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Nigeria's manufacturing sector performance: An econometric diagnosis of the effects of renewable energy resources consumption

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Abstract
Despite ambitious objective to strengthen the secondary goods producing sector's performance via renewable energy utilization, its contribution to gross domestic product has remained relatively poor over time. Thus, this research as its aim; empirically examines how renewable energy resources use impacted on performance of the Nigeria's manufacturing sector, with the sector's aggregate domestic outputs, hydro energy use, solar energy use and renewable energy consumption per capita selected as the indicators, and included transportation infrastructure investment as moderating factor in the model. 1990 to 2023 yearly secondary data were extracted 'from the 2023 Nigerian apex bank's statistical bulletin, Development Indicators' data base of the Worl Bank and International Energy Agency's report. Employing the estimation tool of Autoregressive Distributed Lag, the established short period's outcome and long-term's outcome revealed hydro energy consumption as exerted positively insignificant impact on manufacturing sector gross domestic product; solar energy use, renewable energy consumption per person and transportation infrastructure investment appeared to have had significant positive impacts on the sector's domestic real production. Sequel to the preceding expositions, it is concluded that renewable energy resources use is contributory to enhancing the economy's manufacturing sector's performance. Following the concluded empirical outcomes, it is suggested that the Nigerian government and private sector operators should prioritize investments in hydro and solar energies infrastructure to enhance renewable energy generation and supply while improving investment in and upgrading transportation infrastructure, which put together will complementarily reduce operating costs, enhance competitiveness and spur the manufacturing sector's performance in future.

Keywords: Renewable Energy, Hydro Energy, Solar Energy, Transport Infrastructure, Manufacturing Sector, Nigeria, Autoregressive Distributed Lag.

INTRODUCTION

Energy is one of the factor inputs which drives socioeconomic activities around the world. Undeniably, it is an irreplaceable facilitator for propelling real growth, as numerous productive and consumptive activities require electricity (energy) in the inputs' model. For this reason, electrical energy is one critical factor behind the production of industrial goods and economic progress performance. All aspects of economic activity in modern society require energy in its primary or secondary forms to function adequately. Human society advancement and development are impossible without energy use, which has remained essential for driving socio-politico-economic advancement. It inarguably contributes to enhancing business growth, leading to financial progress in economies around the globe, not excluding Nigeria. Developmental states that make conscious efforts at generating and distributing reliable energy, tend to enable improved energy use per capita, resulting in invigorated economy and industries (Umeh, Ochuba, and Ugwo, 2019). With the plausible significance of energy in improving quality of life, it is imperative that clean energy development is vigorously pursued. This is important not only for the environment but to keep our energy supply safe. So, providing for renewable energy use as opined by Campos, Da Silva and Perreira, (2016) has become a must for keeping economies strong.

The United Nations Environment Programme (UNEP, 2015) defines 'renewable energy' as type of energy which can be obtained from replenishable sources and this includes hydropower, geothermal, solar, tidal, wind, biomass and biofuels. In 2015, renewable sources constituted about '53.6 percent of total gigawatts installed capacity of energy technologies', except large hydroelectric installations. The International Energy Agency (IEA, 2015) has reported the growing prevalence of renewable energy technologies across both developed and developing economies with reductions in cost, increases in reliability and better availability. Renewable energy does not have limited advantages regarding environment, it can hedge against possible price fluctuations in conventional fuels through portfolio energy diversification, help ease budget and trade deficits, hence, creating new opportunities for domestic economies that contribute to poverty reduction and economic growth through its driving impact on manufacturing sector. Given the importance of renewable energy to manufacturing activities, empirical research to study the impacts of renewable energy use has grown substantially during the last ten (10) years, with George, Anthony, Eberechukwu, Ezeh, Okenyeka and Mbadiwe (2023); Goshit and Shido-Ikwu (2022); Uzokwe and Onyije (2020); Ekone and Amaghionyeodiwe (2020); Maji, Chindo, and Rahim (2019) and Aliyu, Lawal and Beki (2018) among others variously studying the effects non-renewable, renewable and mixed energies consumption exert on Nigeria's and selected countries' economies.

