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Carbon Footprint Reduction and its Impact on Economic Development in Nigeria

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Abstract
Nigeria relies on heavy fossil fuels for energy. Nigeria emitted 0.57 metric tonnes of CO2 per capita in 2018. From 0.44 metric tonnes in 2016 to 0.56 metric tonnes in 2017, this figure has increased 29%. The issue is the lack of data on carbon footprint reduction and economic development in Nigeria. time series data from the 1990–2019 was employed to examine the relationship between carbon footprint reduction and economic development in Nigeria. How carbon footprint reduction affects Nigerian economic development was the main research subject. Carbon footprint reduction and economic development were examined using quantitative methods and ordinary least squares linear multiple regression. From the regression result, CO2 emission total CO2 emission from fossil (TCO2 has p-values below 0.05 (5%), indicating significance. The results showed that a unit increase in CO2 from TCO2 will decrease economic development by 0.003381. The study suggests lowering carbon footprint. The study's findings will help Nigeria's government reduce carbon emissions and boost economic growth.

Keywords: *Global warming, Carbon footprint, Greenhouse gas, Human Development index*

1.0 Introduction

Global warming is a major issue today (Yurtsever & Firat, 2019). Nigeria relies heavily on fossil fuels for energy. Fossil fuels create global warming, a major health concern. (Zou, 2018). Signatory to the France accord on global warming, Nigeria has made frantic attempts to reduce greenhouse gases to the lowest level before 2030. These impacts have left no durable solution. Nigerian CO2 emissions per capita in 2018 were 0.57 metric tonnes. In 2016, it was 0.44 metric tonnes; in 2017, it was 0.56 metric tonnes, a 29% increase. (2019 World Data Atlas). The issue is a paucity of data on Nigeria's carbon footprint reduction and economic progress (Efe, 2016).

Zou (2018) investigated the link between energy consumption, carbon emission, and economic growth; Chindo et al. (2015) investigated the relationship between energy consumption, carbon dioxide (CO2) emissions, and GDP in Nigeria. Neither Zou, Chindo et al. and other studies looked at the relationship between carbon footprint and economic development. I seek to fill the gap by investigating the nexus between Nigeria's carbon footprint and economic development using the Human Development Index (HDI), a proxy for Economic development.

The aim of this quantitative study was to determine the nexus between Total carbon dioxide (CO_2) emission and economic development in Nigeria, using time series data for the period 1990-2019. The study's dependent variable was economic development. The independent variables was total CO_2 emission (TCO2)

2.0 Literature review

Rising CO_2 emissions cause climate change.Inglesi-Lotz & Dogan (2018); Change et al. (2006). As well as being damaging, fossil fuel is depletable and expensive to produce and maintain (Day & Day, 2017; Li et al., 2017). Renewable energy (RE) sources like wind, water, solar, and geothermal are clean and renewable.

Future energy supply depends on renewable energy (Ellabban et al., 2014). Heidari et al. (2015) used Panel Smooth Transition Regression (PSTR) model to examine economic development, CO_2 emissions, and energy consumption in five southeast Asian nations from 1980–2008. Ercan et al. (2016) examined US public transportation's carbon footprint reduction potential. A dynamic panel threshold approach was used by Aye and Edoja (2017) to examine CO_2 emissions in 31 developing nations. Friedrichs and Inderwildi (2013) examined fuel-rich countries and high CO_2 intensities using the carbon curse theory. A dynamic panel threshold methodology was used by Frondel et al. (2010) and Aye and Edoja (2017) to evaluate CO_2 emissions in 31 developing nations.

Antonakakis et al. (2017) examined the link between energy use, CO_2 emissions, and real GDP per person from 1971 to 2011 using panel VAR. Kucukvar and others, 2015. Global, scope-based carbon footprint modelling was done for successful carbon-cutting programmes. In Turkey's industrial supply chains, power, gas, and water were most essential and had the highest carbon footprint. Kucukvar et al. (2015) modelled Turkish carbon footprints to offer efficient carbon reduction initiatives. From an Indian perspective, Luthra et al. (2015) justified renewable/sustainable energy technology adoption obstacles. Perry et al. (2008) examined how waste-renewable energy integration reduces locally integrated energy sectors' carbon footprint. Schwenkenbecher (2014) explored why people reduce their carbon footprint. Kais and Ben-Mbarek (2017) evaluated the link between CO_2 emissions, economic growth, and energy consumption in three North African nations from 1980–2012. Arfanuzzaman (2016) investigated Bangladesh's environmental performance index (EPI) and CO_2 emission, per capita income, and HDI. According to Erdoğan (2019), a fully modified OLS technique was used to analyse the causal relationship between economic growth and CO_2 emissions in BRICS- Results show a bidirectional relationship between carbon emissions and economic growth.

