# Carbon Emission and Economic Growth in Nigeria: Toda-Yamamoto Causality Approach

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***Abstract***

*Environmental pollution has been neglected in literature especially in developing countries like Nigeria. Carbon emission is a great source of environmental pollution. Thisposes a great challenge to economic growth in Nigeria. There has been controversy if carbon emission leads to economic growth or if economic growth leads to carbon emission. Therefore, this study examined the effect of carbon emission on economic growth in Nigeria and also determined the direction of the relationship using the Toda Yamamoto Approach. Annual time series data between 1981 and 2020 were employed. The dependent variable is economic growth (Y), the independent variables includes, carbon emissions (CO2), energy consumption, capital (K), and labour (L). Unit root result shows that the variables are stationary after first differencing. The cointegration result indicates there is long run relationship among the variables. Toda Yamamoto causality shows there is a bi-directional causality between economic growth and carbon emissions in Nigeria. Also, the study finds that carbon emission (CO2) had positive and significant effect on economic growth in Nigeria. The study recommends that the effect of carbon emission should not be neglected due to environmental hazard caused by it. Therefore, the government/non-governmental organizations should increase awareness on the effect of carbon emission and* *encourage eco-friendly technology to drive economic activities so that it can lower carbon emissions in the long run.*

***Keywords:*** *Carbon emissions, Economic growth, Nigeria, Toda-Yamamoto causality.*

## Introduction

Carbon emission is a major cause of environmental pollution. These pollution leads to global warming and climate change problem. These are detrimental to the existence of the world and hence, calls for attention. Energy consumption is the major source of carbon emission. The importance of driving economic activities through energy consumption cannot be over emphasized. According to Ekpo (2013), energy consumptionis prerequisite in the component of the production function just as how important is the labour and capital. This implies the higher the consumption of energy the more economic activities booms and as a result leads to economic growth. Moreover, since energyconsumption is the major source of Carbon emission (CO2 emission), it implies that the higher the consumption of energy especially fossil fuel energy the higher the carbon emission. This intuitively means that higher CO2 emission is related to expansion of economic growth. Mesagan (2015) supported this argument and posited that the greater the energy consumption to drive economic productivity, the greater the carbon emission resulting from consumption because the fossil fuel (Oil & Gas) constitute almost 75 % of Nigeria's energy consumption while the renewable energy plays a minimal role. Eregha and Mesagan (2017) posited that a high level of carbon emissions has often been traced to economic activities. This is the reason why the nexus between good carbon emission and economic activities had attracted the attention of a wide range of researchers from multidimensional disciplines but the empirical evidence provided is conflicting, perhaps due to the variation in the choice of methodology, data, and region of study. Again, the emission of CO2 is a major cause of global warming and climate change problem.

Nigeria is the highest emitter of carbon emission in West Africa. This is perhaps attributable to the pace of economic growth and development as Nigeria is the largest economy in Africa by its size of population and norminal GDP (Statista, 2021). Nigeria isendowed with both conventional and unconventional energy resources such as coal, crude oil, gas, solar, hydro, biogas and wind. The abundance of these energy resources serve as a source of revenue to the government and they constitutes primary sources of energy use in the country to propel economic productivity. As a matter of fact, Adejumo (2019) posited that

Nigeria encourage the consumption of fossil fuel energy through excessive subsidy support. The consumption of these energy sources drive economic growth.

On the contrary, the springing up of industries and the expansion of existing firms in an economy can substantially increase the level of carbon emission in an economy. As the industries increases production, CO2 emission increases and output also increases leading to increase in economic growth. In the same vein, the transportation industry is also a key driver of economic growth and also emitters of CO2. This means that intensity of transportation system usage in an economy cans significantly drive carbon emission the reason is that transportation means depends on fossil fuel which are strong contributors of CO2 emission. This is indicate that emission flowing from the transport system may correlate with economic growth as transportation is important in driving economic prosperity.

According to the World Development indicator (2021) carbon emission has increased from 0.08 metric tonne (MT) in 1960 to about 0.12 MT in 1968. However, by 1974 carbon emission in Nigeria had reached an all-time high of 1.01MT. Between 1981 and 1992, the Nigeria's CO2 emission reached about 0.85MT and 0.86MT respectively. Moreover, by 1989 to 2000 the emission has dropped to 0.46MT in 1989 but rose to 0.68MT in 2000. In the same manner, from 2010 to 2020 CO2 emission had reason from 0.57MT to about 0.67MT.

