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ELECTRICITY CONSUMPTION AND MANUFACTURING SECTOR PERFORMANCE IN NIGERIA: A VECTOR AUTOREGRESSIVE (VAR) APPROACH

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Abstract: This paper aims at investigating the relationship between electricity consumption and manufacturing sector performance in Nigeria over the period 1981 to 2018. Electricity consumption per capita was used to represent electricity consumption, while manufacturing sector performance was captured by manufacturing value added. The paper utilized Augmented Dickey-Fuller unit root technique, Granger causality test, and the Vector Autoregressive (VAR) approach. The Granger causality test indicated that a unidirectional causality flows between electricity consumption per capita and manufacturing value added. This therefore supports the feedback thesis. Meanwhile, the VAR result indicated that both electricity consumption and manufacturing value added were strongly endogenous. That is, they significantly predict themselves. However, electricity consumption is weakly exogenous in predicting manufacturing value added rather, manufacturing value added is strongly exogenous in predicting electricity consumption in Nigeria. This therefore points to the prevalence of the growth-driven electricity consumption thesis in Nigeria. This thesis is in support of the conservation of electricity. The variance decomposition and impulse response indicated that variations in manufacturing value added responded more to shocks in itself than from shocks electricity consumption. Therefore, the government have a key role to play in ensuring that as the domestic production accelerates and the demand on electricity is rising, adequate provision is made to converse electricity for the future. Alternative energy sources should be developed and utilized so as to free the environment from carbon monoxide emissions associated with running diesel plants during manufacturing activities as a result of epileptic electricity power supply.

Keywords: electricity consumption per capita, granger causality, impulse response function, manufacturing value added, variance decomposition

I. Introduction

The neoclassical economic theory had so far focused on the role of capital and labour in propelling productive activities hence, capital and labour have been pointed out to be the drivers of economic growth. Meanwhile, productive activities in the manufacturing sector can barely be carried out without electricity. This has spurred the view that electricity is indispensable for driving manufacturing sector output which in turn will offshoot increase in economic performance

(Tang, 2008). Further, other researchers are also of the view that electricity is the backbone of industrial development in modern Africa (Simpson, 1969); and that it controls a great deal of industrial output (Sanchis, 2007).

This new dimension of identifying electricity as one of the key inputs in manufacturing outlets therefore prompts the importance of electricity in the economy of any nation. Just like labour and capital, electricity and other forms of power is considered as an inputs in the manufacturing activities (Baxter & Rees, 1968). Therefore, it can be said that production and consumption activities will be impossible in the absence of energy, which is an indispensable input and a driver of growth (Ibrahim, Mukhtar & Gani, 2017); and that efficiency in power distribution network (transmission and distribution linkages) will go a long way to facilitate manufacturing activities of any nation.

The role of electricity in influencing the real sector of the economy have led to the formation of four theses to show the relationship between electricity and output growth. These are: (i) the electricity-led growth thesis which sees electricity as a catalyst for growth; (ii) the growth-driven electricity consumption thesis that views growth as the driver of electricity; (iii) the feedback thesis which reports a bidirectional causation, implying that the two variables cause each other; and the neutrality thesis that is of the view that no causal relationship exists between the units of electricity consumed and growth in the economy. These four strands of thought and studies that reported them will be discussed in the literature review meanwhile, this lack of unanimous conclusion on the linkages between electricity consumption and the real sector of the economy necessitates further studies to elicit more information on the subject matter.

It has been noted that small-scale and medium-scale enterprises in Nigeria commit a substantial portion of their total investment capital to provide about 50% of their total electricity requirement, while a great chunk of the ample enterprises generated electricity by themselves to curb interrupted power supply so as to achieve efficiency in their performance (Ibrahim, Mukhtar & Gani, 2017; and Iloeje, Olayinde & Yusuf, 2004). This indicates that the problem of electric power supply is inherent in the Nigerian society and thus, since electricity is an important input in the production function, a poor performance of the manufacturing sector is inevitable. Instance can be taken from the dwindling manufacturing sector contribution to the GDP over the years while the service sector has been gaining addendum as the major contributor to total output. Also, the manufacturing value added has expressed series of fluctuations over the years as shown in Figure 1.

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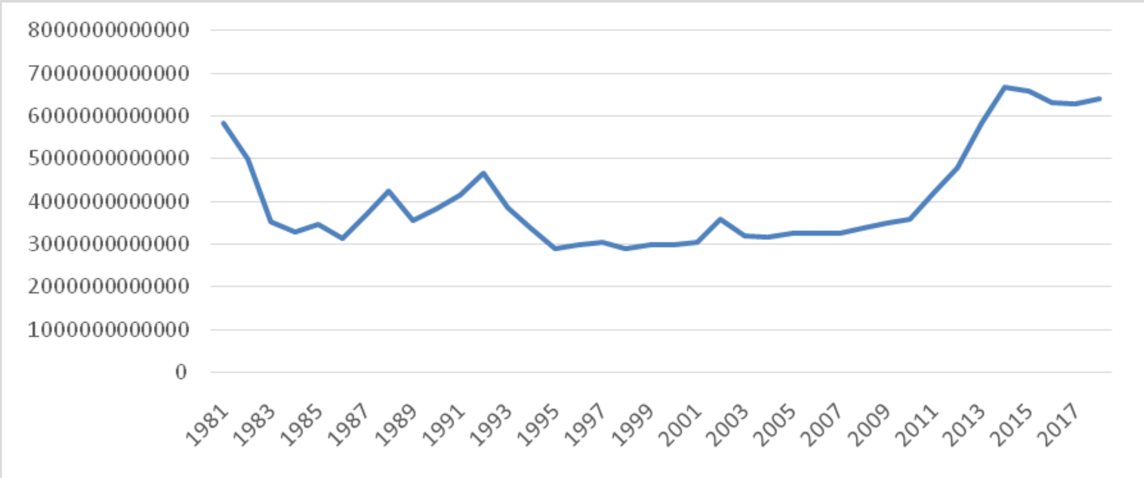

Figure 1: *Manufacturing Value Added*

It therefore becomes pertinent to examine the relationship between electricity consumption and manufacturing sector performance in Nigeria. The study specifically seeks to investigate the relationship between electricity consumption and manufacturing value added; and to investigate whether manufacturing value added responds to shocks in electricity consumption.

