SSR
Social Science Review, Volume 3 (Issue No. 2), 197-204. August-December, 2024

Carbon-dioxide Emission and Economic Growth: Var Model

John Ikechukwu Okpara and Harrison Eromosele
Department of Economics, Federal University Otuoke, Bayelsa State, Nigeria

Abstract
The study investigates carbon-dioxide emission and the growth of the economy of Nigeria considering the variables like; gross domestic product growth, population growth, access to electricity, carbon-dioxide emission and renewable energy consumption. The Vector Autoregressive model was used to examine the link between the dependent variable (GDP growth) and the independent variables (renewable energy consumption, access to electricity, carbon-dioxide emission and population growth); which were sourced from the world bank data base. The data analyzed showed that the granger causality relationship that exists between all the independent variables: Access to electricity, population growth, renewable energy consumption, and carbon dioxide emission. The study recommends that the policymakers should initiate environmental policies in order to promote economic growth in Nigeria, through reducing carbon pollution. Besides, the population growth that increases which increase emission of carbon emission should be effectively checked through the advocacy and encouragement to the use of renewable energy sources.

Keywords: Carbon-dioxide Emission, Access to Electricity, Population Growth, Renewable Energy Consumption, GDP Growth.

Introduction

The changes experienced in climate as a result of carbon-dioxide emission affects productivity level and improvement in the country. The use of fossil fuel that causes the emission of carbon-dioxide reveals that the economy does not use more of renewable energy sources, has a large population which improves the economy of a nation or retards growth of that nation (Abiodun, 2012). The emission of carbon-dioxide has been on the increase in Nigeria for decades irrespective of the efforts that government has put in the reduction of carbon emissions (Ameyaw & Yao, 2018). Gross Domestic Product gross is important in determining the improvement of both the developed and growing economy, because it is used to show if the economy as achieved increased output over time. Growth of the economy for developing nations and Nigeria in particular fluctuates due to variations in currencies, governance short comings, recession and the changes in the prices of oil (World Development Indicators, 2021). This is why so many economies like that of Nigeria embarked on a medium-term plan to help improve the growth of the economy just like the Economic recovery and growth plan of 2017 which was initiated to generate employment thereby reducing unemployment.

Economic growth is the desire of every economy, because it enhances the solving of challenges faced as nation, but increase in carbon dioxide emission can be attributed to the independent variables that are listed in this study although; carbon-dioxide emission causes environmental hazards thereby reducing production and economic activities in the long run (Muftau, 2014). Nigeria is the ahead of other Sub-Saharan countries when it comes to the usage of non-renewable energy from fossil fuel consumption due to the abundance of crude oil that is domiciled in the country and its exportation of crude oil amounts to over 80% of the national earnings especially from the oil and gas sector (Akpan, 2012).

According to Usman (2009), concerns around is towards the sustained availability and use of fossil fuel springs such as oil, natural gas and coal that increases the carbon-dioxide emission, which are attributed to the high demand for cheap and sustainable source of energy globally. In line with a source cited by Olaniyi (2017), Nigeria is believed to be deficient in supply of power, with some off-grid regions that Nigerians are residing without contact to electricity are over 40% of the entire population. Ohiare (2015), trusting on data by the International Energy Agency (2013) noted that in 2013, Nigeria provided not any contact to electricity to about 42% of her people that lived in the

civilized-urban and the rural communities. Oyedepo (2012) states that Nigeria's crisis in the energy sector has led to the disability of the manufactural and other activities, with epileptic power supply which leads to a loss of resources in an annual basis (Council for Renewable Energy Nigeria (CREN), 2009). In the rural areas of Nigeria, there appears to be an absence of clear electrification tactics (Ohiare, 2015). Tests of the electricity market in the country Nigeria include slow increase of capacity generation, meddling by administration in the deregulating procedure of the power market, wreckage of electrical broadcast lines and delivery apparatus, inadequate maintenance of facilities that are existing among others negatives in Nigeria power sector (Olugbenga, 2013).