Research Problem Statement

Utilization of renewable energy resources by the Nigeria's manufacturing sector is crucial for sustainable economic progress. However, the sector faces significant challenges that hinder the effective adoption and use of renewable energy. These challenges culminate in negative performance ramification for the manufacturing sector, causing further problems including poor productivity, high production costs, and low competitiveness. Specifically, however lack of suitable infrastructure and advanced technologies for harnessing renewable energy resources is a significant barrier. Sustainable (renewable) energy systems, inclusive of 'solar panel systems, wind turbines, and biomass processing plants', need high quality technology and skilled human resources for installation, operation, and maintenance. Inadequate infrastructure is tantamount to inadequate supply of energy, causing manufacturers rely on diesel generators thus escalating production costs. According to the Nigerian Manufacturers

Association, energy cost accounts for roughly forty (40) percent of cost of production for a lot of industries, thereby making it difficult for such industries to compete in the global market. In addition, the initial capital investment needed for installations of renewable energy is overly expensive for many manufacturing firms in Nigeria.

In 2023, an international organization known as the International Renewable Energy Agency (IRENA) opined that Nigeria needs to spend an approximated $10bn per year to shift to renewable energy. Unfortunately, lack of access to affordable financing mechanisms for manufacturers exacerbate the problem. High costs limit ability of manufacturers to shift from fossil fuels to renewable energy hence keeping energy costs high and the consequence is negative on profitability.

Finally, there is high duties on imported renewable energy equipment to Nigeria, which increases the cost and limits accessibility. According to the Nigerian Energy Support Programme (2023), over eighty percent of solar panels in use in Nigeria are imported which makes them unaffordable to many manufacturers. High import costs discourage the adoption of renewable energy sources, perpetuating the dependence on costly and polluting sources of energy.

Objectives of the Study

Deducing from the identified problem, empirically examined here is the effects renewable energy resources use exerted on Nigeria’s manufacturing sector, with the specific purposes that:

i. Determined the effect of hydro energy consumption on the economy’s gross domestic product from the manufacturing sector.
ii. Assessed how solar energy consumption influenced gross domestic product from the country’s manufacturing sector.
iii. Analyzed how renewable energy consumption per capita impacted manufacturing sector’s gross domestic product of the economy.

RELATED LITERATURE REVIEW

Theoretical Framework

Energy-Growth Hypotheses

This study has utilized as its theoretical framework the Energy Growth Hypotheses. Research Scholars have since the 1970s employed this theory as foundation to investigate the nature of link between energy resource use and growth. Kraft and Kraft (1978) first showed that, in the United States, increases in the gross national product were preceded by increase in energy use between 1947 and 1974. Subsequent research has further opened the case of energy consumption and economic expansion (Yildirim & Aslan, 2012). Four major concepts have been developed to explain how energy use associates with economic growth. Accordingly, energy consumption and its link with growth of any economy is put forth in the Growth Hypothesis, the Conservation Hypothesis, the Feedback Hypothesis, and the Neutrality Hypothesis, which are significant points to consider for formulating relevant policies (Ekeocha, Penzin & Ogbuabor, 2020).

Growth Hypothesis: It states that energy use is a basic engine for driving growth in an economy. It focuses on the function adequate supply and utilization of energy plays for economic growth. This viewpoint tends to suggest that deficient modern energy supplies can impede the business activity and economic performance, thus, leading to adverse financial outcomes (Emeka, Nenubari & Godsgrace, 2019).

Conservation Hypothesis: According to Emeka, Nenubari, and Godsgrace (2019), this proposition states that economic growth is on the contrary the determinant of energy consumption. It posits that energy saving policies for reducing energy consumption would not negatively impact economic progress.

Feedback Hypothesis: This hypothesis as agreed by Emeka, Nenubari and Godsgrace, 2019 predicts bi-directional causal relationship between using energy and growth of an economy. This means, consumption of energy and economic progress are interrelated. Consequently, energy-use encouragement could improve real economic outcome which in turn galvanize energy use.

Neutrality Hypothesis: As formulated by Ouedraogo (2013), this hypothesis put forward energy consumption as not affecting the production growth aspect of the economy, suggesting that change in energy use does not induce performance changes in an economy. This idea is supported by proof that energy use and economic growth are unrelated. If this is true, then policies that try to save energy by cutting back on how much energy we use will have no impact on economic growth.

