Environmental Sustainability and Inclusive Growth in Nigeria

Adetunji Olayemi Sijuwola & Olusola Kayode Fadogba

Abstract
This study examined the effect of carbon emissions on inclusive growth in Nigeria using analysed annual time series data for the period 1970 to 2022. The theoretical underpinning for the study is the Environmental Kuznets curve. The study employed the Autoregressive Distributed Lagged Model to determine the short-run and long -run effect of carbon emissions on inclusive growth. According to the findings, cointegrating long run relationship exists between carbon emissions and inclusive growth in Nigeria. The regression results indicate that the effect of carbon emissions on inclusive growth was positive in the short-run but inversely on the long run. Additionally, the short-run effect was insignificant while the long run was significant. Carbon emissions are negatively related to inclusive growth in Nigeria. Therefore, Policy makers should prioritize strategies that curtail carbon emissions without compromising economic development, implementing eco-friendly practices across industries.
Keywords: Carbon Emissions, Inclusive Growth, Per Capita Income, Inflation Rate and Foreign Direct Investment

Introduction

Inclusive growth is a fundamental pursuit for nations globally. This is because it captures the imperative of not just economic expansion but also equitable distribution of benefits across all sectors of society (Ofori et al., 2022). In Nigeria, this pursuit is of immense importance due to entrenched challenges of poverty, income disparity, and limited access to basic services. Nigeria faces socio-economic challenges, including high unemployment rates, income inequality, and inadequate infrastructure. Meanwhile, Nigeria faces pressing environmental issues like deforestation, pollution, and climate vulnerability which worsen societal disparities (Nneka et al., 2023).

Inclusive growth refers to economic development that benefits all segments of the society, ensures that the opportunities and benefits of growth are distributed fairly across different socio-economic groups (Mochurova & Totev, 2022). Inclusive growth focuses on reducing disparities and improving living standards for all individuals, regardless of their socio-economic background, gender, ethnicity, or location.

Carbon emissions is the release of carbon compounds, particularly carbon dioxide (CO_2), into the atmosphere (Li et al., 2022). According to Guo et al., (2022), these emissions primarily originate from human activities, such as burning fossil fuels like coal, oil, and natural gas for energy production, transportation, industrial processes, and deforestation. Carbon emissions contribute significantly to the greenhouse effect, trapping heat in the Earth's atmosphere and leading to climate change. Managing and reducing carbon emissions are crucial steps in addressing climate change and its adverse effects on the environment, ecosystems, and human health.

Nigeria stands at a critical juncture where economic growth and environmental sustainability intersect. The pursuit of rapid economic development often comes at the cost of environmental degradation, posing significant challenges to achieving inclusive growth (Omisore, 2018). Despite the nation's rich natural resources and potential for economic expansion, the absence of comprehensive environmental sustainability measures has raised concerns regarding its impact on inclusive growth (Ofori et al., 2023).

In the pursuit of rapid economic growth in Nigeria, the absence of robust integration of environmental sustainability within its development framework has raised concerns about hindering inclusive growth (Ofori et al., 2022). Carbon emissions, the main source of threat to environmental sustainability ((Raihan & Tuspekova,

2022), can affect inclusive growth in various ways. On one hand, carbon emissions can create barriers to inclusive growth by increasing the costs of energy, transportation, agriculture, and other sectors that depend on fossil fuels. Carbon emissions can also exacerbate the effects of climate change on vulnerable populations, such as those living in coastal areas, small island states, or arid regions (Leal Filho, 2021). These effects can undermine human well-being, livelihoods, and social cohesion. On the other hand, carbon emissions can create opportunities for inclusive growth by stimulating technological innovation and market transformation thereby creating new jobs, industries and enhancing productivity and competitiveness (Hepburn et al., 2021).

The depletion of natural resources, escalating pollution, inadequate waste management, and ecosystem degradation pose significant challenges to inclusive growth in Nigeria. These environmental issues disproportionately affect marginalized communities, exacerbating socio-economic disparities and impeding their participation in the growth process. The absence of cohesive policies harmonizing economic expansion with environmental protection exacerbates vulnerability to climate change, perpetuating exclusionary trends and threatening long-term growth prospects (Martin et al., 2023).

In the literature, there have been inconclusive results as to whether carbon emissions improve inclusive growth or not. Studies such as Xiang et al., (2022) and Murshed et al., (2022) as well as Khan et al (2021) found positive effect of carbon emissions on inclusive growth while Hao et al., (2021), Qin et al., (2021) as well as Wang and Guo (2022) opined that carbon emissions impacted inversely on inclusive growth. The inconclusive result, therefore, puts policy makers at crossroads as to the basic effect of carbon emissions on inclusive growth which poses a problem. Several studies including, Maduka et al., 2022 and Olayungbo et al., 2022 have looked at the effect of carbon emissions on economic growth. However, the relationship between environmental sustainability and inclusive growth have been inadvertently ignored. This study, therefore, examined the effect of carbon emissions on inclusive growth in Nigeria.

Apart from the introduction, the rest of the paper is organized as follows: Section two offers a comprehensive review of the existing literature; section three provides the methodology employed. Section four presents the empirical results derived from the study's methodology. Finally, in section five, the paper concludes and provides policy recommendations based on the study's outcome.