The controlled access to fuel for conformist generation in the country need that another fronts of generation of power, mostly energy sources that are renewable, be explored (Energy Commission of Nigeria (ECN) and United Nations Development Program (UNDP, 2005). Hence Nigeria ought, as a matter of importance follow up in the quest for neater, diverse and sustainable energy blend (Olugbenga, 2013. The reposition of renewable energy which is viewed as the main driver for sustainable economy, the need arises for alteration towards the future energy blend towards sustainable and renewable energy sources (United Nations Conference on Trade and Development, 2010). In the mist of other strategies are the energy policies harmonization to improve access to workable energy that is renewable in developing countries like Nigeria are faced with many challenges.

There is the necessity to blend and place in an appropriate policy of energy that is hinged on the detail that developing countries, often features by ineffective governance, struggle to create power that would stimulate economic growth. Usman (2009) explained in his study on rural solar electrification in Nigeria: Energy that is renewable holds potentials and distribution for rural development, the importance of reduction of carbon-dioxide emission in Nigeria. Energy policy has to lead to sustained power generation, and this also generates job openings. The importance that Energy plays cannot be overemphasized due to the role it plays in economic development (like in the reduction of poverty through better energy access) (Kanagawa & Nakata, 2007, 2008). Importance of energy generation and access is revealed further that 'per capita energy consumption' is a means of the per capita income and a means of the success of a nation. Therefore, the gain of sustainable development in developing countries needs intensive efforts to offer effective and steadfast electricity systems. The remaining of this paper is in this structured: literature review followed by method and data is in section three, result and discussion is in section four and the concluding part is the conclusion, followed by recommendation in the fifth section.

Literature Review

Theoretical Review

The underpinning theory that this work anchors on is Solow`s neoclassical theory of growth of the economy, that the technological progress as considered as necessary being the enduring factor that explains growth in a long-term. For the purpose of this study, we adapt the work by Bekar (2018) which hypothesize that the reaction of the independent variables causes the change that is experienced in the dependent variable. Scholars, argued the CO2 emission as a major effect to the growth of the economy (Jammeh, 2022). Some determinants of growth of an economy as cited in the work are FDI, Trade openness, Domestic Credit and Gross fixed capital formation. The variables are linked theoretically with dependent variable (Ejuvbekpokp, 2014; Mesagan, 2015).

Conceptual Review

Growth of an Economy is an upsurge in the productive process of economic services and goods, from one period in view to another period. Growth of an Economy can be procedures as real and/ or nominal. This study measured the economic growth in nominal terms (Mesagan, 2015). From another perspective, emissions like C02 emission are emissions that stems from the fiery burning of coal, natural gas and oil. These emissions are measured from the burning's fossil fuel like; coal, oil, natural gas and wastes for use in the generation of energy (Akpan & Akpan, 2012). Although, the annual growth of the GDP is the percentage growth rate of gross domestic product based on local

currency. Whereas, annual population growth in percentage is the population advance rate for a year is the multiplied in many folds considering mid-year population from one year to another, expressed as a percentage (Olaniyi, 2007). Population is based on the original definition of population, that numbers of a particular community irrespective of legal status (WDI, 2023). Renewable energy consumption (% of total final energy consumption): Energy consumption of renewables are the share of energy (Jammeh, 2022).

Empirical Literature Review

Some studies are limited on the impact/ effect of C02 emissions, renewable energy consumption, population growth and access to electricity on GDP growth. Studies that are existing, focuses on the inter-relationship between emissions of C02 and growth of the economy are geared towards the determination of the performance of the economy. Akpan and Akpan (2012) used the method called the multivariate vector error correction to judge the long run and relationship between consumption of electricity in Nigeria between 1970 to 2008. The result of the analysis reveals that, economic growth is significantly positively associated when you consider the emissions carbon dioxide. Mesagan (2015) in his study, the relationship that exist carbon emission and growth of the economy from 1970 to 2013 using the mechanism of error correction. The result show/ reveals that growth of the economy has a positive influence on carbon emission in the country.