Empirical Review

The study by George, Anthony, Eberechukwu, Ezeh, Okenyeka and Mbadiwe (2023) looking at how using energy that is renewable influences financial expansion in Nigeria from 1990 to 2020 stated that the TREC - Yamamoto augmented Granger causality estimation, and the Bounds' Autoregressive Distributed Lag (ARDL) analysis showed a clear, positive link between renewable energy use and financial expansion. Goshit and Shido-Ikwu (2022) did a study using data from 1990-2019 with a related method, finding a clear negative connection between renewable energy and financial expansion in Nigeria for both long-term and short-term figures. Somoye, Ozdeser, and Seraj (2022), using non-linear autoregressive distributed lag (NARDL) from 1990Q1 to 2019Q4, reported that, long run renewable energy use negatively impacted manufacturing gross domestic product, while less use had a positive impact. Udo, Idamoyibo, Victor, Akpan, and Victor (2021), using existing data from 2000Q1 to 2018Q4, found that billing systems and gaps in demand for energy and its supply generate negative causal effect on energy distribution and use in Nigeria as evident from using the ARDL Error Correction approach.

Ekone and Amaghionyeodiwe (2020) studied how renewable energy use affects financial expansion in Nigeria from 1990 to 2016. Their tests established renewable energy use to have no positive influence on Nigeria's financial growth. Uzokwe and Onyije (2020) found in their study of renewable and non-renewable energy use on financial expansion in Nigeria from 1984 to 2015 that no causality, which backed up the neutrality idea, and direct link between energy use that cannot be renewed, those that can be renewed, and financial expansion in both short and long runs. Looking at how energy use links with financial expansion of the Nigerian economy sampling from 1999Q1 to 2016Q4, and applying the Nonlinear or asymmetric ARDL model as well as the ARDL-ECM (asymmetric) model. The study as reported by Ekeocha, Penzin, and Ogbuabor (2020) showed that energy use only slightly helped growth. Maji, Chindo, and Rahim (2019) looked at how linked are renewable energy use and financial expansion in 15 selected West African countries over 1995 to 2014 using panel dynamic ordinary least squares (DOLS). The outcome suggested that renewable energy use slows down financial expansion in these countries.

Mallesh and Asharani (2019) studied renewable energy use, emissions, and financial expansion from 1965-2016. They stated that tests of cointegration and vector error correction estimation showed long-term balance among the variables, but natural gas use led to financial expansion in China, while there was no short run causality in India. In Malaysia, Haseeb, Abidin, Hye, and Hartami (2019) investigated how renewable energy influences financial well-being over 1980 to 2016. Utilizing the ARDL process, the empirical outputs clearly depict short and long run positive effects on financial well-being from renewable energy utilization.

Research Gap

Having reviewed the related theoretical and empirical literature with respect to renewable energy resources use and manufacturing sector in Nigeria, some gaps in knowledge are identified and this study ultimately attempts to bridge these gaps. To start with, most studies focused on how of consumption energy from renewable sources influence growth of the Nigerian economy, while empirical studies about renewable energy resources use on the Nigeria's manufacturing are scarce. Secondly, the most recent sample period covered in other studies is 2020, while the current study has included up to 2023 data to capture recent realities in the study area. Founded on the identified gaps, this study empirically diagnosed how renewable energy resources use impacted the economy's manufacturing sector considering annual sample dated, 1990 - 2023.

ESTIMATION MODEL AND METHODS

Estimation Model

Employed for this empirical investigation is the '*ex-post facto* research design'. It is often applied as the true experimental research alternative used for estimating cause-effect association of a study's quantities without the researchers' interference. The secondary and yearly time series data covering thirty-four years (1990 to 2023) were gathered as included in the 2023 statistical bulletin of the apex bank in Nigeria, World Development Indicators (2023) and International Energy Agency report (2023).

The econometric model adopted in this study is adapted to that of Ekone and Amaghionyeodiwe (2020) with relevant modification effected to include all the variables adopted for the objective of estimating the effects of 'renewable energy resources consumption on the Nigeria's manufacturing sector'. Expressing the model in its functional form, we have:

$$MGDP = f(HYE, SLE, REC, TSI) \quad (3.1)$$

Expressing the model in its mathematical form, we have:

$$MGDP = \beta_0 + \beta_1 HYE + \beta_2 SLE + \beta_3 REC + \beta_4 TSI \quad (3.2)$$

