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ENERGY CONSUMPTION OF MANUFACTURING SECTOR: A SEARCH FOR SUSTAINABLE ENERGY SOURCE IN NIGERIA

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Abstract
Manufacturing companies in a bid to realize high-quality development, figure out how to make the most use of their materials and improve their operating processes in a sustainable way. With an emphasis on sustainable energy practices that lessen reliance on fossil fuels and cut CO2 emissions, this study examines the relationship between energy consumption, manufacturing output, and economic growth in Nigeria. The study examines the effects of natural gas, renewable biofuels, fuel oil, gas/diesel, gasoline, and electricity on manufacturing production using time series data covering 1990 to 2019. It employed an autoregressive distributed lag (ARDL) model estimate technique. The short-run dynamics and long-run relationships are examined in the ARDL model. In the short-run motor gasoline, natural gas renewable biofuel, gas/diesel and fuel oil are economically and statistically significant both in the current year and up to the second lagged period. While the ARDL bound test reveals that there is cointegration among the variable in the long run. Renewable biofuels and fuel oil are the only variables that have a direct and statistically significant positive relationship with GDP manufacturing output. Therefore, increasing the use of these energy sources is likely to increase the output of GDP manufacturing in the long run.According to the Granger Causality Test, there is a bidirectional relationship between manufacturing output and both gasoline and renewable biofuel. In contrast, there is a Granger causality relationship between manufacturing output and gas/diesel and electricity. Furthermore, the test indicates that manufacturing GDP only has a Granger cause renewable biofuel. The findings show the individual effects of the renewable biofuel energy source and thus its importance viz-a-viz reduction of CO2 emissions, sustainability, sufficiency in capacity (in Nigeria context) can increased Gross Domestic Product (GDP) manufacturing output. It is therefore recommended that policymakers ensure a switch and make available renewable biofuel sources.

1. Introduction

Economic boundaries are becoming less important in the growing transition towards a global economy, which causes the elements that influence the dynamic response to economic growth to change constantly. Several studies over the years have identified and continue to isolate critical factors that tend to shape and influence changes in economic growth or GDP growth (Ramey, 2017; Barro et al., 2004; Mankiw et al., 1992). Thus, energy consumption has been identified as a key element responsible for

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variability in economic growth among economies around the world. It can be conceptualized as a core factor influencing manufacturing output growth.

The relationship between energy consumption and economic growth has long been investigated in the works of literature (Ekeocha et al 2020; Gozgoret al 2018; Bamidele & Matthew, 2013). This is because of its role in promoting economic growth, alleviating poverty, and reducing inequality. Therefore, the production and consumption of high-graded energy resources will magnify the impact of technology and create terrific economic growth. However, excessive use of fossil fuels is harmful to the environment. In general, countries with high energy consumption are more developed than those with low-level consumption (Sari et al., 2008). The ripple effect of energy consumption is evident in other areas of development namely: an increase in the employment ratio of energy industry workers, an increase in foreign income when energy products are exported, advancement in infrastructural capacity caused by the exploitation of energy resources and an improvement in workers' welfare due to increase in workers' wages and salary.

Energy is the main creator of wealth in Nigeria and one of the largest hydrocarbon producers in Africa with oil reserves surpassing a billion tons and the country is in twelfth place worldwide. Nigeria relies majorly on its petroleum industry for economic growth as the sector is responsible for 80% of government revenues and 95% of foreign exchange (Iwu, 2008). The country also has natural gas reserves totalling 5.2 trillion cubic meters which makes it the seventh biggest natural gas reserve in the world (Corporate Nigeria, 2012).

Energy drives the wheels of economic growth since it is a key factor of production, along with capital, and labour (Abosedra et al, 2015). The higher the GDP per capita, the more the energy demand. Energy is widely regarded as a propelling force behind any economic activity and indeed industrial production. High grade energy resources can intensify the impact of technology and create remarkable manufacturing output growth. The scale of energy consumption per capita is an important indicator of economic modernization. In general, countries that have higher per capita energy consumption are more developed than those with low level of consumption (Fouquet 2014).

Through a number of pathways, rapid economic growth can have a major impact on energy use. The increased need for energy to power economic activities like manufacturing, transportation, and building is one of the most direct channels. The need for energy to run the machinery and equipment utilized in these activities rises as economic growth results in increasing output and consumption of products and services. The usage of fossil fuels like coal, oil, and gas as well as clean energy sources like wind and solar energy may rise as a result. Energy usage may fluctuate as the economy changes in structure. A shift away from energy-intensive businesses like manufacturing and toward less energy-intensive industries like services and technology may occur as economies grow more diversified and industrialized. It may also lead to a shift toward cleaner and more sustainable energy sources, which could lead to a reduction in overall energy consumption (Gülen & Kinaci, 2017). Thus, in the quest for optimal development

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and efficient management of available energy resources, equitable allocation and efficient utilization can put the economy on the path of sustainable growth and development. Arising from this argument, an adequate supply of energy thus becomes central to the radical transformation of the nation's economy.