2. Literature Review

What is the possible link between electricity power consumed and manufacturing sector performance? In answering this cogent question, economists have taken heed to carry out studies in earlier years and there have been four key answers to the question. Studies have revealed that a unidirectional causality flows from electricity consumption to output; creating the electricity-led growth thesis in the literature (Lee, 2005; Narayan & Singh, 2007; Asafu-Adjaye, 2000; Squalli, 2007; and Apergis & Payne, 2009). Also, it has been observed that causality flows from output to electricity consumption. That is, a unidirectional causality flowing from output to electricity consumption; leading to the growth-driven electricity consumption hypothesis (Cheng & Lai, 1997; Kraft & Kraft, 1978; and Al-Iriani, 2006). Further, it was also observed that a bidirectional causality exists between electricity consumption and output, of which the findings gave birth to the feedback hypothesis (Glasure & Lee, 1997; Soytas & Sari, 2007; Oh & Lee, 2004; Hondroyiannis, Lolos & Papapetrou, 2002; Ozturk, & Salah Uddin, 2012; Ebohon, 1996; and Jumbe, 2004). However, the presence of no causality was reported by some studies too, where the neutrality thesis originated (Yildirim, Aslan, & Ozturk, 2014; Murray & Nan, 1996; Erol & Chu, 1987; and Yu & Jin, 1992).

Empirically, Adebusuyi and Obamuyi (2016) examined how electricity demand impact the performance of the Nigerian manufacturing sector. The study was conducted over 1970 to 2014 period, and the Autoregressive distributive lag (ARDL) bounds test for cointegration along with the OLS approach were utilized in the study. The bounds test for cointegration presented an evidence of a long run relationship existing between electricity demand and manufacturing sector performance; while the OLS result of the translog function indicated that electricity is a weak substitute for both capital and labour.

A positive impact of energy consumption on manufacturing sector output was obtained by Adenikinju (1998), when he examined how efficiency in energy consumption impacts on the manufacturing sector productivity growth in Nigeria. The study employed panel data technique and it was discovered that energy used by firms in the Nigerian manufacturing sector enhanced productivity growth. Meanwhile, Soytas and Sari (2007) investigated the causal relationship which exists between industrial electricity consumption and manufacturing value-added for Turkey with the use of cointegration and vector error correction framework. the result indicated that a unidirectional causal runs from electricity consumption to manufacturing value added.

Danmaraya and Hassan (2016) utilized the Granger causality test and autoregressive distributed lag approach to investigate both the short run and long run relationship between electricity consumption and manufacturing productivity in Nigeria for the period 1980 to 2013. The ARDL bounds test for cointegration indicated that electricity consumption, manufacturing productivity, and capital are cointegrated hence, there exist a long run relationship between electricity consumption and manufacturing productivity. Also, the granger causality test demonstrated an evidence of bidirectional causality between manufacturing productivity and energy consumption.

Similar study was conducted by Abokyi, Appiah-Konadu, Sikayena & Oteng-Abayie, (2018) where they investigated the flow of causality between electricity consumption and industrial growth in Ghana for the period 1971 to 2014 based on the ARDL bounds test for cointegration, error correction mechanism, and Toda-Yamamoto test. The bounds test supported evidence of long run relationship which was further established through the vector error correction mechanism. The Toda-Yamamoto test presented an evidence of a one-way causality running from electricity consumption to Ghana's industrial growth.

In Malaysia, Kermani, Ghasemi, & Abbasi (2015) employed Johansen cointegration test, vector error correction mechanism and Granger causality test to examine the relationship between electricity consumption and industrial value-added. Results shows that there was no short-run and long-run causal relationship between industry value-added and electricity consumption. This finding therefore support the neutrality thesis in the Iran's manufacturing sector. Meanwhile, similar study in Tunisia reported a long-run unidirectional causality that flows from electricity consumption to industry GDP; but the neutrality thesis prevails in the short run (Abid & Mraihi, 2015). Using ARDL bound testing and Innovative Accounting Approach (IAA), one-way causality was also observed to be running from electricity consumption to industrial growth in Bangladesh (Shahbaz, Salah Uddin, Ur Rehman & Imran, 2014); while in Singapore, it was observed that industrial output is caused by electricity consumption (Sun & Anwar, 2015).

In examining the relationship between electricity consumption, manufacturing output, and financial development in Nigeria, Ibrahim, Mukhtar and Gani (2017) analysed time series data for the period 1981 to 2015 using the Granger causality test and error correction mechanism. The study revealed evidence of long run relationship and that there is a unidirectional causality between electricity consumption and manufacturing output.

Aliero and Ibrahim (2012) investigated the outcome of electricity issues on the manufacturing and productivity growth in Nigeria and establish that epileptic power supply has caused manufacturing sector to divert their attention to the use of alternative source of power supply. Similarly, the penalties of power sector predicament on industrial sector productivity in Nigeria was analysed using a multiple regression. It was established that the truncated pattern of electricity generation is impeding manufacturing production in Nigeria (Olayemi, 2012).

Bernard and Oludare (2016) examined the contribution of energy consumption on industrial sector output in Nigeria using annual time series data for the period 1980 to 2013. By utilizing the error correction mechanism, it was observed that there is evidence of long run linkages between electricity consumption and industrial sector output hence, there is convergence between electricity consumption and industrial output.

Finally, Olufemi (2015) studied the association between electricity consumption and industrial growth in Nigeria for the period 1980 to 2012 under cointegration and error correction mechanism framework. The study reported a positive and significant long run effect of electricity consumption, electricity generation, labour employment and foreign exchange rate; while a negative relationship between industrial growth and capital input was also observed. Thus, electricity is crucial for industrial sector performance.

3 Methodology

3.1 Model Specification

To examine the connection between electricity consumption and manufacturing sector performance in Nigeria, we utilize the neoclassical production function augmented with electricity as a one of the variable. This similar model was utilized by Kasperowicz (2014) when he studied energy consumption and economic growth in Poland. The model for the study is specified as follows:

Y = f(K, L, E) - - - - (1)

Where Y is output; K is capital, L is labour, and E is electricity.

