantages over previous and traditional cointegration methods. The first is that the ARDL does not require that all of the variables under study are integrated in the same order; it can be used when the underlying variables are integrated in order one, order zero, or fractionally integrated. The ARDL test is also relatively more efficient in the case of small and finite sample data sizes. The final and third advantage is that we obtain unbiased estimates of the long-run model by using the ARDL technique [39]. However, as noted by Quattara (2004) as reported by [40], the presence of 1(2) variables invalidates the bounds test computed F-statistics because they are based on the assumption that the variables are either I(0) or I(1) and, in some cases, mutually cointegrated.

C. Model Specification

The ARDL version of the vector error correction model (VECM) can be specified as follows:

$$\Delta LMVA_t = \beta_0 + \beta_1 LMVA_{1t-1} + \beta_2 LENGL_{2t-1} + \beta_3 LELC_{3t-1} + \beta_4 LINF_{4t-1} + \beta_5 LML_{5t-1} + \sum_{j=0}^{p} \delta_j \Delta LMVA_{1t-j} + \sum_{1=0}^{q} \phi_1 \Delta LENGL_{2t-1} + \sum_{m=0}^{q} \delta_m \Delta LELC_{3t-m} + \sum_{n=0}^{q} \eta_n \Delta LINF_{4t-n} + \sum_{a=0}^{q} \mu_a \Delta LML_{5t-a} + \varepsilon_t \quad (1)$$

where: MVA = Manufacturing Sector Value Added, ENGL = Energy Loss, ELC = Electricity Consumption, INF = Inflation Rate, ML = Manufacturing Sector Loan.