Much of the research aimed at exploring the long-run relationship and the direction of causality between economic growth and energy use has included several other variables, for example, population, urbanization, financial development, and so forth, to better understand the underlying dynamics of the relation. Wolde-Rufael (2009) argued that the rise in energy demand in African countries is closely linked to income. Population growth creates pressure on rural resources, forces people to move to urban areas, and thus increases energy demand. For sustained economic growth, the increased energy demand over a long period must be met from new sources, or by developing cost-effective alternative energy.
Against the backdrop of increasingly competitive global markets and climate change, manufacturers aim to reduce costs and increase sustainability without negatively affecting the yield of their finished products, thus maintaining or improving profits. An improvement in energy efficiency or reduction in energy use during manufacturing is an effective method of achieving both goals. The link between energy consumption and economic growth falls within the realm of environment and macroeconomics. Efficiency production cannot take place without energy use whether in the primary, secondary or tertiary levels. Sustainable energy has been challenge to economic activities, which is a result of low productivity yields. According to the International Energy Agency (2019) and the World Bank (2019), energy production and consumption is over an average of 40,000 megawatts in South Africa, whereas it is only a little above an average of 4,000 megawatts in Nigeria. In line with foregoing, the size of manufacturing is a factor of price and availability of energy; and this is the propelling force shooting the South African economy into the number economy in Africa

Given the fact that there are channels through which energy consumption and economic growth are linked together, there is therefore a dire need to explore this relationship empirically using manufacturing output growth to lend some contribution to the literature. Hence, this study aims to examine the effects of energy consumption on manufacturing output growth and the direction of causality between energy consumption and manufacturing output growth in Nigeria.

2.0 Theoretical Review

Various theories underlie this study. These are:

(i). Neoclassical Theory of Growth

The Neoclassical growth theory (NGT) is usually in the form of the frequently used Cobb-Douglas production function as pin-pointed by Elijah and Nsikak (2013). Interestingly, the NGT is built on the principles of the Solow growth model which assumes that output productivity is a function of inputs such as labour, capital and technological progress. And since technology is exogenously determined, it could be argued that there exist a direct relationship with energy. This is because the amount of technology per unit of time requires some level of energy to work. Technology in this regard refers to plants, machinery and equipment. Without an adequate supply of energy, current technological stock will be unproductive.

(ii) Endogenous Growth Theory

The endogenous growth theory also known as the new growth theory, considers physical and human capital, and technical-know-how as fundamental inputs. In the model, the variables are determined from within. The major difference between the neoclassical and endogenous growth theory is based on the assumption of diminishing marginal utility (Barro & Sala-i-Martins, 1995). Unlike the neoclassical growth model which is built on the assumption of diminishing marginal utility, the endogenous growth experiences return to scale. These parameters of the inputs (human capital and physical capital) are most times either equal to or greater than one. Technological innovations are the main foundation of the endogenous growth model promoting cheaper and greater quantities of energy production which triggers productivity. Similarly, higher energy consumption promotes the discovery of new technologies which when diffused, shared or imitated trigger increased productivity. These dual interactions trigger further arguments leading to the causality test. Thus, as far as energy infrastructure is concerned, ecological economists have strongly considered energy as an essential factor of production.

The aggregate production function of the endogenous theory is as follows:
$Y=F(A, K, L)$ where
Y = aggregate real output.
K = stock of capital.
L = stock of labour.
A = Technology (or technological advancement) Technology is seen as an endogenous factor which could be related to energy. Most technology as given per time is dependent on the availability of useful energy to power it. Without an adequate energy supply (in this case electricity or petroleum) then the technology will not be available. The law of thermodynamics helps to justify this by stating that "no production process can be driven without energy conversion. Energy is not the sole determinant of technology but is a necessary factor to ensure that technology (at whatever level) is being utilized. The conversion of energy from its raw state into the useful state is highly technology oriented. Taking a cue from the technology-oriented nature of energy production, it is known that energy production is capital-intensive. Huge machinery is required to produce useable energy. This means that huge amount of capital will be required to produce energy. Huge investments must then be made on energy not only to produce but to attain energy efficiency. For the sake of justifying the endogenous growth model, capital and labour will be used alongside various energy sources in the specification of the model.

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2.1 Overview of Energy Consumption in Nigeria

Nigeria has huge energy resources and if this were optimised, it would possibly give the country ample opportunity to transform her economy and invariably the lives of her citizens. Nigeria sits astride over 35 billion barrels of oil, 187 trillion cubic feet of gas, 4 billion metric tons of coal and lignite, as well as enormous reserves of tar sands, hydropower and solar radiation, amongst others (Adenikinju, 2008; Odularu & Okonkwo, 2009).

Today, Nigeria is seen as one of the highest developing nations in Africa with highly endowed natural resources with potential energy resources. Table 1 reveals the stock of energy and CO2 emissions in Nigeria in comparison with the United States of America (USA)

Table 1 Energy Balance and CO2 Emission
Energy Balance

Electricity	total	Nigeria per capita	USA per capita
Own consumption	24.61 bn kWh	115.33 kWh	11,744.38 kWh
Production	29.32 bn kWh	137.41 kWh	12,198.66 kWh

Crude Oil	Barrel/day	Nigeria per capita	USA per capita
Own consumption	483,100.00 bbl	0.002 bbl	0.062 bbl
Production	1.65 m bbl	0.008 bbl	0.054 bbl
Export	1.89 m bbl	0.009 bbl	0.006 bbl

Natural Gas	Cubic meters	Nigeria per capita	USA per capita
Own consumption	18.79 bn m³	88.04 m³	2,583.79 m³
Production	46.30 bn m³	216.95 m³	2,914.02 m³
Import	0.00 m³	0.00 m³	239.57 m³
Export	27.51 bn m³	128.91 m³	567.66 m³

CO_2 emissions

	CO_2 emissions in 2019	Nigeria per capita	USA per capita
total	115.28 m t	0.57 t	14.52 t
› of which diesel + gasoline	67.41 bn t	331.55 t	7,179.51 t

› of which natural gas	36.86 bn t	181.28 t	5,073.94 t
› of which coal	231.00 m t	1.14 t	3,246.58 t

However, increasing access to energy in Nigeria has proved to be not only a non-stop challenge but also a persistent issue with the international community. The significance that the country has placed on crude oil is relatively very high. The over-reliance of crude oil in Nigeria is a major challenge because it has failed to spread its energy consumption and ensure a fitting energy mix. The consumption of oil is highly essential because there is no alternative to it presently (Odularu and Okonkwo, 2009).