Expressing the model in its logged econometric form, we have:

$$\ln MGDP_t = \beta_0 + \beta_1 \ln HYE t + \beta_2 \ln SLE_t + \beta_3 \ln REC_t + \beta_4 \ln TSI_t + e_t \quad (3.3)$$

A Priori Expectation: $\beta_1 > 0$; $\beta_2 > 0$; $\beta_3 > 0$; $\beta_4 > 0$

Where: $MGDP_t$ is manufacturing sector's gross domestic product captured in billion Naira; HYE is hydro energy use indicated in Naira per kilowatt consumption; SLE is solar energy use captured in Naira per kilowatt consumption; REC is renewable energy consumption adopted as percentage of population and defined as the proportion of a country's population that has access to and utilizes renewable energy sources; and TSI is transportation infrastructure employed as moderating variable and measured in billion Naira. It is defined as investments in physical facilities and networks, such as roads, railways, ports, and airports, essential for facilitating goods and people movement. β_0 is the constant term as e_t is the adopted symbol for error term with subscript t as period sampled.

Techniques of Analyses

In proceeding for the empirical analyses, the summary statistics used to diagnose the normality behaviour of each adopted variable is firstly estimated focusing the Jarque-Bera statistics. Subsequently, unit-root estimation for each individual indicator is conducted with the goal of ascertaining the integration levels. To effectively do this, the augmented Dickey and Fuller, 1981 developed test technique for is utilized at the yardstick of 5 percent significance. The ADF's generalized unit roots estimation equation is expressed below:

$$\Delta Y_t = \lambda_0 + \lambda_1 + \delta Y_{t-1} + \sum_{i=1}^{n} \lambda_1 \Delta Y_{t-i} + \mu_t \quad (3.4)$$

Where, Y = the time series variables under consideration, t = Linear time trend, Δ = First difference operator, λ_0 = Constant term, n = Optimum number of lags on the dependent variables and μ_t = the stochastic error term.

To find the long-term effect in this study, the Autoregressive Distributed Lag (ARDL) bounds cointegration test (Pesaran, Shin & Smith, 2001) is applied. This test is applicable when unit roots check reveals mixed integrations, specifically I(0) for level and I(1) for first differences. The ARDL's approach leads to one of three conclusions: a cointegrating relationship exists, no such relationship exists, or the results are inconclusive. The conclusion depends on where the established F-statistic falls compared with the I(1) and I(0) (upper and lower bounds respectively). When the F-statistic is relatively above the 'upper bound', cointegration is revealed, but when it is comparatively inferior to the lower bound, no long run association is evident but short run while falling in-between them, depicts inconclusiveness.

Furthermore, the ARDL's generalized bounds cointegration model is stated below.

$$Y_t = \Delta_t Y_{t-1} + \ldots \Delta_p Y_{t-p} + \delta R_t + U_t \quad (3.5)$$

Where Y_t = the time series variables under consideration in time t, Y_{t-1} and Y_{t-p} = cointegrating equations estimates, Δ= First difference operator and U_t = stochastic error term.

Based on the established ARDLs' Bounds cointegration estimates, long and short runs' dynamics were estimated thereby deriving the theoretical and statistical implications of the causal variables as captured by this study. Accordingly, to reach this point, specified below is the ARDL model's specification which captures the error correction term.

$$\begin{aligned}\Delta\ln(MGDP_t) = {} & \beta_0 + \beta_{1i}\Delta\ln(MGDP_{t-1}) + \beta_{2i}\Delta\text{In}(HYE_{t-1}) + \beta_{3i}\Delta\text{In}(SLE_{t-1}) \\ & + \beta_{4i}\Delta\text{In}(REC_{t-1}) + \beta_{5i}\Delta\text{In}(TSI_{t-1}) + \sum_{t=1}^{p} \alpha_{1i}\Delta 1n(MGDP_{t-1}) \\ & + \sum_{t=1}^{q} \alpha_{2i}\Delta In(HYE_{t-1}) + \sum_{t=1}^{q} \alpha_{3i}\Delta 1n(SLE_{t-1}) + \sum_{t=1}^{P} \alpha_{4i}\Delta In(REC_{t-1}) \\ & + \sum_{t=1}^{P} \alpha_{5i}\Delta In(TSI_{t-1}) + \Omega ECT_{t-1} + e_t \end{aligned} \quad (3.6)$$

Thus, as indicated in the specification, Δ depicts difference operator; β_1 to β_5 are coefficients of long-run and α_1 to α_5 serve short-run dynamic coefficients; e_t is stochastic disturbance. Moreover, the error correctio term and its coefficient are defined and discussed in the short run, Omega associated with the ECT measures the yearly speed of adjustment from a previous period disequilibrium to achieve long term equilibrium. The ECT indicator is expectedly negative and statistically significant. The method however is limited if all adopted variables appear nonstationary and subsequently stable after first differencing.