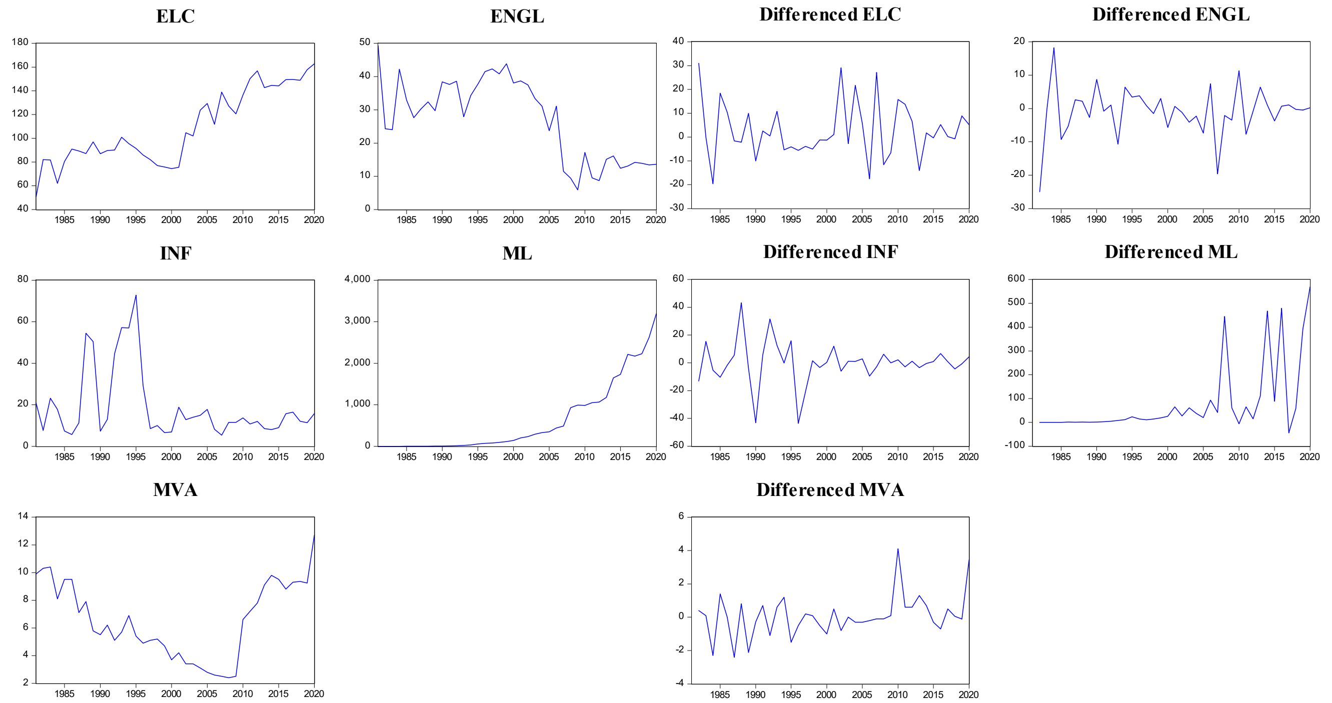
D. Empirical Result and Analysis

1. Series Trend Analysis

Data from time series frequently exhibit increasing or decreasing trends, with fluctuations. As a result, trend analysis is required prior to unit root testing to determine whether or not the series has a unit root. Except for the inflation rate, the results of the graphical display in Fig. 3 (A) show that the series exhibits a random walk with drift and trend. Fig. 3 (B) depicts a trend with a pattern of large fluctuations, indicating that the series is non-stationary.

2. Unit Root Tests

To validate the technique used in this study, it became necessary to test for the order of cointegration to ensure that there are no $I(2)$ cointegrating equations in the series. As a result, a unit root test would provide valuable information to justify the use of the ARDL estimation technique in this study. The series is estimated using the method of [41]. Table II summarizes the results of the ADF tests at level, constant and trend, none, and first difference.



A: The Series In Their Raw (Undifferentiated) Form
Source: Researcher's Computation Using Eviews 9

B: Results Of The Series Trend Test After First Difference
Source: Researcher's Computation Using Eviews 9

Fig. 3 Trend Analysis

TABLE II
UNIT ROOT TESTS RESULT

Variables	ADF Test Statistic				PP Test Statistic			
	Constant	Constant & Trend	None	First Difference	Constant	Constant & Trend	None	First Difference
LMVA	-1.15	0.93	-0.11	-5.88*	-1.36	-0.94	-0.14	-5.92*
LENGL	-2.07	-2.86	-0.68	-8.74*	-2.08	-2.78	-1.27	-9.18*
LELC	-2.23	-3.70*	1.26	-8.69*	-2.21	-3.89*	1.42	-8.99*
LINF	-3.45*	-3.50	-0.82	-6.95*	-3.33*	-3.28	0.59	-9.83*
LML	-0.75	-2.01	1.29	-4.96*	-0.87	-0.74	2.37	-4.94*

Source: Researcher's calculations from Eviews 9, 2022.

Notes (ADF): Test critical values at 5% (At level: constant = -2.94, Constant and trend = -3.53, none = -2.63 while at First difference = -2.95); P-value = Probability value, * signifies stationarity.

Notes (PP): Test critical values at 5% (At level: constant = -2.94, Constant and trend = -3.53, none = -2.63 while at First difference = -2.94); P-value = Probability value, * signifies stationarity.

When tested at a level with a constant and constant trend, the inflation variable (INF) is stationary, as indicated by the asterisk. As a result, we conclude that the INF series is stationary at the level, because data are stationary when the ADF test statistics are less than the test critical values at the level $5\%(ADF\ test\ statistics < test\ critical\ value\ at\ 5\%)$. For stationary data, the corresponding probability value is less than $0.05(P-value < 0.05)$. All series, with the exception of INF, are non-stationary at level but stationary at first difference after the ADF test. However, ADF tests are frequently influenced by the lag length (p) chosen and lose power when estimating a large sample. As a result, the Phillips–Perron (PP) test validates the ADF test results.

The advantage of the PP test over the ADF test is that the test corrects any heteroscedasticity and serial correlation in the errors terms (u_t). Also, PP tests do not require lag selection and are based on a serially correlated regression error term. Similar to the ADF test, the null for PP is also based on the null that the series are non-stationery. The results of the PP test are indicated in Table II. The results indicate that the series are non-stationary at level but stationary at first difference except inflation and energy consumption (constant & trend). Fig. 3 (B) shows the variables in their differenced form. This result justifies the use of ARDL model for estimation.

3. Optimal Lag Order Check

The issue of determining the proper lag length for each of the underlying variables in the ARDL model is critical because we want Gaussian error terms (i.e., standard normal error terms that do not suffer from non-normality and non-stability). According to [42], when selecting the appropriate model for the long run underlying equation, the optimum lag length (k) must be determined using appropriate model order selection criteria such as the Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), or Hannan-Quinn Criterion (HQC). The appropriate lag length for each variable is shown in Table III. According to the table, lag 1 has the lowest AIC value, which is also less than the SIC value at lag 1. As a result, the model (Lag 1) is chosen to estimate (1). The cointegration outcome is shown in Table III.