Fossil fuels like coal are insignificantly extracted in the country. The coal located in eastern Nigeria is bituminous which means that it burns slowly and gives out a lot of heat. Subsequently, it is also low in Sulphur and ash content. Coal has been the oldest commercial fuel used in Nigeria since it was discovered in 1916. Since the discovery of oil in Nigeria, coal has been relegated to less importance and became highly dormant. With a reserve of over 2 billion metric tons, Nigeria produces about 200000 to 600000 tons yearly.

Per capita power consumption in Nigeria is estimate at 82KW, which is grossly inadequate in relation to other African counter-parts. For instance, South Africa has a per capita consumption of 3793KW. Nevertheless, with vast abilities, energy can be adequately supplied in the country when well tapped. When consumption is positively related to economic growth, the benefits of increased consumption includes generating more income, increasing economic activities which will boost economic growth and increased growth especially poverty reduction (Odularu and Okonkwo, 2009).

2.2 Empirical Literature

Empirical studies designed to test the causal relationships between energy consumption and economic growth are generally grouped into three, energy consumption is a precondition for economic growth, bidirectional or feed-back relationship between energy consumption and economic growth and no causality between energy consumption and economic growth.

Energy consumption is a precondition for economic growth given that energy is a direct input in the production process and also, energy is an indirect input that complements labour and capital inputs (Odhiambo, N.M, 2009). Such selected articles related to energy efficiency, economic consequences, and productivity in different sectors and countries. The results imply that energy conservation policies would have a damaging repercussion on economic growth for Tanzania.

Mulugeta et al. (2010) analyzed the relationship between energy consumption and economic growth in the Common Market for Eastern and Southern Africa (COMESA) region and found that energy consumption is a crucial component for economic growth, directly or indirectly, as a complement to capital and labor in the production process. Similarly, Stern (2010) analyzed the relationship between energy use and economic

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growth in a global context and found that energy is a critical input for economic growth and development.

From an epistemological perspective, Keen et. al. (2019) argue that energy is an input to both labour and capital and production is impossible without it, energy plays a crucial role in economic development. Halkos et. al. (2019) examine energy efficiency across 28 selected EU Member States and explore the potential for energy recovery from waste. They emphasize the importance of energy efficiency in reducing energy consumption and greenhouse gas emissions. Li et. al. (2021) revisits the renewable energy-economic growth nexus in seven European countries over a 34-year period. They find evidence of a long-term positive relationship between renewable energy and economic growth.

Kumar et. al. (2020) use an input-output model to understand the economic effects of using crop residue for electricity production. They analyze the effects on the economy, land, labour, and other factors and suggest that crop residue utilization can have positive economic and environmental impacts.

Jackson et. al. (2021) develop a model (TranSim) to simulate the economic and financial implications of an energy technology transition involving a reduction in energy return on investment (EROI). They combine the stock-flow consistent (SFC) approach with an input-output (IO) model and use time-series data to estimate parameter values.

Khalid et. al. (2021) use the ridge regression technique to estimate parameter values from time-series data covering the period 1980-2017. Their analysis focuses on the relationship between economic growth and various factors such as energy consumption, population, and trade. Hoque et. al. (2021) examine the trends in partial and total factor productivity (TFP) growth of India's pharmaceutical industry over a 25-year period. They analyse the effects of policy changes such as product patent laws on productivity growth.

Soomro et. al. (2021) examine the nonlinear effect of labour productivity on the environment in China. They find that there is an inverted U-shaped relationship between labour productivity and environmental degradation. Finally, Oryani et. al. (2021) explores the relationship between energy consumption, economic growth, and environmental degradation in 25 selected Asian countries. They use panel data analysis to estimate the relationships and suggest policy options to promote sustainable development.

Adamu & Adediran (2020) analyzed the relationship between electricity consumption and economic growth in Nigeria and found that electricity consumption is positively related to economic growth, indicating that access to electricity is a precondition for economic growth in Nigeria.

The implication of the bi-directional relationship is that energy consumption and economic growth are complementary.

This implies that consumption will increase accelerate energy economic growth, and contrariwise, an increase in economic growth will stimulate energy consumption (Hou, 2009; Omotor, 2008). Some studies, such as Zafar et al. (2019) and Zafar et al. (2020), explore the feedback effect and bidirectional causal associations among economic growth, renewable energy consumption, and nonrenewable energy consumption. Other studies, such as Jebli et al. (2019), examine the causal relationships between renewable energy consumption, the number of tourist arrivals, trade openness ratio, economic growth, foreign direct investment, and carbon dioxide emissions in Central and South American countries. Wang et al. (2019) adopt the Granger causality test approach and impulse response function analysis to examine the relationship between financial development, renewable energy consumption, and economic growth in 186 countries. The studies also employ different econometric methods, such as the autoregressive distributed lag bounds testing approach used by Rehman et al. (2019) to investigate the long-run and short-run causality relationships between electric power consumption, renewable electricity output, renewable energy consumption, fossil fuel energy consumption, energy use, carbon dioxide emissions, and gross domestic product per capita for Pakistan. These studies provide valuable insights into the interplay between energy consumption, and economic growth.