Transforming Equation (1) into a double log function and capturing variables of interest in its estimable form, we have Equation (2) as follows:

$logMVA = \Upsilon_0 + \Upsilon_1 logGFCF + \Upsilon_2 logLABR + \Upsilon_3 logELEC + \mu$ - - - (2)

where:

logMVA = log of manufacturing value added (a proxy for manufacturing sector performance),

logGFCF = log of gross fixed capital formation (a proxy for capital),

logLABR = log of population aged 15 – 64 years (a proxy for labour),

logELEC = log of electricity consumption per capita in kilowatts,

ϒ0 to ϒ3 = parameters to be estimated,

μ = the error term.

3.2 A priori Expectation

The A priori expectation for the parameters in use includes:

$$\frac{\delta logMVA}{\delta logGFCF} > 0; \frac{\delta logMVA}{\delta logLABR} > 0; \; and \; \frac{\delta logMVA}{\delta logELEC} > 0$$

Implying that they are all expected to be positive. That is, all the explanatory variables in the model are expected to yield a positive influence on manufacturing value added.

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3.3 Data and Sources

The data for the study were obtained from World Bank Data Base on World Development Indicators (2018) and covers the period 1981 to 2018. The data were collected on four variables – manufacturing value added, gross fixed capital formation, labour, and electricity consumption. The data covers thirty-eight (38) years but not all the variables have the data set that covers the 38 years' period. For instance, data on electricity consumption per capita is only available up to 2014. The remaining years (2015 – 2018) were generated using a four-year moving average.

3.4 Estimation Technique

The estimation techniques utilized in this study include unit root test, Granger causality test, and the vector autoregressive model.

3.4.1 Unit Root Test

The test for unit root is conducted to ascertain the order in which the time series variables are integrated, which such variables may be affected by time. The execution of this test helps us to free a non-stationary time series variable from the effect of time; thereby making it fit for econometric analysis. The unit root test technique employed in this study is the Augmented Dickey-Fuller technique. The estimation follows the constant linear trend assumption with the lag length automatically selected using the Schwarz Information Criterion (SIC). The general form of the unit root test is specified as follows:

$$\Delta y_t = \alpha_0 + \delta t + \beta_1 y_{t-1} + \sum_{j=1}^{k} \beta_2 \Delta y_{t-j} + \mu_t - - - - - - - - - - - - - - - (3)$$

Where Δ is the first difference operator, t is the time trend, y is the variable to be tested for unit root, j is the lag length, and μ is the error term.

From Equation (3), the coefficient of importance is β_1 which is tested for significance. It is expected that it should be negative and strongly significant. The null hypothesis for the test is specified as follows:

$H_0: \beta_1 = 1$

Implying that there is a unit root.

3.4.2 Granger Causality Test

In examining the causal relationship between the manufacturing value added the explanatory variables in the model, the Pairwise Granger causality test is utilized. The significance of the F-statistic is an indication that one variable causes the other. The general form of the model for the Granger causality test is presented as follows.

$$\begin{cases} y_t = \theta + \sum_{k=1}^{k} \beta_1 y_{t-1} + \sum_{k=1}^{k} \beta_2 x_{t-1} + \varepsilon_t \\ x_t = \theta + \sum_{k=1}^{k} \beta_1 x_{t-1} + \sum_{k=1}^{k} \beta_2 y_{t-1} + \varepsilon_t \end{cases} - - - - - - - - - - - - - - - - (4)$$

Where k is the lag order, t is the time period, y_t and x_t are the variables to be tested for the existence of causality. When the causality test is conducted, three outcomes are eminent: unidirectional causality – where only one variable causes the other; bidirectional causality – where the two variables causes each other; and no causality – where none of the variables causes each other.

3.4.3 Vector Autoregressive (VAR) Model

The Granger causality test gives information on whether to employ a VAR framework in the analysis. The bidirectional causality test result will prompt the use of a VAR model. In this study, we utilize the VAR(1) model which is presented as follows.

$$logMVA_t = \beta_{01} + \sum_{i=0}^{1} \vartheta_1 logMVA_{t-i} + \sum_{i=0}^{1} \beta_1 logGFCF_{t-i} + \sum_{i=0}^{1} \beta_2 logLABR_{t-i} + \sum_{i=0}^{1} \beta_3 logELEC_{t-i} + \mu_t - - - - - - - - - - - - - (5)$$

$$logELEC_t = \beta_{02} + \sum_{i=0}^{1} \vartheta_2 logELEC_{t-i} + \sum_{i=0}^{1} \beta_1 logGFCF_{t-i} + \sum_{i=0}^{1} \beta_2 logLABR_{t-i} + \sum_{i=0}^{1} \beta_3 logMVA_{t-i} + \mu_t - - - - - - - - - - - - - (6)$$

$$logGFCF_t = \beta_{03} + \sum_{i=0}^{1} \vartheta_3 logGFCF_{t-i} + \sum_{i=0}^{1} \beta_1 logMVA_{t-i} + \sum_{i=0}^{1} \beta_2 logLABR_{t-i} + \sum_{i=0}^{1} \beta_3 logELEC_{t-i} + \mu_t - - - - - - - - - - - - - (7)$$

$$logLABR_t = \beta_{04} + \sum_{i=0}^{1} \vartheta_3 logLABR_{t-i} + \sum_{i=0}^{1} \beta_1 logGFCF_{t-i} + \sum_{i=0}^{1} \beta_2 logMVA_{t-i} + \sum_{i=0}^{1} \beta_3 logELEC_{t-i} + \mu_t - - - - - - - - - - - - - (8)$$

Estimating Equations (5) to Equation (8) is done simultaneously and the VAR framework automatically estimates them in a convenient way while utilizing an econometric software package. The general form of the VAR model is specified in Equation (9).

$$Y_t = V + AY_{t-1} + \mu_t - - - - - - - - \quad (9)$$

The VAR estimates is often linked to the Variance Decomposition so as to ascertain the share of the forecasted error variances that is being explained by the variables itself, or by other variables. If a variable strongly explains itself, then it is strongly endogenous otherwise it is weakly endogenous. But if a variable strongly predicts another variable, then it is strongly exogenous otherwise, it is weakly exogenous.

