ENERGY GENERATION AND AGGREGATE OUTPUT IN NIGERIA: EVIDENCE FROM NARDL

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ABSTRACT

Energy generation has received a little or no attention over a period of time. Most scholars are focused on energy consumption and economic growth. This study empirically examined the asymmetric impact of energy generation on aggregate output in Nigeria between 1980 and 2019 using Nonlinear Autoregressive Distributed Lag (NARDL) Model. The stationarity test was conducted on the variables employed to avoid spurious regression. The result revealed that the variables were mixed at level and the first difference. The bound test result revealed that the variables are not cointegrated in the long run. Also, Wald test indicates that energy generation has short run impact on aggregate output in Nigeria. As revealed from the empirical results, from all sources of significant energy generation in Nigeria, gas generation brings the desired result to aggregate output in Nigeria. The study therefore suggests that action should refocus on the gas production subsector. This subsector needs to be developed carefully to avoid wasting this energy source by incineration. Also, the government should redirect those subsidies for petroleum products to the gas generation subsector.

1. INTRODUCTION

Energy is a significant variable for the economic growth of any country. Energy outputs smooth the progress of economic development by increasing productivity and income as well as creating employment. Efficient energy production aims to provide energy commodities to power the industrial, transport, household and service sectors of the economy (Rapu et al., 2015). Hence, energy remains the most vital lubricant of sustainable economic growth of any economy.

The poor performance of the subsector has sparked a great debate. With the profusion and potentials of energy resources, there is no reason for Nigeria to import energy in order to achieve a sustainable production capacity for optimal economic growth. Furthermore, Nigeria has managed to follow the collapse of its industrial sector, small and medium enterprises and economic downturn to the inadequate and erratic state of electricity market in the country (Ozoegwu, & Akpan, 2021)

The literature on energy economics examined short-run and long-run relationships between energy consumption and economic growth (Ha & Ngoc, 2020). Simultaneously, the literature on energy consumption and economic growth was also extensively examined (Chen, Pinar & Stengos, 2020; Shahbaz, Raghutla, Chittedi, Jiao & Vo, 2020). The debate is whether or not energy consumption exerts influence on the total output of the economy. However, similar to Azlina (2012), Oyeleke & Akinlo (2019), these studies observed that little or no attention is paid to examining the relationship between energy generation and aggregate output in Nigeria. Most of the reviews are focused on the demand side and neglect the supply side. Also, it is evident from the literature that several studies which examined the relationship between energy and economic growth in Nigeria are mostly focused on investigating the direction of causality between energy consumption and economic development, and linear short-term and long-term relationships between energy production and economic growth (Oyeleke & Akinlo (2019). Also, this study is different as it focuses on the four sources of energy generation (coal, hydropower, oil and gas power) in Nigeria and their effects on aggregate output. Based on the assessment of the empirical literature, it is observed that the contribution of these four sources of energy to total productivity has not been specifically investigated.

Some methodological gaps also exist in the previous literature because most studies used only trend analysis or simple OLS regression to make conclusions. However, using time series data, the relationship can be examined in both the long- and short-run, which is undertaken in this study. Specifically, the paper explores the link between energy generation and aggregate output in a Non-linear Autoregressive Distributed Lag (NARDL) framework. Shin et al. (2014) suggested a method for modelling asymmetric cointegration and dynamic multipliers in a NARDL framework. Through positive and negative partial sum decompositions of the explanatory variables, the approach introduces short-run and long-run nonlinearities. Shin et al. (2014) extend the work in this area and develop a flexible and straightforward non-linear dynamic framework capable of simultaneously and coherently modelling asymmetries both in the underlying long-run relationship and in the patterns of dynamic adjustment. They have the representation of complex error correction of the long-range asymmetric cointegration regression, leading to the NARDL model.

