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EVIDENCE FROM ASYMMETRIC APPROACHES ON THE EFFECTS OF ENERGY SOURCES ON ECONOMIC GROWTH IN NIGERIA

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Abstract:

Nigeria has several renewable energy resources that have not yet been effectively used, despite the nation's commitment to achieving net-zero emissions by 2060, which was put forward at the 26th United Nations Climate Change Conference in 2021 and calls for reduced use of fossil fuels. Despite the fact the aforementioned commitment may cause the nation to lose focus on eradicating poverty as the primary objective of sustainable development, this study aims to determine the asymmetric effects of renewable and non-renewable energy sources used in electricity generation, as well as environmental pollution (CO2 emissions), on the country's economic growth in Nigeria. According to the findings, Nigeria should primarily adopt policies that focus on increasing non-renewable energy consumption in the short term and increasing renewable energy consumption in the long term to achieve higher economic growth. Additionally, the long-run causality findings supporting the sole feedback relationship between renewable energy and economic growth pave the way for Nigeria to significantly increase its share of renewable energy in the long run, enabling it to achieve higher economic growth and, by 2060, approach net-zero emissions, both of which are key objectives of sustainable development.

Keywords: Asymmetric, Environmental Pollution, Energy sources, Economic Growth

Introduction

With Regard to achieving long-term goals for economic development, environmental sustainability has been a major challenge. It appears to be a challenge that developing countries must overcome using an unusual strategy. (Qayyum et al., 2021). This results in climate change and environmental adulteration being equally important global environmental controversies (Rehman et al., 2019a). Governments battle to protect the

situation for future generations in the fight against environmental concerns (such climate changes) at the national level as developmental partners. The majority of nations are sacrificing environmental quality as they develop (Ulucak & Bilgili, 2018), it is debatable whether the fight for economic sustainability in the major emerging nations would result in a stronger additional demand for energy resources. Energy is crucial for economic development and is also the primary driver of environmental deterioration (Adebayo et al., 2021). Nigeria's economy is no exception to the fact that the world's energy consumption is dominated by non-renewable energy, with about 84% of it coming from sources like crude oil, coal, and natural gas. As a result, the world's economies are heavily dependent on energy (Ashibi Ushie & Ranmilowo Aderinto, 2021). The global mix of nonrenewable energy sources, according to the Energy Information Administration (EIA, 2019), consists of 33.1% crude oil, 24.3% natural gas, and 27% coal energy sources, whereas the consumption of renewable energy is broken down into solar, wind, and biofuels at 4%, hydropower consumption at 7.6%, and nuclear energy at 5%. As a result, energy use assumes the role of being the primary cause of CO2 emissions caused by humans, accounting for 84.4% of global emissions. Large portions of global emissions are ascribed to key economic sectors like energy, industry, and agriculture. Despite Nigeria's abundance in energy resources, using fossil fuels for non-essential purposes results in significant air pollution and harmful environmental changes including climate change, and continues to be a significant issue for the nation.

Among the important global initiatives to approach environmental challenges is COP21 (Climate change U N & Conference, 2021). The participating nations pledged to take the necessary steps to reduce their emissions, keep global warming to 2°C, which would keep it at pre-industrial levels, and increase the proportion of clean energy sources in their respective cumulative energy mixes. It is estimated that human biological activity on N2O in surface water and soil account for roughly 55% of N2O emissions globally (Zhang et al., 2020). Emissions from soil has been examined deeply through various scholars (e.g., (Griffis et al., 2013; P. Yang et al., 2022) and is comparatively a well-challenging component of the world

N2O estimation (Quick et al., 2019; Zhang et al., 2020). N2O emission generated from soil is largely contributed by the agricultural sector of an economy (Tian et al., 2020). According to National Oceanic and Atmospheric this emission reaches to 334 PPBV in 2021 (NOAA, 2021). In the case of Nigeria, economic sources are mainly from agricultural part, Nitrous oxide emissions contributed to cumulative GHG emissions by 0.08% (Hansen et al., 2020). International Energy Administration (EIA, 2019) affirmed that Nigeria was emitting 104.27 matric tone of CO2 emission in 2018 representing an addition of 271.6 per cent from 1990 levels of emissions per total greenhouse gases emissions in which CO2 emission is 61.74 per cent, nitrous oxide emission 7.77 per cent, methane 27.82 and fluorinated gas 2.66 per cent (EIA, 2019).