4 Empirical Findings and Discussion

4.1 Static Ordinary Least Squares (OLS) Estimation

The static OLS result on the influence of electricity consumption on the Nigerian manufacturing sector is presented in Table 1.

Table 1. *Long Run Result.*

Variable	Coefficient	Standard Error	t-Statistic	Probability
C	10.69621	4.899716	2.183026	0.0360**
LOGGFCF	0.706272	0.170593	4.140107	0.0002***
LOGLABR	-0.309555	0.231581	-1.336705	0.1902
LOGELEC	0.616412	0.232586	2.650248	0.0121**
R-squared = 0.4603		Adjusted R-squared = 0.4127		
F-statistic = 9.665		Probability of F-statistic = 0.000***		

*Note: ** and *** denotes significance at 5% and 1% level respectively.*

Source: Output Extracted from Eviews 10 Software Package.

From Table 1, it is observed that GFCF and ELEC exerts a positive and significant effect on manufacturing value added. Thus, a unit percentage increase in GFCF will culminates to a 70.63% increase in manufacturing value added; while a unit percentage increase in electricity consumption per capita will yield a 61.64% increase in manufacturing value added. Meanwhile, labour is seen to exert a negative, though insignificant, effect on manufacturing value added. This can be traced to high unemployment rate in the country as well as low employment of labour in the industrial sector. For instance, labour employment in the industrial sector (as percentage of total employment) was 11.654% as at 2010; averaged 11.686% between 2011 to 2018; and a record average of 11.794% between 1991 to 2018. This shows that the industrial sector over the years have not been a major employment of labour thus, labour may not be exerting a negative impact on manufacturing value added as a result of its underutilization. The static result presented about maybe misleading as there may be evidence of serial correlation. Therefore, the examination of the unit root properties of the variables used in the study becomes pertinent.

4.2 Unit Root Test

The result of the Augmented Dickey-Fuller test is presented in Table 2.

Table 2. *Augmented Dickey-Fuller Unit Root Test Result.*

Variable	ADF statistic at Level	ADF statistic at First Difference	Order of Integration
Manufacturing Value Added (LOGMVA)	-2.1673 [-3.5403] (0.4926)	-4.7841 [-3.5403] (0.0025)**	I(1)

Gross Fixed Capital Formation (LOGGFCF)	-5.4681 [-3.5403] (0.0004)**	-------------	I(0)
Labour (LOGLABR)	-0.6861 [-3.5628] (0.9654)	-3.8385 [-3.5628] (0.0277)**	I(1)
Electricity Consumption Per Capita (LOGELEC)	-3.5937 [-3.5366] (0.0441)	-----------------	I(0)

*Note: ** denotes significance at 5% level. The ADF τ-statistics are enclosed in [ ] while the probabilities are in ( ). The estimation follows a constant linear trend assumption.*

The result of the unit root test, as presented in Table 2, indicates that the variables are stationary at mixed order of integration. Manufacturing value added and labour are both stationary at first difference, I(1), as indicated by the significance of the tau (τ) statistic at the 5% level of significance; while electricity consumption per capita and gross fixed capital formation are stationary at levels, I(0).

4.3 Granger Causality Test

In examining the nature of the relationship between electricity consumption and manufacturing sector performance in Nigeria, the result of the Pairwise Granger causality test is presented in Table 3 as follows.

Table 3. *Pairwise Granger Causality Test Result.*

Hypothesis	F-statistic	Probability	Nature of Causality	Decision
Gross Fixed Capital Formation does not Granger Cause Manufacturing Value Added	2.72874	0.1078	Unidirectional Causality	Accept
Manufacturing Value Added does not Granger Cause Gross Fixed Capital Formation	4.43033	0.0428**		Reject
Labour does not Granger Cause Manufacturing Value Added	9.32143	0.0044**	Unidirectional Causality	Reject
Manufacturing Value Added does not Granger Cause Labour	0.06309	0.8032		Accept
Electricity Consumption Per Capita does not Granger Cause Manufacturing Value Added	7.88794	0.0082**	Bidirectional Causality	Reject

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Manufacturing Value Added does not Granger Cause Electricity Consumption Per Capita	3.48254	0.0707*		Reject
Labour does not Granger Cause Gross Fixed Capital Formation Gross Fixed Capital Formation does not Granger Cause Labour	12.3035 11.4464	0.0013** 0.0018**	Bidirectional Causality	Reject Reject
Electricity Consumption Per Capita does not Granger Cause Gross Fixed Capital Formation Gross Fixed Capital Formation does not Granger Cause Electricity Consumption Per Capita	8.56736 2.90607	0.0061** 0.0974*	Bidirectional Causality	Reject Reject
Electricity Consumption per Capita does not Granger Cause Labour Labour Does not Granger Cause Electricity Consumption Per Capita	0.17655 6.64672	0.6770 0.0144**	Unidirectional Causality	Accept Reject

*Note: * and ** respectively denotes significance at 10% and 5% levels.*

Source: Output Extracted from Eviews 10 Software Package

The Pairwise Granger causality test a unidirectional causality flows from manufacturing value added to gross fixed capita formation; from labour to manufacturing value added; and from labour to electricity consumption per capita. However, a bidirectional causality flows between electricity consumption per capita and manufacturing value added; labour and gross fixed capital formation; and between electricity consumption per capita and gross fixed capital formation. Since our main interest is between electricity consumption and manufacturing value added, the bidirectional causality that flows between the two variables prompts the use of vector autoregressive approach. This bidirectional causality further indicates that there is the prevalence of the feedback thesis between electricity consumption and manufacturing value added. This finding tallies some of the findings of earlier studies (Glasure & Lee, 1997; Oh & Lee, 2004; Hondroyiannis, Lolos & Papapetrou, 2002; Ozturk & Salah Uddin, 2012; Ebohon, 1996; Jumbe, 2004; Danmaraya & Hassan, 2016; and Soytas & Sari, 2003).

4.4 Vector Autoregressive (VAR) Model

In examining how shocks in electricity consumption can affect manufacturing sector performance, the result from the VAR model is presented in Table 4. Later, the result is followed by the variance decomposition and the impulse response function.

