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Effect of Energy Sector Productivity on Economic Growth in Nigeria

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Abstract

The continuous increasing demand for energy through increased population and per capita growth has become a matter of concern for policy makers. The paper examines the effect of energy sector productivity on economic growth in Nigeria from 1980 to 2021. The methodology adopted is the Auto Regressive Distributed Lag Error Correction Model (ARDL-ECM). Stationarity, serial correlation, normality, stability, and heteroscedasticity tests were further carried out in the paper. The result shows that oil and gas production have negative but significant relationship with economic growth due to continuous oil theft and use of outdated methods and machineries for production while electricity generation has a positive significant relationship meeting the a priori expectation. The paper concludes that the energy sector plays a significant role in the economic performance and the rate of growth of Nigeria's economy and therefore, recommends continued advanced research that will bring to light more efficient production and generation process to adopt to boost the performance of the energy sector.

Keywords: Energy, Oil, Gas, Electricity, Productivity, Economic growth

JEL Classification: B4, C2, P18

INTRODUCTION

Energy is the oil that lubricates the engine of every economy. It plays a vital role in economic growth, progress, and development as well as poverty eradication and security of a nation. However, increased demand for energy through increased population and per capita growth has become a matter of concern for policy makers. Such an increment could threaten energy security and increase global warming since energy is major a contributor to the emission of carbon monoxide (CO_2) (Bhattacharyya, 2011) to that effect there should be a balance between efficiency and reduction without compromising growth or the environment.

Energy productivity is essential to the environment and economic growth. First, it is the cheapest way to reduce global emission of green gases (Mckinsey, 2007). Secondly, energy saved through productivity measures can also be used in other sectors of the economy. Energy efficiency has been found to be one of the main ways of reducing the impact of the trade-off between reduction in energy consumption and economic growth (Uzah, and Agbugba, 2021).

The strong relation between energy productivity and capital use indicates that energy efficiency may be augmented by optimizing capital use (Zaman *et al.,* 2011). This is because energy is not demanded for its own sake and does not produce output by itself.

Nigeria is endowed with many energy sources with crude, gas and electricity at the fore front and mostly explored (Agbugba *et al.,* 2021). However, there has been underlining factors which are technical or environmental in nature that have interrupted these sources exploration and generation in Nigeria.

In oil production, these factors are more environmental and associated with oil spill. Oil sabotage, pipeline vandalism and theft contribute to most of the oil spill and (or) leakages. Allison *et al.*, (2018), oil siphoning is a profitable enterprise since stolen oil has its own market (the black market) and as such the sabotage and theft is encouraged causing more oil spill.

The amount of gas produced is influenced mostly by technical rather than the environmental factors. The process involved in producing gas is called gas flaring, a method mainly used to dispose of associated gases with crude oil to make it more economically useful (Bassey, 2008), this process causes more of the associated gas to be released into the atmosphere resulting to less economic gas produced. Gas production process that is environmentally friendly has been clamored for recently in the Davos Economic Summit of 2020, 2021 and 2022.

There are technical losses and environmental (commercial losses) factors associated with electricity generation and distribution which are inevitable in the provision of electrical energy. Technical losses occur because the electrical equipment used in the power system, by nature, have losses associated with them which cannot be eliminated. Generators and transformers have losses in their windings (due to the winding resistance) as well as their core (due to Eddy current and hysteresis). Also, technical losses can occur in the generation process as the power plants efficiency is limited by physical laws (Carnot process). Environmental factors occur due to energy theft, poorly estimated billing, defective metering equipment (either deliberately tampered with or not) and unpaid bills. Energy theft can be done by tampering with meters to make them undercount, bypassing the meters, making illegal connections, colluding with utility company meter readers to falsify consumption data or billing department to alter the bill issued to the customer (Nagi *et al.*, 2010).

Having examined factors that contributes to the deficient supply of energy in relation to its demand and the importance of energy to growth, the rationale of the study is to determine the if energy sector productivity has a significant impact on economic growth in Nigeria covering a 40-year period from 1980 to 2021. Relevant theories, methodology to be adopted for the study, results and recommendations will be discussed in sections.