Ejuvbekpokp (2014) assessed the impact of carbon emissions on growth domestic product from 1980 through to 2010 using Ordinary Least Square method of analysis and realized that carbon emission has negative effect on growth of the economy in Nigeria. Chindo (2015) did a study on the association that exist between consumption of energy, emission of CO2 and gross domestic product with the use of ARDL method of data analysis between 1970 to 2010 informing that, CO2 emissions was found to have a positive impact on the growth of the economy. In the study by Alege (2017) it was exposed that surge in CO2 emissions has a encouraging and important outcome on the economy which assessed the performance of carbon dioxide emissions to diverse macroeconomic variables/ key factors influences, with the aid of structural vector autoregressive between 1981–2015 years.

Gambo (2018) assessed the relationship of consumption energy, its emissions and growth of the economy between the 1970–2014 with the aid of Autoregressive Distributed Lag Model; through the result, gross domestic product is reduced as a result of CO2 emission in the Nigerian context. Bekar (2018), also studied the carbon-dioxide emission and its effect on the economy of Turkey. Musibau, Shittu and Ogunlana (2020) examined the connection environmental degradation, energy use and economic growth in Nigeria between 1981 and 2014, with the aid of non-linear ARDL and the study showed that CO2 increases GDP in Nigeria. Shah (2022) in his own research, used the restricted cointegration analysis to figure cointegration relationship among financial development and GDP in the Pakistani economy. Revealing that financial growth leads to economic growth in the long run through indirect or direct means, during the period 1970 to 2020. Also, Jammeh (2022) studied the relationship between local acclaim to the private sector, financial improvement and gross domestic production in countries like Gambia between the years 1967 till 2020 with the aid of VAR approach, reaching the findings that financial improvement has an impact on growth of the economy. The literature as reviewed, used different determinants of growth in analysiing but none of the studies examine the impact of carbon dioxide emission on the GDP growth in Nigeria between the period of 1990-2023.

Methodology

This study used ex post facto design and annual data from 1990 to 2023 which was sourced from WDI to examine carbon-dioxide emission and its effect on the growth of the economy, Nigeria.

The model specification is:

$$GDPG = f(AE, POPG, CAE, RENC \quad (1)$$

$$GDPG = \beta0 + \beta1AE + \beta2POPG + \beta3CAE + \beta4RENC \quad (2)$$

Where: The Gross Domestic Product growth is GDPG) is dependent variable and access to electricity is AE), population growth is POPG, carbon-dioxide emission is CAE, and renewable energy consumption is RENC are the independent variables. The method employed for the estimation of the data was the Vector Autogressive Model (VAR). Several benefits exist with this approach that may be in contrast with other methods in areas like; g is the independent variables ranger causality relationship between the independent variables, the lag length structure, VAR stability condition, residual diagnostics and the autocorrelation test. The VAR method can be employed of the order of integration of the series, I(0), I(1) and I(2) (Zakari & Umar 2020). In addition, the technique can be used even if the samples size is small (Abu & Staniewski, 2019; Umar & Zakari, 2020).

Data Analysis and Results

Table 1. Unit Root test result (Stationarity)

	GDPG	POPG	AE	RENC	CAE
@ level I(0)	-3.73559 (ADF t-stats)/ -2.95402 (5% critical value)				
@ 1st Diff I(1)			-5.541330 (ADF t-stats)/ -2.967767 (5% critical value)		-5.570008 (ADF t-stats)/ -2.957110 (5% critical value)
@2nd Diff I(2)		-4.476812 (ADF t-stats)/ -2.971853 (5% critical value)			