They follow Pesaran et al. (2001) and use a bound test approach to test for the existence of a stable long-run relationship, which is valid regardless of whether the underlying regressors are I(0), I(1), or mutually cointegrated. They also derive asymmetric cumulative dynamic multipliers that permit the display of the asymmetric adjustment patterns following positive and negative shocks to the explanatory variables. Prior to the development of this flexible approach suggested by Shin et al. (2014), there were a few other studies that employed a NARDL framework: Lin & Ankrah, (2019) investigated the economic impact of renewable energy and also examined the output and substitution elasticity for the two energy types (renewable and non-renewable) in Nigeria using ARDL. Awodumi & Adewuyi (2020) investigated the role of non-renewable energy in economic growth and carbon emissions among the top oil-producing economies in Africa between 1980 and 2015 using NARDL. Also, Sharma & Kautish (2020) examined the impact of coal-fired and oil-fired electrical power generation on CO2 emissions in India between 1976 and 2016 using NARDL. This study applies a NARDL analysis of cointegration between the energy generation and aggregate output in Nigeria between 1970 and 2019.

1.1. Energy supply in Nigeria

Since 2014 Nigeria's crude oil exports have averaged about 1.50 million barrels per day (mbd), with the United States being a major importer. However, since 2010, demand for oil from the United States has decreased as the economy has gradually attained self–sufficiency in oil production. The dynamics of supply and the possibility of the United States contending for the same export market with cheaper oil do not necessarily indicate that the supply market is narrowing, especially for Nigerian crude. As demand remains strong in the non-member countries of the Organization for Economic Co-operation and Development, such as China and India, it is expected that Nigeria will take advantage and seek new markets outside the United States. This is vital given that Nigeria's oil sector accounts for 80.1 percent of Nigeria's export earnings at the end of 2014.

Available information depicted that Nigeria exported over 28.27 million standard cubic meters (SCM) of gas in 2013, making Nigeria the 5th largest exporting country globally. Europe is Nigeria's biggest export market and the largest exporter in the Atlantic basin. However, the risk for Nigeria lies in the potential of the United States to export its shale gas to the global market. With its proven gas reserves of approximately 187 TCF (trillion cubic feet), as such, Nigeria can best be described as a gas province. Despite Nigeria's abundant gas wealth, none of this has been used, with the country's primary goal of crude oil production and the nation's primary focus on crude oil production. The domestic gas market is generally underdeveloped, with a high gas combustion record and a significant percentage of available natural gas exported as liquefied natural gas. Nigeria needs to develop clear regulatory and competition policies to open its market and focus on being a competitive, low cost and highly reliable supplier to the global market.

The sustained effort to generate electricity in Nigeria over the years has revealed the richness of energy resources in addition to oil and gas resources. These include hydro, tidal wave, sun, wind, coal gas, and some elements of uranium for nuclear power. These energy forms for electricity power generation abound in sizeable commercial quantities in the best natural form across the country to support a vibrant electricity market. Studies conducted by the NNPC, the Ministry of Mines and Steel Development, and the Nigeria Export Promotion Council showed that Nigeria is endowed with various natural energy resources. The Federal Government under the Ministry of Mines and Steel Development (FMMSD) in 2012 discovered supplementary quantities of coal situated in Nassarawa, Kogi and Benue States, in addition to the reserves in Enugu State.

1.2. Energy and aggregate output: an empirical review

Oyeleke & Akinlo (2019) have specifically focused on two sources of energy production and looked at the effect of energy generation on economic development in Nigeria. The study covered the period 1980–2017 and used the Error Correction Model (ECM) as a technique of estimation. The results indicated the existence of cointegration among the variables and also found that gas energy, physical capital, and interest rates are crucial to the determinant of economic growth in the long run. However, hydropower contributed to economic growth in the short run. Hence, the two sources of energy generation need massive investment and upgrading as the current generation is not sufficient for economic expansion in Nigeria. The productivity of gas fire plants is hindered by the lack of gas, while the productivity of hydropower is hampered by the lack of modern technology and old installations.

Lin & Ankrah (2019) investigated the economic impact of renewable energy and also examined the output and substitution elasticities for the two energy types (renewable and non-renewable) in Nigeria. The study takes into consideration the problem of multicollinearity among the variables employed; the ridge regression was employed as the estimation strategy. The empirical results, based on the application of a yearly observation of the input factors over the period 1980-2015, within the framework of the translog production function model, show that capital and labour are the main drivers of output in Nigeria. However, the economic impact of both energy types (renewable and non-renewable) is insignificant, even though positive. With positive output and substitution elasticities, this study confirms the feasibility of transitioning to renewable energy generation but also highlights the limitations associated with such a transition, citing inherent issues such as power density and size, expense, and location. Based on Nigeria's economic and industrialization policy, this study agrees with the respective policies contained in the Renewable Energy Program, but advises that its adoption be incremental and in line with Nigeria's economic priorities.