MATERIALS AND METHODS

Productivity is a critical aspect in a company's or a country's ability to produce goods. More so, real income improves people's ability to acquire goods and services, enjoy leisure, improve housing and good education, and contribute to social and environmental initiatives, therefore increasing national production can raise living standards. Increased productivity can also help organizations become more profitable (Sickles and Zelenyuk, 2019). Productivity is used as a yard stick to determine efficiency as productivity measures output per unit of inputs.

The capacity or power to do work, such as the capacity to move an object (of a given mass) by the application of force. Energy refers to available power or motivation to move, it also refers to power that is used with exertion or force (Collins, 2012).

In physics, energy is the power or heat that is created when something moves, is burned, or is exerted. It is typically represented in two forms: potential and kinetic energy. Potential energy is power that is stored in something as it sits still or is unburned. Growth is best described as a transformational process (Agbugba *et al.*, 2018). The process by which a country's wealth increases over time is known as economic growth. Although the phrase is frequently employed in talks about short-term economic performance, it refers to a gain in wealth over a long period of time in economic theory. In its most basic form, economic growth refers to an increase in an economy's total output. Aggregate production gains are frequently, but not always, associated with higher average marginal productivity. As a result, salaries rise, encouraging consumers to open their wallets and spend more, resulting in a higher material quality of life or standard of living, physical capital, human capital, labor force, and technology are all often used to model economic performance in economies (Uzah and Agbugba, 2021).

Theoretical Framework

Stern's Model on Energy and Economic Growth

David Stern a neoclassical economist developed a model in 2008 that created a linkage between energy and growth. In his model he referred to Neoclassical perspective of the production function to examine the factors that could reduce or strengthen the linkage between energy use and economic activity over time and depicted that there has been a decoupling of economic output and resources, which implies that the limits to growth are no longer as restricting as in the past. A general production function of Stern can be represented as follows:

$$(Q_i \ldots Q_m)\ f\ (A, \ldots X_i \ldots, X_n, E_k, \ldots, E_p) \qquad \text{where:}$$

the Q_i are various outputs (such as manufactured goods and services), the X_i are various inputs (such as capital, labour, etc.), the E_k are different energy inputs (such as coal, oil, etc.), and A is the state of technology as defined by the total factor productivity indicator.

Stern's model can be translated to become the output (GDP) is a function of capital, labour, holding energy inputs and technological change constant. The relationship between energy and an aggregate of output such as gross domestic product can then be affected by substitution between energy and other inputs, technological change (a change in A), shifts in the composition of the energy input, and shifts in the composition of output. Also, shifts in the mix of the other inputs for example, to a more capital-intensive economy from a more labor-intensive economy─can affect the relationship between energy and output. It is also possible for the input variables to affect total factor productivity, though in models that invoke exogenous technological change, this is assumed not to occur (Stern, 2004).

Empirical Reviews

Amin *et al.* (2022), evaluated the impact of eco-innovation and energy productivity on trade-adjusted consumption-based carbon emissions for the Next Eleven (N-11- the Philippines, Nigeria, South Korea, Bangladesh, Egypt, Iran, Indonesia, Mexico, Pakistan, and Vietnam) economies from 1995–2019. Panel data econometric techniques such as cross-sectional autoregressive distributed lag model (CS-ARDL), Westerlund cointegration test, and augmented mean group approach, which helps to tackle the problem of cross-section dependency and heterogeneity was employed in their study. The empirical outcomes confirm the long-run cointegrating relationship for consumption-based carbon emissions with exports, imports, gross domestic product, energy productivity, and eco-innovation. The results from CS-ARDL indicate that energy productivity, eco-innovation, and exports decrease carbon emissions by − 0.181%, − 0.0148%, and − 0.292%, respectively. However, economic growth and imports cause carbon emissions to increase by 1.201% and 0.225%, respectively. Moreover, the results also confirmed that any policy targeting energy productivity, exports, imports, gross domestic product, and eco-innovation should help to achieve equilibrium in approximately more than 1 year. This study recommends that the role of energy productivity and environment-related innovation is crucial for achieving the carbon neutrality target of the Next Eleven economies.