Many researchers have studied energy sources separately applying the framework of EKC hypothesis and have come up with inconsistent conclusions. Remarkably, the majority of the studies focused on CO2 emission to measure climate change or environmental quality which majorly is considered as the principal actor for global pollution. To look unique from those studies, we combined CO2 emission and N2O emission to examine environmental pollutions jointly with energy sources to explore their influence to economic growth on the context of Nigeria. As such, this study aims empirically to examine the asymmetric association of energy sources to economic growth of Nigeria. The contributions of this paper are in four-ways; firstly, is through applying carbon dioxide and nitrous oxide emissions to examine the role of environmental impact as moderating variables on economic growth which will stand as a unique paper in the field of literature particularly on the studies on Nigeria. Secondly, the paper employs nonlinear asymmetric approach to determine both positive and negative influence of the concerned variables. Through application of NARDL (Nonlinear Autoregressive Distributed Lag), we study asymmetric short and long run correlation (Shin et al., 2012a). Thirdly, we apply Diks-Panchenko causality test as nonlinear causality approach to examine the flows of the causality. Fourthly, to avoid omitted variables bias and to have more room for policy recommendations we added some variables such as population growth and foreign direct investment in

addition to moderating variables to examine economic growth of Nigeria.

The paper is structured in the remaining part as follows; Section 2 provides literature review of the research work, Section 3 presents the methodology, Section 4 deals with the analysis of the study and the last section draws the conclusion, policy implication and possible recommendation.

2 Literature review

2.1 Theoretical review

Environmental quality and economic development are crucial for the welfare and advancement of people (Farhani et al., 2014). Environmental contamination is allegedly the root of social and economic problems, which has led many academics to concentrate on the pollution's affecting factors. Research findings differ depending on the environment, historical period, and methodology used. More and more research has shown how nonlinear methods can significantly alter results. For relationships like the one between growth, environment, and energy, nonlinear evaluation techniques work well. (Bildirici & Turkmen, 2015). In addition, several research on urbanization and CO2 emissions included nonlinear factors. Despite this, the results are extremely conflicting and mixed in terms of the accuracy of the nonlinear influence due to the complex economic growth systems, regional variables, erratic econometric patterns, sample variability, and biased omitted variable assumptions (Hashmi et al., 2020). Some experimental researches have established an inverse U-shaped influence of urbanization to CO2 emission (Ahmed et al., 2019a). In related findings, Zhang & Xu, (2017) argue that, higher level of urbanization can induce the development of green energy efficiency, infrastructural technology, ecological friendly, production and industrial processes, advance labor productivity, improve standard of living, and mitigates environmental challenges. In the esteem, EMT (Ecological Modernization Theory) advanced by Poumanyvong & Kaneko (2010) explains the friendly results of urbanization in the course of the higher stages of economic growth and urban development.

The earlier work on nonlinear relationships between pollution and urbanization produced conflicting and ambiguous results. These conflicting and inconclusive findings across

the province are caused by variations in economic levels, demographics, cultural variances, and structural changes unique to each location (D. Yang et al., 2018). Due to the distinct patterns in economic growth, urban management, and development difficulties throughout the various nations and areas, the opposing findings are likewise highly diverse (Du & Xia, 2018; Xu & Lin, 2015). Due to the growth of buildings and infrastructure, paved roads, increased energy use, adequate transportation for bus services and motorization, reductions in arable land for urban expansion, and high population density, urban migrations and the growth of large cities have systematically impacted urban environmental pollution and climate (Zhao & Zhang, 2018).

Similar to how burning fossil fuels as a source of energy for commercial operations releases CO2 emissions into the environment, human actions have resulted in climate change and global warming (IPCC, 2014). Therefore, the inverse effects of these emissions would be strongly felt more in low-income economies (IPCC, 2014). According to other research, the use of fossil fuels and the scarcity of uranium indicate that energy will continue to be both expensive and plentiful. advocating for the promotion of renewable energy sources (Arto et al., 2016). Although, Akizu-gardoki et al. (2018) contend that the usage of renewable energy is not only necessary for the environment but also advantageous from a social and economic standpoint. When a nation has a larger percentage of renewable energy sources than a nation with a lower percentage, there would be a negative link between CO2 emissions and energy (Hanif, 2018; Nicolli & Vona, 2019). According to Shahbaz et al., (2012) this corresponds to a favorable connection between carbon emissions and energy use. The two variables do, however, have a negative long-term association in Nigeria (Birnintsaba et al., 2021).

Energy is a source that is not only used to provide electricity but also for the industrial process, which controls economic expansion. (Ahmed et al., 2019b) Energy is also a key component in fostering and maintaining a nation's economic prosperity, according to Shafiei & Salim (2014) and Wesseh & Lin (2015). The use of renewable energy also improves environmental qualities, according to numerous researches (Allard et al., 2018; Balsalobre-Lorente et al., 2018; Zoundi,

2017). Therefore, driving economic growth and industrialization that strengthen a country's economy but also increasing energy consumption (Warr & Ayres, 2010), by consuming renewable energy is thought to be less harmful to the environment than using non-renewable energy (Ahmed et al., 2019b). This energy source has emerged as a crucial part of the world's energy consumption (Rehman et al., 2019b).