There is no causality between energy consumption and economic growth and thus policies that are aimed at conserving energy will not retard economic growth (George and Nickoloas, 2011). The causal relationship between energy consumption and economic growth is investigated applying two multivariate time series models: a demand side model of energy, GDP and real energy price and a production side model of GDP, energy, capital, and labor (Oh et. al., 2004). (Akinlo, 2008) examine the causal relationship between energy consumption and economic growth for eleven countries in sub-Saharan Africa. (Menyah et. al., 2010) explore the causal relationship between carbon dioxide (CO_2) emissions, renewable and nuclear energy consumption and real GDP for the US for the period 1960-2007. In other words, no strong relation is found between energy consumption and economic growth for all income groups considered (Ozturk et. al., 2010).

One puzzling results in the literature on energy consumption-economic growth causality is the variability of results particularly across sample periods, sample sizes, and model specification. In order overcome these issues (Balcilar et. al., 2010) analyze the causal links between energy consumption and economic growth for G-7 countries using bootstrap Granger non-causality tests with fixed size rolling subsamples. (Ouédraogo, 2010) establish the direction of causality between electricity consumption and economic growth in Burkina Faso for the period 1968-2003. (Alam et. al., 2011) investigate the causality relationships among energy consumption, carbon dioxide (CO_2) emissions and income in India using a dynamic modeling approach. (Alam et. al., 2012) investigate the possible existence of dynamic causality between energy consumption, electricity consumption, carbon emissions and economic growth in Bangladesh. Using a novel approach that may detect causalities when the time-constant hypothesis is rejected (Ajmi et. al., 2015) find significant time-varying Granger causalities among the variables under consideration. Other influential work includes (Chontanawat et. al., 2008).

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3.0 METHODOLOGY

This study employed annual secondary data covering 1990 to 2019 on Real Gross Domestic Product on Manufacturing, Electricity, Renewable energy of bio-fuel and Fuel oil, Natural gas, gas/diesel fuel and they were obtained from National Bureau of Statistics (NBS), Central Bank of Nigeria (CBN) and International Energy Agency (IEA). For this study, we adopt the Aqeel & Butt (2001) model. Aqeel and Butt (2001) developed a model to analyze the causal relationship between energy consumption and economic growth in Pakistan. The model includes the following variables, Real GDP (RGDP), Energy Consumption (EC), Capital Stock (K) and Labour Force (L).

Energy consumption is sourced from Petroleum consumption and electricity consumption data is gotten from IEA 2020 (International Energy Agency and the American Energy Information Administration), while Manufacturing GDP from the Central Bank of Nigeria Statistical Bulletin 2020. The empirical model used for this study is designed to investigate the effect of energy consumption on manufacturing output growth.

Model Specification

Aqeel and Butt's model to analyze the relationship between energy consumption and economic growth in Pakistan included the following variables:

- Electricity consumption causes economic growth.
- Economic growth causes oil consumption.
- Total energy consumption.

When energy is taken as an independent variable then the model can be stated as:

$$Y = f(K, L, Z) \tag{3.1}$$

Where Y = Output, K = Capital, L = Labour, Z = Control Variables

However, there are four (4) main energy types in Nigeria and they include petroleum, electricity, coal and Gas. These four energy types will be summed to derive the total energy consumption. Therefore, the resultant model would be:

ARDL Estimated Equation:

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$$MAN\_GDP = \alpha_1 MAN\_GDP(-1) + \alpha_{21} NAT\_GAS + \alpha_{22} NAT\_GAS(-1)$$
$$+\alpha_{23} NAT\_GAS(-2) + \alpha_{31} RE\_BIOFUELS + \alpha_{41} GASOLINE + \alpha_{42} GASOLINE(-1)$$
$$+\alpha_{43} GASOLINE(-2) + \alpha_{51} GAS\_D + \alpha_{52} GAS\_D(-1) + \alpha_{53} GAS\_D(-2) + \alpha_{61} FUEL\_OIL +$$
$$\alpha_{62} FUEL\_OIL(-1) + \alpha_{63} FUEL\_OIL(-2) + \alpha_{71} ELECT + \alpha_0$$

The model which consists of six variables which includes

Manufacturing Output - MAN_GDP,

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Natural gas - NAT_GAS,
Renewable biofuel - RE_BIOFUELS
Fuel oil - FUEL_OIL
Gas/diesel - GAS_D
Gasoline – GASOLINE
Electricity - ELECT.

Moreover, the a-priori expectations are stated as follows; $\beta_1, \ldots, \beta_5 > 0$ and $\beta_6 < 0$. It is therefore expected that all the explanatory variables have a direct relationship with the Gross Domestic Product Growth Rate.