Table 4. *VAR Estimates.*

	LOGMVA	LOGGFCF	LOGLABR	LOGELEC
LOGMVA(-1)	0.945705	0.154695	0.002888	0.183377
	(0.08643)	(0.09065)	(0.00150)	(0.09983)
	[10.9421]**	[1.70645]*	[1.92714]*	[1.83690]*
LOGGFCF(-1)	0.228036	0.484604	-0.006990	-0.030397
	(0.10245)	(0.10745)	(0.00178)	(0.11833)
	[-2.22591]**	[4.50986]**	[-3.93485]**	[-0.25688]
LOGLABR(-1)	0.251148	0.266006	1.005088	0.350830
	(0.11836)	(0.12415)	(0.00205)	(0.13671)
	[2.12191]**	[2.14269]**	[489.732]**	[2.56620]**
LOGELEC(-1)	-0.046864	-0.079545	-0.002522	0.448003
	(0.12564)	(0.13178)	(0.00218)	(0.14512)
	[-0.37301]	[-0.60363]	[-1.15776]	[3.08720]**
C	4.062964	6.422728	0.070524	-8.135536
	(2.65445)	(2.78421)	(0.04603)	(3.06604)
	[1.53063]*	[2.30684]**	[1.53222]*	[-2.65344]**
R-squared	0.870784	0.720021	0.999968	0.825562
Adjusted R-squared	0.854632	0.685023	0.999964	0.803757
F-statistic	53.91167**	20.57353 **	247523.0**	37.86157**

*Note: Standard errors are enclosed in normal brackets ( ) while the t-statistics are enclosed in square brackets [ ]. ** and * represents significance at 5% and 10% respectively.*

Starting from the manufacturing value added (LOGMVA), manufacturing value added strongly predicts itself since the t-statistic is significant at the 5% level hence, manufacturing value added is strongly endogenous. It therefore implies that the past realization of manufacturing value added is associated with 94.57% increase in manufacturing value added on the average *ceteris paribus*. LOGGFCF and labour (LOGLABR) are also observed to significantly predict manufacturing value added as represented by the significance of their respective t-statistic at the 5% level. Thus, both labour and GFCF are strongly exogenous. This implies that a unit percentage increase in GFCF will account for 22.80% increase in manufacturing value added. Similarly, a unit percentage increase in labour will cause manufacturing value added to increase by 25.11% on the average. However, LOGELEC does not have any significant impact on manufacturing value added since the t-statistic is not statistically significant, though the impact is negative. This supports the neutrality thesis. The R-squared of 0.8708 indicates that the variables explain 87.08% of the total variation in manufacturing value added.

LOGGFCF is also seen to be strongly endogenous as its past value strongly predicts itself. The implication here is that the past realization of gross fixed capital formation is associated with 48.46% increase in gross fixed capital formation on the average, *ceteris paribus*. Both manufacturing value added and labour also have a significant impact on GFCF hence, they are strongly exogenous. Thus, a unit percentage increase in manufacturing value added will on the average led to a 15.47% increase in gross fixed capital formation; while a unit percentage increase in labour will account for a 26.60% increase in GFCF, *ceteris paribus*. Also, electricity consumption does not significantly impact GFCF hence, it is weakly exogenous. The R-squared (0.6850) shows that the variables explain 68.50% of the total variations in gross fixed capital formation.

The t-statistic of past value of labour (LOGLABR) is statistically significant hence, labour is strongly endogenous. Thus, the past realization of labour is associated with 100% increase in labour on the average, *ceteris paribus*. Manufacturing value added and GFCF are also strongly exogenous in explaining labour. A unit percentage increase in manufacturing value added amounts to a 0.29% increase in labour; while a unit percentage increase in GFCF will on the average lead to a 0.70% increase in labour. Meanwhile, ELEC does not significantly impact on labour. The R-squared (0.9999) indicates that 99.99% variations in labour is explained by the explanatory variables.

Finally, ELEC is also strongly endogenous since its past value significantly predicts its itself. Therefore, on the average, the past realization of ELEC is associated with 44.80% increase in ELEC *ceteris paribus*. Manufacturing value added and labour are strongly exogenous in impacting on ELEC. Therefore, a unit percentage increase in manufacturing value added will lead to 18.39% increase in ELEC. This significant impact of manufacturing value added on ELEC upheld the growth-driven electricity consumption thesis. Further, a unit percentage increase in labour will trigger ELEC by 35.08%. the R-squares of 0.8256 indicates that 82.56% of the total variations in electricity consumption is explained by the explanatory variables in the model.

4.5 Variance Decomposition

To track the proportion of the forecasted error variance that is being predicted by each of the variables, the variance decomposition becomes an imperative. The result with respect to manufacturing value added, GFCF, Labour, and ELEC is presented in Table 5 to Table 8 respectively.

Table 5. *Variance Decomposition for Manufacturing Value Added (LOGMVA).*

Period	Standard Error	LOGMVA	LOGGFCF	LOGLABR	LOGELEC
1	0.099494	100.0000	0.000000	0.000000	0.000000
2	0.141092	97.26781	2.582498	0.028778	0.120914
3	0.170360	94.30694	5.478905	0.044900	0.169251
4	0.191502	91.94131	7.833860	0.051333	0.173497
5	0.206788	90.18943	9.592606	0.053798	0.164163
6	0.217822	88.92152	10.86995	0.055091	0.153439
7	0.225782	88.00810	11.79089	0.056315	0.144692
8	0.231526	87.34788	12.45601	0.057861	0.138250
9	0.235677	86.86716	12.93933	0.059841	0.133664
10	0.238682	86.51377	13.29354	0.062267	0.130426

Source: Output Extracted form Eviews 10 Software Package

As evidence from Table 5, the first period is characterized by 100% of the forecasted error variance of manufacturing value added being explained by manufacturing value added itself; with GFCF, labour, and ELEC contributing nothing. Meanwhile, this value continues to decline over time, with GFCF explaining up to 13.29% to the forecasted error variance of manufacturing value added. By period 10, manufacturing value added still explains 86.51% of the forecasted error variance by itself; while other variables jointly explain 13.49% which is quite low. This supports our earlier findings that manufacturing value added is strongly endogenous.