Literature Review

Conceptual Review

Carbon emissions are the release of greenhouse gases, such as carbon dioxide and methane, into the atmosphere (Yusuf et al., 2020). Carbon emissions are caused by natural processes, such as the exchange of carbon dioxide between the oceans and the atmosphere, or by human activities, such as burning fossil fuels, deforestation, and agriculture. Carbon emissions is measured in different units, such as tonnes of carbon dioxide equivalent (tCO2e), which takes into account the global warming potential of different greenhouse gases.

Inclusive growth embodies an economic development model that prioritizes not just overall economic advancement but ensures that the benefits of growth are widely and equitably shared among all segments of society. It goes beyond the expansion of gross domestic product to emphasize the fruits of economic progress reaching marginalized and disadvantaged groups, reducing disparities in income, opportunities, and access to essential services. The aim of inclusive growth is to create an environment where everyone has access to and can participate in the growth process, leading to reduced poverty, increased employment opportunities, better education, improved healthcare, and overall enhanced well-being for the entire population (Alekhina & Ganelli, 2023).

Stylized Fact

Figures 1 and 2 presents the trend of carbon emissions in Nigeria in kilotons (kt) and gross domestic product

(GDP) per person employed ($), a proxy for inclusive growth (Zhuang & Hasan, 2008) between 1990 and 2022. The figures show an overall increase in carbon emissions and gross domestic product (GDP) per person employed but with different rates and patterns. CO2 emissions in Nigeria increased from 48,626.3 kt in 1970 to 114,641.1 kt in 2022, with an average annual growth rate of 3.23%. The highest level of carbon emissions was recorded in 2019 at 119,544.1 kt and the lowest level was recorded in 1970 at 48,626.3 kt. CO2 emissions exhibited a generally upward trend, with some dips in 1998, 2007, 2009, 2015, and 2020. Nigeria also experienced significant increase in carbon emissions between 1996 and 2018, which corresponded to some periods of economic recovery and expansion in Nigeria, such as the debt relief in 2005, and the exit from recession in 2017. On the other hand, GDP per person employed exhibited a more erratic trend between 1970 and 2000 after which it continued to increase steadily till 2015. GDP per person employed increased from $9,837.5 in 1970 to $15,707.9 in 2022, with an average annual growth rate of 1.54%. The highest value of GDP per person employed was recorded in 2014 at $18,631.9 and the lowest value was recorded in 1999 at $6,049.8. The figures reveal a widening gap between carbon emissions and GDP per person employed in Nigeria over time, indicating a divergence between the environmental and economic performance of the country. This suggests that Nigeria has not been able to achieve a low-carbon and inclusive growth path, which would require a more efficient and equitable use of its natural and human resources.

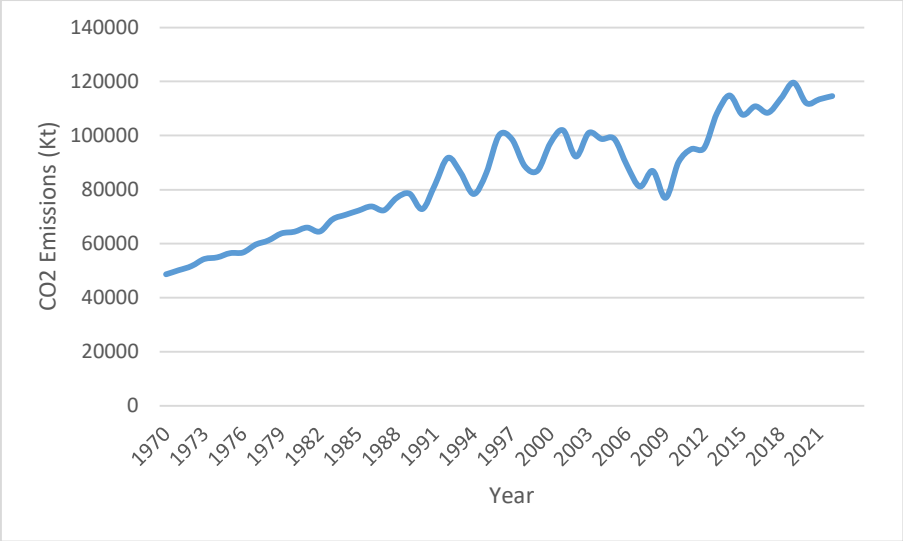

Figure 1: Trend of Carbon Emissions in Nigeria (1990-2022). Source: World Development Indicators (2023)

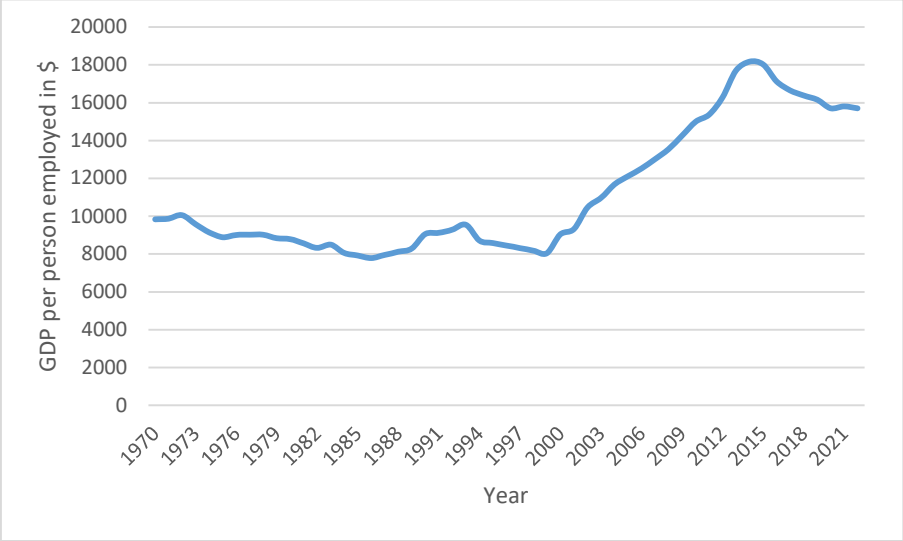

Figure 2: Trend of Inclusive Growth in Nigeria (1990-2022). Source: World Development Indicators (2023)