The Granger causality test is a statistical hypothesis test for determining whether one-time series is useful in forecasting another. Granger (1980) argued that causality in economics could be reflected by some sort of tests. A time series X is said to granger-cause Y if it can be shown, usually through a series of t-test and f-tests on lagged values of X (and with lagged values of y also included), that those X values provide statistically significant information about future values of Y. The Granger causality equation is presented below as:

$$MAN\_GDP_t = C + \sum_{i=1}^{p} \alpha_{1i} MAN\_GDP_{t-i} + \sum_{i=1}^{p} \alpha_{2i} NAT\_GAS_{t-i} + \sum_{i=1}^{p} \alpha_{3i} GASOLINE_{t-i} + \sum_{i=1}^{p} \alpha_{4i} GAS\_D_{t-i} + \sum_{i=1}^{p} \alpha_{5i} ELECT + \sum_{i=1}^{p} \alpha_{6i} FUEL + \varepsilon_{1t}$$

4.1 Data Analysis

The statistical summary of the mean, minimum, and maximum of each of the variables expressed in the unit of measurement is appropriately displayed in Table 2

Table 2 Summary Statistics

	MAN_GDP	NAT_GAS	RE_BIOFUELS	FUEL_OIL	GAS_D	GASOLINE	ELECT
Mean	3161.617	89428.00	3145576.	384.8571	1884.107	6589.107	15331.89
Maximum	6684.218	175819.0	4385399.	839.0000	3427.000	12836.00	25774.00
Minimum	1412.444	30326.00	2145298.	123.0000	540.0000	2625.000	7871.000
Sum	88525.28	2503984.	88076124	10776.00	52755.00	184495.0	429293.0
Observations	28	28	28	28	28	28	28

The average value of the contribution of manufacturing to gross domestic product (MANUF_GDP) is N3161.61 billion. It ranges from ₦1412billion to ₦6684 billion. The

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highest natural gas and electricity use during the period of review is about 175819 and 25774 respectively. The average of renewal biofuel for the period covered is 3145576

Unit Roots Tests

The unit root tests are applied to check for the order of integration of the data series. All the data series on Real Gross Domestic Product on Manufacturing (MAN_GDP), Electricity (ELECT), Renewable energy of bio-fuel (RENEW-BIOFUEL) and Fuel oil (FUEL_OIL), Natural gas (NAT_GAS), gas/diesel fuel (G_FUEL) are checked to apply the Augmented Dickey-Fuller (ADF) unit test. Table 3 shows the results of the ADF unit roots test. ELECT, RENWEN-BIOFUEL, FUEL_OIL G_FUEL and NAT_GAS are the first difference stationary at 5% except for MAN_GDP at 10% level of significance. The results showed that all series were nonstationary at level but stationary at the first difference and therefore integrated of order one I (1).

Table 3 Unit Root

Variables	**At Level**		**1st Difference**		**Order Of Integration**
	ADF Statistics	***Critical value @5%***	***ADF Statistics***	***Critical value @5%***	
LMANUF_GDP	-0.390505	-2.981038	-2.762785	-2.632604*	I(1)
ELECT	-0.084652	-2.976263	-6.174833	-2.981038	I (1)
FUEL_OIL	-2.169249	-2.976263	-5.851203	-2.981038	I (1)
LRENEW_BIOFUELS	0.802675	-3.644963	-3.741440	-3.658446	I (1)
GAS_D	-1.746894	-2.976263	-5.078449	-2.981038	I(1)
GASOLINE	-0.024756	-2.976263	-4.889164	-2.981038	I(1)
NAT_GAS	-1.344176	-2.976263	-5.452499	-2.981038	I(1)

Source: Author's computation 2021

Research Objectives and Inference from Estimated Model

To examine the first research question, the short-run and long-run coefficient of the ARDL result is used. Specifically, the magnitude and signs of the estimates are explained. Hence, the relationships between GDP manufacturing output growth and various energy source used by the sector. The second objective, which is based on the causal direction of each variable, is to evaluate the output of the Granger causality test. Finally, the statistical significance of each explanatory variable is considered.

Table 4 ARDL Model Short run Dynamics and the long run estimates

Panel A			**Panel B**		
Dependent Variable: MAN_GDP			ARDL Error Correction Regression		
Selected Model: ARDL(1, 2, 0, 2, 2, 2, 0)			ECM Regression		
Variable	Coefficient	Prob.*	Variable	Coefficient	Prob.
MAN_GDP(-1)	0.463595	0.0014	NAT_GAS	-0.003562	0.1890
NAT_GAS	0.002697	0.0184	RE_BIOFUELS	0.002749	0.0003
NAT_GAS(-1)	-0.000847	0.4237	GASOLINE	-0.027696	0.8085
NAT_GAS(-2)	-0.003761	0.0032	GAS_D	-0.193605	0.2220
RE_BIOFUELS	0.001475	0.0008	FUEL_OIL	3.347024	0.0000

GASOLINE	0.176402	0.0097	ELECT	0.066206	0.1762
GASOLINE(-1)	-0.089367	0.1354	C	-7095.752	0.0000
GASOLINE(-2)	-0.101891	0.0561			
GAS_D	-0.123499	0.1852	CointEq(-1)*	-0.536405	0.0000
GAS_D(-1)	-0.089125	0.3386			
GAS_D(-2)	0.108773	0.2119			
FUEL_OIL	0.642066	0.0496			
FUEL_OIL(-1)	0.476984	0.1357			
FUEL_OIL(-2)	0.676310	0.0401			
ELECT	0.035513	0.1522			
C	-3806.198	0.0004			

Source: Author's computation from Eviews 10

Effects of Energy Consumption on Manufacturing Output Growth

The estimates of the analysed short-run dynamics of the ARDL model evidenced that the short-run dynamics as shown by the signs and values of the coefficients (up to the second-difference lagged) independent variables are statistically significant.