Therefore, it becomes expedient to carry out a scientific enquiry on the impact of carbon emission and economic growth and also the direction of causality between economic growth and carbon emission in Nigeria.

Further, Kahia, Jebli, and Belloumi (2019), Padhan, Haouas, Sahoo, and Heshmati (2019) and Mesagan and Olunkwa (2020) have argued on the presence of a direct link between economic activities and carbon emission. This denotes that economic growth measures are accompanied by a corresponding increase in carbon emission which consequently affects environmental quality. This is because, in the quest to drive economic productivity, economies consume energy sources like fossil fuel, gas, and coal that are considered cheaper to use but with high environmental repercussions. The essence is to maximize the gain from economic activities. This argument supports the first-order condition of the Environmental Kuznets Curve (EKC) preposition that at the initial stage of growth, carbon emission rises which affects the environment negatively because the economy is not wealthy enough to employ less carbon-emitting technology to propel their needed growth.

Additionally, Salahuddin and Gow (2019) raised a different line of argument that evidence of a direct or indirect relationship between carbon emission and economic growth is not sufficient enough upon to design appropriate policy to facilitate economic growth and reduce CO2 emissions since its rises put the environment in danger. Therefore, there is a need to unravel the influence that both carbon emission and economic growth have on each other. In this respect, Abdouli and Hammami (2017) argued that carbon emission and economic growth can causal relationship. This means that in the process of engaging in economic activities like production in firms and consumption of fuel by business and household can cause carbon emission to rise. On the other hand, the consumption of energy to facilitate production and distribution activities increases carbon emission and consequently rise in carbon emission triggers rise in GDP. In this respect, the study of Abdouli and Hammami (2017) provided a unidirectional causality moving from economic growth to carbon emission. This means that as economic activities such as production, distribution, and consumption rise, carbon emission rises because the economic activities are accompanied by biodiversity destruction, deforestation in the quest to build industries and production plants, and carbon emission arising from the consumption of thick energy. Supporting this argument, Danish and Wang (2018), Akadiri, Bekun, Taheri, and Akadiri, (2019), and Saud, Chen, and Haseeb (2019) posited that there is a bidirectional causality between carbon emission and economic growth. It means that economic performance cause carbon emission to increase while on the other hand, carbon emission causes improvement in economic growth. This shows that the attempt to lower carbon emission to improve environmental quality can hurt economic performance while the attempt to lower carbon emission to improve the quality of the environment can hurt the economy.

## Review of Related Literature

### Environmental Kuznets Curve (EKC) Theory

The EKC hypothesis was propounded by Kuznet (1955). The theory holds that pollution and income growth exhibit a U-shaped relation. The key assumption of the theory holds that at first stage of economic expansion pollution increases but the later stage of economic expansion pollution decreases. This forms the U-shaped hypothesis. In this respect, population growth rate, the rates of technological progress for both labour and abatement-augmenting technologies are determinants of aggregate pollution. The pollution growth rate relies on the long-run trend but changes with variation in the level of expansion of the economy and national output. The accumulation of capital and output growth rate per worker are major determinant of aggregate pollution. Moreso, the transitional changes of environmental quality depends on the composition and the magnitude of the economic stages of growth. The path and magnitude of economic growth depend on technological advancement. As a result, the time path of aggregate pollution is not necessarily monotonic and the process of intensifying economic activities can trigger the EKC proposition.

Ang (2008) posited that through the World Bank development report, Grossman and Krueger popularize the EKC model by ascertain its potential impact on NAFTA. It is the application of Kuznets's curve to environmental studies. It has been said to be a potential reflection of the Pollution Haven Hypothesis. The Kuznets curve was propounded by Simon Kuznets in 1955. The principal suggestion of Kuznets is that the first phase of economic growth, income distribution worsen; but at a later phase of economic growth income distribution tend to improve. The per capita income and its equality of income distribution reflect an inverted-U shape curve (Andreoni and Levinson, 2001). Kuznets's explanation for worsened inequality at the early stages of economic growth was related to structural changes in an economy as it transform from a classical to a modern economy. This includes: (i) the state of technology, factor-input ratios, output mix are determinant of production scale.(ii) The output mix changes and economic development accounts for pollution intensities for different industries.(iii) The input mix changes requires the interchange of environmentally friendly inputs for more environmentally unfriendly inputs and vice versa; (iv) Production efficiency is required by improving the state of technology through the substitution of emission input towards less emission input. Hence, there is convincing evidence that the EKC preposition is valid for some pollutants such as particulate matter in the air, carbon dioxide, sulphur dioxide and nitrogen oxides.