Theoretical Framework

The theoretical framework guiding this study is the Environmental Kuznets Curve (EKC) theory, which offers insights into the relationship between environmental degradation, specifically carbon emissions, and economic development. The EKC theory posits a non-linear association between these variables as a country progresses economically. Initially, during the early stages of economic growth, environmental degradation, represented by increasing carbon emissions, tends to escalate. However, the theory suggests that beyond a certain threshold of economic advancement, there exists a turning point where further growth begins to mitigate environmental degradation. In the context of examining the impact of carbon emissions on inclusive growth in Nigeria, this framework allows for the exploration of how different stages of economic development correlate with the relationship between carbon emissions and inclusivity in growth patterns.

Empirical Review

Mamman et al., (2023) examined the impact of climate change on inclusive growth across 51 African countries, analyzing time series data spanning from 1996 to 2020. The study employed the Augmented Mean Group (AMG) estimator to analyze the collected data. The results found a significant impediment posed by climate change on inclusive growth. Additionally, the findings highlighted a sustained adverse effect of climate change on inclusive growth, particularly attributing this to a lack of adaptive mechanisms prevalent among impoverished and vulnerable groups.

Yusuf (2023) examined the dynamics of energy consumption, economic growth, international trade, and urbanization on environmental degradation in Nigeria for the period covering 1980 to 2020. He employed the Autoregressive Distributed Lag technique while considering structural breaks within the data. The outcomes revealed support for the environmental Kuznets curve hypothesis in both short and long-term contexts within Nigeria. Specifically, the study highlighted that energy consumption and total imports exacerbated environmental degradation in both short and long-term perspectives, whereas total exports contributed positively to environmental quality over the same durations

Borgi et al., (2023) conducted an empirical study examining the impact of environmental change on inclusive finance in African countries from 1996 to 2020. Data collected were analyzed using the Generalized Method of Moment (GMM). The study revealed a significant adverse effect of environmental change on inclusive finance

while highlighting that government quality, particularly across political, institutional, and economic dimensions, plays a crucial role in moderating this relationship, indicating a positive influence on financial inclusion when economic governance is considered.

Abubakar and Abdullahi (2023) analysed the impact of carbon dioxide emissions on economic growth in Nigeria from 1980 to 2020, exploring whether this relationship hinges on the level of financial development. The study employed the Autoregressive Distributed Lag estimation technique (ARDL) to analyse the data. The empirical evidence suggested limited long-term influence of CO_2 emissions on economic growth independently. The findings also revealed that the conjunction of CO_2 emissions with financial development positively influences long-term economic growth, hinting at CO_2 emissions' economic impact being contingent on the presence of financial development.

Natufe and Osagie (2023) focused on the interplay between carbon emissions and Nigeria's economic growth spanning from 1985 to 2021. The ARDL approach was used to analyse the data. Findings revealed a short-term positive impact of carbon emissions on economic growth. Additionally, a long-term negative effect of impact of carbon emissions on economic growth was also reported in line with the Kuznets curve hypothesis proposed by Grossman and Krueger (1995).

Amaefule et al., (2022) investigated the influence of climate change, through carbon emissions, on agricultural productivity in Nigeria. Data analysed spanned from 1960 to 2019. The data were analysed through the ARDL Bounds test method of estimation. According to the findings, a long-term relationship exists between carbon emissions and agricultural productivity in Nigeria. The findings also indicated that changes in CO_2 emissions and intensity had differing impacts on Agricultural productivity and posed a threat to Nigeria's agricultural productivity.

Musibau (2021) investigated the potential ramifications of climate change on Nigeria's economic growth by analyzing time series data from 1980 to 2017. Data collected were analysed using the Auto-regressive distributive lagged model. The research found considerable short- and long-term impacts of annual average rainfall on economic growth. Furthermore, it revealed a notably positive and significant relationship between carbon emissions, foreign direct investment, gross fixed capital formation, and economic growth.

Methodology

Model Specification

The study followed the model by Abubakar and Abdullahi, (2022) with a slight modification. The functional form of the model is presented as follows:

$$INCgr = f(CO_2,\ IFR, GCEX, PKY) \quad 1$$

Where:

GPPE= Gross domestic product per person employed as a proxy for inclusive growth

CO_2 = Carbon emissions

FDI = Foreign direct investment, net inflows (% of GDP)

IFR = Inflation, consumer prices (annual %)

PKY = GDP per capita (current US$)

In econometric terms equation 1 is formulated as

$$INCgr_t = \beta_0 + \beta_1 CO_{2t} + \beta_2 FDI_t + \beta_3 PKY_t + \beta_4 IFR_t + \varepsilon_t \quad 2$$

Where: β_0= Constant, $\beta_1 - \beta_4$= Coefficient of the independent variables and ε_t = is the error term. Although, the aim of the study was to determine the effect of carbon emissions on inclusive growth in Nigeria, FDI, PKY and IFR were added as control variables are they are regarded as determinants of inclusive growth as supported by Oluseye and Gabriel (2017).