Table 4 (Panel A) shows the results of the short-run relationship. One year lagged of manufacturing GDP (MAN_GDP-1) increases the current GDP by 46%. Current year Natural gas has a positive effect on manufacturing output that is statistically significant. Renewable biofuels and gasoline also reveal that a positive relationship exists between each of these types of energy consumption and GDP (manufacturing output). Current gasoline increases the GDP by 17%

Fuel oil consumption has also a positive significant effect on the GDP. An increase in the consumption of fuel oil by 1% causes an increase 64%. Electricity is economically significant (shows a positive relationship with manufacturing output) but it is not statistically significant.

With the estimates of the short-run relationship between the variables, the error correction term (ECT) is calculated. Table 3 displays the error correction term (ECT). ECT refers to the long-term balance, in the speed adjustment with one shock in the model. ECT (− 1) is negative and statistically significant at 1% significance level. It also indicates that any previous period shock in the short run in this model will be adjusted in the long run equilibrium with a speed of 53%.

To explain more on the relationship between energy consumption and GDP Manufacturing, the long-run relationship is examined. Table 4 (Panel B) depicts the long estimates of the relationship between energy consumption and GDP. The long-run relationship represents the equilibrium relationship between the GDP Manufacturing and the independent variables in the long run. It shows how the GDP Manufacturing responds to changes in the explanatory variables in the long run. Hence, the identified underlying economic relationships between the variables modelled are as follows: Renewable biofuels and fuel oil are the only variables that have a direct/positive relationship with GDP manufacturing output and are statistically significant at a 5 per

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cent level. Therefore, increasing the use of this source of energy will increase the output of GDP manufacturing in the long run.

The result of the bound test indicates a co-integration among the variables in the long run. The F-statistics, 15.33 is greater than the upper and lower bound values at 5%. Hence, the null hypothesis of no relationship, in the long run, is rejected and therefore concludes that there is a long-run relationship among Real Gross Domestic Product on Manufacturing, Electricity, Renewable energy of bio-fuel, Fuel oil, Natural gas, and gas/diesel fuel.

Table 5 Diagnostic Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.887314	Prob. F(11,15)	0.5711
Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.764271	Prob. F(2,13)	0.4855
Histogram Normality Test:			
Jarque-Bera statistics	5.4612000	Probability	0.065180

Source: Author's computation from Eviews 10

Diagnostic tests

Table 5 shows the results of different residual diagnostic tests. The heteroscedasticity of the residuals for the ARDL model is checked using the Breusch-Pagan-Godfrey heteroscedasticity test. The result shows that there is no evidence of the presence of heteroscedasticity. Since the probability of the F- statistics (0.57) is greater than that of the critical value of 0.05 level of significant.

To check for the serial correlation, Breusch-Godfrey correlation LM tests is employed. The result shows that there is no autocorrelation among the error terms because the probability value of the F-statistics of 0.48 is greater than the critical value of 5% level of significance. Histogram normality test is use to know whether the residual is normally distributed. In doing this the probability value (0.07) of the Jarque-Bera statistics is compare with the critical value of 5%. Since the probability value is greater than 5% hence, we can conclude that the residual are normally distributed.

Table 6: Granger causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
GASOLINE does not Granger Cause MAN_GDP	26	7.50171	0.0035
MAN_GDP does not Granger Cause GASOLINE		6.87613	0.0050
GAS_D does not Granger Cause MAN_GDP	26	5.87152	0.0094
MAN_GDP does not Granger Cause GAS_D		0.76191	0.4793
FUEL_OIL does not Granger Cause MAN_GDP	26	1.31409	0.2899
MAN_GDP does not Granger Cause FUEL_OIL		0.41022	0.6687

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ELECT does not Granger Cause MAN_GDP	26	5.63397	0.0110
MAN_GDP does not Granger Cause ELECT		0.21057	0.8118
NAT_GAS does not Granger Cause MAN_GDP	26	0.04066	0.9602
MAN_GDP does not Granger Cause NAT_GAS		2.41522	0.1137
RE_BIOFUELS does not Granger Cause MAN_GDP	26	15.8570	6.E-05
MAN_GDP does not Granger Cause RE_BIOFUELS		6.25054	0.0074

Causality between Energy Consumption and Manufacturing Output Growth

In order to discuss the second objective of this study, the Granger causality test is applied to determine the direction of causality as displayed in Table 6. This test is applied to know whether manufacturing output Ganger - cause energy consumption or energy consumption Ganger-cause manufacturing output. There is bi-directional relationship between gasoline and manufacturing output, renewable biofuel and manufacturing output, while gas/diesel, and electricity granger cause manufacturing output while manufacturing GDP only granger cause renewable biofuel.

4.3 Discussion of Findings

Research results show that in the short run, motor gasoline, natural gas renewable biofuel, gas/diesel and fuel oil are economically and statistically significant both in the current year and up to the second lagged period. Also, in ARDL bound test reveals that there is cointegration among the variable in the long run. Hence, we can conclude from the findings of this result that there is a positive/direct relationship between energy consumption and manufacturing output.

The Granger causality result shows that a bi-directional relationship exists between gasoline and manufacturing output, renewable biofuel and manufacturing output. And that one-directional relationship exists also with gas/diesel granger cause manufacturing GDP, electricity granger cause manufacturing GDP, and lastly manufacturing GDP granger cause renewable biofuel.