Pal & Mitra (2019) examined the responses of the purchasing power of the US dollar asymmetric to crude oil price fluctuations using a multiple threshold Non-Linear Autoregressive Distributed Lag model (MTNARDL). The study employed monthly data between January 1990 and June 2019, and it revealed a short-run asymmetric transmission of oil price fluctuations into the purchasing power of the US dollar. The results of the MTNARDL model showed the magnitude of variations in purchasing power in response to a minor or to a major change in the oil price. It also found corroborative evidence for a more rapid response of the purchasing power to the upward oil price shocks than to the downward movement in the oil price. This entails that the purchasing power of the US dollar experiences a sharp reduction with the rise in the oil price; nonetheless, the advantage of a drop in the oil price is not entirely transmitted to the purchasing power as its correction takes a much longer period than expected.

Benli, Altintaş & Kaplan (2019) investigated the impact of changes in oil prices on the real economic activity in Turkey. For this purpose, the study employed the Non-Linear Autoregressive Distributed Lags (NARDL) model, which allows both short-run and long-run asymmetries to be examine and the appropriate response of economic growth to changes in its regressors to be measured. The results confirm the asymmetric effect of oil price changes on economic growth. An increase in oil prices has an inverse influence on economic growth in the long run, and this impact has a larger magnitude relative to decline in oil prices which is found to be statistically insignificant. In other words, the increase in production does not respond to oil price decline, but to oil prices rise.

Ogunjimi (2020) examined the asymmetric effects of oil price on sectoral output in Nigeria using time series data between 1981 and 2017. It employs the Non-Linear Autoregressive Distributed Lag (NARDL) model developed by Shin et al. (2014) that introduced short-run and long-run nonlinearities via positive and negative partial sum decompositions of oil price. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root test results show that the variables used in the study are mixed at the first difference(I(1)) and level (I(0))series, hence the bounds test approach is employed to measure the long-run relationship whose results were affirmative. Also, the results of the short-run and long-run NARDL models revealed that oil price has asymmetric effects on the performance of the oil and non-oil sector of the Nigerian economy in the short-run and only long-run asymmetric effects on the non-oil sector. In addition, the result revealed that oil price shocks (positive and negative) have positive effects on non-oil output while a positive and negative oil price shocks have corresponding effects on oil output in the short run. Furthermore, oil price shocks have more effects on the oil sector than on the non-oil sector.

Awodumi & Adewuyi (2020) examined the role of non-renewable energy in economic growth and carbon emissions among the top oil-producing economies in Africa between 1980 and 2015. The study examined nonlinearity and structural break in unit root test and cointegration analysis and it employed the Non-Linear Autoregressive Distributed Lag (NARDL) technique. The study revealed the evidence of the asymmetric effect of per capita consumption of both petroleum and natural gas consumption on economic growth and carbon emission per capita in all the selected countries except Algeria. Nigeria's carbon emission has decreased while the non-renewable energy use delays have changed positively. In the case of Gabon, an increase in energy demand stimulates development and improves efficiency of the climate. Such energy consumption has a minimal effect on the emissions of the climate in Egypt, as it promotes industrial development. While a positive change in the non-renewable energy consumption facilitates economic growth in Angola, the effect on carbon emission is mixed across time and energy types. Also, the impact of negative changes in petroleum and natural gas use is comparable to that of positive changes in Egypt and Nigeria.

Sharma & Kautish (2020) examined the impact of coal-fired and oil-fired electrical power generation on CO2 emissions in India for the period of 1976−2016 using NARDL. The simulation results revealed that the upside shocks in coal-fired electricity would contribute considerably to the increase in the pollution level in the long run. Conversely, the effect of downside variations was found to be negative and significant.