**Environmental Externality Theory**

The theory of environmental externalities was advanced by Arthur C. Pigou in his book 'The Economics of Welfare' first published in 1920. An economic externality is the consequence of an economic activity that is borne by a third party. It could be positive or negative. The theory of economic externality examines instances where the costs or benefits of activities extend beyond the parties directly involved and third parties are impacted. A positive externality is the benefit that accrues to an unrelated third party as a result of an activity carried out while negative externalities are negative effects that originate during the production process of a good or service; or while carrying out an activity. An example of negative externality is air pollution from burning fossil fuels, anthropogenic climate change as a result of greenhouse gas emissions from burning fossil fuel, water pollution by industries that harm plants and livestock, etc.

According to Charfeddine and Khediri (2016), AC Pigou proposed a solution to negative externalities through his 'pollution pays principle'. He studied smoke emitted by a factory and its damaging impact on businesses and residents. His solution was to impose a per unit tax on output of the firm generating the negative externality. This is known as the Pigovian tax. The per unit tax should be equal to the difference between the social marginal cost and the private marginal cost corresponding to the social optimal output, with the output satisfying price equals social marginal cost conditions. He said that imposition of taxes will increase the prices of output and reduce demand thereby aiding consumers and producers of the product in factoring in environmental costs. Pigou however recognized that government involvement and authoritative control are needed in case of complications.

**Empirical Literature Review**

The relationship between carbon emission and economic growth has been discussed in several way by past studies. For instance, Adhikari and Chen (2012) studied energy consumption and economic growth with the aim of examining the long-run relationship between energy consumption and economic growth for 80 developing countries from 1990 to 2009. The 80 countries involved were divided into three income groups, namely, upper middle-income countries, lower middle-income countries and low-income countries and the empirical results revealed a long-run cointegrated relationship between energy consumption and economic growth. The study also found a strong relation between energy consumption and economic growth for upper middle-income countries and lower middle-income countries, while also finding a strong relation that runs from economic growth to energy consumption for low income countries, suggesting that energy consumption had a positive and statistically significant impact on economic growth in the long-run for these countries.

Isola and Mesagan (2014) researched into the link between energy consumption and human condition in Nigeria. The study proxied environmental degradation with carbon emission, while life expectancy, and infant mortality rate are employed as proxies of human condition and data covered a period of 1980 to 2012. The study which employed the vector autoregressive (VAR) model observed that energy consumption has negative impact on human welfare in Nigeria.

Ben-Jebli, Ben-Youssef, and Ozturk (2015) applied a panel ordinary least squares and fully modified least squares co-integration approach to examine the validity of the environmental Kuznets curve (EKC) hypothesis (economic growth and carbon emission) in 24 SSA countries over 1980 and 2010. The long-run result did not support the EKC hypothesis of an inverted U relationship. Also the study considered export and import scenario and they found that export and import have positive and negative impact on carbon emissions respectively in SSA.

Mesagan (2015) examined carbon emission and economic growth in Nigeria between 1970 and 2013. The research employed carbon emission, real gross domestic product, capital investment, and trade openness in carrying out the analysis. Error correction model was used in the study, and the result clearly showed that in the first period, economic growth positively impacts carbon emission, while it negatively impacts carbon emission in the lagged period. It also revealed that trade openness and capital investment, positively impact carbon emission in Nigeria.

Tang and Tan (2015) studied the relationship between CO2 (carbon dioxide) emissions, energy consumption, FDI (foreign direct investment) and economic growth in Vietnam over the period from 1976 to 2009. The techniques of cointegration and Granger causality are adopted to examine the relationship between the variables. The results confirm the existence of long-run equilibrium among the variables of interest. Meanwhile, energy consumption and income positively influence CO2 emissions, but square of income has negative impact on CO2 emissions in Vietnam. The causality result also shows that there are bi-directional causalities between CO2 emissions and income, and between FDI and CO2 emissions in Vietnam.