TABLE III
VAR LAG ORDER SELECTION CRITERIA

Lag	LogL	LR	FPE	AIC	SC	HQ
0	9.949600	NA	0.044880	-0.267546	-0.049854	-0.190799
1	38.32526	47.54841*	0.010231*	-1.747312*	-1.486082*	-1.655216*
2	38.47066	0.235782	0.010734	-1.701117	-1.396349	-1.593672
3	38.49553	0.038983	0.011341	-1.648407	-1.300101	-1.525613

* indicates lag order selected by the criterion
Source: Researcher's calculations from Eviews 9, 2022.

4. Cointegration Test

To determine whether the variables are cointegrated in the long run, the applicable hypothesis is that there is no long-run relationship, such as:

- H_0: $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$ (there is no long-run relationship)
- H_1: $\lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq 0$ (there is a long-run relationship)

TABLE IV
THE ESTIMATION RESULTS OF THE COINTEGRATION (LONG RUN) EQUATION (ORDINARY LEAST SQUARES TECHNIQUE)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LMVA(-1)	0.524721	0.160590	3.267449	0.0031
LMVA(-2)	0.315639	0.150971	2.090732	0.0469
LENGL	0.231801	0.098583	2.351336	0.0269
LENGL(-1)	-0.357521	0.105741	-3.381104	0.0024
LENGL(-2)	-0.350271	0.119977	-2.919493	0.0073
LINF	0.040462	0.019978	2.025316	0.0536
LINF(-1)	-0.054310	0.022558	-2.407535	0.0238
LINF(-2)	0.067659	0.019175	3.528595	0.0016
LELC	0.269702	0.109534	2.462267	0.0210
LELC(-1)	-0.304401	0.135446	-2.247390	0.0337
LELC(-2)	-0.166836	0.112917	-1.477510	0.1520
LML	0.010725	0.023259	0.461130	0.6487
C	1.544433	0.630315	2.450257	0.0216

R-squared = 0.94; Adjusted R-squared = 0.91; Prob. (F-statistic) = 0.000; DW = 2.1
Source: Researcher's calculations from Eviews 9, 2022.

5. Model Checking

To ensure that there is no serial correlation in the long-run model, the null hypothesis is tested, with a guideline to accept the null hypothesis (H0) if the probability is greater than 5%. The findings in Table V show that there is no serial correlation. In the same vein, the normalcy test is performed. The results in Fig. 4 show that the skewness is 0.36 and the kurtosis is 2.81. The JB is represented by 0.91, with a corresponding probability value of 0.63, which is not significant at a 5% critical value. Our model is normally distributed based on this test. The heteroscedasticity test in Table VI indicates constant variance. Both R-square probability values observed for the Breusch-Pagan-Godfrey Test are not significant at 5% critical value. This means that the LMVA systems equation is stationary, homoscedastic and, as such, valid for economic analysis. The stability test results, as shown in Fig. 5, reveal that the Cusum of squares plots and recursive coefficients did not cross the 5% critical lines, indicating that the model is stable. The diagnostic tests indicate that our model is valid because all of the probability values for the tests are greater than 5%, implying that our manufacturing sector long-run equation is suitable for economic analysis.

TABLE V
SERIAL CORRELATION TEST

F-statistic	0.789503	Prob. F(1,24)	0.3831
Obs*R-squared	1.210235	Prob. Chi-Square(1)	0.2713

Source: Researcher's calculations from Eviews 9, 2022.

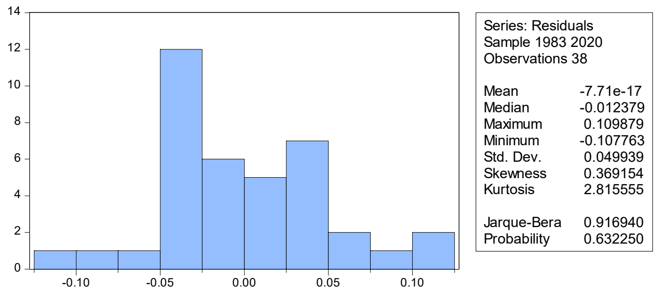


Fig. 4 Normality Test

TABLE VI
HETEROSKEDASTICITY TEST: BREUSCH-PAGAN-GODFREY

F-statistic	1.173350	Prob. F(12,25)	0.3524
Obs*R-squared	13.69101	Prob. Chi-Square(12)	0.3209
Scaled explained SS	5.379324	Prob. Chi-Square(12)	0.9441

Source: Researcher's calculations from Eviews 9, 2022.