Furthermore, relevant post diagnoses such as Ramsey RESET, normality via Jarque-Bera, serial correlation, as well as heteroscedasticity are considered in the current study to respectively check whether or not the ARDL model **is** specified correctly, adopted variables in the model appeared jointly normally distributed, regressors' residuals exhibited serial independence, and whether there is homoscedasticity to necessitate policy recommendation.

EMPIRICAL ESTIMATES AND DISCUSSIONS

Variables' Characteristics Estimates

This section shows the descriptive features' estimates of each variable in Table 1 below.

The manufacturing sector's 'gross domestic product' (MGDP) which measures the sector's performance in Nigeria recorded over the period an average of N6312.448 billion with a maximum manufacturing sector gross domestic product per annum value of 28442.9 billion in Naira and minimum per annum value of approximately N87.96 billion. Also, hydro energy (HYE) use recorded over the period an average of 6338.824MW on the average with maximum and minimum levels placed at 8349.0MW and 4387.0MW respectively. In addition, solar energy (SLE) consumption exhibited an average of 91.32MW per annum. The maximum and minimum of solar energy use per annum over the period were 147.0MW and 76.0MW respectively. Renewable energy consumption (REC) recorded over the period an average of 86.72MW, with maximum and minimum of 89.22MW and 82.96MW respectively. Lastly, transportation infrastructure (TSI) recorded over the period an average of N559.58 billion on the average with maximum and minimum investments of N1488.33 billion and N184.57 billion respectively.

Table 1

Data Descriptive Statistics

MEASURES	MGDP	HYE	SLE	REC	TSI
Mean	6312.448	6338.824	91.32353	86.71529	559.5750
Median	2801.170	5995.000	86.50000	86.81500	548.7500
Maximum	28442.90	8349.000	147.0000	89.22000	1488.330
Minimum	87.96000	4387.000	76.00000	82.96000	184.5700
Std. Dev.	8168.260	1066.157	14.48661	1.533626	335.3009
Skewness	1.617652	0.452437	2.340719	-0.545265	0.642491
Kurtosis	4.513267	2.290589	8.528872	2.818230	2.827522
Jarque-Bera	18.07266	1.872922	74.35273	1.731583	2.381317
Probability	0.000119	0.392013	0.000000	0.420718	0.304021
Sum	214623.2	215520.0	3105.000	2948.320	19025.55
Sum Sq. Dev.	2.20E+09	37510773	6925.441	77.61625	3710081.
Observations	34	34	34	34	34

Source: Researchers' 2024 Computation, (EViews 12.0).

In addition, manufacturing sector performance indicator and solar energy resource use appeared not normally distributed as their respective Jarque-Bera values which are 18.07266 and 74.35273 are higher than the 5.9 benchmark, with probability values as 0.000119 and 0.000000 are significant but expected to be insignificant while hydro energy use, renewable energy consumption and transportation infrastructure investment are normally distributed as evidently tabulated above.

Pre-Estimation Tests

Unit Root Test

This study tested for unit root status of adopted variables using the Augmented Dickey-Fuller's specification. As evidentially tabulated in Table 2 below, the Mackinnon critical value rejected the unit root hypothesis for transportation infrastructure (TSI), suggesting it is level stationary and order zero, I(0) integrated, while manufacturing Sector Gross Domestic Product (MGDP), solar energy (SLE), hydro energy (HYE) and renewable energy use (REC) accepted their unit roots hypotheses and are first difference stationary, thus, order one, I(1) integrated.

