Developmental Imperative of Carbon Footprint Reduction in the Oil and Gas Industry in Nigeria

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DOI: 10.56201/jbae.v9.no3.2023.pg170.182

Abstract
There is a high dependence on heavy fossil fuels as a source for energy generation in Nigeria. The carbon dioxide (CO2) emissions per capita for Nigeria in 2018 was put at 0.57 metric tons. This figure has been on the increase within the last three years, with a value of 0.44 metric tons in 2016 and 0.56 metric tons in 2017, accounting for a 29% increase over the period. The specific problem is the apparent lack of sufficient information on the relationship between carbon footprint reduction, and economic development in Nigeria. The aim of this study was to determine the nexus between carbon footprint generated due to transport and other sector, and economic development in Nigeria, using time series from 1990-2019. The central research question asked was the impact of carbon footprint reduction on economic development in Nigeria. The study employed quantitative approach with ordinary least squares linear multiple regression technique to examine the relationships between carbon footprint reduction from Tranport and Other sector and economic development. From the regression output, CO2 emission from other sectors (OSC), and CO2 emission from Transport sector (TRPT) both have a p-value less than 0.05 (5%), which indicates that these two independent variables are significant at 5% level. The result revealed that a unit increase in CO2 generated from other sector (OSC) will result in a 0.0038 unit decrease in economic development; similarly, a one unit increase in CO2 generated from transport sector will reduce economic development by 0.003903. The study recommends measure aims as reducing carbon footprint. Knowledge gained from the study will provide Nigeria's government with sufficient information on reducing carbon footprint in the country and improving Nigeria's economic development.

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

1.0 Introduction

Global warming has emerged as a prominent issue in recent years (Letcher, 2021). Nigeria heavily relies on fossil fuels as its primary energy source. Fossil fuel is the primary catalyst for the phenomenon of global warming, which has emerged as a significant apprehension for the continued existence of humanity. (Zou, 2018). The Nigerian government has signed the France agreement on combating global warming and has been making vigorous measures to minimise the escalating levels of greenhouse gases to the lowest possible extent by 2030. Nevertheless, these impacts have not resulted in a permanent resolution. In 2018, Nigeria's per capita carbon dioxide (CO2) emissions were recorded at 0.57 metric tonnes. This figure has been steadily rising over the past three years. It was 0.44 metric tonnes in 2016 and increased to 0.56 metric tonnes in 2017, representing a 29% growth over the period. The source of this information is the World Data Atlas, specifically from the year 2019. The issue at hand is the perceived insufficiency of knowledge on the correlation between the decrease in carbon footprint and the economic development in Nigeria (Efe, 2016).

Zou (2018) examined the correlation between energy consumption, carbon emissions, and economic growth. Chindo et al. (2015) explored the association between energy consumption, carbon dioxide (CO2) emissions, and GDP in Nigeria. Both Zou, Chindo et al. and other research did not examine the correlation between carbon footprint and economic development. I want to address the knowledge gap by examining the relationship between Nigeria's carbon emissions and economic progress, utilising the Human Development Index (HDI) as a measure of economic development.

This quantitative study aimed to establish the relationship between carbon emissions from the transport industry and other sectors, as well as economic development in Nigeria. Time series data from 1990 to 2019 were utilised for analysis. The study measured economic development using the human development index as a proxy. The independent variables consisted of carbon emissions from the transport sector (TRPT) and the other sector (OSCT).

2.0 Literature review

Rising CO2 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 economicdevelopment, CO2 emissions, and energy consumption in five southeast Asian nationsfrom 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 CO2 emissions in 31 developing nations. Friedrichs and Inderwildi (2013) examined fuel-rich countries and high CO2 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 CO2 emissions in 31 developing nations.

Antonakakis et al. (2017) used panel VAR to evaluate the relationship between energy use, CO2 emissions, and real GDP per capita growth in 106 countries from 1971 to 2011. Kucukvar et al. (2015) modelled global, scope-based carbon footprints for successful carbon reduction measures. Electricity, gas and water supplies dominated Turkish industrial supply chains with the biggest carbon footprint. Kucukvar et al. (2015) modelled Turkish carbon footprints to offer efficient carbon reduction initiatives. Froman 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 CO2 emissions, energy consumption, and economic growth in three North African nations from 1980–2012. Arfanuzzaman (2016) investigated Bangladesh's environmental performance index (EPI) and CO2 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 CO2 emissions in BRICS- Resultsshow 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, CO2 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 ecological footprint, which estimates human impact on Earth's ecosystems, inspired the carbon footprint. It is a standardised indicator of natural capital demand that may differ from the planet's ecological regeneration capability. It is the ecologically productive land and marine area needed to feed humans and absorb their waste. Gao et al. (2014). Country carbon footprint is the amount of carbon dioxide released into the atmosphere by humans. Annual CO2 emissions are quantified in equivalent tonnes of carbon dioxide. Aichele & Felbermayr (2012); Change et al. Modern society faces a major challenge: climate change. International and local authorities want a tool to monitor climate change's impact, which is measured by greenhouse gas emissions. Carbon footprint was used to measure greenhouse gas emissions easily.