Table 6. *Variance Decomposition for Gross Fixed Capital Formation (LOGGFCF).*

Period	Standard Error	LOGMVA	LOGGFCF	LOGLABR	LOGELEC
1	0.104358	2.697462	97.30254	0.000000	0.000000
2	0.116776	2.413073	96.97271	0.105674	0.508538
3	0.120278	4.037033	94.75489	0.218019	0.990057
4	0.122208	6.413779	92.03932	0.292421	1.254481
5	0.123876	8.708296	89.60230	0.332911	1.356497
6	0.125378	10.58636	87.68074	0.353620	1.379282
7	0.126653	12.01104	86.25150	0.364801	1.372661
8	0.127679	13.05433	85.21520	0.371948	1.358524
9	0.128477	13.80638	84.47126	0.377660	1.344698
10	0.129085	14.34495	83.93865	0.383088	1.333304

Source: Output Extracted form Eviews 10 Software Package

In the short run (period 1 to period 5), 97.30% to 89.60% of the forecasted error variance in GFCF is explained by the variable itself; while we observed a steady increase, from 2.70% to 8.71% being explained by manufacturing value added. In the long run (period 6 to period 10), gross fixed capital formation still explains up to 83.94% of its forecasted error variance; while we still observe a continuous steady rise of 10.59% to 14.34% increase in the contribution of manufacturing value added to the forecasted error variance GFCF. We can still say that gross fixed capital formation is strongly endogenous.

Table 7. *Variance Decomposition for Labour (LOGLABR).*

Period	Standard Error	LOGMVA	LOGGFCF	LOGLABR	LOGELEC
1	0.001725	6.933857	0.139999	92.92614	0.000000
2	0.002600	3.151236	8.170212	87.64746	1.031087
3	0.003388	1.936594	16.14616	80.30441	1.612841
4	0.004100	1.496229	22.14771	74.53884	1.817220
5	0.004741	1.286474	26.43994	70.41829	1.855300
6	0.005322	1.151785	29.51003	67.50581	1.832374
7	0.005851	1.046771	31.73761	65.42389	1.791729
8	0.006338	0.957631	33.38395	63.90864	1.749779
9	0.006790	0.879721	34.62442	62.78378	1.712072
10	0.007213	0.811042	35.57696	61.93209	1.679908

Source: Output Extracted form Eviews 10 Software Package

The variance decomposition of labour presents the fact that the variable is strongly endogenous in the short run, but gross fixed capital formation exerts a strong effect in the long run. In the short run, 92.93% to 70.42% of the forecasted error variance of labour is explained by labour itself; while GFCF explained 0.14% to 26.44% of the forecasted error variance of labour. By this period, labour is strongly endogenous. In the long run, the variable explains 67.51% down to 61.93% of the forecasted error variance in labour. By this future period, we see that GFCF explains up to 35.58% of the forecasted error variance in labour. Thus, gross fixed capital formation is strongly exogenous in influencing labour.

Table 8. *Variance Decomposition for Electricity Consumption Per Capita (LOGELEC).*

Period	Standard Error	LOGMVA	LOGGFCF	LOGLABR	LOGELEC
1	0.114921	1.253831	2.299387	13.45963	82.98715
2	0.128280	4.615778	2.575217	12.83849	79.97051
3	0.133614	8.819799	3.037369	12.12849	76.01434
4	0.137464	12.70612	3.626720	11.48537	72.18179
5	0.140682	15.80418	4.263967	10.96593	68.96592
6	0.143324	18.10706	4.872892	10.56939	66.45066
7	0.145418	19.76589	5.407992	10.27527	64.55084
8	0.147034	20.94527	5.853802	10.06061	63.14032
9	0.148259	21.77986	6.213457	9.905553	62.10113
10	0.149180	22.36980	6.498474	9.794473	61.33725

Source: Output Extracted form Eviews 10 Software Package

The VAR result indicated that electricity consumption is strongly endogenous in explaining itself; while labour and manufacturing value added were strongly exogenous in explaining ELEC. This result is validated through the variance decomposition for ELEC since the above mentioned variables are observed to be explaining the forecasted error variance of ELEC. In the first period, ELEC explains 82.99% of the forecasted error variance in itself while other variables explain just 17.01%. But in the long run, ELEC explains 61.34% of its forecasted error variance. Meanwhile, 38.66% of the forecasted error variance in ELEC is explained by other variables in the model. Thus, electricity consumption per capita is strongly endogenous in the short run, while we can say that both labour and manufacturing value added are strongly exogenous in the model.

4.5 Impulse Response Function (IRF)

The response of each of the variables to a shock in another variable is presented below. The diagrammatic presentation is done in Figure 2 while to further portray the direction of the response, we present the result in Table 9 to Table 12. Special attention will be paid to electricity consumption per capita and manufacturing value added since they are the key variables of interest.