Ahmed and Du (2017) assessed the impact of energy production and carbon emission on growth performance for Iran between 1971 and 2011. The study used the dynamic ordinary least square (DOLS) and fully modified ordinary least square (FMOLS) methods of analysis and the result revealed that carbon emission positively affect growth, energy production also affect growth positively in Iran. Additionally, the study revealed that for Iran domestic investment contribute more than foreign investment in the explanation of economic prosperity. Boamah, Du *et al*.(2017) studied the role of international trade in mitigating carbon dioxide emission in China. The study estimated a multivariate model using a time series data for the period of 1970 and 2014. The main variables that constitute the study includes carbon emission, economic growth and trade. The study showed that Granger causality revealed the presence of a unidirectional Granger causality running from energy consumption to economic growth, from import to economic growth, from imports to exports; and from urbanization to economic growth, exports and imports.

Danish and Baloch (2017) focused on transport energy, growth and CO2 emission for Pakistan. The study adopted the ARDL method of analysis from 1971 to 2014. The study showed that the environment deteriorate due to rise in growth and transport energy in Pakistan. The study narrowly captured energy consumption with transport energy consumption and did not show the impact that environmental quality and energy consumption have on growth. Twerefou *et al.* (2017) in a panel study, examined the impact of economic growth and globalization on carbon emission in 36 SSA countries from 1990 to 2013, using a system GMM model. The evidence supports that economic growth affect carbon emission positively, while globalization is found to worsen the quality of the environment by increasing the level of carbon emissions.

Munir, Lean, and Smyth (2019) studied the relationship between CO2 emissions, energy consumption (EC) and economic growth (GDP) for the five main Association of Southeast Asian Nations (ASEAN-5) countries over the period 1980 and 2016. The study applied a new panel test of Granger non-causality that addresses Cross sectional dependence and heterogeneity, the study found considerable heterogeneity. Also, the study revealed unidirectional Granger causality running from gross domestic production to carbon emission for Malaysia, the Philippines, Singapore and Thailand; unidirectional causality running from gross domestic product to energy consumption in Indonesia, Malaysia and Thailand; unidirectional causality running from energy consumption to gross domestic product in Singapore and bidirectional causality between gross domestic product and energy consumption in the Philippines. The study also supported the EKC hypothesis for the ASEAN-5 countries.

Kahia, Jebli, and Belloumi (2019) investigated the impact of renewable energy consumption, economic growth, foreign direct investment inflows and trade on carbon dioxide emissions for a panel of 12 Middle East and North Africa countries over the period 1980 and 2012 using the recent Panel Vector Autoregressive model with multi-domain analysis framework. Granger causality test revealed a bidirectional causality relationship between the candidate variables supporting the feedback hypothesis. The regression result showed that economic growth leads to rise in carbon emission while renewable energy, international trade and foreign direct investment inflows lead to decreases carbon dioxide emissions. Further, Maji and Sulaiman (2019) analyzed the impact of renewable energy on economic growth in West African countries using panel dynamic ordinary least squares (DOLS) by employing a sample of 15 West African countries covering the period of 1995 and 2014 period. The results indicated that renewable energy consumption slows down economic growth in these countries.

Olusanya and Dasuki (2020) employed the ARDL model, Mean Group (MG), and the Pooled Mean Group (PMG) model to examine the Environmental Kuznets Curve (EKC) hypothesis in 43 African countries pooled into 3 income groups from 1980 to 2016. The EKC hypothesis is accepted in only 21% of the sample but rejected in 70% of the countries in the total sample. The carbon emission and economic growth nexus shows that carbon emissions increase as economic growth increases in 79% of the countries while economic growth will lead to lower carbon emissions in only a few countries (21%).Ngonadi, Okere, and Ngonadi (2020) investigated the impact of economic factors on CO2 emission in Nigeria between 2003 and 2015. The study employed the non-linear Autoregressive Distributed Lag. The Study found that energy consumption, carbon emission, and foreign direct investment affects economic growth positively. More so, Wada *et al*. (2020) examined energy use, real output growth, FDI, energy intensity and CO2 emission in Kazakhstan between 1992 and 2016 using the nonlinear ARDL methodology. The study found that energy use positively affects carbon emission, output growth increases carbon emission and foreign direct investment negatively affect the CO2 emission. Additionally, Maduka *et al*. (2022) examined the relationship between economic growth and carbon dioxide and the moderating effect of institutional quality in Nigeria from 1990 to 2020, by employing the Autoregressive Distributed Lag (ARDL) technique. The finding showed that there is a long run relationship between economic growth and carbon emissions. Also, the study rejects the EKC hypothesis and concluded on the relationship between economic growth and carbon emissions is N-shaped.