Equation 2 is reformulated in logarithmic notation to assume the following structure

$$logINCgr_t = \beta_0 + \beta_1 logCO_{2t} + \beta_2 logFDI_t + \beta_3 logPKY_t + \beta_4 logIFR_t + \varepsilon_t \quad 3$$

On apriori, we expect $\beta_1 < 0;\ \beta_2 > 0;\ \beta_3 > 0; and\ \beta_4 < 0$

Data Source and Requirement

This study is based on the annual time series data covering the period from 1970 to 2022, which comprises 53 data points. The data were obtained from the World Bank, World Development Indicators (WDI, 2022). The data used are GDP per person employed (constant 2017 PPP $), Foreign direct investment, net inflows (% of GDP), CO_2 emissions (metric tons per capita), GDP per capita (current US$), and Inflation, consumer prices (annual %).

Estimation Techniques

In time series research, it's crucial to establish the stationarity of all variables to prevent spurious regression and biased findings. Assessing stationarity is vital for dependable results and assists in determining variables' integration order and suitable econometric methods. Consequently, to avoid spurious regression, this study utilizes unit root tests involving the Augmented Dickey-Fuller (ADF) and Philip Perron (PP) to evaluate the stationarity characteristics of the variables used. The ADF test is given as.

$$y_t = c + \beta_t + \alpha y_{t-1} + \phi_1 \Delta Y_{t-1} + \phi_2 \Delta Y_{t-2..} + \phi_p \Delta Y_{t-p} + e_t \quad 4$$

To refute the null hypothesis, assuming a unit root (α=1), the obtained p-value must fall below the chosen significance level, typically set at 0.05. This outcome allows us to infer that the analyzed series exhibits stationarity.

While the Phillip Perron (PP) test provides robust estimates, making it also a valuable tool for time-series unit root testing procedures. The specification of the PP equation is given as:

$$\Delta y_{t-1} = x_0 + \lambda y_{t-1} + \mu_t \quad 5$$

After confirming the stationarity property of the variables used. The study employs the Autoregressive Distributive Lagged (ARDL) model to determine the short – run and the long run effect of carbon emissions on inclusive growth in Nigeria.

Empirical Results

Descriptive Statistics

Table 4.1 provides the descriptive statistics for the variables under consideration. The average GDP per person employed, calculated at a constant 2017 purchasing power parity (PPP) rate, is $11,151.390, displaying a standard deviation of $3,607.206. The range spans from a minimum value of $6,389.220 to a maximum value of $18,168.910. The country's recorded carbon emissions demonstrate an average of 0.710 kilotons, coupled with a standard deviation of 0.114 kilotons. The range between the minimum emissions level of 0.490 kilotons and the maximum of 0.916 kilotons signifies notable variability in carbon output. From the result, GDP per capita employed shows an average value of $1213.767million with a standard deviation of $880.978million. The minimum and maximum values are $161.544million and $3200.953million respectively. The analysis of Foreign Direct Investment (FDI) reveals an average value of $1.383 billion, accompanied by a standard deviation of $1.254 billion. The range between the minimum value of -$1.151 billion and the maximum value of $5.791 billion indicates significant variability in FDI inflows. The inflation rate, as evidenced by the findings, indicates an average of 18.337% alongside a standard deviation of 15.162%. These metrics unveil substantial fluctuations, showcased by the range between the minimum of 3.458% and the maximum of 72.836% suggesting the potential challenges in stabilizing pricing behaviour during the period.

Table 1: Descriptive statistics of variables

	Mean	Std. Dev.	Maximum	Minimum
INCGR	11151.390	3607.206	18168.910	6389.220
CO_2	0.710	0.114	0.916	0.490
PKY	1213.767	880.978	3200.953	161.544
FDI	1.383	1.254	5.791	-1.151
IFR	18.337	15.162	72.836	3.458

Source: Researcher's computation, 2023

Cointegration Test

Table 2 shows the correlation matrix of the variables used. The correlation matrix reveals a notable inverse and statistically significant relationship between inclusive growth and carbon emissions in Nigeria (r = -.752***, $\rho <$ 0.05). This finding indicates a strong negative association between these variables, suggesting that as inclusive growth increases, carbon emissions tend to decrease significantly within the context of Nigeria. In Nigeria, a robust positive and statistically significant relationship emerges between GDP per capita and inclusive growth (r = .714***, ρ<0.05). This strong correlation suggests that as GDP per capita progresses, there is a marked tendency for an increase in inclusive growth. The analysis unveiled a positive yet statistically insignificant relationship between Foreign Direct Investment (FDI) and inclusive growth in Nigeria (r = 0.032, ρ>0.05). This indicates a slight positive association between these variables that isn't strong enough to be considered significant within the context of the study. Despite the observed correlation, it suggests that FDI doesn't significantly influence inclusive growth in Nigeria. The analysis highlights an inverse and statistically insignificant relationship between inflation and inclusive growth in the context of Nigeria (r = 0.242, ρ>0.05). This finding suggests a mild negative association between these variables that doesn't carry enough statistical significance within the study. It implies that inflation rates do not significantly impact the trajectory of inclusive growth in Nigeria.