2.1.2 Sources of CO_2 Emission

CO2 emissions are human caused. Mancini et al. (2016) categorised CO2 emissions from anthropogenic activities into three sources, based on the International Energy Agency: fossil fuel combustion, non-fossil fuel sources like forest fires, gas flaring, cement production, and unsustainable biofuel production, and marine and aviation transport. Mancini et al. reported that the three sources contributed 78%, 19%, and 3% of 2010 emissions. Contrary to Mancini et al., Fenner et al. (2018) believe the built environment accounts for most of society's carbon emissions. Fenner et al. sought a simple, consistent, and easy carbon emission assessment method for buildings. Hussain et al. (2012) found that energy consumption per capita in Pakistan is the main cause of environmental pollution.

3.0 METHODOLOGY

3.1 Sources of Data

The study centred on the Nigerian economy. The study exclusively relied on secondary data. The study focused on analyzing time-series data from 1990 to 2019 to estimate the regression model. The necessary data include CO2 emissions from the transport sector (TRPT) and other sectors (OSC), as well as the Human Development Index (HDI). The data were obtained from the Global greenhouse gas and CO2 emission and the United Nations Development Programme (UNDP).

3.2 Model **Specifications**

To evaluate the impact of carbon emissions on economic development, this study, I adopted a multiple regression model used by Ejuvbekpokpo (2014), Who investigated 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 output 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 variables, with total CO2 emission and distilling CO2 emission into major sources, namely transport, other sectors. We have:

HDI = f (TRPT OSC) (3.2)

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

$$HDI = \beta_0 + \beta_1 TRPT_t + \beta_2 OSC_t + +\varepsilon_t \quad (3.3)$$

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)

TRPT = CO2 emission from transport sector

OSC = CO2 emission from other sector

4.0 Results

Table 1

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

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
OSC	-0.7329 (0.8228)	-6.2610 (0.0000)	Non-stationary at Level; Stationary at 1st difference
TRPT	-2.1721 (0.2200)	-5.5473 (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-None	1st Diff- None	Decision
HDI	3.5267 (0.9997)	-3.5520 (0.0009)	Non-stationary at Level; Stationary at 1st difference
OSC	-1.0322 (0.2648)	-6.1990 (0.0000)	Non-stationary at Level; Stationary at 1st difference
TRPT	1.1855 (0.9355)	-5.6488 (0.0000)	Non-stationary at Level; Stationary at 1st difference

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
OSC	-2.7949 (0.2102)	-6.2368 (0.0001)	Non-stationary at Level; Stationary at 1st difference
TRPT	-2.4613 (0.3432)	-5.4423 (0.0007)	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 cannot be rejected for any variable in the level (Pesaran et al., 1996). Conversely, all variables exhibit unit roots. However, the null hypothesis of a unit root is rejected for variables only when first differenced. The unit root test using the Augmented Dickey-Fuller is found in Tables 1-3

Table 4

Cointegration Test Result

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic
None *	0.764277	93.90579
At most 1	0.517162	53.44306
At most 2	0.445121	33.05697
At most 3	0.315774	16.56485
At most 4	0.191145	5.939782

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic
None *	0.764277	40.46273
At most 1	0.517162	20.38609
At most 2	0.445121	16.49212
At most 3	0.315774	10.62506
At most 4	0.191145	5.939782

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 less than 0.05 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.
OSC	-0.003851	0.000793	-4.855261	*0.0001
TRPT	-0.003903	0.001388	-2.810993	*0.0095
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 means that the independent variables jointly can influence the dependent variable HDI.

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

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)= OSC	0.000513	0.000625	0.820383	0.4212
C(4)=TRPR	0.001805	0.001120	1.611521	0.1220
C(5)=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
OSC and HDI	C(3)	0.4120	0.4212	No short-run relationship
TRPT and HDI	C(4)	0.1071	0.1220	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.