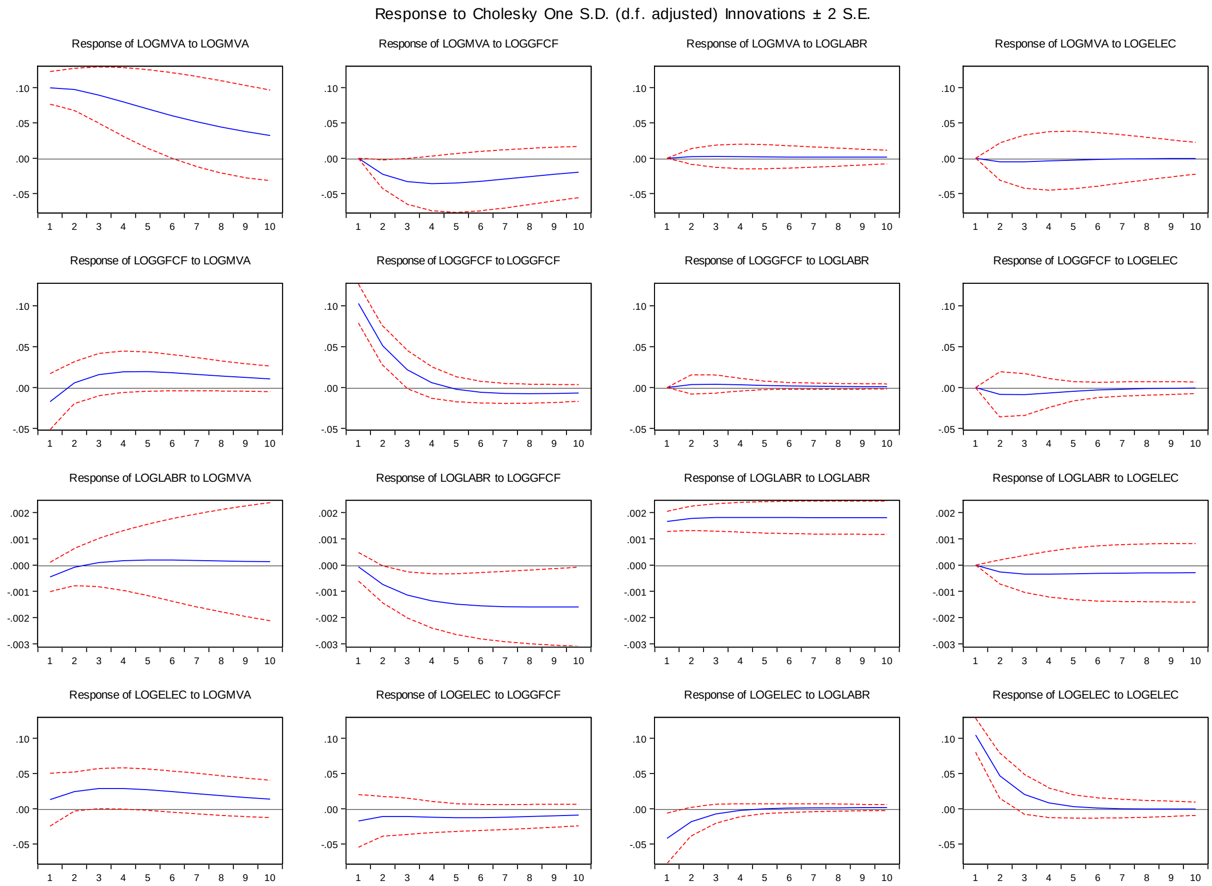

Figure 2. *Impulse Response Function.*

From Figure 2, we observe that a one standard deviation shock to electricity consumption will cause manufacturing value added to decline over the short run, but start rising steadily up to period 9 where after, the variable converges and responds less to any further shocks. Similarly, a one standard deviation shock in manufacturing value added will cause electricity consumption to decline in the long run.

Table 9. *Response of Manufacturing Value Added (LOGMVA).*

Period	LOGMVA	LOGGFCF	LOGLABR	LOGELEC
1	0.099494	0.000000	0.000000	0.000000
	(0.01157)	(0.00000)	(0.00000)	(0.00000)
2	0.097283	-0.022674	0.002394	-0.004906
	(0.01501)	(0.01020)	(0.00553)	(0.01317)
3	0.089484	-0.032803	0.002702	-0.005005
	(0.01996)	(0.01620)	(0.00791)	(0.01887)
4	0.079670	-0.035816	0.002407	-0.003809
	(0.02435)	(0.01942)	(0.00866)	(0.02069)
5	0.069631	-0.035057	0.002044	-0.002563
	(0.02783)	(0.02080)	(0.00854)	(0.02038)
6	0.060200	-0.032488	0.001770	-0.001614
	(0.03035)	(0.02104)	(0.00797)	(0.01896)
7	0.051711	-0.029211	0.001603	-0.000979
	(0.03192)	(0.02064)	(0.00719)	(0.01705)
8	0.044248	-0.025812	0.001519	-0.000589
	(0.03264)	(0.01992)	(0.00636)	(0.01502)
9	0.037775	-0.022584	0.001491	-0.000366
	(0.03262)	(0.01904)	(0.00556)	(0.01307)
10	0.032205	-0.019654	0.001495	-0.000247
	(0.03202)	(0.01808)	(0.00484)	(0.01128)

Note: Standard errors in brackets.

The impulse response of manufacturing value added indicates that the variable responds positively to any shock in its self over the ten-year horizon. The variable responded negatively to shocks in GFCF and ELEC; but responded positively to shocks in labour. In the first period, the variable responds to only itself.

Table 10. *Response of Gross Fixed Capital Formation (LOGGFCF).*

Period	LOGMVA	LOGGFCF	LOGLABR	LOGELEC
1	-0.017140	0.102941	0.000000	0.000000
	(0.01704)	(0.01197)	(0.00000)	(0.00000)
2	0.005941	0.051254	0.003796	-0.008328
	(0.01283)	(0.01198)	(0.00591)	(0.01383)
3	0.015968	0.022005	0.004139	-0.008595
	(0.01292)	(0.01169)	(0.00554)	(0.01283)
4	0.019335	0.006152	0.003483	-0.006643
	(0.01267)	(0.00959)	(0.00388)	(0.00886)
5	0.019453	-0.001972	0.002723	-0.004561
	(0.01198)	(0.00768)	(0.00261)	(0.00589)
6	0.018106	-0.005773	0.002122	-0.002943
	(0.01107)	(0.00662)	(0.00204)	(0.00465)
7	0.016203	-0.007240	0.001712	-0.001835
	(0.01012)	(0.00615)	(0.00187)	(0.00434)
8	0.014193	-0.007499	0.001455	-0.001131
	(0.00923)	(0.00585)	(0.00178)	(0.00417)
9	0.012281	-0.007173	0.001305	-0.000704
	(0.00846)	(0.00553)	(0.00166)	(0.00390)
10	0.010553	-0.006598	0.001223	-0.000455
	(0.00783)	(0.00516)	(0.00152)	(0.00354)

Note: Standard errors in brackets.

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GFCF responded negatively to shocks in manufacturing value added in the first period, but thereafter responded positively throughout the remaining nine-year horizon. The variable responds positively to shocks in itself up to period 4 and thereafter maintained a negative response to shocks from period 5 to period 10. Also, the variable responded positively to shocks in labour throughout the ten-year horizon.

