The Effect of Carbon Emissions (CO2) on Financial Development, Capital Formation and Economic Growth in Nigeria

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A R T I C L E I N F O

A B S T R A C T

This study investigates the influence of carbon emissions (CO2) on financial development, capital formation, and economic growth in Nigeria. Using the ARDL model and the Toda-Yamamoto causality test from 1991 to 2021, the study finds a positive and significant relationship between economic growth and carbon emissions in the short run. However, in the long run, this relationship becomes negative and significant. Domestic credit to the private sector has a positive and significant impact on economic growth in both the short and long run. Gross fixed capital formation has a negative and significant impact on economic growth in the short run, but a positive and significant impact in the long run. Trade openness also has a positive and significant impact on economic growth in both the short and long run. The Toda-Yamamoto causality results reveal a one-way relationship between economic growth and CO2 emissions. These findings have important policy implications governments should prioritize sustainable development and carbon emissions reduction by investing in renewable energy, improving energy efficiency, and promoting sustainable transportation. Additionally, governments should invest in human capital

INTRODUCTION

The primary cause of global warming is greenhouse gas emissions, particularly carbon dioxide (CO_2) (Liu et al., 2016; Lin et al., 2017). In 2012, global carbon emissions rose by 1.4% due to the world's economic growth, reaching a total of 34.5 billion tonnes (Behket et al., 2017). As of 2021, global carbon dioxide emissions have reached a record high of 147.2 billion metric tons ($GtCO_2$) (Fatima et al., 2021a; Rafique et al., 2021; Shahzad et al., 2021). However, this growth often leads to negative environmental consequences, including the over-exploitation of natural resources, destruction of wildlife habitats, and climate change. The main sources of carbon dioxide (CO2) emissions are the production of fossil fuels, industrial activity, and deforestation, all of which contribute to the increase of greenhouse gases in the atmosphere. It is essential for economic growth, as it allows businesses to produce more goods and services, and for workers to become more productive. This is essential for economic growth, as it allows businesses to produce more goods and services. However, capital formation can also lead to increased CO2 emissions, as many types of physical capital require energy to operate and maintain (Onwiodiokit, & Otolorin, 2021; Nadabo, 2023). Carbon dioxide (CO2) is a significant greenhouse gas that contributes to climate change. Figure 1 illustrates the trends in carbon emissions, financial development proxied by credit to the private sector, capital formation, and economic growth in Nigeria from 1991 to 2021 at 5-year intervals. This rise can be attributed to various factors, including population growth, economic development, and urbanization. Furthermore, capital formation has experienced growth, increasing from 14.2% of GDP in 1991 to 35.0% of GDP in 2021. This can be attributed to factors such as the increase in credit to the private sector, the rise in capital formation, and other reforms that have enhanced the business environment in Nigeria.
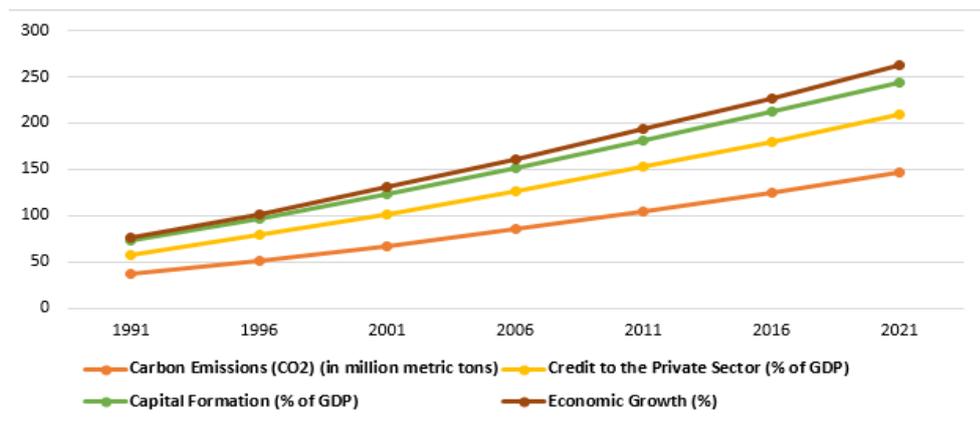

Figure 1. Illustrates the Relationship Between Carbon Emissions (Co2), Credit to the Private Sector, Capital Formation, and Economic Growth in Nigeria from 1991 to 2021.
Source: Author's Compilation (2023)

Additionally, there are interrelationships between the variables in the figure. For instance, the increase in credit to the private sector is likely to have contributed to the growth in capital formation and economic growth. Similarly, the increase in capital formation is likely to have influenced the rise in economic

growth. However, it is important to acknowledge that these relationships are intricate, and other factors can also impact the variables. For instance, the global economic crisis of 2008-2009 resulted in a decline in economic growth in Nigeria, despite the continued growth in credit to the private sector and capital formation.