2.2 Empirical reviews

The present research, particularly those on CO2 emissions (Ito, 2017; Zoundi, 2017), which make up a significant portion of GHG and a significant global pollutant, have examined the roles of renewable and nonrenewable resources. Also split the use of renewable and nonrenewable energy into two portions with reference to the relationship between the two co-variables and economic growth. For example, Apergis & Payne (2012) and Tugcu et al., (2012) accept that both nonrenewable and renewable energy sources play major functions in the advancement of economic growth. Also in a separate analysis, for example, Emrah Koçaka & Aykut Şarkgüneşi (2017) analyzed the influence of renewable energy use on economic progress in Balkan and Black Sea economies, and empirically showed that renewable energy motivates economic growth. This finding matches with that of Ntanos et al. (2018) and has harmonious influence on the social, economic and environmentally sustainable development. In single countries studies, series of researches confirmed positive function of renewable energy in advancing economic growth. For instance, Akella et al. (2009) studied for India, Fang (2011) examined China, Pao & Fu (2013) established feedback correlation in Brazil, Rafindadi & Ozturk (2017) examined German, and Birnintsaba et al. (2021) studied in the context of Nigeria. However, some researchers established neutrality relationship between energy consumption (renewable and nonrenewable) and economic growth. Referring to Yildirim et al. (2012) who applied Toda_Yamamoto approach and causality corrected bootstrap in USA, and Destek (2016) used newly industrialized economies and found similar result with Yildirim et al. (2012). In panel analysis Destek & Aslan (2017) established bidirectional, growth, neutrality and conservational hypothesis in 19 growing

economies. Wang et al, (2018) determined the consequence of GDP and renewable energy use on anthropological advancement with reference to Pakistan. Using simultaneous equation model, their outcomes confirmed that renewable energy and GDP are neutral to human development because of some unidentified factors. Etokakpan et al. (2020) re-examined the natural gas-growth nexus of Malaysia, using 1980 to 2014 data in a framework of multivariate with additional variables like CO2 emission, globalization and capital formation to fix the gap of omitted variables. Their results indicate long run relationship among the variables and confirmed the granger causality flows from growth to energy in the country. Zafar et al. (2019) studying the emerging economies covering the period 1990-2015, implied that nonrenewable energy consumption and CO2 emission are correlated, and equally trade openness has similar relationship with nonrenewable energy sources like that of CO2 emissions (feedback relationship). In addition, the result showed the flow of causality relation only from economic growth to both renewable and nonrenewable energy consumptions. The authors suggested that, those countries can enhance the quality of their environment by cutting down nonrenewable means of energy consumptions without distressing their economic growth.

3 Data and Methodology

3.1 Data

The data applied in this study come from the World Bank's development indicators (WDI) annual data, which covered a 48 Years period from 1971 to 2018 for Nigeria. The multivariate framework included economic growth proxies by gross domestic product (GDP) as the dependent variable. Energy sources (for nonrenewable energy which is proxies by (fossil energy (FEC), and renewable energy source proxies by electricity production by hydropower source (EPHS) as the independent variables. While the moderating variables include Environmental degradation which is proxies by the CO2 emission (CO2) and Nitrous Oxide Emission (N_2O), population growth rate proxies by annual urban population growth and foreign direct investment (FDI). The variables CO2, N2O, and EPHS were transformed into log form.

3.2 Methodology

3.2.1 Modeling Asymmetries in a Nonlinear ARDL Framework

Following the studies of Benkraiem et al. (2019); Shahbaz et al. (2017); and Shin et al. (2012b) the associations among the variables are presented using nonlinear method. The asymmetric ARDL approach was displayed to be insufficient enough to study the connection among the variables for both short and long runs. The idea behind applying the NL (nonlinear) model is due to some unforeseen events happened in previous decades, like global financial crisis, political changes and global pandemic, which cause structural changes to the time series data. To defeat this challenge, nonlinear ARDL approach is adopted as proposed by Shin (Shin et al, 2014) in this study.

3.3 Modeling and Estimations

This study tried to explore the impact of environmental pollution and energy sources on economic growth of Nigeria, using asymmetric approach and causality directions with application of Diks and Panchenko's causality analysis. The model of our study is as follows:

$$GDP_t = f(LEPHS_t, FFEC_t, LCO2_t, N2O_t, AUPG_t, FDI_t) \quad 1$$

The model from Eq 1 is transformed into econometrics and transformed some variables into log form to reduce skewness as displayed in Eq 2 below:

$$GDPt = \vartheta o + \vartheta_1 LEPHS_t + \vartheta_2 FFEC_t + \vartheta_3 LCO2_t + \vartheta_4 LN2O_t + \vartheta_5 AUPG_t + \vartheta_6 FDI_t + \varepsilon_t \quad 2$$

From Equation 2, the constant term of the model is replaced by ϑ_o and ϑ_1, ϑ_2, ϑ_3, ϑ_4, ϑ_5, ϑ_6 represent the coefficients of the independent variables, ε_t is considered as error term of the model.