Studies have examined energy use, carbon emissions, and economic growth. Zou (2018) examined energy usage, carbon emissions, and economic growth. Chindo et al. (2015) examined Nigeria's energy usage, CO_2 emissions, and GDP. Zou, Chindo et al. and other research did not examine Nigeria's carbon footprint and economic development. This study examines Nigeria's carbon footprint and economic development using the HDI as a proxy for economic development to close this gap. This report will spark a national debate on balancing carbon footprint and Nigeria's socioeconomic well-being.

2.1 Conceptual literature

2.1.1 Concept of Carbon Footprint

The idea of the carbon footprint was coined out from the concept of ecological footprint, which is an estimation of the demand human places on the Earth's ecosystems. It is a standardized indication of demand for natural capital that may be at variance with the planet's ecological capacity to regenerate. It constitutes the amount of biologically productive land and sea area necessary to provide the resources consumed by a human population and assimilate the associated waste. (Gao et al., 2014). The carbon footprint of a country is the amount of carbon dioxide released into the atmosphere by anthropogenic activities. Carbon footprint is usually measured as tons of CO_2 emitted per year, usually expressed in equivalent tons of carbon dioxide. (Aichele & Felbermayr, 2012; Change et al.). Climate change has been one of the biggest challenges to our contemporary society. International and local authorities have called for a suitable tool to monitor climate change's impact, which is explained by the amount of greenhouse house gasses released to the environment. Carbon footprint was selected as an easy-to-use tool for monitoring and quantifying greenhouse gas emissions.

2.1.2 Sources of CO_2 Emission

CO_2 emission is the output of anthropogenic activities. Mancini et al. (2016) categorized CO_2 emissions due to anthropogenic activities into three sources which are derived from the International Energy Agency as (i) emissions from the combustion of fossil fuel; (ii) emissions from non-fossil fuel sources such as anthropogenic forest fires, gas flaring, cement production and unsustainable biofuel production; and (iii) emissions from marine and aviation transport. Mancini et al. noted that, the three sources amounted to78%, 19% and 3% of the total emissions in 2010. respectively. Fenner et al. (2018), in contradiction to the opinion of Mancini et al., maintain that the built environment contributes to a dominant fraction of the total carbon emissions in society. Fenner et al. canvassed for an understandable, consistent, and accessible procedure to evaluate buildings' carbon emission. Hussain et al. (2012) examined the nexus between environmental pollution, consumption per capita, and economic growth and energy in Pakistan and concluded that the major causes of environmental pollution in Pakistan is Energy consumption.

3.0 METHODOLOGY

3.1 Sources of Data

The focus of the study was the Nigerian economy. Only secondary data was used in this study. The study's scope was time-series data from 1990 to 2019 which was used to estimate the regression model. The data required included; CO2 generated from fossil (TCO2), and human development Index (HDI), were sourced from the Global greenhouse gas and CO2 emission and United Nations Development Program UNDP.

3.1.1 Model Specification

This study employes a multiple regression model to evaluate the impact of carbon emissions on economic development. In specifying the model, I adopted to a model used by Ejuvbekpokpo (2014). Ejuvbekpokpo examined the impact of carbon emissions on economic growth, using the Forester's growth and pollution model. Ejuvbekpokpo's model specification is as follows:

GDP = f (FOF, GAF, LIF, SOF, CEP) (3.1)

where the dependable variable GDP is a function of emission from fossil fuel (FOF), emissions from gas fuels (GAF), emissions from liquid fuels (LIF), emissions from solid fuels, and emissions from cement production (CEP).

Replacing GDP with Human development index (HDI) and replacing the independent variable, with total CO2 emission, We have:

HDI = f (TCO2) (3.2)

Linearizing the above model and expressing it in standard form, we have

$$HDI = \beta_0 + \beta_1 TCO2_t + \varepsilon_t \quad (3.3)$$

Where: β_0 = constant

β_1 and β_2 are respective coefficients

ε_t = Error term

HDI = Human development index (a proxy for economic development)

TCO2 = Total CO2 emission fossil fuel

4.0 Data Analysis

Table 1

Augmented Dickey-fuller Unit Root Test Results- Case: None

Variable	Level-None	1st Diff- None	Decision
HDI	3.5267 (0.9997)	-3.5520 (0.0009)	Non-stationary at Level; Stationary at 1st difference
TCO2	1.0931 (0.9245)	-5.6574 (0.0000)	Non-stationary at Level; Stationary at 1st difference