2. MATERIALS AND METHODS

Method, data and model specification

The primary motive of this study is to investigate systematically the relationship between energy generation and aggregate output in Nigeria, using annual data from the period 1980-2018. The data comprise aggregate output proxied by GDP per capita and electricity generation using the four sources (hydro, oil, coal, and gas sources) in Nigeria. This study uses the neoclassical Solow growth model as adopted by Oyeleke & Akinlo (2019). In line with Solow's formulation, an aggregate economic output depends on capital accumulation, technological progress, and labour. This can be expressed as:

$$y = Ak^{\alpha} L^{\beta} \qquad (1)$$

NB: $\alpha + \beta = 1$

Where K is the capital accumulation, L represents the size of the labour force in the economy, Y is the aggregate output level, and A denotes technological progress. According to the hypothesis, expanding technological acquisition boosts economic development in emerging open economies. However, it should be noted that in the production process, capital accumulation and labour depend on energy to be efficiently and effectively utilized. Through the transformation of Equation 1 into the intensive form, it becomes:

$$y = Ak^{\alpha} \qquad (2)$$

Where $y = \frac{Y}{L}$, $k = \frac{K}{L}$

By taking the logarithm of both sides of Equation 2 and differencing it,

$$\Delta \log(y) = \log A + \alpha \Delta \log(k) \qquad (3)$$

To incorporate electricity production (a proxy for energy generation) into Equation 3, we divide technology (log A) into two parts. This is based on the argument that electricity is a part of technology. Therefore, we divide technology into two parts:

$$\log A = \Delta \log \gamma + \Delta \log EG \qquad (4)$$

By substituting Equation 4 into Equation 3, it becomes:

$$\Delta \log y = \Delta \log \gamma + \Delta \log EG + \alpha \Delta \log k \tag{5}$$

However, since we have four types of electricity production in Nigeria, different policies are formulated by the government for each source to boost its generation. These include hydro source, oil, coal and gas source. Given the variant policy to improve on generation from each source, we decompose energy generation (EG) into Hydro (HYD), Coal (CO), Oil (OIL) and gas (GAS). Thus, we substitute them for (EG) in Equation 5. By including the control variables and error term, Equation 5 then becomes:

$$\begin{aligned}\Delta \log y = \Delta \log \gamma + \Delta \log HYD + \Delta \log CO + \Delta \log OIL + \Delta \log GAS + \\ + \alpha \Delta \log k + \Delta \log INF + \Delta \log EXHR + \Delta \log INTR + \varepsilon\end{aligned} \tag{6}$$

Where: HYD represents hydropower, CO denotes Coal power, OIL indicates Oil sources power, GAS indicates Natural gas power, INF denotes inflation, EXHR indicates Real Exchange Rate, and INT represents real interest rates.

Nonlinear Autoregressive Distributive Lag Model (NARDL approach)

Shin et al. (2014) suggest a NARDL approach where the regressor is divided into its negative and positive partial sums. For capturing the asymmetric impact, Energy generation is decomposed into the positive and negative partial sum:

Y = f(HYD_POS, HYD_NEG, CO_POS, CO_NEG, OIL_POS, OIL_NEG, GAS_POS, GAS_NEG)

3. RESULTS AND DISCUSSIONS

This section presents and analyses the results obtained from the analysis based on the time series data and collected from different publications. This section is sub-divided into the following: Unit Root Test, regression result and discussion of the findings.

The results of the unit root test based on the Augmented Dickey-Fuller (ADF) and Phillip Perron methods are presented in Table 1 below:

Table 1. Time Series Unit Root Test Results

Variables	Augmented Dickey-Fuller (ADF) Test		Phillip Perron (PP) Test		Conclusion on the Order of Integration	
	Levels	1st Diff.	Levels	1st Diff.	Levels I(0)	1st Diff. I(1)
GDPGR	-5.431369 (0.0000)	-8.242572 (0.0000)	-5.444357 (0.0000)	-11.29854 (0.0000)	Yes	Yes
OIL	-2.226515 (0.2001)	-8.352858 (0.0000)	-2.233289 (0.1978)	-9.623275 (0.0000)	No	Yes
COAL	-3.190935 (0.0271)	-8.109199 (0.0000)	-3.315426 (0.0200)	-8.109199 (0.0000)	Yes	Yes
GAS	-1.923924 (0.3187)	-7.698248 (0.0000)	-1.923924 (0.3187)	-7.719423 (0.0000)	No	Yes
GFC	-5.677704 (0.0000)	-12.63644 (0.0000)	-5.313392 (0.0001)	-26.69607 (0.0001)	Yes	Yes
EXCHR	2.479215 (1.0000)	-4.661466 (0.0004)	2.228211 (0.9999)	-4.665879 (0.0004)	No	Yes
INF	-3.946190 (0.0036)	-7.087763 (0.0000)	-3.249099 (0.0231)	-14.30655 (0.0000)	Yes	Yes
INTR	-1.821068 (0.3661)	-7.786409 (0.0000)	-1.773417 (0.3889)	-7.805243 (0.0000)	No	Yes

Source: Author's computation, 2021.