NARDL approach of the model in accordance with (Pesaran et al., 2001; Shin et al., 2012b), the ECM setup turns out to be presented as follows:

$$\Delta GDP_t = \beta_o + \theta_1 GDP_{t-1} + \theta_2^+ LEPHS_{t-1}^+ + \theta_3^- LEPHS_{t-1}^- + \theta_4^+ FFEC_{t-1}^+ + \theta_5^- FFEC_{t-1}^- + \theta_6^+ LCO2_{t-1}^+ + \theta_7^- LCO2_{t-1}^- + \theta_8^+ LN2O_{t-1}^+ + \theta_9^- LN2O_{t-1}^- + \theta_{10}^+ AUPG_{t-1}^+ + \theta_{11}^- AUPG_{t-1}^- + \theta_{12}^+ FDI_{t-1}^+ + \theta_{13}^- FDI_{t-1}^- + \sum_{i=0}^{p} \beta_1 \Delta GDP_t + \sum_{i=0}^{q} \beta_2 \Delta LEPHS_{t-1}^+ + \sum_{i=0}^{q} \beta_3 \Delta LEPHS_{t-1}^- + \sum_{i=0}^{q} \beta_4 \Delta LFFEC_{t-1}^+ + \sum_{i=0}^{q} \beta_5 \Delta LFFEC_{t-1}^- + \sum_{i=0}^{q} \beta_6 \Delta LCO2_{t-1}^+ + \sum_{i=0}^{q} \beta_7 \Delta LCO2_{t-1}^- + \sum_{i=0}^{q} \beta_8 \Delta LN2O_{t-1}^+ + \sum_{i=0}^{q} \beta_9 \Delta LN2O_{t-1}^- + \sum_{i=0}^{q} \beta_{10} \Delta AUPG_{t-1}^+ + \sum_{i=0}^{q} \beta_{11} \Delta AUPG_{t-1}^- + \sum_{i=0}^{q} \beta_{12} \Delta FDI_{t-1}^+ + \sum_{i=0}^{q} \beta_{13} \Delta FDI_{t-1}^- + \varepsilon_t \quad (3)$$

The above model in Equation 3, which outlined ECT allows to describe the asymmetry in the economic growth-energy consumption-environmental degradation nexus in combined short and long terms. This feature of the Nonlinear-ARDL modeling is the primary benefit over the techniques of conventional time series. Shin et al, (2014) elucidate that the scientific methodology of Pesaran et al, (2001) in calculating Equation 3 in addition to applying the F-test to study co-integration, are still authentic to be applied and used for Equation 4.In Equation 4 the assessment of θ_2 to θ_{13} conventionalized on θ_1 will apprehend the long-run asymmetric impacts on environmental degradation, as well as in $\sum_{i=0}^{p} \beta_1$ to $\sum_{i=0}^{p} \beta_{13}$ depicting short-run asymmetric shocks. To authenticate long-run asymmetric influence of Y on X, there is need for - $\frac{\theta_2}{\theta_1}$ to be substantially different from - $\frac{\theta_3}{\theta_1}$. In addition, the significance of short run asymmetric requires $\sum_{i=0}^{p} \beta_2$ being dissimilar to $\sum_{i=0}^{p} \beta_3$ for Y, $\sum_{i=0}^{p} \beta_4$ being dissimilar to $\sum_{i=0}^{p} \beta_5$ for X. These can be conducted by applying Wald test, the more negative and positive changes are meaningful, the Equation 4, as cointegration is purported first to be confirmed, the F-statistic test is applied for $H_o = \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = \theta_6 = \theta_7 = 0$ against $H_1 \neq \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq \theta_5 \neq \theta_6 \neq \theta_7 \neq 0$. With notations as ΔGDP_{t-1}^+ ΔGDP_{t-1}^- $\Delta LEPHS_{t-1}^+$ $\Delta LEPHS_{t-1}^-$ $\Delta LFFEC_{t-1}^+$ $\Delta LFFEC_{t-1}^-$ $\Delta LCO2_{t-1}^+$ $\Delta LCO2_{t-1}^-$ $\Delta LN2O_{t-1}^+$ $\Delta LN2O_{t-1}^-$ $\Delta AUPG_{t-1}^+$ $\Delta AUPG_{t-1}^-$ ΔFDI_{t-1}^+ ΔFDI_{t-1}^- respectively

3.4 Diks and Panchenko's nonlinear Causality test

Granger (1969) causation has become out to be an important conception for characterizing confident correlation amidst time series in econometrics and economics fields. For

details about this method refers to Saliminezhad et al., (2021)

4 Analysis of Findings and discussion

To examine the stationary and structural breaks positions of the variables, ADF (1981) (Dickey & Fuller, 1981), PP (1988) (Phillips & Perron, 1988), DF-LGS (1992), and ZA (1992) (Zivot & Andrews, 1992) respectively, were tested using Stata and Eviews and the results shown as displayed in Tables 2 &3, that all the variables are I(1) at conventional 1% and 5% levels of significance. The advantages of Zivot and Andrews test is that; the test is viewed generally as fitting test for the rule of null hypothesis that the order has a unit root. Moreover, renders a unit root result that comprises endogenic structural breaks. The outcomes of the results are displayed in Table 2 & 3. Table 1 displays the description of the variables.