The null hypothesis of the absence of a long-run relationship among all stationary series included in (1) is to be tested using the ARDL technique to cointegration analysis as advanced by [38]. The primary goal here is to determine where the Wald test computed F-statistic for the long-run model using the OLS estimation technique falls. Table VII shows the calculated F-statistics for the "bounds" tests, as well as the critical values for the upper and lower bounds provided by [38]. The calculated F-statistic is 6.960313, which exceeds both the upper and lower bound critical values at 5% and 10% levels of significance with no intercept and no trend. This means that the null hypothesis of no co-integration can be rejected, and that there is a long-term relationship between manufacturing sector and energy loss.

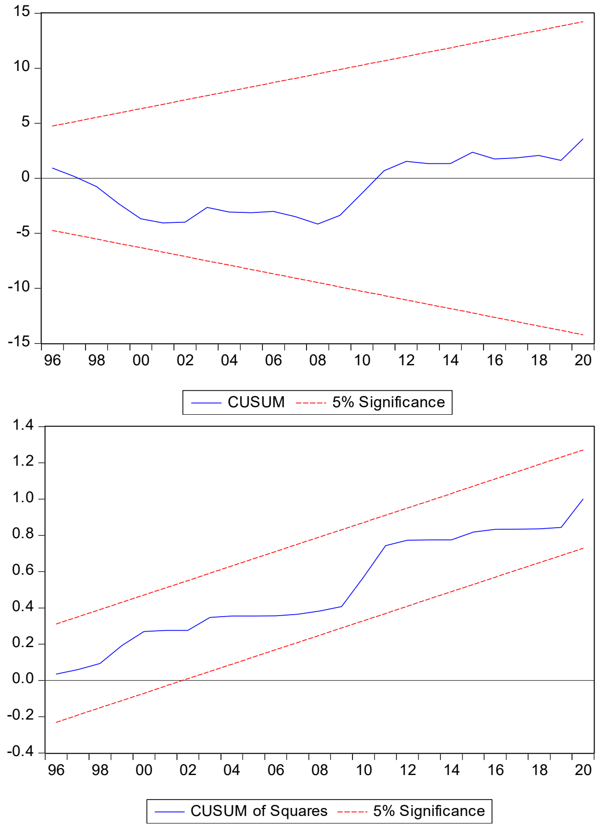


Fig. 5 Stability Test

TABLE VII
BOUNDS TEST FOR CO-INTEGRATION ANALYSIS

Test Statistic	Value	k
F-statistic	6.960313	4
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

Source: Researcher's calculations from Eviews 9, 2022.

6. The Error Correction Model

$$\sum_{j=0}^{p}\delta_j \Delta LMVA_{1t-j} + \sum_{1=0}^{q}\phi_1 \Delta LENGL_{2t-1} + \sum_{m=0}^{q}\delta_m \Delta LELC_{3t-m} + \sum_{n=0}^{q}\eta_n \Delta LINF_{4t-n} + \sum_{a=0}^{q}\mu_a \Delta LML_{5t-a} + \varepsilon_t \quad (2)$$

TABLE VIII
ERROR CORRECTION MODEL

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.024332	0.023513	1.034810	0.3090
D(LMVA(-1))	0.462558	0.226124	2.045594	0.0497
D(LELC(-1))	-0.332960	0.157197	-2.118112	0.0426
D(LENGL(-1))	-0.297292	0.133314	-2.230015	0.0334
D(LINF(-1))	-0.022866	0.022426	-1.019591	0.3161
D(LML(-1))	-0.254530	0.228519	-1.113824	0.2742
ECT(-1)	-0.991227	0.381074	-2.601143	0.0143

Source: Researcher's calculations from Eviews 9, 2022.

E. Model Checking

The findings in Table IX show that there is no serial correlation. In the same vein, the normalcy test is performed. Our results in Fig. 6 show that the skewness is 1.5 and the kurtosis is 6.1. The JB is represented by 28.6, with a corresponding probability value of 0.00, which is significant at a 5% critical value. In [43], the violation of the normality assumption of large sample sizes (> 30 or 40), should not cause major problems. The stability test result, as shown in Fig. 7, reveals that the Cusum plot tests statistic did not cross the 5% critical lines, indicating that the model is stable. The Cusum of squares plot test in Fig. 7, wondered away from equilibrium but later reverted back. The diagnostic tests indicate that our model is valid because all of the probability values for the tests are greater than 5%, implying that our manufacturing sector short-run equation is suitable for economic analysis.