Oyeleke and Akintola (2019), examined the impact of energy generation on economic growth in Nigeria from 1980–2017, and made use of the ARDL-ECM as a technique of estimation. The study revealed that gas energy, physical capital and interest rates are crucial to the development of economic growth in the long run. However, in the short run, hydropower contributed to the development of the economy. Increased investment in research to employ energy generation process that is efficient to boost energy productivity and economic expansion in Nigeria.

Ukoima and Ekwe (2019) investigated the impact of electricity supply on economic growth from 1983 to 2017 using Umudike as a case study. The results obtained showed that 100% of stake holders and 68% of the public in Umudike, Abia state, Nigeria agreed that power supply in Nigeria has improved in recent times. Although, with an improved current generating capacity of 7000 megawatts and distribution capacity of 4600 megawatts, factors such as an increase in load growth, poor maintenance of existing transmission and distribution facilities and lack of adequate physical structure still cause epileptic power situation in most parts of Nigeria (Uzah and Agbugba, 2021).

Henry (2019), reviewed gas production and utilization in Nigeria and outlines strategies for long term development. His study shows a 41% daily average domestic gas supply obligation performance. The study revealed low output gas production resulting from inconsistency and utilization. With respect to the Nigerian Gas Master plan that if not fully implemented, relatively low gas flare penalty will be impossible and insufficient domestic gas is inevitable. The proposed strategy for the long-term gas production and utilization in Nigeria includes sustainable management structure, sustainable governance and regulatory structure and sustainable financing structure (Isukul *et al.*, 2019).

Onyeisi *et al.* (2016) examined the impact of power generation capacity on economic growth in Nigeria from 1980 – 2015 using VECM estimation technique and a stable long run relationship exists between the dependent and explanatory variables in the model as supported by the presence of two co integrating equations. However, their study concluded that there is no causality between power generation capacity and economic growth in Nigeria within the study period.

Ackah (2015) examined the effect of energy consumption, investment, and productivity on per capita growth in oil producing African countries (Algeria, Nigeria, Ghana, and South Africa) by employing a dynamic simultaneous panel data model. The study recommends that there should be investment in productivity to enhance economic growth and minimize energy consumption.

METHODOLOGY

This paper relies on country-specific time series data. Specifically, data on Oil and Gas production are sourced from NNPC annual statistical bulletin. Electricity generation is sourced from EIA (Electricity Information Administration) online database and economic growth (RGDP) from Central Bank of Nigeria (CBN) Statistical Bulletin 2021. The paper uses the Autoregressive Distributed Lag (ARDL) estimation method. There are two steps to the ARDL method. First step is the F-test or bound testing approach is used to determine the existence of any long run link among the variables of interest. The second stage entails estimating and determining the long run relationship between the variables, as well as the short run elasticity of the variables using the ARDL model's error correcting representation (ECM). The ECM version of the ARDL is used to determine the speed with which the system adjusts to equilibrium.

From the bounds co-integration test if there is a long run relationship, the ECM model will show the degree of convergence to equilibrium in the long run from disequilibrium that exist in the short run.

Model Specification

Adopting the production function;

$$Q = f(X) \tag{1}$$

where:

Q= output (proxy as economic growth (RGDP))

X = input (proxy as energy sector productivity (ESP))

and incorporating Stern's model of energy and growth (denoted by real gross domestic product) subject to the available technology;

$$Q = f\,(\text{ESP}) \quad (2)$$

Expanding;

$$\text{RGDP} = f\,(\text{oil production, gas production, electricity generation}) \quad (3)$$

Re-arranging to get the functional or implicit form of the model;

$$\text{RGDP} = f\,(\text{OILP, GASP, ELECP}) \quad (4)$$

It is expressed explicitly as

$$RGDP_t = \alpha + \beta_1 OILP_t + \beta_2 GASP_t + \beta_3 ELECP_t + u_{1t} \quad (5)$$