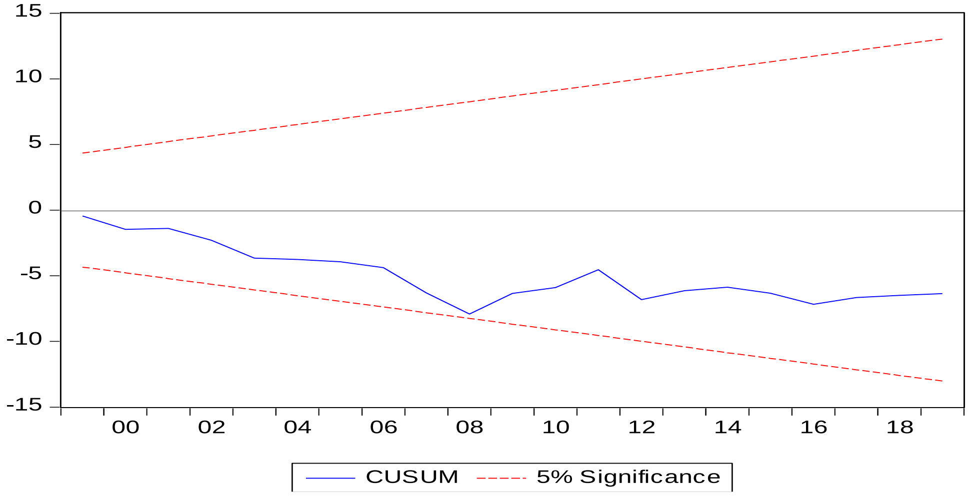
Table 8

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

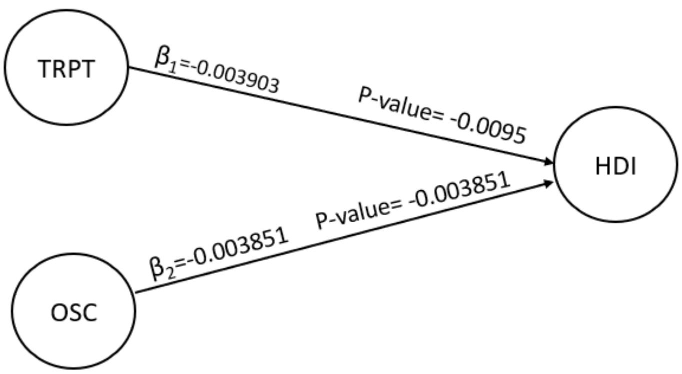
4.2.4 Model Estimation

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 variables cumulatively explain 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 variables jointly 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 6, CO_2 emission from other sector (OSC) and Transport sector (TRPT) have a p-values less than 0.05 (5%) which indicates that these two independent variables are significant at 5% level.

Further analysis of the study revealed that CO_2 emission from other sector (OSC) has a negative effect on economic development with a coefficient of -0.003851, which meant that if the emission from other sector increases by one-unit economic development will reduce by 0.003851. Similarly, CO_2 emission from transport sector has a negative effect on HDI with a coefficient of -0.003903, which meant that an increase in CO_2 emission from transport (TRPT) by one unit will reduce HDI (economic development) by 0.003903. 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 three of the independent variables. Beside the value of R-squared is less than Durbin-Watson stat indicating that the model is fit.

Figure 2 below depicts the pictorial representation of the variables (HDI, TRPT, and OSC). It shows the p-values and the respective value for the coefficient (β_1, and β_2).

Figure 1
Heuristic Model



NB. β refers to coefficients,
Source: (Researcher's Study Outcome, 2023).

5.1 Conclusion

5.1.1 CO2 Emission from the Transport Sector and Economic Development

There is a statistically significant relationship between CO2 emission from transport sector and economic development in Nigeria from the study. We can conclude that an increase in CO2 emission from transport sector will lead to a decrease in economic development.

5.1.2 CO2 Emission from Other Sector and Economic Development

There is a statistically significant relationship between CO2 emission from other sector and economic development in Nigeria from the study. We can conclude that an increase in CO2 emissions from other sectors will reduce economic development.

5.2 Recommendations

This section highlights the recommendations for policy and future research. This study will help address the preponderance of greenhouse gasses. It 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 how to reduce carbon footprint in the country.

5.2.1 Recommendation for Policy

The policy recommendations that could be gleaned from the study are as follows:
Reduce the emission of CO2 from transport sector, and other sectors.
5.2.1.1For the transport sector, Nigeria should

- Reduce transportation of essential goods by trucking; it should consider developing the rail system to move most of its agricultural produce and oil derivative.

- Nigeria should invest in Mass transit to reduce the number of cars on the road.
- The transport department should insist that cars that emit huge amounts of carbon particles should be taken off Nigerian roads.
- Nigeria should join other countries at the forefront in a carbon-neutral economy's ambition by investing in electric cars.

5.2.1.2 For other industry combustion, the following measure are encouraged:

- Nigeria should come out with the ambition to be carbon neutral in all their processes.
- The reforestation program of the government should be strengthened.

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