Table 11. *Response of Labour (LOGLABR).*

Period	LOGMVA	LOGGFCF	LOGLABR	LOGELEC
1	-0.000454	-6.46E-05	0.001663	0.000000
	(0.00028)	(0.00027)	(0.00019)	(0.00000)
2	-8.19E-05	-0.000740	0.001778	-0.000264
	(0.00036)	(0.00035)	(0.00023)	(0.00023)
3	9.57E-05	-0.001140	0.001813	-0.000340
	(0.00046)	(0.00044)	(0.00026)	(0.00035)
4	0.000171	-0.001367	0.001820	-0.000347
	(0.00057)	(0.00052)	(0.00028)	(0.00044)
5	0.000194	-0.001490	0.001817	-0.000334
	(0.00068)	(0.00058)	(0.00030)	(0.00049)
6	0.000192	-0.001554	0.001814	-0.000319
	(0.00079)	(0.00063)	(0.00031)	(0.00052)
7	0.000179	-0.001584	0.001811	-0.000307
	(0.00089)	(0.00067)	(0.00031)	(0.00054)
8	0.000162	-0.001595	0.001809	-0.000299
	(0.00098)	(0.00070)	(0.00032)	(0.00055)
9	0.000145	-0.001598	0.001809	-0.000294
	(0.00105)	(0.00073)	(0.00032)	(0.00056)
10	0.000128	-0.001596	0.001810	-0.000291
	(0.00112)	(0.00076)	(0.00032)	(0.00056)

Note: Standard errors in brackets.

Labour responded positively to shocks in itself over the ten-year period. The variable responds negatively to shocks in manufacturing value added in the first three periods but thereafter maintained a positive response to shocks in manufacturing value added throughout the remaining period. Meanwhile, the variable responds negatively to GFCF and ELEC over the ten-year horizon.

Table 12. *Response of Electricity Consumption Per Capita (LOGELEC).*

Period	LOGMVA	LOGGFCF	LOGLABR	LOGELEC
1	0.012868	-0.017426	-0.042161	0.104690
	(0.01883)	(0.01866)	(0.01790)	(0.01217)
2	0.024371	-0.010959	-0.018305	0.046901
	(0.01378)	(0.01409)	(0.01019)	(0.01614)
3	0.028549	-0.010885	-0.007253	0.020273
	(0.01430)	(0.01293)	(0.00677)	(0.01418)
4	0.028747	-0.011961	-0.002244	0.008307
	(0.01463)	(0.01111)	(0.00459)	(0.01049)
5	0.026961	-0.012593	-3.12E-05	0.003103
	(0.01470)	(0.00984)	(0.00350)	(0.00824)
6	0.024324	-0.012533	0.000916	0.000942
	(0.01461)	(0.00921)	(0.00305)	(0.00721)
7	0.021454	-0.011942	0.001307	0.000103
	(0.01441)	(0.00885)	(0.00279)	(0.00660)
8	0.018664	-0.011042	0.001463	-0.000185
	(0.01411)	(0.00852)	(0.00256)	(0.00602)
9	0.016101	-0.010012	0.001524	-0.000262
	(0.01372)	(0.00813)	(0.00231)	(0.00540)
10	0.013818	-0.008969	0.001551	-0.000266
	(0.01324)	(0.00770)	(0.00206)	(0.00478)

Note: Standard errors in brackets.

Electricity consumption per capita responded positively to shocks in itself through period 1 to period 7. Thereafter, the variable responded negatively to any shock in itself. Meanwhile, ELEC responded positively to manufacturing value added throughout the ten-year period; but responded negatively GFCF from period 1 to period 10, and negatively responded to shocks in labour from period 1 to period 5 (the short run period) after which the variable responded positively to shocks in labour from period 6 to period 10 (the long run period).

5. Conclusion

Electricity is a crucial input in manufacturing activities. The epileptic power supply has caused manufacturing outlets to resort to the use of generating plants which has some explicit cost implications, with its attendant effect in dampening manufacturing activities. This paper has studied the rapport between electricity consumption and manufacturing sector performance in Nigeria using time series data that covers 1981 to 2018. The study utilized the Granger causality test to examine the nature of the association between electricity consumption and manufacturing sector performance; and the VAR model to investigate how manufacturing sector performance respond to shocks in electricity consumption. Meanwhile, we utilized manufacturing value added to capture manufacturing sector performance and electricity consumption per capita to represent electricity consumption.

Our result from the Granger causality test shows that there is a bidirectional causality flowing between electricity consumption per capita and manufacturing value added. This therefore points to the fact that the there is a feedback thesis in the association between electricity consumption and manufacturing sector performance. That is, high electricity consumption will cause an improvement in manufacturing sector performance; and high manufacturing performance will prompt greater demand for electricity. Also, the VAR result indicated that electricity consumption does not significantly predict manufacturing sector performance. Hence, electricity consumption is weakly exogenous. The implication is that the combination of other factor inputs, couple with the substitutes in diesel fuel in generating private electricity could be the source of improvement in the manufacturing sector performance. However, manufacturing sector performance was observed to be strongly exogenous in explaining itself. Thus, the past realization of manufacturing value added is associated with 94.57% increase in manufacturing value added on the average *ceteris paribus*.

Further, manufacturing value added was strongly exogenous in predicting electricity consumption per capita. Thus, the growth-driven electricity consumption thesis. Thus, a unit percentage increase in manufacturing value added will amount to an 18.34% increase in electricity consumption per capita. Electricity consumption was also strongly endogenous in explaining itself. Hence, the past realization of electricity consumption per capita is associated with 44.80% increase in electricity consumption per capita *ceteris paribus*. The findings of the VAR model were further validated through the use of the IRFs and the variance decomposition.

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Based on our findings, the government have a key role to play in ensuring that as the domestic production accelerates and the demand on electricity is rising, adequate provision is made to conserve electricity for the future. Alternative energy sources should be developed and utilized so as to free the environment from carbon monoxide emissions associated with running diesel plants during manufacturing activities as a result of epileptic electricity power supply. Since labour and capital cannot be a close substitute to electricity, manufacturing enterprises should source for alternative energy sources that drive its productive activities. Meanwhile, reforming the electricity supply is of necessity so as to create room for steady power supply which is a key driver of manufacturing activities.

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