Table 2

Augmented Dickey-fuller Unit Root Test Results- Case: Constant

Variable	Level-Constant	1st Diff-Constant	Decision
HDI	0.4078 (0.9798)	-4.5360 (0.0012)	Non-stationary at Level; Stationary at 1st difference
TCO2	-3.0420 (0.0427)	-5.6102 (0.0001)	Non-stationary at Level; Stationary at 1st difference

Note. values in parenthesis are t-statistics while values in bracket are p-values

Table 3

Augmented Dickey-fuller Unit Root Test Results- Case: Constant & Trend

Variable	Level-Constant & Trend	1st Diff- Constant & Trend	Decision
HDI	-1.4596 (0.8203)	-4.5518 (0.0059)	Non-stationary at Level; Stationary at 1st difference
TCO2	-2.9483 (0.1631)	-5.5025 (0.0006)	Non-stationary at Level; Stationary at 1st difference

Note. values in parenthesis are t-statistics while values in bracket are p-values.

The null hypothesis of a unit root will not be rejected for any variable in the level form (Pesaran et al., 1996). Conversely, all variables exhibit unit roots. nevertheless, the null hypothesis of a unit root is rejected for variables only when first differenced. The unit root test by Augmented Dickey-Fuller is found in Table 1-3

Table 4

Cointegration Test Result
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.764277	93.90579	88.80380	0.0203
At most 1	0.517162	53.44306	63.87610	0.2746
At most 2	0.445121	33.05697	42.91525	0.3336
At most 3	0.315774	16.56485	25.87211	0.4481
At most 4	0.191145	5.939782	12.51798	0.4680

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.764277	40.46273	38.33101	0.0280
At most 1	0.517162	20.38609	32.11832	0.6214
At most 2	0.445121	16.49212	25.82321	0.5013
At most 3	0.315774	10.62506	19.38704	0.5524
At most 4	0.191145	5.939782	12.51798	0.4680

There are two tables to check while interpreting the result of the cointegration test. The trace statistic and Max- Eugen statistics. When the trace statistics is greater than the critical value at 5% level of significance and the p-value is lower than 0.05, hence we reject the Null hypothesis of no cointegration. The other way is to check the Max- Eugen statistics: if the Max-Eugen statistics is greater than the critical value and p-value is less than 0.05 (5% level of significance).

4.1.7 Model Estimation

The output of the regression model is shown in Table 5 below.

Table 5

Regression Output (Dependent Variable: HDI

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TCO2	0.003381	0.000979	3.452940	*0.0020
C	0.424637	0.027649	15.35793	0.0000
R-squared	0.882482		Mean dependent var	0.477867
Adjusted R-squared	0.863679		S.D. dependent var	0.032800
F-statistic	46.93340		Durbin-Watson stat	1.035203
Prob(F-statistic)	0.000000			

From the value of R-squared being 0.8825, this indicates that the model is 88.25 % fit; this implies that the regression model is a very good fit because the independent variables cumulatively explains 88.25 % of the dependent variable. The combined f-statistic is significant because the p-value is less than 0.05 (5%), which shows that the expanable variables combinedly can influence the dependent variable HDI.

Table 6 below shows the long-run equation between the independent and dependent variable.

Table 6

Long run Regression Equation Estimation -VECM

	Coefficient	Std. Error	t-Statistic	Prob.
C(1) =HDI	-1.107443	0.275505	-4.019686	0.0006
C(2)= D(HDI)	0.227281	0.163450	1.390525	0.1789
C(3)= TCO2	-0.000908	0.000649	-1.399747	0.1762
C(4)=C	0.002708	0.001141	2.373196	0.0273
R-squared	0.619871		Mean dependent var	0.003714
Adjusted R-squared	0.511263		S.D. dependent var	0.006188
S.E. of regression	0.004326		Akaike info criterion	-7.836169
Sum squared resid	0.000393		Schwarz criterion	-7.503118
F-statistic	5.707399		Durbin-Watson stat	1.965450
Prob(F-statistic)	0.001193			

From Table 6 above, the coefficient C1 is the speed of adjustment towards a long-run equilibrium but must be significant and should be negative.