Incorporating the ARDL the explicit model in an ARDL model, we have:

$$\text{RGDP}_t = \psi + \sum_{i=1}^{p} RGDP_{t-1} + \sum_{i=1}^{q} \alpha_1 OILP_{t-1} + \sum_{i=1}^{q} \alpha_2 GASP_{t-1} + \sum_{i=1}^{q} \alpha_3 ELECP_{t-1} + \sum_{i=1}^{p} \Delta RGDP_{t-1} + \sum_{i=1}^{q} \beta_1 \Delta OILP_{t-1} + \sum_{i=1}^{q} \beta_2 \Delta GASP_{t-1} + \sum_{i=1}^{q} \beta_3 \Delta ELECP_{t-1} + \lambda ECT_{t-1} + \mu_t \quad (6)$$

where;

RGDP = Real Gros Domestic Product (proxy for economic growth)

OILP = Oil Produced

GASP = Gas produced

ELECP = Electricity generated

α = intercept

$\beta_1 - \beta_3$ = parameter estimates of the regressors

u_1 = stochastic error terms.

In = natural log notation

A priori Expectation

The a priori expectation tells the pre-determined signs based on theory, between the dependent and independent variables. The *a priori* expectations for the coefficients are symbolized as illustrated in Table 1.

Table 1: *A priori* Expectation

	Dependent Variables	**Independent Variables**	***A priori* expectation**	**Signs**
Specified Model	**RGDP**	**OILP**	$\alpha_1 > 0$	+

		GASP **ELECP**	$\alpha_2 > 0$ $\alpha_3 > 0$	+ +

RESULTS AND DISCUSSION

Unit Root (Stationarity Test)

The importance of unit root test for time series data is identified by Dickey and Fuller (1979) as they explained that it is useful in investigating time series data whether they exhibit random walks that needs to be white noised before using them for estimation purposes. They further explained that failure to do so could result in spurious regression analysis.

In view of this, the Augmented Dickey Fuller (ADF) by Dickey and Fuller (1981) approach to unit root was used to test for stationarity in each of the variables. Specifically, the null hypothesis of a unit root (non-stationarity) was tested against the alternative hypothesis of no unit root (stationarity) in each of the variables at 5 percent level. From the result presented in Table 2, there is no problem of trend stationarity as all variables were stationary at level and first difference.

Table 2: ADF Stationarity Test

Variables	**ADF**	**Critical Values**	**Order of Integration**
RGDP	-2.772182	-2.609066**	I (1)
OILP	-6.702524	-3.529758*	I (1)
GASP	-9.277727	-3.562882*	I (0)
ELECP	-6.866719	-3.533083*	I (1)

Note: *, ** denotes stationary at 5% (constant and trend), 10% (constant only) level of significance

Source: Author's computation using EVIEWS 10, 2022.

The stationarity test results show mixed order of integration of the variables; hence, co-integration test is carried out to determine if a long run relationship exists amongst the variables. Therefore, the ARDL estimation technique is the best suitable, however, it is necessary to test for long run relationship (co-integration) to know if the ECM will be included in the ARDL model estimation regression. The bounds test for co-integration is employed given that the order of integration are I (1) and I (0). The result is illustrated in Table 3.

Table 3: Bounds Test for Co-integration

F-Bounds Test				**Null Hypothesis: No levels relationship**
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	4.333892	10%	2.97	3.74
K	3	5%	3.38	4.23
		2.5%	3.8	4.68
		1%	4.3	5.23

Source: Author's computation using EVIEWS, 10, 2022.

The bounds test indicates long run relationship exits given that the F- statistics value of 4.33 is greater than the lower I (0) and upper I(1) bounds at 5% level of significance. Hence, the null hypothesis of no co-integration is rejected, and the alternative of co-integration is accepted. Thus, the ARDL-ECM is employed to estimate the regression.

Estimation Regression Result

The regression result is presented in Table 4. The constant implies autonomous RGDP is negative and insignificant of 40.06 million without input from the energy sector. Oil produced (OILP) in the current period is statistically insignificant while in the first, second and third lag period are positive and statistically significant. By implication, one-billion-barrel increase in oil produced led to 6.657914, 4.269767 and 3.557415 -billion-naira increase in RGDP respectively.

Gas produced (GASP) in its current and lag periods are statistically significant but negative which doesn't conform with the *a priori* expectation. Electricity generated (ELECP) is positive and statistically significant in current and lag periods which by implication one kilo watt increase in electricity generated led to 404.3655 and 210.5345-billion-naira increase in RGDP respectively.