5.0 Conclusion

The nature and composition of a country's economy is expected to change as its manufacturing output grows and the role of energy in this growth process is typically a subject of interest. While several analysts believe that energy plays a great role in the economic growth of a nation others are of contrary opinion and in this study, we have attempted to examine the role of energy in the manufacturing sector and tend to search specifically which of the energy source aids an environmentally friendly technique of manufacturing in Nigeria. Based on the long-run result, renewable biofuels and fuel oil are the only variables that have a direct/positive relationship with GDP manufacturing output and are statistically significant at a 5 per cent level. Biofuels are produced from renewable feedstocks and have the potential to reduce some undesirable aspects of fossil

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fuel production and use, including conventional and greenhouse gas pollutant emissions, exhaustible resource depletion, and dependence on unstable foreign suppliers.

5.1 **Recommendations**

Everything should be done to bolster the availability of energy sources for the purpose of consumption and subsequently manufacturing. Biofuel has the potential to be a renewable and sustainable energy source that can reduce some of the undesirable aspects of fossil fuel production and use. Here are some recommendations on biofuels as a renewable energy source:

(i) Governments should invest in research and development to improve the efficiency and sustainability of biofuel production and use.
(ii) Policies should be put in place to support the development of a better biofuel economy, such as subsidies and tax incentives for biofuel producers and users.
(iii) Governments should work to create a regulatory environment that encourages the use of biofuels and discourages the use of fossil fuels.
(iv) Consumers can support the development of a better biofuel economy by choosing to use biofuels and supporting policies that promote their use.

References

Abalaba, B. P., & Dada, M. A. (2013). Energy consumption and economic growth nexus: new empirical evidence from Nigeria. *International Journal of Energy Economics and Policy, 3*(4), 412-423.

Abdulnasser, H. & Manuchehr, I. (2005). “Energy Consumption and Economic Growth in Sweden: A Leveraged Bootstrap Approach.” Journal of Applied Econometrics and Quantitative Studies, 2(4), 87-98.

Abosedra, S., Shahbaz, M., & Sbia, R. (2015). The Links between Energy Consumption, Financial Development, and Economic Growth in Lebanon: Evidence from Cointegration with Unknown Structural Breaks. Journal of Energy, 2015

Adamu, P. A., & Adediran, O. S. (2020). Electricity consumption and economic growth in Nigeria: evidence from novel non-parametric tests. Energy Economics, 92, 104930. https://doi.org/10.1016/j.eneco.2020.104930

Adenikinju, A., (2008) Energy demand in Nigeria, a co-integration analysis, *International Journal of Energy Economics*, 45, 12-21

Aghion, P., & Howitt, P. (1998). *Endogenous Growth Theory*. MIT Press.

Aguegboh, S. E. & Mudueme, S. I., (2013). “Energy consumption and economic growth nexus: Empirical evidence from Nigeria”. Proceedings of the 2013 NAEE/IAEE conference on energy resource management in a federal system, challenges, constraint, and strategies, 305-332

Akadiri, S.S., Bekun, F.V., Taheri, E. and Akadiri, A.C. (2019). Carbon emissions, energy consumption and economic growth: causality evidence. *Int. J. Energy Technology and Policy*, 15 (3), 320–336.

Akin, Iwayemi. (2008). Nigeria’s Dual Energy Problems: Policy Issues and Challenges. International Association for Energy Economics (17-21)

Akinlo, A.E., (2008). Energy consumption and economic growth: Evidence from 11 Sub-Sahara African countries, *Energy Economics,* 30(5), 2391-2400.

Asafu-Adjaye, J. (2000). The relationship between energy consumption, energy prices and economic growth: Time series evidence from Asian developing countries. *Energy Economics*, 22,635-625.

Aqeel, A., & M.S. Butt (2001). The relationship between energy consumption and economic growth in Pakistan. *Asia-Pacific Development Journal,* 8, 101-110.

Ayres, Robert U & Kneese, Allen V, (1969). Production, Consumption, and Externalities, *American Economic Review,* 59(3), 282-297.

Babatunde, M.A. & Adenikinju, A.F. (2016). Energy consumption and economic growth in Nigeria: A time-varying framework analysis. In the *Quest for Development*, Essays in Honour of Prof. Akin Iwayemi, Economics Department, University of Ibadan, Oyo State, Nigeria.

Bamidele, P. A. & Mathew, A.D. (2013). Energy consumption and economic growth nexus: Empirical evidence from Nigeria. Proceedings of the NAEE/AEE conference on energy resource management in a federal system, challenges, constraint, and strategies, Nigeria., 241 257.

Barro, R. J., & Sala-i-Martin, X. (2004). *Economic Growth*. MIT press.

Birol, F. (2007) 'Energy Economics: A Place for Energy Poverty in the Agenda?' *The Energy Journal*, 28, 3: 1–6.

Central Bank of Nigeria (CBN)

Chifter, A. & Ozun, A. (2007). "Multi-Scale Causality Between Energy Consumption and GNP in Emerging Markets: Evidence from Turkey." MPRA Paper No. 2483 available at (http://mpra.ub.uni-muenchen.de/2483)

Costanza, R. (1980) Embodied Energy and Economic Values. Science, 210, 1219-1224. https://doi.org/10.1126/science.210.4475.1219

Elijah, U. & Nsikak, J. (2013). Energy requirements and industrial Growth in Nigeria: An ARDL approach. Proceedings of the NAEE/AEE conference on energy resource management in a federal system, challenges, constraint, and strategies. Nigeria, 74-96

Energy Information Administration - EIA - Official Energy Statistics from the U.S. Government

Erbaykal, E. (2008). "Disaggregate Energy Consumption and Economic Growth: Evidence from Turkey." International Research Journal of Financial Economics, Vol.1(20), pp. 172-179.