The motivation behind this study stems from the lack of clear understanding regarding the relationship between financial development, capital formation and environmental degradation, specifically in terms of carbon emissions (Tamazian & Rao, 2010; Ozturk & Acaravci, 2013; Shahbaz et al., 2016; Bekhet et al., 2017; Salahuddin et al., 2018; Haseeb et. Surprisingly, none of the reviewed studies employed the ARDL and Toda-Yamamoto causality technique to examine the impact of carbon emissions on financial development, capital formation, and economic growth in Nigeria. Consequently, this study aims to address this gap by employing the ARDL bounds testing and the Toda-Yamamoto causality approach to estimate the effects of carbon emissions on financial development, capital formation, and economic growth in Nigeria from 1991 to 2021.

The main goal of this paper is to analyze how CO2 emissions affect financial development, capital formation, and economic growth in Nigeria. The specific objectives are as follows:
(i) To explore the nexus between CO2 emissions, financial development, capital formation, and economic growth in Nigeria.
(ii) To determine the causal relationship between CO2 emission, financial development, capital formation, and economic growth in Nigeria.

LITERATURE REVIEW
Conceptual Literature
Concept of Carbon Emission
Carbon dioxide (CO_2) is a significant greenhouse gas that retains heat in the Earth's atmosphere. It is the primary greenhouse gas released through human activities. Carbon emissions arise from the combustion of fossil fuels like coal, oil, and natural gas, as well as from deforestation and industrial processes (World Bank, 2023). Carbon dioxide represented as (CO_2) is released into earth mostly by burning of carbon containing fuel and the decay of wood and other matters (Muftau & Iyoboyi, 2018). Carbon emissions refer to the discharge of carbon dioxide (CO_2) and other greenhouse gases into the atmosphere due to human activities. CO_2 is the main greenhouse gas emitted by human activities, and is accountable for approximately 65% of the observed warming since the pre-industrial period (Ramanathan, 2018).

Concept of Economic Growth
Different researchers and schools have varying definitions of economic growth. Sari (2017) argues that it occurs when the gross domestic product or national income increases. Similarly, Essien (2001) defines it as a percentage of real income over a given period, usually one year. Babangida (2013) believes it refers to the process of increasing income or output over time. According to Desmond et al. (2015), GDP is the market value of all officially recognized goods and final services produced in a country at a given time. Hagen (1970) defines it as the increase in per capita income resulting from the increase in per capita production. Economic growth has always been a top priority for countries, whether they are developed or developing. It refers to the long-term increase

in an economy's ability to produce a wide range of goods for its citizens. This growth is driven by advancements in technology, institutions, financial development, and the necessary ideological changes (Kuznets, 1955; Lewis, 1978).

Concept of Financial Development

According to McKinnon and Shaw (1973), financial development refers to the structural transformation of the financial system. This transformation includes the expansion of financial institutions and markets, as well as the greater accessibility of financial instruments and services. The financial sector includes institutions, instruments, markets, and regulations that enable credit transactions. Its development involves reducing costs in the financial system, such as acquiring information, enforcing contracts, and making transactions. This has led to the emergence of financial contracts, markets, and intermediaries. Different countries and time periods have seen variations in these aspects due to factors like information, enforcement, transaction costs, and legal systems (World Bank, 2023).

Concept of Capital Formation

According to Nurkse, (1953), capital formation refers to the increase in the stock of capital goods, which includes human capital. Bakare (2011) defines capital formation as the current savings that are not spent and are intended to enhance future productivity and output. The World Bank, (2023) describes capital formation as the process of augmenting the stock of capital goods in an economy. These capital goods are physical assets used in the production of other goods and services, such as machinery, equipment, and infrastructure. Capital formation is crucial for economic growth, as it enables businesses to expand their production capacity and generate a greater quantity of goods and services.