## Research Methodology

### Theoretical Framework

This study is based on the theoretical foundation of the Solow neoclassical growth model of Solow (1956) and Swan (1956). The proposition of the model holds that output (economic growth) depends on the level of capital accumulation (K), labour (L) and technological progress (A). Meaning that variation in K, L, and A will affect output expansion. Mathematically, the Solow neoclassical growth model is specified as thus:

$$Y(f) = A(t)K(t)^{1-\beta} L(t)^{\beta} \qquad (1)$$

Where $K$ and $L$ are capital and labour inputs respectively, $\alpha = 1 - \beta$ and $\beta$ are their shares of output ($Y$) and $A$ is an index of production efficiency.

With the need to determine the effect of carbon emission on economic growth, it is now pertinent to include carbon emission into the Solow neoclassical growth.

### Methodological Framework

Economic research seeks to provide a conjunction of economic theory and actual measurements, using the theory and techniques of statistical inferences as a bridge pier (Haavelmo 1994). In order to choose a methodology to help establish mathematical and econometric relationship between economics variables, the objectives of the study must be taken into consideration. Such use of econometric techniques in the establishment of these relationships enables us to obtain the estimated parameters in order to draw relevant conclusions. The Toda Yamamoto causality approach and the ordinary least Squares (OLS) method of regression will be used as the estimation technique in this study and the regression will be run using the E-Views 9 regression software package. The choice of this methodology is based on the fact that the estimators that will be used are point estimators and secondly, the OLS method is intensiveness appealing and mathematically much simpler than other methods. According to Gujarati (2007), under certain assumptions, the method of ordinary least square has some very attractive properties that have made it one of the most powerful and popular method of regression analysis.

Furthermore, Toda and Yamamoto (1995) propose an Augmented Granger causality test which is an improvement on the most commonly used technique of causality test as proposed by Granger (1969). The Toda-Yamamoto causality test uses a Modified Wald (MWALD) test for restrictions on the parameters of the VAR (k) equations. When a VAR (k+w) is estimated. The test has an asymptotic Chi-square distribution with k degrees of freedom in the limit (here, k is optimal lag length and w is maximum order of integration for the variables in the system).

**Model Specification**

The study specified the model following the prediction of Solow neoclassical growth model as,

$$Y(f) = A(t)K(t)^{1-\beta}\,L(t)^{\beta} \qquad (1)$$

Where $K$ and $L$ are capital and labour inputs respectively, $\alpha = 1 - \beta$ and $\beta$ are their shares of output ($Y$) and $A$ is an index of production efficiency. Also following the study of Mesagan (2015), Maji and Sulaiman (2019), and Maduka et al. (2022) the study incorporate carbon emission in the model to represents an extension to the Solow model.

$$Y_{it} = \phi_0 + \phi_1 K_{it} + \phi_2 L_{it} + \phi_3 CO2_{it} + \phi_4 EN_{it} + \phi_5 TO_{it} + \mu_{it} \qquad (2)$$

In equation (2), $\phi_0$ is the constant term; $\phi_{1-5}$ are parameter coefficients; $\mu$ is the error term; $t$ is the time factor. Further, $Y$ is real GDP per capita and $K$ is capital investment, $L$ is labour force, CO2 is carbon emissions, EN is energy consumption and TO is trade openness they are control variable in the model.

**A Priori Expectations**

The study expect that labour force, capital, carbon emission, energy consumption and trade openness to positively affect economic growth. Hence, the study expect positive signs.

**Nature and Sources of Data**

All the data used for this study are secondary source. Table 1 shows the description and the sources of the data.