TABLE IX
SERIAL CORRELATION TEST OF THE DYNAMIC MODEL

F-statistic	0.067826	Prob. F(1,29)	0.7964
Obs*R-squared	0.086335	Prob. Chi-Square(1)	0.7689

Source: Researcher's calculations from Eviews 9, 2022.

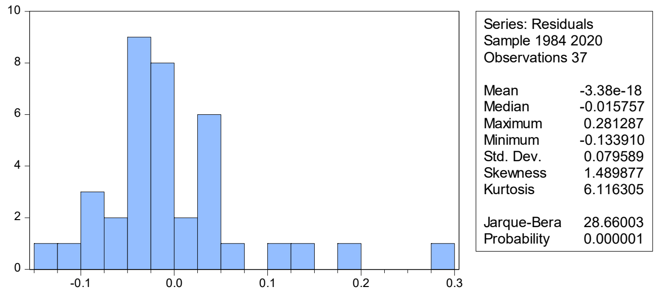


Fig. 6 Normality Test

F. Discussion of Results

To examine the parameter estimates, an error correction mechanism was used. This hypothesis was tested by regressing energy loss (ENGL), inflation (INF), electricity consumption (ELC), and manufacturing loans (ML) against MVA. The regression analysis results were summarized, and they show that the model for the effect of energy consumption and energy loss on manufacturing sector value added is correct. Table IV displays the results of the long-run equation. The empirical results show that the coefficients of the explanatory variables are not all correctly signed, indicating that the apriori expectations are not met. Furthermore, the coefficient of determination (R^2) of 0.94 indicates that between 1981 and 2020, changes in independent variables explain approximately 94% of the variation in the dependent variable (LMVA). This implies that MVA is statistically significant and positively related to its first and second lags. The target variable (energy loss) has a positive sign and is statistically significant. In Nigeria, a 1% reduction in energy loss increases MVA by 36% in the first lag and 35% in the second lag. The findings indicate that a sufficient amount of energy can result in an increase in manufacturing value. According to ecological economists [25], energy is not only important for manufacturing, but it also helps the economy grow.

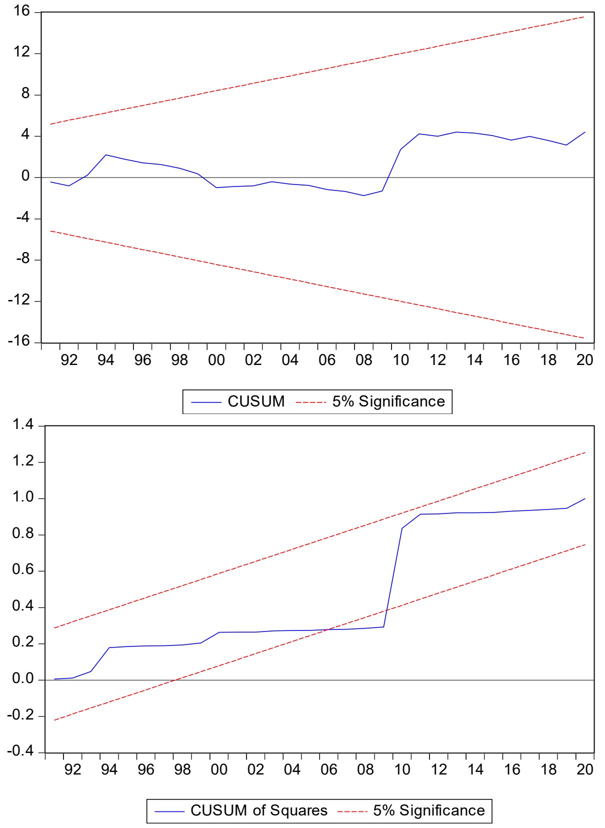


Fig. 7 Cusum Stability Test

According to Table IV, electricity consumption is a fundamental factor determining MVA in Nigeria. The findings show that the relationship between LELC and LMVA is statistically significant. The findings show that a 1% increase in electricity consumption reduces MVA by 30% in the first lag, which is contrary to our apriori expectation. This is consistent with findings of [10] (2021). The findings confirm that when energy is produced or generated, so much of it is lost during the transmission and distribution processes that the benefits are minimal, indicating waste due to inefficient transmission and distribution systems. According to the World Bank (2020), the country's installed capacity is actually 12,522 MW, but the typical operating power is only 3,879 MW, 7.4% of which results in inadequate transmission with up to 27.7% refused load at delivery. Nigeria currently has approximately 2.519 MW of productive and non-productive capacity available for use by productive and non-productive sectors, and even if this capacity is doubled, manufacturing companies will still spend approximately 40% of their production overhead on generating electricity privately, resulting in higher operating costs and prices for goods manufactured in the country. Reference [21] discovered a significant impact on the relationship between energy resources, energy policy, and economic development in a country, which confirms the type of political governance in Nigeria.