Table 1: Descriptive Statistics of the Variables

	GDP	LCO2	LEPHS	FFEC	LN2O	AUPG	FDI
Mean	6.329	12.125	3.526	17.868	7.697	4.779	1.499
Median	5.971	12.221	3.520	18.799	8.015	4.778	1.191
Maximum	15.329	12.648	4.466	22.845	8.378	5.851	5.791
Minimum	0.061	11.413	2.828	5.968	6.654	4.054	-1.151
Std. Dev.	4.481	0.309	0.420	3.939	0.673	0.526	1.241
Skewness	0.584	-0.325	0.353	-1.563	-0.360	0.369	1.304
Kurtosis	2.337	2.038	2.734	4.949	1.285	2.132	5.582
Jarque-Bera	3.608	2.699	1.140	7.129	6.922	2.594	6.937
Probability	0.165	0.259	0.566	0.116	0.131	0.273	0.101
Observations	48	48	48	48	48	48	48

Table 2: ADF (1981), PP (1988), and DF-GLS (1992)

	ADF		PP		DF-GLS		Integration
Variables	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	
GDPt	-2.366	-13.922*	-4.045*	-	-2.183	-5.078*	I(1)
LCO2t	-1.169	-6.539*	-1.658	-6.547*	-2.703	-3.592**	I(1)
LEPHSt	-1.654	-7.769*	-1.669	-7.670*	-1.853	-3.051***	I(1)
FFECt	-2.563	-6.631*	-2.570	-6.630*	-1.195	-4.288*	I(1)
N2Ot	-1.193	-6.641*	-1.192	-6.640*	-1.472	-4.424*	I(1)
AUPGt	-2.615	-5.395*	-1.761	-6.646*	-1.631	-4.627*	I(1)
FDIt	-4.135*	- -	-4.101*	-	-3.323**	-	I(0)

The obstetric *,** and *** represent 1%, 5% and 10% respectively, ADP, PP, and DF-LGS refers to Augmented Dickey Fuller, Phillips Perron and Dickey Fuller- generalized least squares accordingly

The output shows that all the variables are I(1) in ADF and DF-GLS tests except that of FDI showing I(0), however, in the PP test, GDP and FDI are I(0) while the other variables remain I(1). The results are displayed in Table 2.

Table 3: Zivot and Andrews Unit roots test

T-stat	I(0)	Break Year	I(1)	Break Year	movements	Integration
GDPt	-3.116	1979	-14.070*	2003	Trend	I(1)
LCO2t	-3.115	2011	-6.520*	19982	Trend	I(1)
LEPHSt	-2.372	2003	-5.633*	1984	Trend	I(1)
FFECt	-4.121	1980	-7.467*	1983	Both	I(1)
LN2Ot	-2.569	2002	-7.097*	1983	Trend	I(1)
AUPGt	-2.223	1997	-6.924*	1982	Trend	I(1)
FDIt	-5.444*	1989	-	-	Intercept	I(0)

The obstetric *, represent 1%

Considering the weak position of traditional unit roots tests to display structural breaks usually found in time series data, due to multiple random shocks on economic, financial, and energy series. This insinuated that the outcomes of diverse traditional tests are bias. Therefore, we applied structural breaks test by (Zivot & Andrews, 1992) to meet up with challenge in the other traditional tests methods. This test makes it easy to display some essential changes over time in the variables. The output is displayed in Table 3 with break dates and conditions of the stationarity of the variables all at I(1) except FDI which shows I(0) stationarity level.

Table 4: NARDL Bound Test Results

NARDL F-bounds test statistics		**Null hypothesis: no levels relationship**						
		Significant	**Level**	**1st Diff**	**Serial-corr**	**Heterosk**	**Cusum**	**Cusum Sq**
F-Stat	9.487*	1%	2.54	3.86	2.401(0.1470)	1.096(0.449)	Stable	Stable
K	12	5%	2.06	3.24		R^2 32.55(0.391)		
		10%	1.83	2.94				

The * represent 1% significant level

Table 5 above displayed the NARDL bounds test output, showing the computed values of F-statistics from the model, is greater than critical values of it upper bound value of

(Narayan, 2005; Pesaran et al., 2001) accordingly using constant without trend and become significantly and statistically at 1% level. This signified the existence of long-run relationship among the series and becomes an alternative for examine the existence of long-run correlation. It's debated that if ECM (error correction model) lagged value bear negative and statistically significant, it confirmed the flow of the long run correlation (Pesaran et al., 2001).