Table 2

Unit Roots Estimates

	Levels		1st Difference			
Variables	**ADF's Test Statistics**	**5% Critical Values**	**ADF's Test Statistics**	**5% Critical Values**	**Stationarity**	**Order of Integration**
LOG(MGDP)	-1.808189	-2.963972	-3.681306	-2.967767	1st Diff.	I(1)
LOG(HYE)	-2.959383	-2.954021	-6.704812	-2.957110	1st Diff.	I(1)
LOG(SLE)	-0.394927	-2.957110	-9.066614	-2.957110	1st Diff.	I(1)
LOG(REC)	-2.274499	-2.954021	-5.953973	-2.957110	1st Diff..	I(1)
LOG(TSI)	-5.365052	-2.954021	-	-	Level	I(0)

Source: Researchers' 2024 Computation, (EViews 12.0).

As evident from the unit roots' estimation outcomes which indicated mixed integrated orders as 1(0) and 1(1), the estimation technique of Autoregressive Distributed Lag (ARDL) becomes the most appropriate method.

ARDL's Bounds Cointegration Estimates

Table 3

Bounds Cointegration Test Outcomes

Critical Values	Lower Bound Values	Upper Bound Values
10%	2.2	3.09
5%	2.56	3.49
2.5%	2.88	3.87
1%	3.29	4.37
Computed F-statistic: F_{MGDP}(HYE SLE REC, TSI) = 5.437584 K = **4**.		

Source: Researchers' 2024 Computation, (EViews 12.0).

Further, as displayed in Table 3 above, F-statistic value is 5.437584, suggesting the 3.49 upper bound value is relatively lower at 5 percent significance benchmark. It indicates rejection of the stated null hypothesis of no cointegration, thus, confirming cointegration existence among manufacturing sector gross domestic product, hydro energy, solar energy, renewable energy consumptions and transportation infrastructure investment over the data period sampled.

Optimum Lag Length Criteria

The ideal lag selection is based on the criteria results tabulated in Table 4.4:

Table 4

Optimal Lag Length Criteria Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-968.8126	NA	1.86e+20	60.86329	61.09231	60.93920
1	-849.5261	193.8405	5.26e+17	54.97038	56.34451	55.42587
2	-778.4504	93.28685*	3.34e+16*	52.09065*	54.60988*	52.92571*

Source: Researchers' 2024 Computation, (EViews 12.0).

It is deduced from Table 4 that the optimum lag selected for this study as indicative from the Akaike Information Criterion (AIC) is two. This result suggestively supports the estimated meaningful cointegration result. For this reason, subsequent analyses shall be conducted with this ideal lag length of two.

The Estimated Autoregressive Distributive Lag (ARDL) Dynamic Results

The examined short and long runs' dynamics outcomes are presented in Table 5 below

Table 5

Estimated Model Results

Dependent Variable = LOG(MGDP)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
Short-Run Results				
DLOG(MGDP(-1))	0.591710	0.079334	7.458502	0.0000
DLOG(HYE)	0.090449	0.101669	0.889639	0.3842
DLOG(SLE)	0.249199	0.092598	2.691182	0.0227
DLOG(SLE(-1))	-1.219851	0.634229	-1.923359	0.0833
DLOG(REC)	2.330813	0.665434	3.502698	0.0057
DLOG(TSI)	0.143964	0.024955	5.769045	0.0000
DLOG(TSI(-1))	-0.376491	0.159844	-2.355373	0.0288
CointEq(-1)*	-0.259725	0.036481	-7.119531	0.0000
Adjusted R^2 = 0.721256; Durbin-Watson stat = 1.973987				
Long-Run Results				
LOG(HYE)	1.916218	1.153077	1.661831	0.1121
LOG(SLE)	0.683644	0.148176	4.613743	0.0010
LOG(REC)	2.255056	0.571161	3.948197	0.0027
LOG(TSI)	1.867431	0.214636	8.700459	0.0000
C	-6.411514	37.94714	-0.168959	0.8675

Source: Researchers’ 2024 Computation, (EViews 12.0).

The estimated respective short and long runs’ results displayed in Table 5 revealed that hydro energy exerted positive (0.090449) (1.916218) and non-significant (0.3842) (0.1121) effects on the manufacturing sector’s aggregate domestic output for Nigeria over the sampled period. This implies, improvement of hydro energy consumption by a kilowatt insignificantly amplified short and long runs’ performance of the sector’s total domestic output by about 0.09 and 1.92 per cents respectively.