Other outcomes are equally intriguing. Loans to the manufacturing sector (LML), for example, are insignificant and negatively related to MVA, which is contrary to our apriori expectation. The quality of institutions and governance is one of the most frequently cited reasons for the hypothesis that energy resources may be a curse to long-term development. During the study period, the manufacturing share of total commercial bank loans was 14.2%, indicating that obtaining funds from banks is extremely difficult. The inflation result, on the other hand, is well signed. According to the findings, a 1% increase in LINF reduces LMVA by 0.05% in the first lag, demonstrating a significant negative relationship with MVA.

Table VIII shows the results of the estimates of the error correction model presented in (2). The estimated error correction model shows the short-run relationship between LMVA and LELC, LELC, LINF, and LML. The (lag) difference between these variables is reported. The one-lagged error-correction term ECTt-1, which measures the disequilibrium between the actual and equilibrium LMVA, is statistically significant and has the correct sign at a 1% level of significance. According to the estimated coefficient for ECTt-1, LMVA converges to a long-run steady state in about 0.46 years (i.e., one divided by the estimated coefficient for ECTt-1). Furthermore, the estimated results indicate that the model has a reasonable good fit with robust diagnostic tests for error processes such as serial correlation and instability.

Table VIII also shows that the coefficient of energy loss is statistically significant and negatively related to MVA. This means that, if all other variables remain constant, a percentage change in LENGL will result in a -0.297292% change in LMVA. This is consistent with our assumption that lower energy loss leads to higher MVA.

IV. Conclusion

Finally, using annual data from 1981 to 2020, the goal of estimating the MVA equation was to examine the short- and long-run effects of electricity consumption, energy loss, and other explanatory factors included in the system's equation on Nigeria's manufacturing sector.

Given the shortcomings of the standard Johansen and Juselius (1990) cointegration procedure, it is critical to investigate the ARDL approach to cointegration or bound procedure for a long-run relationship proposed by [36] and [37]. Some shortcomings include identifying the cointegrating vector(s) when there are multiple cointegrating relations and applicability when only one cointegrating vector of different order exists.

This study examined the ARDL approach to cointegration testing in terms of application, estimation, and interpretation. According to the study's findings, energy loss has a negative impact on MVA in Nigeria. According to the study, electricity consumption has not increased manufacturing value. The level of energy produced and finally consumed by Nigerians is directly deleterious to the manufacturing sector.

V. Policy Implications

The findings (a 1% reduction in energy loss increases MVA by 36% in the first lag and 35% in the second lag) necessitate immediate action, almost on par with an emergency, backed by a thorough understanding of the underlying root causes of the losses in Nigeria's energy system. High technical losses, a lack of cost recovery pricing, a poor maintenance culture, low equipment reliability, low productivity, capital scarcity, economic inefficiency, a lack of basic industries to service the power sectors, vandalism, insecurity, ineffective billing methods, debt and deficit, corruption, and crippling nonpayment of mounting debt are among the root causes.

To improve Nigeria's energy supply situation, the following are recommended:

- Climate change mitigation efforts will be guided, as will energy trading.
- The government should expedite the ongoing renovation of existing power plants across the country, as well as the construction of new gas-fired power plants. This will solve a variety of issues, including overpricing of electricity due to grid failure.
- The government should not stop at increasing generation capacity; it should also improve gas availability in the upstream sector and add transmission capacity in the downstream sector.
- Effective measures should be put in place to ensure the security of electrical installations. Funding should be increased so that local businesses can invest in the electricity industry.

REFERENCES

[1] G. Tapsin. The link between industry value added and electricity consumption in Turkey. *European Scientific Journal*. Vol. 13 (13) 2017.

[2] F. Kassim, and Isik. Impact of energy consumption on industrial growth in a transition economy: evidence from *Nigeria. Munich Personal RePEc Archive*. 10 July, 2020.