Table 4: ARDL-ECM Estimation Analysis Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	11076.78	2018.101	5.488712	0.0000
D(RGDP(-1))	-0.400624	0.221563	-1.808170	0.0864
D(OILP)	0.328196	1.095262	0.299651	0.7677
D(OILP(-1))	6.657914	1.968171	3.382793	0.0031
D(OILP (-2))	4.269767	1.535474	2.780748	0.0119
D(OILP(-3))	3.557415	1.148057	3.098639	0.0059
D(GASP)	-0.022564	0.003437	-6.565273	0.0000
D(GASP(-1))	-0.096233	0.018975	-5.071498	0.0001
D(GASP(-2))	-0.090717	0.018089	-5.015143	0.0001
D(GASP(-3))	-0.093927	0.018654	-5.035290	0.0001
D(ELECP)	404.3655	79.44714	5.089743	0.0001
D(ELECP(-1))	210.5345	101.6048	2.072093	0.0521
CointEq(-1)*	-0.013426	0.002621	-5.121665	0.0001
R-squared	0.866212	Durbin-Watson stat		2.337015
Adjusted R-squared	0.796410	F-statistic		12.40953
		Prob(F-statistic)		0.000000

Source: Author's computation using EVIEWS 10.0, 2022.

The error correction term (coint. equ.) is negative, less than one and statistically significant at 5%. The error correction term (ECT) coefficient value of -0.013426 revealed that once there is disequilibrium in the system, it takes a (annual) speed of 1.34 percent to restore a long-run relationship between the energy productivity on economic growth in Nigeria.

The adjusted R-squared which was used to measure the goodness of fit of the estimated model, indicates that the model is reasonably fit in prediction. It showed that 86.62 percent changes in economic growth were collectively due to oil produced, gas produced, and electricity generated, while 13.38 percent unaccounted variations were captured by the error term.

Furthermore, the F-statistics which examines the overall significance of regression model equally showed that the overall result is statistically significant at 1 percent. This was indicated by the value of the F-statistic captured as 12.40953 with an associated p-value of 0.0000 which was found to be significant at the 1 percent. The auto correlation statistic of Durbin Watson shows the model is free from auto correlation given the statistic value approximately 2.

Table 5: Long run ARDL result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
OILP	-726.5808	4652.414	-0.156173	0.8775
GASP	5.051097	34.72023	0.145480	0.8859
ELECP_	-7198.084	58264.22	-0.123542	0.9030

Source: Author's computation using EVIEWS 10.0, 2022.

OILP and ELECP have a negative and insignificant relationship with RGDP, thus, a barrel and kilo watt increase in oil production and electricity generation led to ₦726.5808 million and 7198.084billion decrease in RGDP respectively while GASP and are positive and significant relationship with RGDP as a billion cubic square feet increase in gas production led to ₦5.05 billion increase in RGDP, see Table 5.

Post Estimation Tests

To check the robustness of the result, the normality, serial correlation, and heteroscedasticity test are carried out. The p-value greater than 5% indicate normal distribution, no serial correlation and homoscedasticity hence null will be accepted in all cases. This further implies the reliability of the model and the suitability of the model in explaining the relationship between the dependent and independent variables.