Table 2: Correlations

		INCgr	CO_2	PKY	FDI	IFR
INCgr	Pearson Correlation	1.000				
	Sig. (2-tailed)					
	N	53				
CO_2	Pearson Correlation	-.752**	1.000			
	Sig. (2-tailed)	(0.000)				
	N	53	53			
PKY	Pearson Correlation	.714**	-.825**	1.000		
	Sig. (2-tailed)	(0.000)	(0.000)			
	N	53	53	53		
FDI	Pearson Correlation	0.032	0.137	-.357**	1.000	
	Sig. (2-tailed)	(0.820)	(0.329)	(0.009)		
	N	53	53	53	53	
IFR	Pearson Correlation	-0.163	0.115	-0.214	0.157	1.000
	Sig. (2-tailed)	(0.242)	(0.413)	(0.124)	(0.260)	
	N	53	53	53	53	53

Source: Researcher's computation, 2023 Note: *** denote significance at 5%

Unit Root Test

Table 3 presents the Augmented Dickey Fuller (ADF) and Phillip Perron (PP) unit root tests for all the variables

used.. As presented, logINCgr, logCO_2 and logPKY were stationary after their first difference (I(1)), implying that it exhibits a trend and requires differencing to achieve stationarity. On the other hand, logFDI and logIFR were stationary at level I(0), suggesting that it is stationary in its original form without requiring differencing. Since the result are mixture of both (I(1) and I(0)), it indicates the presence of immediate and long-term dynamics in the relationship and hence support the use of the ARDL estimation techniques.

Table 3: Result for ADF and PP Unit Root Test

	ADF		**PP**	
Variables	**Level I(0)**	**First Diff. I(1)**	**Level I(0)**	**First Diff. I(1)**
logINCgr	-0.339	-6.016***	-0.439	-6.009***
	(0.912)	(0.000)	(0.895)	(0.000)
logCO_2	-0.828	-7.048***	-0.555	-7.624
	(0.802)	(0.000)	(0.871)	(0.000)
logPKY	-1.450	-5.646***	-1.525	-5.669***
	(0.551)	(0.000)	(-0.800)	(0.000)
logFDI	-3.327***		-3.247	
	(0.019)		(0.023)	
logIFR	-4.318		-4.119	
	(0.001)		(0.002)	

Source: Researchers computation 2023. Note: *** denotes significance of the variable at 5%

Cointegration Test

To investigate the potential long-term relationship between carbon emissions and inclusive growth in Nigeria, the study employed the Bound Test developed by Pesaran, Shin, and Smith (2001). The outcome of this analysis is detailed in Table 4. The critical values recommended by Kripfganz, and Schneider (2018) was used. The F-statistic value obtained was 6.192, which surpassed the upper bound I(I) and did not fall below any of the critical values at the lower bound I(0) in all the level of significance. As a result, it is concluded that existence of a significant long-run relationship exists between carbon emissions and inclusive growth.

Table 4: Bound Test

	Lower Bound	Upper Bound	F-Statistics
Critical Value	I(0)	I(1)	
10%	2.45	3.52	
5%	2.86	4.01	6.192***
2.5%	3.25	4.49	
1%	3.74	5.06	

Source: Researchers computation 2023 Note: *** denotes significance at 5%

Short Run and Long Run Estimates

The short-run and long run estimates of the impact of carbon emissions on inclusive growth in Nigeria are presented in Table 5. As reported, in the short run, D(CO_2) and D(CO_2(-1)) impacted positively on inclusive growth in Nigeria, specifically, a 1% increase in , D(CO_2) and D(CO_2(-1)) is associated with an increase in inclusive growth by 0.225% and 0.160% respectively. However, the effect was insignificant with p>0. D(PKY) impacted positively on inclusive growth but was also insignificant with a 1% increase in D(PKY) leading to an increase in inclusive growth by 0.025%. Result also shows that a 1% increase in D(FDI) and D(FDI(-2)) is associated with an increase in inclusive growth by 0.010% and 0.019% respectively. The result was however not

significant with p>0.05. Also, a 1% increase in D(FDI(-2)) is associated with a decrease in inclusive growth by 0.019% and significant wit p<0.05. Also, a 1% increase in D(IFR) is associated with an increase in inclusive growth by 0.001% but insignificant while a 1% increase in D(IFR(-1)) is associated with a decrease in inclusive growth by 0.028% but the result was significant. The cointegrating equation shows a value of -0.126 with p<0.05. The cointegrating equation, revealing a coefficient of -0.126 with a p-value less than 0.05, holds significant implications for understanding the dynamics of short-term adjustments. This coefficient signifies the speed at which the system returns to its equilibrium state following a disturbance, offering insights into the short-term behavior of the variables under consideration. The negative value of -0.126 suggests that the adjustment process occurs relatively swiftly, emphasizing that any deviations from the equilibrium state are corrected at a reasonably brisk pace in the short run.

The long-run result shows that a 1% increase in carbon emissions is associated with a decrease in inclusive growth by 1.441%. The result was also significant which shows that carbon emissions is an important factor that determines inclusive growth in Nigeria. The findings supported the outcome by Onofrei et al., (202). Per capita income from the result shows a positive and significant impact on inclusive growth in Nigeria. Specifically, a 1% increase in per capita income is associated with an increase in per capita income by 0.194%. The result was significant with p<0.05. This implies that in Nigeria, per capita income stands as an important factor that determines inclusive growth in Nigeria. The findings supported the outcome by Yang et al., (2023)

The result also shows that foreign direct investment impacted positively on inclusive growth in Nigeria. As reported, a 1% increase in FDI is associated with an increase in inclusive growth by 0.411%. The result was significant with p<0.05. This shows that FDI stand as an important factor that determine inclusive growth in Nigeria. The study supported the findings by Kang, et al (2022). Inflation from the result shows an inverse relationship with inclusive growth with a 1% increase in inflation reducing inclusive growth by 0.129%. The result was insignificant with p<0.05. The result supported the findings by Ali and Asfaw (2023).