Source: Authors' Computation

The table below shows that AE at lag 2 has a positive significant effect on itself, with a coefficient of 0.36. however, other variables like CAE, POPG and RENC do not have a significant effect on AE. Whereas CAE is significantly influenced by its own past values. Specifically, CAE (-1) has a positive and significant effect with a coefficient of 0.963, while other variables (AE, POPG, RENC) show no significant impact. Population growth is mostly affected by its own past values, especially POPG (-1) which has a highly significant positive effect (coefficient= 1.482). CAE and AE show no significant impact on population growth. Lastly, renewable energy consumption is influenced by its own past values but not significantly by other variables like AE, CAE and POPG. These results show a strong autoregressive behaviour in all the variables, where each variable's past values are the main drivers of their current levels, with little interaction among them.

Table 2 (VAR Result)

	AE	CAE	POPG	RENC
AE(-1)	-0.004489	-9.05E-05	0.002070	0.028665
	(0.21978)	(0.00500)	(0.00244)	(0.13299)
	[-0.02043]	[-0.01809]	[0.84865]	[0.21555]
AE(-2)	0.336403	-0.001976	-0.000736	-0.018928
	(0.16592)	(0.00378)	(0.00184)	(0.10040)
	[2.02746]	[-0.52290]	[-0.39954]	[-0.18853]
CAE(-1)	-45.15433	0.962815	0.110024	-2.726130
	(16.0463)	(0.36542)	(0.17808)	(9.70958)
	[-2.81400]	[2.63484]	[0.61783]	[-0.28077]
CAE(-2)	16.02677	-0.346287	-0.034024	8.912700
	(14.7081)	(0.33494)	(0.16323)	(8.89981)
	[1.08966]	[-1.03387]	[-0.20844]	[1.00145]
POPG(-1)	-4.271431	-0.295715	1.481912	1.458759
	(17.6812)	(0.40265)	(0.19623)	(10.6989)
	[-0.24158]	[-0.73443]	[7.55208]	[0.13635]
POPG(-2)	-1.659139	0.156776	-0.549531	-0.875224
	(17.3608)	(0.39535)	(0.19267)	(10.5050)
	[-0.09557]	[0.39655]	[-2.85219]	[-0.08332]
RENC(-1)	-1.420362	0.015852	0.006638	0.612443
	(0.64116)	(0.01460)	(0.00712)	(0.38796)
	[-2.21531]	[1.08569]	[0.93284]	[1.57861]
RENC(-2)	0.868327	-0.005621	-0.002023	0.114205
	(0.65432)	(0.01490)	(0.00726)	(0.39593)
	[1.32707]	[-0.37722]	[-0.27858]	[0.28845]
C	114.7037	-0.149435	-0.330522	16.60500
	(54.4891)	(1.24086)	(0.60472)	(32.9712)
	[2.10508]	[-0.12043]	[-0.54657]	[0.50362]

Source: Author's computation

Table 3 Var Lag Order Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-92.90219	NA	0.005016	6.056387	6.239604	6.117118
1	18.38818	187.8025*	1.31e-05*	0.100739*	1.016824*	0.404395*
2	30.22533	17.01590	1.79e-05	0.360917	2.009870	0.907498

Source: Author's computation

The Table 2 shows that the lag length structure in the VAR model was determined using several criteria with the following insights; the log likelihood ratio (LR) chose lag 1 as the optimal lag length while the final prediction error (FPE) also selected lag 1, indicating that this lag minimizes forecast errors. The Akaike information criterion (AIC) and the Hannan Quinn Criterion (HQ) preferred lag 1 as well and so did the Schwarz Criterion (SC) is slightly higher but still preferred lag 1. This suggests that including lag 1 is sufficient for the VAR model.