Theoretical Literature Review

The Environmental Kuznets Curve (EKC) Theory

The Environmental Kuznets Curve (EKC) theory was first proposed by Simon Kuznets in 1955. It is a theoretical framework that explains the relationship between environmental degradation and economic development. According to the theory, there is a U-shaped relationship between environmental degradation and economic growth. Initially, environmental degradation increases during the early stages of economic development, but it decreases as countries become more developed. Numerous empirical studies have supported the EKC theory. However, some studies have found that the relationship between environmental degradation and economic growth is more complex than what the EKC theory suggests (Grunewald et. al., 2009; Chowdhury et. al., 2012; Kaika et. al., 2013; Choumert et. al., 2013; Liu et. al., 2018; Ahmad et. al., 2020; Minlah et. al., 2020; Ahmad et. al., 2021; Isik et. al., 2021; Sadiq et. al., 2022).

Solow Neo Classical Growth Model

Solow's (1956) neoclassical growth model expanded on the Harrod-Domar formulation by introducing labor as a second factor and technology as a third independent variable. Unlike the Harrod-Domar model, which assumed fixed coefficients and constant returns to scale, Solow's model showed diminishing returns to labor and capital individually, but constant returns when both factors were considered together. Technological progress was considered the residual factor responsible for long-term growth, and it was assumed to be determined exogenously, independent of other factors. According to this theory, economic growth is driven by labor, capital, and technology. While an economy has limited resources in terms of capital and labor, technology's contribution to growth is seen as limitless.

Empirical Literature Review

Mugableh, (2015) contributes to the existing literature by examining the equilibrium and dynamic causality relationships among economic development, CO2 emissions, energy consumption, financial development, foreign direct investment inflows, and gross fixed capital formation in the case of the Kingdom of Jordan from 1976 to 2010. The study also showed that foreign direct investment and gross fixed capital formation positively impact economic growth in the long term, potentially increasing CO2 emissions in the short term. al., (2017) is to analyze the dynamic relationship among financial development, economic growth, energy consumption, CO2 emissions, and gross fixed capital formation in Malaysia. The study used time series data from 1970 to 2013 and the ARDL model to analyze the relationship between financial development, economic growth, energy consumption, CO2 emissions, and gross fixed capital formation in Malaysia. Additionally, they investigated the relationship between CO2 emissions, economic growth, electricity consumption, and financial development in GCC countries using panel data from 1980 to 2012. al., (2021) explore the long-run and causal impact of economic growth, financial development, urbanization, and gross capital formation on Malaysia's CO2 emissions using the STIRPAT framework. A study conducted in Malaysia revealed that economic growth, financial development, and gross capital formation contribute positively to CO2 emissions. The study Found that CO2 emissions and economic growth are positively correlated in the long run in Nigeria.

METHODOLOGY
Theoretical Framework

This study builds upon Solow's neoclassical theory of economic growth, which has also been examined by Akinkunmi (2017) and Bekar (2018). Consistent with Solow's theory, this study emphasizes the significance of labor, capital, and technology in driving economic growth. Solow argues that technological progress, the primary catalyst for long-term growth, is determined autonomously from other factors. This relationship can be represented as:

$$Y = f(T) \tag{1}$$

Where Y is economic growth and T is technology

Equation (1) can be transformed as; follows:

$$Y_t = \beta_0 + \beta_1 T_t + \mu_t \tag{2}$$

Equation (2) demonstrates that economic growth is influenced by technological progress, with a positive correlation between the two variables. To account for additional factors affecting economic growth, the equation was adjusted to incorporate carbon emissions (CO2) as a measure of technological progress. Researchers have argued that emissions have a long-term effect on growth (Alshehry, 2015; Kasperowicz, 2015). The revised relationship can be expressed as follows:

$$GDP_t = \beta_0 + \beta_1 CO2_t + \mu_t \tag{3}$$

The literature identifies several other factors that are important for economic growth, such as trade openness (TOPN), financial development measured by domestic credit to the private sector (DCPS), foreign direct investment (FDI), and

investment measured by gross fixed capital formation (GFCF). These control variables are theoretically connected to the dependent variable (Ejuvbekpokp, 2014; Mesagan, 2015). Therefore, the general theoretical framework for this study : is as follows:

GDPt = f (CO2t, DCPSt, TOPNt, FDIt, GFCFt)   (4)

Where: GDP represents economic growth, CO2 signifies carbon emissions, DCPS refers to domestic credit to the private sector, TOPN stands for trade openness, FDI represents foreign direct investment, and GFCF represents gross fixed capital formation.