Table 5: Short-Run and Long -Run Estimate

Cointegrating Form				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(CO_2)	0.225	0.146	1.537	0.133
D(CO_2(-1))	0.160	0.132	1.213	0.233
D(PKY)	0.025	0.027	0.920	0.363
D(FDI)	0.010	0.015	0.633	0.531
D(FDI(-1))	-0.058	0.016	-3.675	0.001
D(FDI(-2))	0.019	0.016	1.171	0.249
D(IFR)	0.001	0.016	0.080	0.937
D(IFR(-1))	-0.028	0.016	-1.830	0.075
CointEq(-1)	-0.126	0.050	-2.538	0.016
Long Run Coefficients				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
CO_2	-1.441	0.603	-2.391	0.023
PKY	0.194	0.081	2.395	0.035
FDI	0.411	0.154	2.665	0.011
IFR	-0.129	0.166	-0.778	0.442
C	3.404	0.599	5.679	0.000

Source: Researchers computation 2023

Diagnostics Tests

To assess the validity and reliability of the regression model, the Breusch-Godfrey Serial Correlation LM test, the Breusch-Pagan-Godfrey Heteroskedasticity test, and the Ramsey RESET test were conducted. Table 6 shows the results of these tests. The Breusch-Godfrey test for serial correlation had an F-statistic of 2.203 and a p-value of 0.378, the Breusch-Pagan-Godfrey Heteroskedasticity test had an F-statistic of 1.850 and a p-value of 0.582, while the Ramsey RESET test had an F-statistic of 1.918 and a p-value of 0.983. The non-significance of the p-values at the 5% level of significance indicate a failure to reject the null hypotheses of no serial correlation, no heteroskedasticity, and no omitted variables or functional form errors in the model.

Table 6. Serial Correlation, Heteroskedasticity and Ramsey RESET Test

Test	F-stat.	Prob.
Breusch-Godfrey Serial Correlation LM	2.203	0.378
Breusch-Pagan-Godfrey Heteroskedasticity	1.850	0.582
Ramsey RESET Test	1.918	0.983

Source: Researcher's Computation, 2023

Stability Test

To test the stability of the model, the CUSUM test and the CUSUM of squares test were conducted. Figure 3 shows the results of the CUSUM test, while Figure 4 shows the results of the CUSUM of squares test. The blue lines in both figures represent the test statistics, and the dotted red lines represent the 5% critical bounds. In both tests, the blue lines stay within the critical bounds, indicating no structural breaks or significant shifts in the relationship between CO2 emissions and inclusive growth between 1970 and 2022. The stable behaviour of these tests suggests that CO2 emissions and inclusive growth had a robust and consistent link over time.

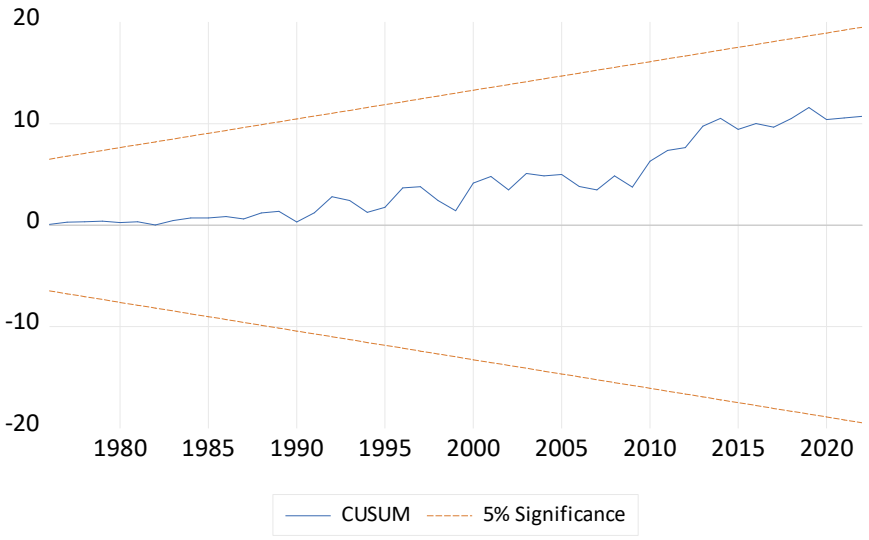

Figure 3. Cumulative Sum of Residuals (CUSUM)