**Table 1: Data Description and Source**

| Variables | Name | Measurement | Source |
|---|---|---|---|
| Y | Economic growth | Measured with realGDP income per capita | WDI, 2020 |
| K | Capital | Measured with thegross capital formation in % of GDP | WDI, 2020 |
| L | Labour | Measured with total labour force | WDI, 2020 |
| EN | Energy consumption | energy consumptionmeasured in kilogram of oil equivalent per capita | WDI, 2020 |
| C02 | Carbon Emission | carbon emission measured in million tonne (MT) per capita | WDI, 2020 |
| TO | Trade openness | trade in % of GDP | WDI, 2020 |

Source: Author's Compilation

**Result and Discussion of Findings**

**Units Root Test**

The analytical technique discussed in the previous chapter were applied to the model of the study and the result presented in this section. Empirical analysis based on time series data would be biased with a spurious result if the underlying data are nonstationary. The unit root test becomes necessary to check for the stationarity of the variables. As earlier noted, the test used for testing the stationarity of the series is the Augmented

Dickey-Fuller (ADF) test**.** The results are summarized in table 4.1 below:

**Table 4.1: Summary of ADF Unit Root test result**

| Variables | ADF Statistics | Order of integration | Remarks |
|---|---|---|---|
| Y | -3.516991 | I(1) | Stationary at first difference |
| K | -4.450900 | I(1) | Stationary at first difference |
| L | -5.699926 | I(1) | Stationary at first difference |
| CO2 | -7.498315 | I(1) | Stationary at first difference |
| EN | -6.024692 | I(1) | Stationary at first difference |
| TO | -5.094514 | I(1) | Stationary at first difference |

***Source:*** *Researcher's Compilation using E-views 9*

From table 4.1 all the variables are stationary at first order of integration. This necessitateto test for cointegration.

## Cointegration Test

Cointegration test shows the long-run relationship among the series. The test is carried-out using the Johansen's Cointegration Test. The hypothesis for this test is stated below
Hypothesis

Ho: There is no cointegration among the series
Hi: There is cointegration among the series

**Decision Rule**
Reject the null hypothesis (Ho) if the trace statistic is greater than the 5% critical value or if the probability value is less than 0.05. The Cointegration Result is presented below

**Table 4.2: Trace Statistic (Johansen's Cointegration)**

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.708913 | 127.9871 | 95.75366 | 0.0001 |
| At most 1 * | 0.544121 | 82.32421 | 69.81889 | 0.0036 |
| At most 2 * | 0.536999 | 53.25969 | 47.85613 | 0.0143 |
| At most 3 | 0.357388 | 24.76869 | 29.79707 | 0.1699 |
| At most 4 | 0.186791 | 8.406795 | 15.49471 | 0.4230 |
| At most 5 | 0.020236 | 0.756424 | 3.841466 | 0.3844 |

*Source: Author's Compilation using E-views 9*

Johansen's Cointegration test in table 4.2 above shows that there is three (3) cointegratingequation. This is based on the trace statistic.

**Table 4.3: Maximum Eigen Value (Johansen's Cointegration)**

| Hypothesized No. of CE(s) | Eigenvalue | Max-Eigen | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.708913 | 45.66292 | 40.07757 | 0.0106 |
| At most 1 | 0.544121 | 29.06452 | 33.87687 | 0.1686 |
| At most 2 * | 0.536999 | 28.49100 | 27.58434 | 0.0382 |
| At most 3 | 0.357388 | 16.36190 | 21.13162 | 0.2044 |
| At most 4 | 0.186791 | 7.650371 | 14.26460 | 0.4154 |
| At most 5 | 0.020236 | 0.756424 | 3.841466 | 0.3844 |

*Source: Author's Compilation using E-views 9*

The maximum eigen value confirmed the trace statistic evidence by showing two (2) cointegrating equation. This indicate the presence of long run association among the variables. Hence we reject the null hypothesis and accept the alternative hypothesis there is a cointegration among the series.