ARDL Bound test

In view of the unit root test result, some empirical investigation on the long-run relationship in the model can be examined. Though the unit root test does not strictly satisfy the condition for embarking on a bound test, doing this will help establish if any of the set of variables may be cointegrated. The most prominent and widely used technique for ARDL model in the literature was that developed by Pesarant (2011).

Table 2. ARDL Bound Test Result

ARDL Bound Test Date: 03/31/21 Time: 23:53 Sample: 1972 2015 Included observations: 44 Null Hypothesis: No long-run relationships exist		
Test Statistic	Value	K
F-statistic	4.605979	12
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	4.78	4.94
5%	5.73	5.77
2.5%	6.68	6.84
1%	7.84	5.59

Source: Author's computation, 2021.

From the result, the F statistic value is lower than the bound values at different significance levels. Hence, we fail to reject the null hypothesis of no cointegration among variables in the long run. With this result, Short run NARDL model was employed for general estimation of this model.

Serial Correlation Test

Table 3. Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.195875	Prob. F(1,30)	0.2829
Obs*R-squared	1.725048	Prob. Chi-Square(1)	0.1890

Source: Author's computation, 2021.

The result revealed that the model is free from the problem of serial correlation since F-statistic probability is greater than 5% level of significance.

Normality Test

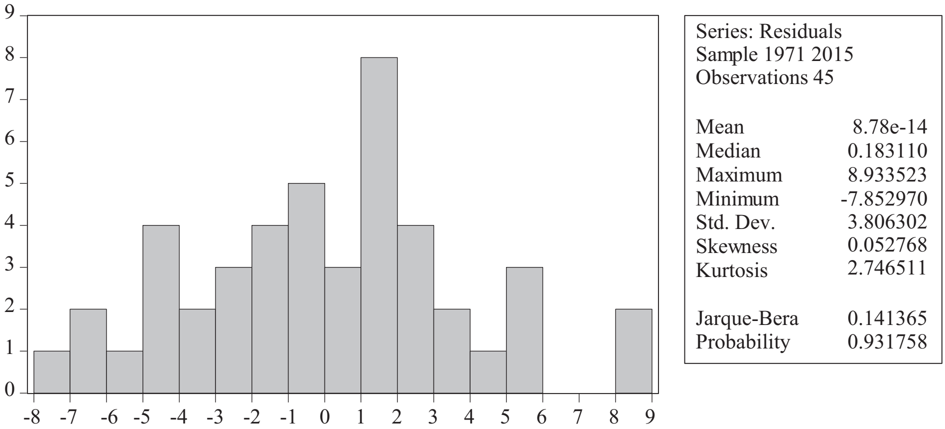

Figure 1. Normality Test of the Model

Source: Author's computation (2021)

The figure 4.2 above depicts the normality of the model over the period of investigation. From the result, the model mean value is 8.78, Jarque Bera value of 0.14 with probability value of 0.93. The null hypothesis states that the model is normally distributed. From the result, the probability value is greater than 5% level of significance, hence we fail to reject null hypothesis. Therefore, we conclude that the model is normally distributed over the period of investigation.

Stability Test

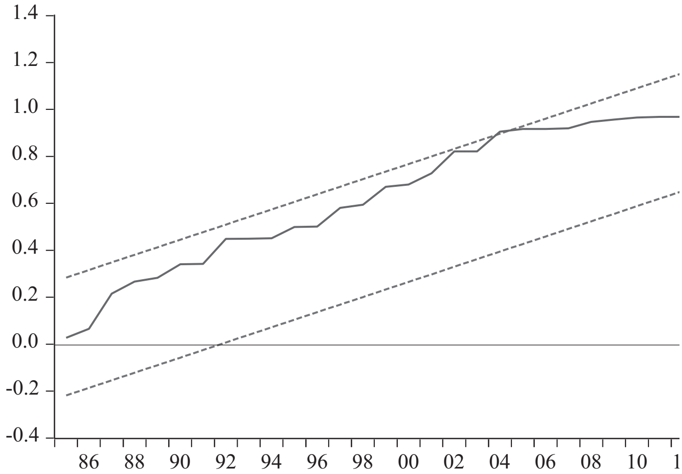

Figure 2. Cusum of Square Stability Test

Source: Author's computation, (2021)

The above graph depicts the stability of the model over the period of investigation. From the result, the model is stable for the period of investigation since the stability trend falls within acceptance region of 5% level of significance. Hence, the model does not suffer from any structural break.