Table 5: Bootstrapping-ARDL approach of (McNown et al., 2018)

Bounds testing approach to cointegration						Diagnostic tests		
Estimated models	Lag	Break	F_{PSS}	T_{DV}	T_{IV}	Q-Stat	LM (2)	JB
GDP= f (FDI, AUPG, LN2O, LEPHS, FFEC, LCO2)	(3, 1, 1, 3, 1, 2)	2001	11.38**	-4.65**	-2.15*	7.63	1.01	3.53

Notes: ** and * indicate significantly at the 0.05 and 0.1 levels, respectively, based on the critical values generated by the bootstrap procedure (999 iterations). Akaike information criterion (AIC) is used for selecting the optimal lag lengths. F_{PSS} is the F-statistic based on the asymptotic critical bounds that are sourced using the bootstrap technique, T_{DV} and T_{IV} are t-statistics for the dependent and independent variables. The *LM* and *JB* refer to the Lagrange Multiplier test and the Jarque-Bera test, respectively.

As a robust for the cointegration results to confirm the validity and fitness of the result from bounds tests, a bootstrap ARDL test was conducted, the empirical findings for the bootstrap ARDL reported in the above Table 5, indicating that the null hypothesis of no co-integration can be rejected based on the statistics represented by the F and t-tests for the lagged dependent and independent variables. This supports the presence of a long-run equilibrium co-integrating association.

The diagnostic tests highlight the robustness of the obtained results. We fail to reject the null of serial correlation using the Breusch-Godfrey LM test, indicating the independence of each observation for each variable. The normal distribution is documented using Jarque Bera (JB) test statistics. The evidence of non-rejection of Q-statistics validates that the variables are all independently distributed and, therefore, residual would be white noise. Based on this result of bootstrap, long and short-run estimation becomes essential

Short-Run and Long-Run Asymmetric using Stepwise Regression

With establishment of long run correlation amongst the series (variables), the researchers proceed in estimating long and short run coefficients applying OLS regression approach on equation 3.

Table 6: Short-run Asymmetric NARDL using Stepwise Regression

Var.	Coeff.	S.E	P
ECM_{t-1}	-1.002	0.130	0.000*
$\Delta GDP^{(-1)}$	0.447	0.073	0.000*
$\Delta FFEC^{N(-1)}$	1.115	0.285	0.001*
$\Delta AUPG^{P(-1)}$	-6.898	1.512	0.000*
$\Delta LEPHS^{N}$	19.858	5.060	0.001*
$\Delta GDP^{(-2)}$	0.181	0.068	0.012**
Diagnostic Tests			
B-G LM-Test	F 0.045 (0.957)	R.SQ 0.159 (0.922)	
Heteroskedesticity	F 0.817 (0.662)	R.SQ 15.285 (0.575)	
Ramsey RESET Test	F 1.019 (0.322)	-	
ARCH	F 0.053 (0.819)	R.SQ 0.056 (0.813)	

Note: Var., Coeff., S.E., P, represents Variables, coefficient, standard errors, and probability values. The abstric * and ** denotes to 1% and 5% significance levels respectively

Tables 7 and 8 displayed the results of short-term and long –term asymmetric NARDL. The result shows, that energy source, and urban population growth have short-run influence to economic growth. And ECM (error correction model) is statistically significant at 1%, this implies that at 1% previous errors can be address 100%, equally in the short–term economic growth as represented by GDP at lag 1 can influence itself by 44.7% at any point of time when GDP is affected by 1% changes. The negative effect of Fossil fuel energy consumption ($\Delta FFEC^{N(-1)}$) is positive and statistical significance at 1%, which mean 1% change a fossil fuel usage will negatively influence economic growth of Nigeria by 111.5%. In the case of positive effect of urban population growth ($\Delta AUPG^{P(-1)}$) lag one, is negative and statistical significance at 1% level. This by implication 1% increase in urban population annually has negative influence to economic growth at -689.8%. On renewable energy, only negative effect of electricity production on hydropower source ($\Delta LEPHS^{N}$), is positive and significance at 1%. This implies that, economic growth can be influence as a result of 1% reduction in the application of hydroelectricity as a means for productivity in Nigeria by 1985.8%. This finding contradicted the finding of (Baz, Cheng, Xu, Abbas, Ali, & Ali, 2021) who established negative influence from the negative shocks of renewable energy in Pakistan

Table 7: Long-run Asymmetric NARDL using Stepwise Regression

Var.	Coeff.	S.E	P
C	15.916	1.589	0.000*
$LCO2^{P(-1)}$	23.838	7.045	0.002*
$LCO2^{N}$	-25.215	12.590	0.055**
FDI^{P}	0.808	0.304	0.013**
$FDI^{N(-1)}$	0.752	0.306	0.021**
$AUPG^{P(-1)}$	11.824	7.778	0.000*
$AUPG^{N(-1)}$	0.309	0.237	0.815
$LN2O^{P(-1)}$	-0.413	3.032	0.893
$LN2O^{N}$	-9.343	56.545	0.870
$LEPHS^{P(-1)}$	-16.715	2.894	0.000*
$LEPHS^{N(-1)}$	15.054	3.590	0.000*
$FFEC^{P(-1)}$	-1.377	0.379	0.001*
$FFEC^{N(-1)}$	-0.474	0.141	0.002*