Regression Result Table 4.4: Regression Result:

**Dependent variable: LogRGDP**

| | | | | |
|---|---|---|---|---|
| **K** | 0.001382 | 0.001018 | 1.357746 | 0.1838 |
| **L** | 0.411020 | 0.190725 | 2.155043 | 0.0386 |
| **CO2** | 0.085265 | 0.048179 | 1.769732 | 0.0860 |
| **EN** | 3.081173 | 0.675624 | 4.560485 | 0.0001 |
| **TO** | -0.001190 | 0.000702 | -1.696784 | 0.0992 |
| **$R^2$=0.8707** | Adj $R^2$=0.8511 | F-stat= 44.455 | F-prob=0.0000 | D-Wat= 1.9016 |

*Source: Researcher's compilation from E- Views 9 output*

From Table 4.4 above, the estimated coefficient of capital (K), labour force (L), and carbon emission (CO2), energy consumption (EN) are 0.0013, 0.4110, 0.0852 and 3.0811. This means that capital (K), labour force (L), and carbon emission (CO2), energy consumption (EN) have a positive impact on the Nigerian economy. Such that a unit change in capital (K), labour force (L), carbon emission (CO2), and energy consumption (EN) cause economic growth to rise in Nigeria by about 0.0013, 0.4110, 0.0852 and 3.0811 units respectively. Also, trade openness (TO) coefficient is -0.0011. This means that trade open has negative impact on economic growth in Nigeria.

## Toda Yamamoto Causality Approach

The study present the Toda Yamamoto causality result in Table 4.5 below as:

| Table 4.5: Toda Yamamoto Causality | | | |
|---|---|---|---|
| Dependent variable: Y | | | |
| Excluded | Chi-sq | Df | Prob. |
| CO2 | 6.330151 | 2 | 0.0422 |
| All | 6.330151 | 2 | 0.0422 |
| Dependent variable: CO2 | | | |
| Excluded | Chi-sq | Df | Prob. |
| Y | 3.454620 | 2 | 0.0567 |
| All | 3.454620 | 2 | 0.05967 |

*Source: Researcher's compilation from E- Views 9 output*

The Toda-Yamamoto causality result in Table 4.5 shows that the p-values are 0.0422 and 0.0567. Since the P-values are less than 5% critical values, it indicate that carbon emission and economic growth have a bi-causal relationship. This means that both economic growth and carbon emissions causes each other. This support theoretical evidence that as economic growth increases energy use increases, thereby causing rise in carbon emission.

**Statistical Criteria (First Order Test)**

A. Coefficient of Determination ($R^2$)

The R-Squared measure the overall goodness of fit of the regression. The value of the R- Squared is 0.8707 approximately 87% indicating that the independent variables jointly explain the dependent variable by about 87%. The Adjusted R-Squared is 0.8511. This implies that after the adjustment for degree of freedom the data set fits the model by about 85%.

B. T- Statistics

This test is carried out mainly to check the individual significant of the explanatoryvariable. This test will be interpreted based on the underlying hypothesis

HO: The individual explanatory variable is not statistically significant
H1: The individual variable is statistically significant

**Decision Rule**:

At 1%, 5% and 10% level of Significant, accept the null hypothesis (Ho) if P- Value is within 0.01, 0.05, and 0.10 otherwise reject the null hypothesis and accept the alternative hypothesis. The T-test is summarized in table 4.7.

**Table 4.7 Summary of T-test Result**

| Variable | t- value | P- Value/ Decision Rule | Remarks |
|---|---|---|---|
| K | 1.357746 | 0.1838>10% | Insignificant |
| L | 2.155043 | 0.0386<5% | Significant |
| CO2 | 1.769732 | 0.0860<10% | Significant |
| EN | 4.560485 | 0.0001<1% | Significant |
| TO | -1.696784 | 0.0992<10% | Significant |

*Source: Author's compilation*

From Table 4.7Labour force (L), carbon emission (CO2), and energy consumption (EN) are statistically significant while capital (K) is not significant.

**F- statistic**

The F-statistic is used to test for simultaneous significance of all the estimated parametersHypothesis:

HO: The explanatory variables are not significant HI: The explanatory variable are significant

**Decision Rule:**

At 5% level of significance, accept the null hypothesis if P- value > 0.05, otherwise rejectthe null hypothesis and accept the alternative hypothesis.

From our regression result, the F-statistics is 44.455 p- value is 0.0000 < 0.05. Hence we reject the null hypothesis as stated above and accept the alternative hypothesis that the explanatory variables have simultaneous significant on the regressand.

**Econometrics Criteria (Second order test)**

1. Test for Autocorrelation (Durbin Watson Test) form the regression result the Durbin- Watson test for autocorrelation was used to test for the presence or otherwise of autocorrelation in the model

The test hypothesis is this

HO: There is no autocorrelation HI: There is autocorrelation

**Decision Rule**

Using the rule of the thumb, at 5% level of significance, we reject the null hypothesis if the value of the Durbin-Watson Statistics is approximately 2.