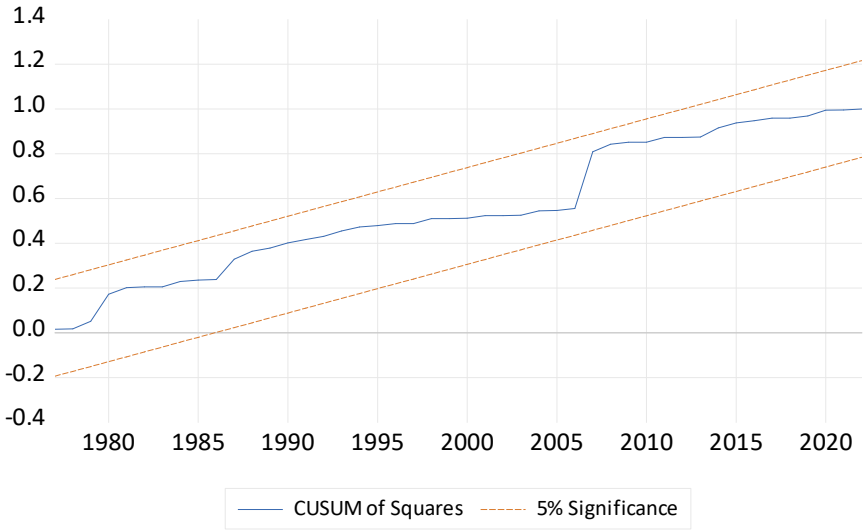

Figure 4. Cumulative Sum of Squares of Residuals (CUSUM)

Conclusions and Policy Recommendations

The research investigated the impact of carbon emissions on Nigeria's inclusive growth between 1970 and 2022, utilizing the Autoregressive Distributed Lagged Model to discern short and long-term effects. The study's conclusions revealed a long-run association between carbon emissions and inclusive growth in Nigeria. Also, carbon emissions displayed a positive influence on inclusive growth in the short term but shifted to a negative impact over the long term. Notably, while the short-term effect lacked significance, the long-term implications stood as statistically meaningful. Additionally, it highlighted that inclusive growth thrives on increased per capita GDP and Foreign Direct Investment (FDI), whereas inflation detrimentally affects inclusive growth. Based on the findings, the following recommendations are suggested to foster sustainable inclusive growth in Nigeria. Firstly, policies should prioritize strategies that curtail carbon emissions without compromising economic development. This could involve investing in renewable energy sources and implementing eco-friendly practices across industries. Secondly, enhancing economic indicators like per capita GDP and attracting Foreign Direct Investment (FDI) should remain focal points. Encouraging initiatives that stimulate economic growth while ensuring equitable distribution of resources could significantly bolster inclusive development. Additionally, addressing inflationary pressures through prudent monetary policies and measures to stabilize prices is crucial to mitigate their adverse impact on inclusive growth.

References

Abubakar, H., & Abdullahi, K. T. (2022). Carbon dioxide emissions and economic growth nexus in Nigeria: The role of financial development. *American Journal of Social Sciences and Humanities*, *7*(2), 69-84.

Abubakar, H., & Abdullahi, K. T. (2022). Carbon dioxide emissions and economic growth nexus in Nigeria: The role of financial development. *American Journal of Social Sciences and Humanities*, *7*(2), 69-84.

Alekhina, V., & Ganelli, G. (2023). Determinants of inclusive growth in ASEAN. *Journal of the Asia Pacific Economy*, *28*(3), 1196-1228.

Ali, A. K., & Asfaw, D. M. (2023). Nexus between inflation, income inequality, and economic growth in Ethiopia. *Plos one*, *18*(11), e0294454.

Amaefule, C., Shoaga, A., Ebelebe, L. O., & Adeola, A. S. (2023). Carbon emissions, climate change, and Nigeria's agricultural productivity. *European Journal of Sustainable Development Research*, *7*(1).

Borgi, H., Mabrouk, F., Bousrih, J., & Mekni, M. M. (2023). Environmental Change and Inclusive Finance: Does Governance Quality Matter for African Countries?. *Sustainability*, *15*(4), 3533.

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The quarterly journal of economics*, *110*(2), 353-377.

Guo, X., Wang, X., Wu, X., Chen, X., & Li, Y. (2022). Carbon emission efficiency and low-carbon optimization in Shanxi Province under "Dual Carbon" background. *Energies*, *15*(7), 2369.

Hao, L. N., Umar, M., Khan, Z., & Ali, W. (2021). Green growth and low carbon emission in G7 countries: how critical the network of environmental taxes, renewable energy and human capital is?. *Science of the Total Environment*, *752*, 141853

Hepburn, C., Qi, Y., Stern, N., Ward, B., Xie, C., & Zenghelis, D. (2021). Towards carbon neutrality and China's 14th Five-Year Plan: Clean energy transition, sustainable urban development, and investment priorities. *Environmental Science and Ecotechnology*, *8*, 100130.

Kang, H., & Martinez-Vazquez, J. (2022). When does foreign direct investment lead to inclusive growth?. *The World Economy*, *45*(8), 2394-2427.

Khan, I., Han, L., & Khan, H. (2021). Renewable energy consumption and local environmental effects for economic growth and carbon emission: evidence from global income countries. *Environmental Science and Pollution Research*, 1-18.

Kripfganz, S., & Schneider, D. C. (2018). Response surface regressions for critical value bounds and approximate P-values in equilibrium correction models (manuscript). In *Manuscript*. University of Exeter and Max Planck Institute for Demographic Research.

Leal Filho, W., Krishnapillai, M., Sidsaph, H., Nagy, G. J., Luetz, J. M., Dyer, J., ... & Azadi, H. (2021). Climate change adaptation on small island states: An assessment of limits and constraints. *Journal of Marine Science and Engineering*, *9*(6), 602.

Li, S., Wang, W., Diao, H., & Wang, L. (2022). Measuring the efficiency of energy and carbon emissions: a review of definitions, models, and input-output variables. *Energies*, *15*(3), 962.