Similarly, the estimates established solar energy use as exerted positive short run (0.249199) and long run (0.683644) as well as respectively significant (0.0227) (0.0010) effects on manufacturing sector’s aggregate internal output in the economy. Thus, suggesting a kilowatt solar energy use increase translated to short run significant boost in the sector’s produce by 0.25 percent and long run significant growth by 0.68 percent.

Also, the empirical outcomes as tabulated in Table 5 indicated that renewable energy consumption positively (2.330813) (2.255056) and significantly (0.0057) (0.0027) improved the short and long terms’ total domestic output from the sector over the sampled period. This means that an improvement in renewable energy consumption by one kilowatt per person significantly enhanced the manufacturing sector gross domestic product by 2.33 and 2.26 per cents in the short and long runs respectively.

Additionally, the both periods’ estimates revealed transportation infrastructure investment as positively (0.143964) (1.867431) and significantly (0.0000) (0.0000) influenced the outputs of the manufacturing sector. This is suggestive as short run transportation infrastructure’s investments expansion significantly spurred gross domestic product in the sector by about 0.14 percent while the sector had about 1.87 percent long run inducement effect.

Furthermore, as Table 5 indicates, the short-run dynamic interactions have the same signs as those of long-run estimates. As established, -0.259725 (p 0.0000) indicates the error correction coefficient and its probability value in bracket. It is apparently signed negatively which is correct, but clearly established about 26 percent slow adjustment trajectory to current year’s steady state after disequilibrium. The Adjusted R^2 is 0.721256, meaning that hydro-energy, solar-energy, renewable-energy-consumption, and investment in transportation-infrastructures explained about 72% systematic variation in the sector's gross output while the remaining 28% is explained by factors not included. The Durbin-Watson statistic is 1.973987, suggesting no serial correlation in the estimated model.

Post-Diagnoses

Table 6

Post-Tests' Results

Tests	F-Statistic	Probability	Null Hypotheses	Decisions
Serial Correlation LM Test	1.890217	0.0794	H_0: No Serial Correlation	Retain H_0
Normality Test	0.963390	0.6177	H_0: Normal Distribution	Retain H_0
Heteroscedasticity Test	1.654966	0.0858	H_0: Homoscedasticity	Retain H_0
Ramsey RESET test	0.435886	0.5170	H_0: Correctly Specified	Retain H_0

Source: Researchers' 2024 Computation, (EViews 12.0).

The serial correlation LM test shows no sign of autocorrelation, as the Breusch and Godfrey LM test probability exceeds 0.05. The normality test confirms the study's model estimates to have followed normal distribution. The heteroscedasticity test results support the homoscedasticity assumption, and the Ramsey's RESET diagnosis established correct specification of the model.

Results Discussion

This current study investigated to ascertain how Nigeria's renewable energy use influenced the manufacturing sector's GDP by utilizing time series data. Established from this study are that; hydro energy use exerted slightly encouraging, but insignificantly on the manufacturing sector's GDP. This finding is not too different from expectations, and aligns with those of Somoye, Ozdeser and Seraj (2022) who discovered positive relationship between the utilization of hydroelectric renewable energy and economic growth. Also, the current study further reveals that utilization of solar energy has a significantly positive influence on the sector's GDP, which is harmonious with theory. This outcome is likewise consistent with the revelations of Ekone and Amaghionyeodiwe (2010) whose study established that utilization of solar energy, which represents replenishable energy use, contributes to Nigeria's growth. Similarly, the research outcome suggests that Nigeria's GDP from the manufacturing sector responded significantly and positively to per capita renewable energy use as theoretically predicted. This is similar to the conclusions that usage of inexhaustible energy exerted significantly positive short and long horizons implications on economic well-being (Haseed, Abidin, Hye & Hartami, 2019). Finally, the analyses proved that investment in transportation infrastructure produced significant encouragement for the country's manufacturing sector's GDP, thus, substantiating relevant hypothesis and supporting the results of Bennee, Okoye and Amahalu (2021) that investment for improvement of roads, railways and air transport significantly boosts growth in the Nigerian economy.

CONCLUDING REMARKS AND RECOMMENDATIONS

The research focused on ascertaining the impact of renewable energy resource utilization on Nigeria's manufacturing sector's performance. The results showed that using hydroelectricity, solar and other green sources of energy served as key indicators that promoted consumption and stimulated output of the manufacturing sector. Accordingly, the research concluded that using energy resources which are sustainable importantly improve performance of the manufacturing in Nigeria.