[3] E. Ejoh. Electricity: Nigeria's economy losses N534bn to inefficiency in 2016. Accessed from https://www.vanguardngr.com/2017/10/electricity-nigerias-economy-losses-n534bn-inefficiency-2016, 2017.

[4] The World Bank, "World development indicators," (Online). Available: https://data.worldbank.org/. (Accessed 716 April, 2021).

[5] O.M. Komolafe and K.M. Review of electrical energy losses in Nigeria. *Nigerian Journal of Technology*. Vol. 39, No. pp. 246 – 254, 1, January, 2020.

[6] I.A. Danmaraya and S. Hassan. Electricity consumption and manufacturing sector productivity in Nigeria: an autoregressive distributed lag-bounds testing approach. International *Journal of Energy Economics and Policy*. 6(2) pp. 195-201, 2016.

[7] B. Ohwofasa, O. Obeh,and J. Erakpoweri. The impact of electricity supply on economic growth, 1980-2010: an error correction method. *Research Journal of Finance and Accounting*. Vol. 6 pp. 124-128. 2015.

[8] N.E. Okoligwe, and O.A Ihugba. Relationship between electricity consumption and economic growth: evidence from Nigeria (1971-2012). *Academic Journal of Interdisciplinary Studies*, 3(5), 137-152 July, 2014.

[9] M.O. Olarinde, and A.O. Joseph. Electricity consumption, institutions, and economic growth in Nigeria. *Journal of Economics and Sustainable Development*. Vol. 5(12), 40-55, 2014.

[10] J.A. Abiola, I.L Adedoyin., H. I Egbezien, O.O Adenike, O.O. Akinyomade, M.S Olayemi, and C.O. Igbolekwu. Electricity consumption and manufacturing sector performance: evidence from *Nigeria. International Journal of Energy Economics and Policy*. 11(4), 195-201, 2021.

[11] L. M Adesina, and A. Ademola. Determination of power system losses in Nigerian electricity distribution networks. *International Journal of Engineering and Technology*. Vol. 6, no. 9, pp. 322-326, 2016.

[12] D. I. Stern. Is energy cost and accurate indicator of natural resource quality? *Ecological Economics*, 31, pp.381-394, 1999.

[13] N. Vlahinić-Dizdarević, and S. Žiković. The role of energy in economic growth: the case of Croatia. *Zbornik Radova Ekonomskog Fakulteta u Rijeci / Proceedings of Rijeka School of Economics*. Vol. 28 • sv. 1 • 35-60, December, 2010.

[14] N. Georgescu-Roegen. The entropy law and the economic process. *Harvard University Press, Cambridge, Mass*, 1971.

[15] R. Solow. A contribution to the theory of economic growth. *Quarterly Journal of Economics*, 70(1), pp.65-94, 1956.

[16] A. Zon, A. and I.H. Yetkiner. An endogenous growth model with embodied energy-saving technical change. *Resource and Energy Economics*. Vol. 25, pp. 81- 103, 2003.

[17] J.D. Sachs, and A.M. Warner. Natural resource abundance and economic growth. *Center for International Development and Harvard Institute for International Developmen*t: Harvard University, 1997.

[18] W. Easterly, and R. Levine. Tropics, germs, and crops: how endowments influence economic development. *Journal of Monetary Economic*, 50, pp.3-39, 2003.

[19] D. Acemoglu, S. Johnson, and J.A. Robinson. Reversal of fortune: geography and institutions in the making of the modern income distribution. *The Quarterly Journal of Econometrics*. 118, pp.1231-94, 2002.

[20] D. Rodrik, A. Subramanian, and F. Trebbi. Institutions rule: the primacy of institutions over geography and integration in economic development. *Journal of Economic Growth*. Vol. 9, pp. 131-65, 2004.

[21] J.M. Chevalier. Winning the battle? In: Chevalier, J.M. (Ed.), the new energy crisis: climate, economics and geopolitics, New York: *Palgrave Macmillan*, pp. 256-281, 2009.

[22] J. Paavola, and W.N. Adger. Institutional ecological economics. *Ecological Economics*. Vol. 53, pp.353-368, 2005.

[23] D.G. Ockwell. Energy and economic growth: grounding our understanding in physical reality. *Energy Policy*. Vol. 36(12), pp. 4600-4604, 2008.

[24] J. Gever, R. K. Kaufmann, D. Skole, and C. Vörösmarty. Beyond Oil: The Threat to Food and Fuel in the Coming Decades, *Cambridge, MA: Ballinger*, 1986.