Asymmetric Test

The study proceeds to examine the short run asymmetric among the various energy generations using Wald test and the result is presented below:

Table 4. Asymmetric Test

Wald Test:			
Equation: NARDL01			
Test Statistic	Value	Df	Probability
t-statistic	0.877054	30	0.3874
F-statistic	0.769223	(1, 30)	0.3874
Chi-square	0.769223	1	0.3805
Null Hypothesis: C(3)/C(2)=C(4)/C(2)			
Null Hypothesis Summary:			
Normalized Restriction (= 0)		Value	Std. Err.
C(3)/C(2) - C(4)/C(2)		0.133957	0.152735
Delta method computed using analytic derivatives.			

Source: Author's computation (2021).

As can be seen from the above result, we fail to reject the null hypothesis of equality as p value is greater than 5%. Wald test indicates there is asymmetric in the short run impact of energy generation and aggregate output in Nigeria.

NARDL Estimate

Having established the fact that some of the explanatory variables in the model do have short-run relationship with the dependent variable it will pertinent to also examine the direction of and magnitude impact of the relationship between aggregate output and the set of explanatory variables captured in the model. In this sense the aim is to obtain empirical estimates measuring the impact of regressors of on the dependent variable.

For this purpose the Non Linear Autoregressive Distributed Lag (NARDL) is employed for the estimation.

The result for the regression analysis is shown in Table 4. The table contains the parameter estimates obtained from the NARDL estimation approach.

In the table the values in the brackets are the probability values of the parameter estimates of the model. The significance of the estimated coefficients is tested from the probability value of the estimated coefficients. If the probability value of the estimated coefficient is less than 5% then the explanatory variable has a significant impact on the dependent variable. Hence the research hypothesis cannot be upheld.

There exists an inverse relationship between the current aggregate output and previous output in Nigeria but the result is not significant at 5% since the probability value of 0.4949 is greater than 0.05. Hence, previous aggregate output is not an important determinant of aggregate out in Nigeria.

There is a direct relationship between positive changes in Coal generation and aggregate output. From the result, 1% positive increase in Coal generation will bring 6.69% increase in aggregate output. However, the result is not significant since the probability value is greater than 5%. Also, 1% decrease in coal generation will bring 6.23% increase in aggregate output in Nigeria and the result is significant at 5% level of significant. Hence, it becomes clear that reduction in Coal generation in Nigeria will increase the aggregate output and it is an important variable determining aggregate output. This result is not surprising because of environmental pollution associated with the production of coal which can cause havoc to productivity of labour and entire population at large.

Table 5. Non Linear Autoregressive Distributed Lag Estimate

Dependent Variable: GDPGR
Method: ARDL
Date: 04/04/21 Time: 21:17
Sample (adjusted): 1972 2015
Included observations: 44 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Dynamic regressors (0 lag, automatic): COAL_POS COAL_NEG HYDRO_POS HYDRO_NEG GAS_POS GAS_NEG OIL_POS OIL_NEG GFC INF EXCR INTR
Fixed regressors: C