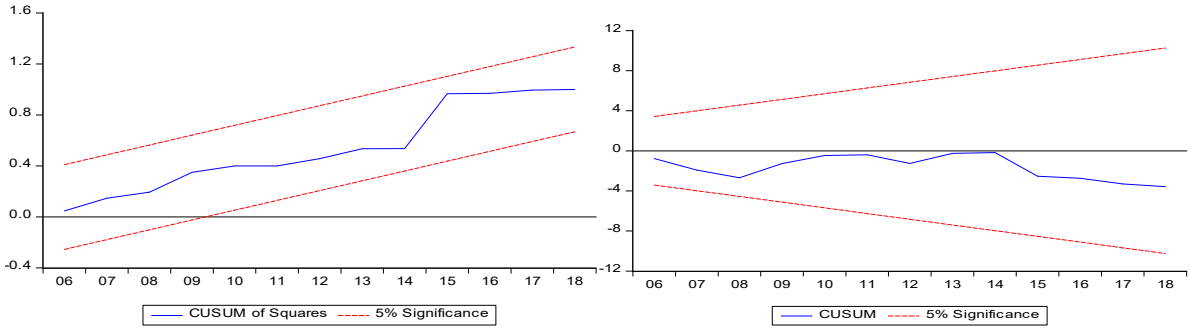
Note: Var., Coeff., S.E., P, represents Variables, coefficient, standard errors, and probability values. The signs * and ** denotes to 1% and 5% significant levels respectively

However, in the long-run, the relationship between environmental degradation is best established with carbon dioxide emission, which displayed asymmetric relationship between the two variables, while nitrous oxide emission shows symmetric relationship with economic growth in Nigeria. The positive effect of $LCO2^{P(-1)}$ lag one is positive and statistically significance at 0.002%, this mean that, 1% increase in carbon emission will leads to the increase in economic growth of the country by (coeff 23.838). This finding corroborates the findings of (Rahman, 2017; Rahman et al., 2020) as productivity growth require for fuel and gas, coal, and electricity which induces CO2 emissions. As a result, emissions of CO2 are inevitable for the purpose of economic growth. However, the negative effect of $LCO2^{N(-1)}$ lag one, is negative and statistically significance at 5% with (coeff -25.215), this implies that, 5% decrease in $LCO2^{N(-1)}$ which leads to the increase in economic output of Nigeria by 252.15% in the long run. in the case of foreign direct investment, positive effect of FDI^{P} is positive and significance at 5%, therefore, 5% increase in FDI will leads to an increase in economic growth of Nigeria by (coeff. 0.808) while negative effect of $FDI^{N(-1)}$ is negative and significance at 5%, this means that, 5% decrease in FDI in Nigeria will cause the reduction of economic growth by (0.752) this equally displayed asymmetric relations and corresponded with result of

(Baz, Cheng, Xu, Abbas, Ali, Ali, et al., 2021) in Pakistan. Considering population growth as represented by Annual urban population growth, shows positive and negative effects of ($AUPG^{P(-1)}$, $AUPG^{N(-1)}$) lag one, are all positive and significance on the positive effect at 1%. This explained that, 1% annual increase in urban population growth influence economic growth of the country by (11.824) while the negative effect is insignificance, by implication the relationship is asymmetric. Nitrous oxide emission displayed symmetric correlation to economic growth of Nigeria by showing insignificance to the economic growth. In the case of renewable energy, which represented by electricity production using hydropower source, shows that, positive effect of $LEPHS^{P(-1)}$lag one, is negative on economic growth as a dependent variable, and significance at 1%. This implies that, increase in energy production via hydropower in Nigeria will leads to decrease in GDP by (-16.715) and negative effect of $LEPHS^{N(-1)}$ is positive and significance at 1%, this implies that a decrease in the energy production via hydropower in Nigeria by 1% will cause decrease in GDP by (15.054). This finding corresponded with finding of (Baz, Cheng, Xu, Abbas, Ali, & Ali, 2021) in Pakistan and opposed the result of (Jafri et al., 2021) who studied similar variables, and their findings shows positive shocks of renewable energy sources has positive effect to GDP and negative effect of renewable energy source negatively and significantly influence economic growth of Pakistan. on nonrenewable energy sources in Nigeria, as proxy by fossil fuel energy consumption, the output shows that, positive and negative effects of $FFEC^{P(-1)}$, $FFEC^{N(-1)}$ lag one, are all negative and significance at 1% each. These means, 1% increase in the consumption of fossil fuel as a mean of energy source, will leads to the decrease in the economic advancement of Nigeria by (-1.377) while the negative effect indicated that, 1% decrease in the consumption of fossil fuel will leads to an increase in the economic growth by (-0.474). In summary, the out long-run asymmetric shows that, all the variables exhibit asymmetric correlation to economic growth except Nitrous oxide emissions which shows symmetric correlation to economic growth while in the short-run, renewable and nonrenewable energy, and urban population growth display significance relationship to

economic growth via positive and negative effects.