Predicated on the research outcomes and the concluding remarks, the recommendations presented hereunder are critical for spurring the economy's aggregate output from focal sector:

i. The government and private sector operators in Nigeria should prioritize investments in hydro infrastructures. Such measures will improve the supply of energy derived from this source and reduce costs of production, improve competitiveness, and develop manufacturing performance.

ii. Government authorities and policymakers should formulate policies for incentivizing manufacturers to use renewable energy, such as tax incentives and subsidies or low interest loans to enable investors install renewable energy infrastructure. These measures should also include financial incentive for integration of solar panels; energy efficient machinery; use of green technologies as part of industrial development process to promote development of manufacturing activity.

iii. Government should invest and upgrade transportation infrastructure to provide smooth logistics for raw materials and finished goods, lower transportation costs, and achieve economic integration. This can be done through expanding and modernizing road networks, railways and ports to enhance connectivity and relieve bottlenecks in moving goods and people. Public-private partnerships (PPPs) should be promoted to expand and update infrastructure to support sustainable growth of manufacturing sector.

References

Aliyu, A. K., Modu, B., & Tan, C. W. (2018). A review of renewable energy development in Africa: A focus in South Africa, Egypt and Nigeria. *Renewable and Sustainable Energy Reviews*, *81*(1), 2502–2518.

Bennee, E., Okoye, P. V.C., & Amahalu, N. N. (2021). Infrastructural development and economic growth of Nigeria. *African Journal of Business and Economic Development, 1*(12), 43-56.

Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica, 49*, 1057-1072.

Ekeocha, P. C., Penzin, D. J., & Ogbuabor, J. E. (2020). Energy consumption and economic growth in Nigeria: A test of alternative specifications. *International Journal of Energy Economics and Policy, 10*(3), 369-379.

Ekone, F. A., & Amaghionyeodiwe, L. (2020). Renewable energy consumption and economic growth in Nigeria: Any causal relationship? *The Business and Management Review, 11*(1), 59-76.

Emeka, N., Nenubari, I., & Godsgrace I. J. (2019). Energy consumption and economic growth in Nigeria: A revisit of the energy-growth debate. *Bussecon Review of Social Sciences*, *1*(2) 01-09.

George, U., Anthony, O. A., Eberechukwu, E. E., Ezeh, M.C., Okenyeka, O. N., & Mbadiwe, T. O. (2023). Renewable energy consumption and economic growth in Nigeria. *African Journal of Social Sciences and Humanities Research*, *6*(1), 3448-3465.

Goshit, G. G., & Shido-Ikwu, S. B. (2022). Impact of renewable energy consumption on economic growth in Nigeria. *International Journal of Economics & Development Policy (IJEDP), 5*(1), 153 – 168.

Haseeb, M., Abidin, I. S., Hye, Q. M., & Hartani, N. H. (2019). The impact of renewable energy on economic well-being of Malaysia: Fresh evidence from auto regressive distributed lag bound testing approach. *International Journal of Energy Economics and Policy, 9*(1), 269-275.

International Energy Agency, (2015). *Key world energy statistics*. Available from http://www.iea.org/publications/freepublications/publication/key-world-energy-statistics.2015.Html

Maji, I., Chindo, S., & Abdul, R. (2019). Renewable energy consumption and economic growth nexus: A fresh evidence from West Africa. *Energy Reports*, *5*, 384–392.

Mallesh, I., & Asharani, H. (2019). The role of natural gas and renewable energy consumptions on CO2 emissions and economic growth during 1965-2016. *Energy*, *Sustainability and Society*, *2*(15), 1-17.

Ouedraogo, N. S. (2013). Energy consumption and economic growth: Evidence from the Economic Community of West African States (ECOWAS). *Energy Economics*, *36*: 637-647.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bound Testing Approaches to the Analysis of Level Relationships. *Journal of Applied Econometrics, 16(3), 289-326.*

Somoye, A. O., Ozdeser, H., & Seraj, M. (2022). The impact of renewable energy consumption on economic growth in Nigeria: fresh evidence from a non-linear ARDL approach.

Udo, E. S., Idamoyibo, H. R., Victor, I., Akpan, J. E., & Victor, N. (2021). Energy consumption and sectorial value addition on economic growth in Nigeria. *Universal Journal of Accounting and Finance*, *9*(1), 74-85.