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
GDPGR(-1)	-0.154825	0.222237	-0.696670	0.4949
COAL_POS	6.692852	4.267419	1.568361	0.1342
COAL_NEG	-6.230162	2.202112	-2.829176	0.0111**
HYDRO_POS	4.746650	3.591416	1.321665	0.2028
HYDRO_NEG	6.353523	3.237758	1.962322	0.0654*
GAS_POS	6.494254	3.109137	2.088764	0.0512*
GAS_NEG	4.364868	3.515049	1.241766	0.2303
OIL_POS	5.305880	3.338414	1.589342	0.1294
OIL_NEG	6.474012	3.123066	2.072967	0.0528*
GFC	0.017670	0.036899	0.478864	0.6378
INF	0.043310	0.075506	0.573596	0.5733
EXCR	0.102600	0.053695	1.910814	0.0721*
INTR	-0.433605	0.331270	-1.308916	0.2070
R-squared	0.819857	Mean dependent var		3.510990
Adjusted R-squared	0.569658	S.D. dependent var		5.655993
S.E. of regression	3.710355	Akaike info criterion		5.748133
Sum squared resid	247.8013	Schwarz criterion		6.802427
Log likelihood	-100.4589	Hannan-Quinn criter.		6.139116
F-statistic	3.276825	Durbin-Watson stat		2.579196
Prob(F-statistic)	0.005979**			

*Note: p-values and any subsequent tests do not account for model selection.

Source: Author's computation, (2021).

Hydro-electric power generation is another important determinant of aggregate output in Nigeria. From the result, 1% positive increase in hydro-electric power generation will bring 4.75% increase in aggregate output in Nigeria but the result is not significant at 5%. Also, 1% decrease in hydro-electric power generation will lead to 6.35% reduction in aggregate output and the result is significant at 10% level of significance. Hence, any reduction in hydro-electric power generation in Nigeria will significantly influence aggregate output.

Gas is also principal energy source that has significantly affected the aggregate output in Nigeria. From the result, 1% increase in Gas generation will lead to 6.49% increase in aggregate output in Nigeria and the result is also significant at

10%. Also, 1% decrease in Gas generation will lead to about 4.36% decrease in aggregate output within the period of investigation but the result is not significant since the probability value is greater than 10% level of significance.

Oil generation is another important energy source in Nigeria. From the result, 1% increase in oil generation will lead to about 5.31% increase in aggregate output. Also, 1% reduction in oil generation will lead to about 6.47% decrease in aggregate output and the result is significant at 10% significance level.

Gross fixed capital (GFC) and Inflation (INF) depict direct relationship with aggregate output but the relationship is not significant.

Exchange Rate (EXCR) is also an important determinant of aggregate output in Nigeria. Exactly 1% increase in exchange rate will lead to 0.10% increase in aggregate output and the result is significant at 10% level of significance. The result is not surprising because the economy is highly depended on other economy for its aggregate output expansion.

Interest rate shows an inverse relation with aggregate output but the result is not significant. However, the higher the interest rate is, the lower the aggregate output is in Nigeria.

The R square of the model shows that the exogenous variables account for about 82% variation of the aggregate output in Nigeria. The F-statistic value of 3.28 with probability value of 0.0060 shows that the overall model is significant. Durbin Waston value of 2.6 depicts the absence of serial correlation in the model.

4. CONCLUSIONS AND POLICY IMPLICATIONS

In this study, the relationship between energy generation and aggregate output is empirically examined. For this purpose, the study adopts nonlinear autoregressive distributed lags (NARDL) model. The model allows us to test the short-run and long-run asymmetries simultaneously and enables us to measure the appropriate response of aggregate output to changes in its regressors. As revealed from the results, of all the source of observed energy generation in Nigeria, Gas generation brings desirable result to aggregate output in Nigeria. Coal, oil and hydro-electric energy generation brings increase in aggregate output. However, decrease in the generation of above stated sources of energy generation leads to significant increase in aggregate output. Implicitly, if Nigeria wants to expand its aggregate output, concise efforts must be made to reduce these source of energy in order to curb their environmental hazard. In Nigeria, action should be refocused on the gas production subsector. The outcome is consistent with the recent increase in demand for domestic gas by households and businesses in Nigeria as an alternative energy source. This subsector needs to be developed carefully to avoid wasting this energy source by incineration. In order to improve the general well-being of people and to quell the heated debate among those in charge of petroleum product subsidies, the government should redirect those subsidies to the gas generation subsector.

Conflict of interests

The authors declare there is no conflict of interest.

REFERENCES

Awodumi, O. B. & Adewuyi, A. O. (2020). The role of non-renewable energy consumption in economic growth and carbon emission: Evidence from oil-producing economies in Africa. *Energy Strategy Reviews*, *27*, 100434.

Azlina, A. A. (2012). Energy consumption and economic development in Malaysia: A multivariate cointegration analysis. *Procedia-Social and Behavioral Sciences*, *65*, 674-681.