Figure 1: CUSUM-Squares and CUSUM



The coefficients stability is determined via the CUSUM and CUSUM Sq, and the significant value pass through the limits of 5% level and analysis remains stable as shown in figure 1 above.

Table 8: Diks and Panchenko's nonlinear test results

Nexus Setting		*Inferences*
AUPG ↛ GDP 1.36**	GDP ↛ AUPG 0.29	Unidirectional
FDI ↛ GDP 2.34**	GDP ↛ FDI 0.18	Unidirectional
FFEC ↛ GDP 0.69	GDP ↛ FFEC 1.21*	Unidirectional
LCO2 ↛ GDP 1.78**	GDP ↛ LCO2 -0.89	Unidirectional
LEPHS ↛ GDP 1.58**	GDP ↛ LEPHS 1.42*	Bidirectional
LN2O ↛ GDP 0.89	GDP ↛ LN2O 0.77	None

Note: ↛, symbolizes no causal linkge. Results are obtained using a bandwidth of 0.532. The number is cells stand for the corresponding test statistic. **, and * indicate significance levels of 5% and 1%, respectively.

The above Table presents the result of Diks & Panchenko (2006) nonlinear causality relationship among economic growth, energy sources, environmental degradation, population growth and foreign direct investment. The results of the test indicate a single feedback link between economic growth and renewable energy, with hydropower production in Nigeria causing economic growth at a 10% (0.062) p-value and economic growth causing it at a 1% (0.009) p-value. This suggests that both factors are determined together and have a simultaneous impact on one another. The conclusions of Marinaş et al. (2018) who looked at 10 CEE (ten Central and Eastern European) economies, were supported by the discovery. The outcome similarly showed four unidirectional causality pathways. Economic growth is influenced by factors such as foreign direct investment, environmental deterioration (CO2 emissions), and population expansion (annual urban population growth). The "conservation hypothesis," which states that the conservation policies of urban population growth, foreign direct investment, and CO2 emission in Nigeria can be achieved with no or little antagonistic influence on economic growth, states that economic growth also causes nonrenewable energy. This suggests that restricting Nigeria's use of fossil fuel energy may have a negative impact on its GDP and encourage further energy additions, which in turn stimulate economic growth. The "neutrality hypothesis" between the two variables was supported because no causal link flows between economic growth and environmental deterioration (as measured by nitrous oxide emissions) in Nigeria were found.

5 Conclusion and policy recommendations

This study aims to investigate the asymmetric impact of energy sources (renewable and nonrenewable), as well as environmental deterioration, on Nigeria's economic development. In order to give us more alternatives for making policy recommendations, the study also included certain crucial variables as explanatory variables. The structural break unit root test of Zivot-Andrews' as well as three conventional stationary test methods were investigated, to establish the co-integration relationship between the variables; the asymmetric co-integration method was also

used. Additionally, the causality technique (Diks & Panchenko, 2006) was used to ascertain the causal relationships between the variables.

The results of this investigation supported the existence of asymmetries for the variables under consideration in both the short and long terms. Surprisingly, Nigeria's energy sources showed an asymmetrical impact on economic growth at all levels (short and long periods) for both positive and negative effects. Similarly, considering the favorable impact of CO2 emissions on economic growth in Nigeria, our findings are not unexpected. It is important to emphasize that many academics and decision-makers advocate for prioritizing global climate reductions by reducing CO2 emissions while maintaining healthy environmental conditions, regardless of developmental level. The results compelled us to make the suggestion that government officials and policymakers pay close attention to the cause(s) of how growing the use of hydropower for renewable energy sources is lowering the nation's productivity. Given that the generation of renewable energy, including hydropower sources, has a favorable effect on foreign direct investment in some economies with characteristics similar to Nigeria (for instance, Pakistan), the executive arm of government should create an environment that encourages foreign investors to invest in various sectors of the economy.

To achieve long-term sustainable economic growth, all decision-makers and governments in developing economies should routinely consider foreign investment. The performance of Nigeria's economic growth will be impacted by a decrease in the utilization of nonrenewable (fossil fuel) resources. In light of these realities, legislative bodies should establish policies that encourage the transition from nonrenewable to renewable energy sources and address trade imbalances and environmental degradation. Similar to this, the government of Nigeria should exercise caution and discernment in addressing the proper application of energy in a variety of industrial methods. In especially for the case study of Nigeria, this research suffered the same limitations as other studies have in the past. By using both linear and non-linear methodologies, more focus is needed on the study of the renewable energy-growth nexus, particularly hydroelectric sources of energy. Additionally, the impact of each renewable

energy source—wind, solar, and nuclear—on economic expansion can be studied separately. This will make it possible to decide clearly which of them is more useful in the Nigerian situation.

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