4.1.8 Short-Run Relationship Between Variables.

Results of Wald Test for Short-Run Relationship

Table 7

Independent Variable	Coefficient	Chi-Square Prob	F- Stat Prob	Decision
TCO2 and HDI	C(3)	0.1616	0.1762	No short-run relationship

4.1.9 Post Estimation Tests

To draw a reliable economic policy conclusion, it is important to ascertain the regression results' accuracy via post estimation tests. Post estimation test included stability test for linearity and Cusum, Serial correlation, heteroscedasticity, Normality, and collinearity tests. Table 8 below is a summary of the post estimation test.

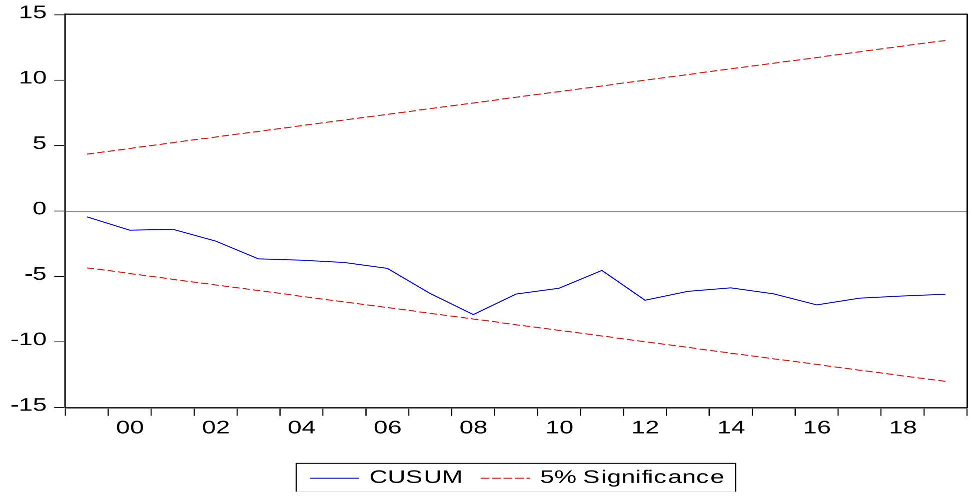
Table 8

The Linearity, Heteroscedasticity, Serial Correlation, and Normality Test

Test	F-Stat	Obs* R-Squared	Prob	Decision
Ramsey Reset test for linearity	4.617	N/A	0.0419	Linear
Breusch-Pagan-Godfrey test for Heteroscedasticity	0.587	7.188	0.7076	Not Heteroscedastic
Breusch- Godfrey LM test for Serial Correlation	0.928	2.49	0.2875	Not Serially correlated
Jarque-Bera test for Normality	N/A	N/A	0.176	Normally distributed

Figure 1

Cusum Stability Test



4.2 Data Analysis

4.2.4 Model Estimation

From the value of R-squared being 0.8825, this indicates that the model is 88.25 % fit, this implies that the regression model is a very good fit because the independent variable explains 88.25 % of the dependent variable. The f-statistics is significance because the p-value is less than 0.05 (5%), it means that the independent variable can influence the dependent variable HDI. For the individual independent variables, if the p-values is less than 0.05 (5%), then the respective variable is significance, that is the independent variables determines the dependent variable HDI in a good way, however if the p-values is greater that 0.05(5%) it meant the variable in question is not significant. From the regression output in Table 5, Total CO2 emission from fossil (TC02) has a p-values less than 0.05 (5%) which indicates that the independent variable is significant at 5% level.

Total CO2 emission from fossil fuel has a positive effect on HDI, with a coefficient of 0.003381 which meant that a one unit increase in total CO2 from fossil will lead to a 0.003381 increase in HDI. The last indicator is the Durbin- Watson stat, this value is used to ascertain if the model is spurious. If the Durbin-Watson stat is less than R-squared then it is an indication of a spurious model. From the regression output, the Durbin-Watson value is 1.03 and the R-squared value is 0.8825, which infer that the model is not spurious. In the final analysis the regression model is a good fit because R-squared has a high value, the F-stat is significant, same goes for the independent variable. Beside the value of R-squared is less than Durbin-Watson stat indicating that the model is fit.

5.1 Conclusion

5.1.1 Total CO2 from Fossil and Economic Development

There is a statistically significant relationship between total CO2 emission from fossil and economic development in Nigeria from the study. We can conclude that an increase in total CO2 emission from fossil will affect economic development.

5.2 Recommendations

This study will stimulate a national discussion on the need to balance carbon footprint and Nigeria's socio-economic wellbeing. Knowledge gained from the study will provide Nigeria's government with sufficient information on the need to reduce carbon footprint in the country. The policy recommendations that could be gleaned from the study is that CO2 emission from should be reduced, despite TCO2 emission having a positive correlation with economic development in Nigeria.

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