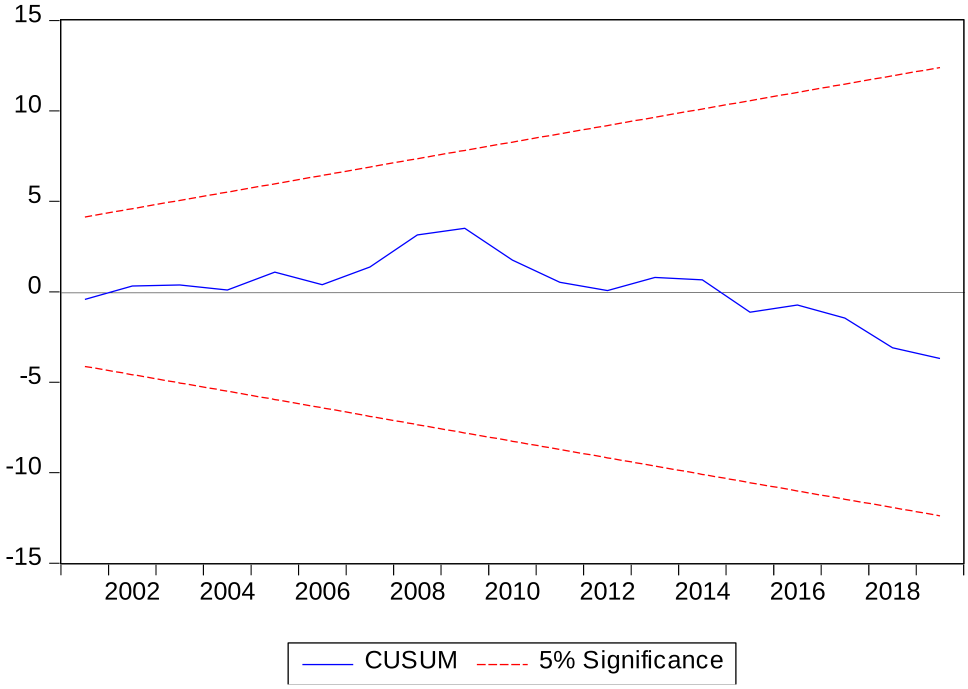
Table 6: Post Estimation Tests

Test type	**F-Statistic**
L-M Serial Correlation (Breusch-Godfrey)	0.1081
Breusch-Godfrey-Pagan (Heteroscedasticity)	0.7782
Normality (Jacque-Bera)	0.7395

Source: Author's computation using EVIEWS 10.0, 2022.

The post estimation tests result is presented in Table 6 shows that there is no issue of serial correlation, there is normality in the model and the error term is homoscedastic, hence, the null hypothesis is accepted. Further post estimation test for stability is illustrated in Figure1 using the cumulative sum (CUSUM) of the recursive estimates.

Figure 1: Stability Test (CUSUM)



Discussion of Findings

Like that of Ukioma and Ekwe (2019), ELECP met the expected sign which is the same result as from their study concluded that the higher a country's per capita electric power usage, the higher its people's level of living. However, OILP and GASP coefficients do not meet the *a priori* expected signs as their production affects RGDP negatively. GASP result is the same as Henry (2019) this is because oil and gas sector production are mostly done in the crude unrefined state and shipped overseas for refinement of their by-products, Peter *et al.* (2016).

Aging infrastructure and oil theft crises were additional factors reported, (Emefiele, 2022) to contribute to the negative relationship. Additionally, Nigeria chooses the extraction process in the oil and gas sector more than refining because profit margins are significantly higher in the extraction than in the refinery business, but refineries still represent the technological core of the oil value chain. In refineries, crude oil is processed into final energy sources such as gasoline, kerosene, diesel, and fuel oil.

CONCLUSION AND RECOMMENDATIONS

The result shows that energy sector plays a significant role in the economic performance and growth rate in Nigeria's economy. In this regard, there have been efforts made by the government to boost productivity in the sector to be able to boost output and economic growth. The study recommends the following:

i. The NLNG Act should be followed to the letter to reduce the amount of gas flared to increase the volume of gas produced using improved gas extraction methods.
ii. In the oil sector, law enforcement agencies should readily exact the law on thieves and vandals when caught rather than lobby for their release.
iii. Regular servicing and change of machineries when wear and tear begins to set in.
iv. Increased investments in research and development to increase efficiency in productivity in the sector such as alternative extraction, refining and generating processes. For instance, in the oil and gas sector, extraction and production process will promote the "green environment."
v. Already adopted in the power (electric) sector, more efficient methods such as the combined cycle power plants (CCPP) and combined heat and power (CHP) technologies.

   CCPP uses both gas and steam turbines to generate 50% more electricity using the same fuel, the waste gas turbine is routed to the nearby steam turbine which generates extra power while CHP is the concurrent production of electricity or mechanical power and useful thermal energy (heating and cooling) from a single source of energy. In some cases, these more efficient technologies have already been introduced, for example at Afam VI, Alaoji, Okpai and Olorunshogo power stations.

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