Ewing, B. T., Sari, R., & Soytas, U. (2007). Disaggregate energy consumption and industrial output in the United States. *Energy policy*, *35*(2), 1274-1281.

Fouquet, R. (2014). Long-run demand for energy services: income and price elasticities over two hundred years. Review of Environmental Economics and Policy, 8(2), 186-207. https://doi.org/10.1093/reep/reu011

ISSN 978-978-53693-8-9

George, E.H., & Nickoloas, G.T. (2011). "The Effect of Energy Consumption on Economic Growth on Countries Economic Efficiency: A Conditional Non-Parametric Approach: MPRA Paper No. 28692

Gozgor, G., Lau, C. K. M., & Lu, Z. (2018). Energy consumption and economic growth: New
evidence from the OECD countries. *Energy*, *153*, 27-34.

Granger, C. W. J. (1980). Testing for Causality: A Personal Viewpoint. Journal of Economic Dynamics and Control, 2(1), 329-352. doi: 10.1016/0165-1889(80)90069-X

Gujarati, D.N. (2006). Basic econometrics. Tata McGraw-Hill Limited, New Delhi

Gülen, G., & Kinaci, C. (2017). Economic Growth and energy consumption in Turkey: Causality
analysis. Renewable and Sustainable Energy Reviews, 68, 572-586. https://doi.org/10.1016/j.rser.2016.09.119

Hall, A.J., Rasheed Suliaman V., Clark, N.G. Yoganand B. 2003. "From measuring impact to learning institutional lessons: an innovation systems perspective on improving the management of international agricultural research," Agricultural Systems 78, pp. 213-241.

Hall, A.J., Yoganand B. Rasheed Sulaiman V., and Clark, N.G. (eds.) 2001. "Sharing Perspectives on Public-Private Sector Interaction," Proceedings of workshop, April 10. ICRISAT Patancheru India. Patancheru, 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid tropics, Patancheru, India and National Centre for Agricultural Economics and Policy Research.

Hou, Q. (2009). "The Relationship Between Energy Consumption Growth and Economic Growth in China." Journal of Economics and Finance, Vol. 1 (2), pp.232-237

Hye, Q.M. and Mashkoor, M. (2010). "Growth and Energy Nexus: An Empirical Analysis of Bangladesh."International European Journal of Social Sciences,Vol.15(2), pp.51-55

International Monetary Fund (IMF)

International - U.S. Energy Information Administration (EIA)www.eia.gov › international › data › world

Jacques Esso, (2010), Threshold cointegration and causality relationship between energy use and growth in seven African countries, Energy Economics, 32, (6), 1383-1391

Kahsai, M. S., Nondo, C., Schaeffer, P. V., & Gebremedhin, T. G. (2012). Income level and the energy consumption–GDP nexus: Evidence from Sub-Saharan Africa. *Energy Economics*, *34*(3), 739-746.

Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. The quarterly journal of economics, 107(2), 407-437. https://doi.org/10.2307/2118477

 ISSN 978-978-53693-8-9

Morimoto, R and Hope, C (2001) 'An extended CBA model of hydro projects in Sri Lanka', Judge Institute of Management Research Paper
Mulugeta, E., Li, X., & Azadi, H. (2010). Energy consumption and economic growth: evidence from COMESA countries. Energy, 35(8), 3412-3418. https://doi.org/10.1016/j.energy.2010.04.040
Mulugeta and al. (2011), Income level and the energy consumption–GDP nexus: Evidence from Sub-Saharan Africa, Energy Economics 34 (2012) 739–746
National Bureau of Statistics (NBS)
Odhiambo, N.M. (2009). Energy Consumption and Economic Growth in Tanzania: An ARDL Bounds Testing Approach, Energy Policy, 37 (2), pp. 617-622.
Odularu, G.O. and C. Okonkwo (2009). Does energy consumption contribute to economic performance? Empirical evidence from Nigeria. Journal of Economics and International Finance 1, 2044-058
Omotor,D.G. (2008). "Causality Between Energy Consumption and Economic Growth in Nigeria." Pakistan Journal of Social Sciences, Vol. 5 (8), pp. 827 -835
Omri, A. (2013). CO2 emissions, energy consumption and economic growth nexus in MENA countries: evidence from simultaneous equations models. Energy Economics, 40, 657-664. https://doi.org/10.1016/j.eneco.2013.08.029
Ramey, V. A. (2017). Macroeconomic Shocks and Their Propagation. Handbook of Macroeconomics, 1, 71-162. https://doi.org/10.1016/bs.hesmac.2016.09.002
Research Group, Document No. 264, Office of Vice Chancellor of Research, University of Illinois at Urbana-Champaign, Illinois
Shahbaz, M., & Feridun, M. (2012). Electricity consumption and economic growth empirical evidence from Pakistan. Quality & Quantity, 46(5), 1583-1599. https://doi.org/10.1007/s11135-011-9468-3
Stern, D. I. (2010). The role of energy in economic growth. Annals of the New York Academy of Sciences, 1219(1), 26-51. https://doi.org/10.1111/j.1749-6632.2010.05890.x
Wolde-Rufael, Y. (2005). Energy demand and economic growth: the African experience.
` Journal of Policy Modeling, 27(8), 891-903. https://doi.org/10.1016/j.jpolmod.2005.05.007
World Development Indicators (2020) - World Bank Data Catalog (WDI)

ISSN 978-978-53693-8-9