[25] C. J. Cleveland, R. Costanza, C. S. Hall, and R. K. Kaufmann. Energy and the U.S. economy: A biophysical perspective, *Science 225*, pp.890-897, 1984

[26] O. A. Bernard, and O. Adenuga. Is Energy consumption relevant to industrial output in Nigeria? *European Journal of Research in Social Sciences*, 4(4), 1-14, 2016.

[27] P.O, Elekwa, C. Dike, and T.I. Ugwoke. Electricity consumption and industrial production in Nigeria. *Journal of Policy and Development Studies*. Vol. 10, No. 2, May, 2016.

[28] O. J. Olufemi. The effects of electricity consumption on industrial growth in Nigeria. *Journal of Economics and Sustainable Development*, 6(13), 54-59, 2015.

[29] Y. Yakubu, S.B Manu, and B Umar. Electricity supply and manufacturing output in Nigeria: autoregressive distributed lag (ARDL) bound testing approach. *Journal of Economics and Sustainable Development*, 6(17), 7-19, 2015.

[30] S.E Akiri, O.A Ijuo, and M.P Apochi. Electricity supply and the manufacturing productivity in Nigeria (1980-2012). *Journal of Economics and Finance*. Volume 6, Issue 6. Ver. I (Nov. – Dec, 2015.), PP 90-94.

[31] C.C Nwajinka, J.Y, Akekere, and O.J. Purumaziba. National electric energy supply and industrial productivity in Nigeria from 1970 to 2010. *Journal of Economics and Sustainable Development*, 4(14), 122-129, 2013.

[32] P. I. Nwosa. Aggregate energy consumption and sectoral output in Nigeria. *An International Multidisciplinary Journal, Ethiopia*, 6(4), .206-215, 2012.

[33] E. Abokyi, A.P Konadu., I. Sikayena and O.F. Abayie. Consumption of electricity and industrial growth in the case of Ghana. *Hindawi Journal of Energy Volume*. Article ID 8924835. 2018:1–11.

[34] M. Abid & R. Mraihi. Energy consumption and industrial production: Evidence from Tunisia at both aggregated and disaggregated levels. *Journal of the Knowledge Economy*. vol. 6, no. 4, pp. 1123–1137, 2015.

[35] J. Mawejje and D.N. Mawejje. Electricity consumption and sectoral output in Uganda: an empirical investigation. *Journal Economic Structures*. Vol. 5:21, August, 2016.

[36] M. Pesaran, and Y. Shin, "An autoregressive distributed lag modeling approach to cointegration analysis" in S. Strom, (ed) *Econometrics and Economic Theory in the 20th* Century: The Ragnar Frisch centennial Symposium, Cambridge University Press, Cambridge, 1999.

[37] M.H Pesaran, R.J, Smith, and Y.Shin. Testing for the existence of a long run relationship, DAE working paper No.9622, *Department of Applied Economics, University of Cambridge*, 1996.
[38] M.H. Pesaran, Y Shin, and R.J Smith. "Bounds testing approaches to the analysis of level relationship." *Journal of Applied Economics* 16: 289-326, 2001.
[39] R. Harris and R. Sollis. "Applied time series modelling and forecasting". *Wiley, West Sussex,* 2003.
[40] O.A Ihugba, J.C Ukwunna, and S. Obiukwu. Government education expenditure and primary school enrolment in Nigeria: An impact analysis. *Journal of economics and international finance*, Vol. 11(3), pp. 24-37, April, 2019.
[41] Dickey D & Fuller W. (1981). Likelihood ratio statistics for autoregressive time series with a unit root, *Econometrica*, 49, 1057-1072.
[42] M. Bahmani-Oskooee, and T. Brooks. New criteria for selecting the optimum lags in Johansson's cointegration technique. *Applied economics*, 35, 875-880, 2003.
[43] https://www.worldbank.org/en/news/press-release/2021/02/05/nigeria-to-improve-electricity-access-and-services-to-citizens (Accessed 7/16 April, 2021)
[44] J.O. Ogunjobi. The Effects of Electricity Consumption on Industrial Growth in Nigeria. *Journal of Economics and Sustainable Development*. Vol.6, No.13, 201
[45] https://data.worldbank.org/indicator/NV.IND.MANF.ZS?locations=NG
[46] https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS?locations=NG
[47] https://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC?locations=NG
[48] Central bank of Nigeria (CBN) statistical bulletin volume 31, December 2020