Benli, M., Altintaş, H. & Kaplan, M. (2019). Asymmetric Effect Of Oil Prices On Economic Growth: Evidence From Turkey. *Bilecik Şeyh Edebali Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *4*(1), 266-279.

Chen, C., Pinar, M. & Stengos, T. (2020). Renewable energy consumption and economic growth nexus: Evidence from a threshold model. *Energy Policy*, *139*, 111295.

Ha, N. M. & Ngoc, B. H. (2020). Revisiting the relationship between energy consumption and economic growth nexus in Vietnam: new evidence by asymmetric ARDL cointegration. *Applied Economics Letters*, 1-7.

Lin, B. & Ankrah, I. (2019). On Nigeria's renewable energy program: Examining the effectiveness, substitution potential, and the impact on national output. *Energy, 167*, 1181-1193.

Ogunjimi, J. (2020). Oil Price Asymmetry and Sectoral Output in Nigeria. Available at SSRN 3531667.

Oyeleke, O. J. & Akinlo, T. (2019). Energy generation and economic growth: empirical evidence from Nigeria. *Environment, Development and Sustainability*, 1-15.

Ozoegwu, C. G. & Akpan, P. U. (2021). A review and appraisal of Nigeria's solar energy policy objectives and strategies against the backdrop of the renewable energy policy of the Economic Community of West African States. *Renewable and Sustainable Energy Reviews*, *143*, 110887.

Pal, D. & Mitra, S. K. (2019). Asymmetric oil price transmission to the purchasing power of the US dollar: A multiple threshold NARDL Modelling Approach. *Resources Policy, 64*, 101508.

Pesaran, M. H., Shin, Y. & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics*, *16*(3), 289-326.

Rapu, C. S., Adenuga, A. O., Kanya, W. J., Abeng, M. O., Golit, P. D., Hilili, M. J., ... & Ochu, E. R. (2015). *Analysis of energy market conditions in Nigeria*. Abuja, Nigeria: *Central Bank of Nigeria.*

Shahbaz, M., Raghutla, C., Chittedi, K. R., Jiao, Z. & Vo, X. V. (2020). The effect of renewable energy consumption on economic growth: Evidence from the renewable energy country attractive index. *Energy*, *207*, 118162.
Sharma, R. & Kautish, P. (2020). Examining the non-linear impact of coal and oil-based electricity production on CO2 emissions in India. *The Electricity Journal*, *33*(6), 106775.
Shin, Y., Yu, B. & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a non-linear ARDL framework. In Festschrift in honor of Peter Schmidt (pp. 281-314). New York, NY, USA: Springer.

Appendix

Data Bank. Source: World Development Index, 2020

ПРОИЗВОДЊА ЕНЕРГИЈЕ И АГРЕГАТНИ ПРОИЗВОД У НИГЕРИЈИ: ДОКАЗИ ИЗ НАРДЛ-а

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САЖЕТАК

Производњи енергије се током времена посвећивало мало, или нимало пажње. Већина научника се фокусира на потрошњу енергије и економски раст. Ова студија је емпиријски испитала асиметрични утицај производње енергије на агрегатни производ у Нигерији између 1980. и 2019. користећи модел нелинеарног ауторегресивног дистрибуираног заостајања (НАРДЛ). Тест стационарности је спроведен на коришћеним варијаблама да би се избјегла лажна регресија. Резултат је открио да су варијабле помијешане на нивоу и првој разлици. Резултат боунд теста је открио да варијабле нису коинтегрисане на дужи рок. Такође, Валд тест показује да производња енергије има краткорочни утицај на агрегатни производ у Нигерији. Као што је откривено из емпиријских резултата, од свих извора значајне производње енергије у Нигерији, производња гаса позитивно доприноси укупном производу у Нигерији. Студија стога сугерише да би се акција требала поново фокусирати на подсектор производње гаса. Овај подсектор треба развијати пажљиво како би се избјегло расипање овог извора енергије изненадним изгарањем; такође, влада би требала да преусмјери субвенције за нафтне деривате у подсектор производње гаса.

Кључне ријечи: *приступ енергији, агрегатни производ, НАРДЛ, снадбијевање енергијом, економски раст, производња енергије*