The Durbin-Watson statistic from the regression result is 1.9016 which is approximately

2. In this case we will reject the alternative hypothesis and accept the null hypothesis that there is no autocorrelation.

**Causality**

In this part, the study test the cause

relationship between carbon emission and economic growth in Nigeria using the Toda Yamamoto causality approach. The hypothesis is that:

Ho1: There is no causality between CO2 and Y

Ho2: There is a causality between CO2 and Y.

**Table 4.8: Toda Yamamoto Causality**

Dependent variable: Y

| Excluded | Chi-sq | Df | Prob. |
|---|---|---|---|
| CO2 | 6.330151 | 2 | 0.0422 |
| All | 6.330151 | 2 | 0.0422 |

Dependent variable: CO2

| Excluded | Chi-sq | Df | Prob. |
|---|---|---|---|
| Y | 3.454620 | 2 | 0.0567 |
| All | 3.454620 | 2 | 0.05967 |

*Source: Author's compilation using E- Views 9*

**Decision Rule:**
Reject the null hypothesis if P- value < 0.05. Accept if otherwise

From the result the p-values of both hypothesis is less than 0.05. This means the study reject the null hypothesis and accept the alternative that carbon emission and economic growth cause each other. This implies a bidirectional causality between CO2 and Y.

**Evaluation of Research Hypothesis**
The hypothesis set up in chapter one will now be tested given the estimates generated from the analysis.

**H01: There is no causal relationship between carbon emission and economic growthin Nigeria.**
Hypothesis 1 is a case of causality and evidence in Table 4.8 shows that there is bidirectional causal relationship between carbon emission and economic growth in Nigeria. Therefore, the study reject the null hypothesis and accept the alternative.

H02: Carbon emission does not have significant impact on economic growth in Nigeria.

For the second hypothesis, table 4.7 shows the t-test evaluation and carbon emission (CO2) is statistically significant at 10% significance level. This means that carbon emission has a significant impact on economic growth in Nigeria. We proceed to accept the alternative hypothesis and reject the null hypothesis.

**Summary**

This study examines the impact carbon emission on economic growth in Nigeria using the Toda Yamamoto approach between the period 1981 and 2020. The study employs time series econometrics to analyze the datasets. Also, the study test for unit root and cointegration existence using the Augmented Dickey Fuller (ADF) and Johansen's cointegration test. The evidence shows that all the series has no unit root after first differencing while the cointegration evidence shows the presence of cointegration among the variables. However, other key findings from the regression results are:

a. Carbon emission (CO2) has a positive and significant relationship with economic growth in Nigeria.
b. Capital (K) has a positive and insignificant relationship with economic growth inNigeria.
c. Labour (L) has a positive and significant relationship with economic growth inNigeria.
d. Energy consumption (EN)) has a positive and significant relationship with economic growth in Nigeria.
e. Trade openness (TO) has a negative and significant relationship with economic growthin Nigeria.
f. Toda Yamamoto causality shows that there is a bidirectional causality between carbon emissions and economic growth in Nigeria.

**Conclusion**

Energy is an infrastructure that plays an important role in economic prosperity and advancement. This is because it interacts with the other sectors of the economy to drive growth. Carbon emission also is a key and important bi-product of energy consumption in any economy. Lowering carbon emission means reducing the level of energy consumption which will affect economic activities. Since most economies including Nigeria are now decarbonizing, it become pertinent to investigate the relationship between carbon emission and economic growth. Therefore the study draws conclusion from the findings. Carbon emission has a positive and significant relationship with economic growth in Nigeria. Energy consumption has a positive and significant impact on economic growth in Nigeria. Capital and Labour force had positive impact on economic growth in Nigeria, trade openness has a negative and significant impact on economic growth in Nigeria, and Toda Yamamoto causality shows bidirectional causality between carbon emission and economic growth.

**Policy Recommendation**

Following the empirical evidence obtained from this study, the study recommends that;

a. The government should be shifting attention to eco-friendly technology to drive economic activities in the nation. Because, the continuous rise carbon emission will constitute threat to the environment.

b. The study also suggest improvement in investment in energy efficiency projects to scale up the campaign of energy efficiency so that the nation can achieve sustainable growth in the long run.

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