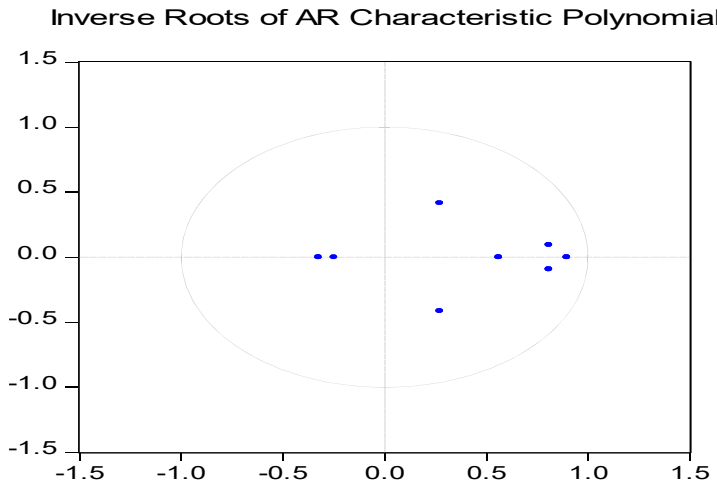

Fig. 1: Var Stability Condition

The Fig. 1, the VAR stability condition test shows that the model meets the stability condition, as all inverse roots lie within the unit circle, indicating that the VAR system is stable and suitable for analysis. From the LM results, for all lags tested (up to lag 4), the p-values are greater than 0.05, meaning that we fail to reject the null hypothesis; which indicates that the residuals do not exhibit serial correlation. The lack of serial correlation suggests that the VAR model is correctly specified and that the results are reliable for interpretation. In the table below, the VAR model is checked for serial correlation between the residuals at different lags and based on the result, for each lag (up to lag 4), the p-values for the LRE* stat and the Rae F-Stat are all greater than 0.05, indicating that the null hypothesis of no serial correlation therefore cannot be rejected. This implies that there is no significant autocorrelation in the residuals across the lags. The absence of autocorrelation confirms that the residuals are white noise, ensuring that the VAR model is properly specified.

Table 5 VAR Residual Serial Correlation LM Tests

Lag	LRE* stat	Df	Prob.	Rao F-stat	Df	Prob.
1	16.13152	16	0.4438	1.022312	(16, 49.5)	0.4508
2	10.33281	16	0.8487	0.620839	(16, 49.5)	0.8516
3	18.87402	16	0.2753	1.227022	(16, 49.5)	0.2820
4	15.99731	16	0.4531	1.012547	(16, 49.5)	0.4601

Lag	LRE* stat	Df	Prob.	Rao F-stat	Df	Prob.
1	16.13152	16	0.4438	1.022312	(16, 49.5)	0.4508
2	27.66757	32	0.6857	0.824836	(32, 45.8)	0.7137
3	58.64874	48	0.1395	1.271559	(48, 32.9)	0.2360
4	87.23323	64	0.0284	1.385904	(64, 17.9)	0.2237

Source: Authors' Computation

Causality Test Result

The causality test results assess whether one variable can predict another. From the chi-square statistics (10.44, p-value = 0.0054) indicates that CAE granger causes AE, meaning that CAE can predict changes in AE. While when considering POPG and RENC; the population growth and renewable energy consumption do not significantly predict AE (p-values= 0.5221 and 0.0780,

respectively). Other relationships show no significant granger causality, meaning that most variables do not predict one another except for CAE- AE relationship.

Conclusion and Recommendations

The study used the examines the effect of carbon-dioxide and on the growth of the Nigerian economy. From the result from the analysis, the positive significant relationship exists between access to electricity and carbon dioxide emission. The CAE, POPG and RENC does not have a significant effect on the present AE (the influence of AE is in no way caused by carbon-dioxide emission, population growth and the renewable energy consumption in the nation). The CAE results showed that previous actions constituted carbon-dioxide emission in Nigeria; the 96% of the entire carbon-dioxide emission affect the economy, whereas other independent variables do not affect significantly the emission of carbon within the period of this study. Finally, only the CAE granger cause the reaction of the AE in the study while other variables do not influence the actions of each independent variable taken as a dependent variable at each time. This study established that the generation of electricity through different channels can cause lower level of emission of carbon-dioxide because energy through renewable energy sources reduces carbon emission and vice versa. The study recommends that the policymakers should initiate environmental policies in order to promote economic growth in Nigeria, through reducing carbon pollution. Besides, the population growth that increases which increase emission of carbon emission should be effectively checked through the advocacy and encouragement to the use of renewable energy sources.