Maduka, A. C., Ogwu, S. O., & Ekesiobi, C. S. (2022). Assessing the moderating effect of institutional quality on economic growth—carbon emission nexus in Nigeria. *Environmental Science and Pollution Research*, *29*(43), 64924-64938.

Mamman, S. O., Sohag, K., & Abubakar, A. B. (2023). Climate change and inclusive growth in Africa. *Cogent Economics & Finance*, *11*(2), 2282869.

Martin, M. A., Boakye, E. A., Boyd, E., Broadgate, W., Bustamante, M., Canadell, J. G., ... & Zhao, Z. J. (2022). Ten new insights in climate science 2022. *Global sustainability*, *5*, e20.

Mochurova, M., & Totev, S. (2022). Inclusive development,nature, aspects, measurement. *Economic Studies*, *31*(3).

Murshed, M., Apergis, N., Alam, M. S., Khan, U., & Mahmud, S. (2022). The impacts of renewable energy, financial inclusivity, globalization, economic growth, and urbanization on carbon productivity: Evidence from net moderation and mediation effects of energy efficiency gains. *Renewable Energy*, *196*, 824-838.

Musibau, O. A. (2021). Climate change and economy in Nigeria: A quantitative approach. *Acta Economica*, *19*(34), 169–186.

Nneka, J. I. N., Oyilieze, A. A., David, A. C., Jane, O. K., Keyna, D., Iko-Ojo, I. V., ... & Obioma, H. (2023). Deforestation Activities in Ezekoro Forest: Implications for Climate Change Risks in Anambra State, Southeast Nigeria. *Land and Environmental Management through Forestry*, 47-75.

Ofori, I. K., Figari, F., & Ojong, N. (2023). Towards sustainability: The relationship between foreign direct investment, economic freedom and inclusive green growth. *Journal of Cleaner Production*, *406*, 137020.

Ofori, I. K., Gbolonyo, E. Y., & Ojong, N. (2022). Towards Inclusive Green Growth in Africa: Critical energy efficiency synergies and governance thresholds. *Journal of Cleaner Production*, *369*, 132917.

Ofori, I. K., Osei, D. B., & Alagidede, I. P. (2022). Inclusive growth in Sub-Saharan Africa: Exploring the interaction between ICT diffusion, and financial development. *Telecommunications Policy*, *46*(7), 102315.

Olayungbo, D. O., Faiyetole, A. A., & Olayungbo, A. A. (2022). Economic growth, energy consumption, and carbon emissions: the case of Nigeria. In *Handbook of research on energy and environmental finance 4.0* (pp. 259-276). IGI Global.

Oluseye, I. C., & Gabriel, A. A. (2017). Determinants of inclusive growth in Nigeria: An ARDL approach. *American Journal of Economics*, *7*(3), 97-109.

Omisore, A. G. (2018). Attaining Sustainable Development Goals in sub-Saharan Africa; The need to address environmental challenges. *Environmental development*, *25*, 138-145.

Onofrei, M., Vatamanu, A. F., & Cigu, E. (2022). The relationship between economic growth and CO_2 emissions in EU countries: A cointegration analysis. *Frontiers in Environmental Science*, *10*, 934885.

Raihan, A., & Tuspekova, A. (2022). Nexus between economic growth, energy use, agricultural productivity, and carbon dioxide emissions: new evidence from Nepal. *Energy Nexus*, *7*, 100113.

Qin, L., Raheem, S., Murshed, M., Miao, X., Khan, Z., & Kirikkaleli, D. (2021). Does financial inclusion limit carbon dioxide emissions? Analyzing the role of globalization and renewable electricity output. *Sustainable Development*, *29*(6), 1138-1154.

Wang, H., & Guo, J. (2022). Impacts of digital inclusive finance on CO_2 emissions from a spatial perspective: evidence from 272 cities in China. *Journal of Cleaner Production*, *355*, 131618.

Xiang, X., Yang, G., & Sun, H. (2022). The impact of the digital economy on low-carbon, inclusive growth: Promoting or restraining. *Sustainability*, *14*(12), 7187.

Yang, Z., Vitenu-Sackey, P. A., Hao, L., & Tao, Y. (2023). Economic freedom, inclusive growth, and financial development: A heterogeneous panel analysis of developing countries. *Plos one*, *18*(7), e0288346.

Yusuf, A. (2023). Dynamic effects of energy consumption, economic growth, international trade and urbanization on environmental degradation in Nigeria. *Energy Strategy Reviews*, *50*, 101228.

Yusuf, A. M., Abubakar, A. B., & Mamman, S. O. (2020). Relationship between greenhouse gas emission, energy consumption, and economic growth: evidence from some selected oil-producing African countries. *Environmental Science and Pollution Research*, *27*, 15815-15823.

Zeng, X., Yu, Y., Yang, S., Lv, Y., & Sarker, M. N. I. (2022). Urban resilience for urban sustainability: Concepts, dimensions, and perspectives. *Sustainability*, *14*(5), 2481.

Zhuang, J., & Hasan, R. (2008). Framework of Inclusive Growth Indicators Key Indicators for Asia and the Pacific 2011 Special Supplement.

Adetunji Olayemi Sijuwola is of the Department of Economics, Ajayi Crowther University, Oyo. Nigeria. a.o.sijuwola@acu.edu.ng
Olusola Kayode Fadogba is of the Department of Economics, Ajayi Crowther University, Oyo. Nigeria. solarsky4u1@gmail.com