References

Abiodun, O. (2012). Review of renewable energy sources in Nigeria - security and challenges. *International Journal of Advanced Renewable Energy Research*, 5(10), 20-32

Akpan, G. E., & Apkan, U. F. (2012), Electricity consumption, carbon emissions and economic growth in Nigeria. *International Journal of Energy Economics and Policy, 2*(4), 293-308.

Alege, P. O., Oye, Q., AduO. O., Amu, B., & Owolabi, T. (2017). Carbon emissions and the business cycle in Nigeria. *International Journal of Energy Economics and Policy, 7*(5), 1-8.

Ameyaw, B., & Yao, L. (2018). Sectoral energy demand forecasting under an assumption-free data-driven technique. *Sustainability 10* (7), 2348–2367.

Bekar, S. A. (2018) The relationship between co2 emission and economic growth in Turkey: 1977-2011. UluslararasıİktisadiveİdariİncelemelerDergisi, 193-206. Central Bank of Nigeria. (2022).

Central Bank of Nigeria Annual Statistical Bulletin. Abuja: Central Bank of Nigeria.

Chindo, S., Abdulrashid, A., Waziri, S. I., Huong, W. M., & Ahmed, A. A. (2015). Energy consumption, CO2 emissions and GDP in Nigeria. *Geojournal, 80*(3), 315-322.

Ejuvbekpokpo, S. A. (2014). Impact of carbon emissions on economic growth in Nigeria. *Asian Journal of Basic and Applied Sciences, 1(*1).

Gambo, S., Ishak, S., Ismail, N., & Idris M. M. (2018). Energy Consumption, Environmental Emissions and Economic Growth: An Empirical Analysis in Nigeria. *Journal of Humanities and Social Science, 23*(2), 11-22.

Jammeh, I. Y. (2022). The Relationship between Domestic Credit, Financial Development and Economic Growth in the Gambia. *International Journal of Social Sciences Perspectives, 10*(2), 43-60.

Mesagan, E. P. (2015). Economic growth and carbon emission in Nigeria. *The IUP Journal of Applied Economics, 14* (4), 61-75.

Mesagan, E., & Olunkwa, C. N (2020). Energy consumption, capital investment and environmental degradation: The African experience. March 2015. DOI: 10.23762/fso_Vol8_no1

Muftau, O., Iyoboyi, M., & Ademola, A. S. (2014). An empirical analysis of the relationship between CO2 emission and economic growth in West Africa. *American Journal of Economics, 4* (1), 1-17.

Ohiare, S (2015). Expanding electricity access to all in Nigeria: A spatial planning and cost analysis. *Energy, Sustainability and Society, 5*(1).

Olaniyi, A.K (2007). Biofuels opportunities and development of renewable energies markets in Africa: A case of Nigeria. Centre for Jatropha Promotions & Biofuels (CEJAB).

Olugbenga, T. K (2013). The current and future challenges of electricity market in Nigeria in the face of deregulation process. *International Journal of Engineering Research, 1*(3), 33-39.

Oyedepo, S.O (2012). Energy and sustainable development in Nigeria. The way forward. *Energy, Sustainability and Society, 2*, 15.

UNDP (2005). The energy challenge for achieving the millennium development goals.

Usman, M., (2009). Rural solar electrification in Nigeria: Renewable Energy Potentials and Distribution for Rural Development, Centre for Energy and Environment.

World Bank (2021, 2022). World Development Indicator.