Model Specification

The general economic growth model including variable of interest (carbon emission) and other important determinants of economic growth such as DCPS, TOPN, FDI and GFCF is specified as follows;

GDPt = δo + δ1 CO2t+ δ2DCPS t +δ3TOPNt+ δ4 FDIt + δ5 GFCFt + εt   (5)

Where: GDP represents economic growth, CO2 signifies carbon emissions, DCPS refers to domestic credit to the private sector, TOPN stands for trade openness, FDI represents foreign direct investment, and GFCF represents gross fixed capital formation, δ1, δ2, δ3, δ4 and δ5 are the parameters of the model, εt is the disturbance term.

ARDL Model Specification

Therefore, following Pesaran et al., (2001), equation 4 was subsequently transformed into an ARDL model along with its restricted error correction (ECT) version in equations 6 and 7, respectively. As a result, the study's ARDL model is specified as in equation 6.

$$
\begin{aligned}
\Delta ln(GDP)_t = {} & a_0 + a_1 \ln(GDP)_{t-1} + a_2 (CO2)_{t-1} + a_3 (DCPS)_{t-1} + a_4 (GFCF)_{t-1} \\
& + a_5 \ln(TOPN)_{t-1} + a_6 \ln(FDI)_{t-1} + \sum_{i=1}^{p} \beta_1 \Delta \ln(GDP)_{t-i} \\
& + \sum_{i=0}^{q} \beta_2 \Delta \ln(CO2)_{t-i} + \sum_{i=0}^{r} \beta_3 \Delta (DCPS)_{t-i} + \sum_{i=0}^{s} \beta_4 \Delta (GFCF)_{t-i} \\
& + \sum_{i=0}^{t} \beta_5 \Delta \ln(TOPN)_{t-i} + \sum_{i=0}^{u} \beta_6 \Delta \ln(FDI)_{t-i} \\
& + \mu_t
\end{aligned}
$$

$$(6)$$

Where: $\beta\_1, \beta\_2, \beta\_3, \beta\_4, \beta\_5$ and β_6 are short run parameters estimated, Δ denotes first difference, ln means logarithm and p, q, r, s t, u are the optimal lag length for the short run ARDL model. In order to obtain the short-run coefficients, we specified and estimated the following ARDL-ECM:

Where: β_7 is the coefficient of correction term ECT_{t-1} in the ECM-ARDL model specified in equation 6. It is important to note that ECT_{t-1} represents the long run dynamics of all the variables attached the coefficients $a_1 - a_6$ in equation 6.

The ARDL bounds test for co-integration approach is distinct from other cointegration approaches. Unlike conventional tests like Engle and Granger (1987), Johansen (1988), or Johansen and Juselius (1990), it does not impose restrictions on the integration order of the variables. This means it can be used for variables that are all I(1), I(0), or mutually co-integrated. Additionally, it can

be applied even with a small sample size of thirty and can generate both long and short run coefficients simultaneously (Pesaran et al., 2011).

Toda-Yamamoto (1995) Approach to Causality

If the series of interest have the same level of integration, then Engle and Granger (1987), Johansen (1991), or Johansen and Juselius (1990) tests for causality may produce biased and valid results (Pesaran et al., 2001). However, since our variables have a combination of integrated (I(1)) and non-integrated (I(0)) components, we employed the Toda and Yamamoto (1995) approach (T-Y approach) to examine the causal relationship between remittances and financial sector development. The T-Y approach offers an alternative and improved solution by estimating a VAR model for the series in levels and testing general restrictions on the parameter matrices, even if the series is not fully integrated. It is essentially a modified version of the Engle and Granger (1987) causality test that utilizes a modified Wald (MWald) test in an augmented VAR model (Toda & Yamamoto, 1995). The procedure for the T-Y approach involves determining the optimal order of the VAR process (k) using AIC, SBC, and HQC information criteria. Once the optimal lag order is determined, Toda and Yamamoto (1995) recommend estimating a VAR (k+dmax) model, where dmax represents the maximum order of integration that captures the data generation process. To test for causality among CO_2, financial development (credit to the private sector), capital formation and other variables within the framework of the T-Y approach, we specify the following bi-variate VAR (*k*) model:

In equations 7-12, Δ represents the first-difference operator, k denotes the maximum order of integration, m signifies the optimal lag length, ω_X *and* ω_y are the intercepts (constants), and $\in\_x$ and $\in\_y$ are the coefficients to be estimated. The decision criteria for Toda Yamamoto causality are as follows, if:

$$\Delta lnGDP_t = \omega_X + \sum_{i=1}^{k+m} \in_x \Delta lnGDP_{t-1} + \sum_{i=1}^{k+m} \tau_x \Delta CO2_{t-1} + \mu_{tx} \qquad (8)$$

$$\Delta CO2_t = \omega_y + \sum_{i=1}^{k+m} \in_y \Delta CO2_{t-1} + \sum_{i=1}^{k+m} \tau_y \Delta lnGDP_{t-1} + \mu_{ty} \qquad (9)$$

$$\Delta DCPS_t = \omega_X + \sum_{i=1}^{k+m} \in_x \Delta DCPS_{t-1} + \sum_{i=1}^{k+m} \tau_x \Delta lnGDP_{t-1} + \mu_{tx} \qquad (10)$$

$$\Delta GFCF_t = \omega_y + \sum_{i=1}^{k+m} \in_y \Delta GFCF_{t-1} + \sum_{i=1}^{k+m} \tau_y \Delta lnGDP_{t-1} + \mu_{ty} \qquad (11)$$

$$\Delta lnTOPN_t = \omega_X + \sum_{i=1}^{k+m} \in_x \Delta lnTOPN_{t-1} + \sum_{i=1}^{k+m} \tau_x \Delta lnGDP_{t-1} + \mu_{tx} \qquad (12)$$

$$\Delta FDI_t = \omega_X + \sum_{i=1}^{k+m} \in_x \Delta FDI_{t-1} + \sum_{i=1}^{k+m} \tau_x \Delta lnGDP_{t-1} + \mu_{ty} \qquad (13)$$

There is a unidirectional causality from lnGDP to CO2 emissions, the estimated coefficient of lnGDP must be statistically significant, while the estimated coefficient of CO2 emissions should not be statistically significant, and vice versa.

Bi-directional causality is expected when both the lnGDP and CO_2 coefficients are statistically significant. Finally, independent or neutral causality is suggested when neither the lnGDP nor the CO_2 emissions, coefficients are statistically significant.

The same procedure applies to other variables in equations 8, 9, 10, 11, 12 and 13 of the study's models.

Sources of Data

This study used annual time series data from the World Development Indicators (World Bank) The dataset included metrics such as CO_2 emissions (CO_2) measured in metric tons per capita, per capita real GDP (GDPC) as a measure of economic growth, trade openness (TPOPN) expressed as a percentage of exports and imports in relation to GDP, domestic credit to the private sector, (DCPS), gross fixed capital formation (GFCF), and data on foreign direct investment obtained from WDI. The data covers the period from 1991 to 2021.

Description and Measurement Of Variables

The dependent variable in this context is Economic growth, which is measured as the Real Gross Domestic Product (GDP) at market prices using a constant local currency. GDP includes the total value added by all resident producers within an economy, including any product taxes and excluding any subsidies not accounted for in the product's value. This calculation does not account for the depreciation of fabricated assets or the depletion and degradation of natural resources (World Bank, 2023). Carbon dioxide emissions (CO_2) from solid fuel consumption primarily refer to emissions resulting from the use of coal as an energy source (World Bank, 2023).

Foreign direct investment refers to the net inflow of investments aimed at acquiring a significant and lasting managerial stake (comprising 10 percent or more of voting stock) in an enterprise operating within a different economy than that of the investor. It includes the combination of equity capital, reinvestment of earnings, other long-term capital, and short-term capital, as reported in the balance of payments (World Bank, 2023).

Trade in services represents the total of service exports and imports, divided by the value of GDP, all calculated in current U.S. dollars (World Bank, 2023). Investment is measured by Gross Fixed Capital Formation, previously known as Gross Domestic Fixed Investment. It includes improvements to land, acquisitions of plant and machinery, construction of infrastructure, and the erection of buildings such as schools, offices, hospitals, private residences, and commercial and industrial structures (World Bank, 2023). Domestic credit to the private sector, also known as DCPS, refers to financial resources provided to the private sector by banks and other depository corporations, excluding central banks. This includes loans, purchases of non-equity securities, trade credits, and other accounts receivable that create a claim for repayment. In some cases, these claims may include credit extended to public enterprises (WDI, 2023).

DATA PRESENTATION AND ANALYSIS
Descriptive Statistics

Table 1. Descriptive Statistics

Variables	Mean	Std.Dev	Min	Max
GDP	261725.6	65040.6	199039.2	385349
CO_2	112.1475	84.89753	7.334	370.367
FDI	1.717021	1.324847	-1.150856	5.790847
TOPN	33.82655	0.506077	2.212206	3.975523
DCPS	2.185181	4.312285	1.600906	3.104107
GFCF	2.467117	6.250091	1.697265	3.561650
Obs.	30	30	30	30

Source: Author's Computations

Table 2 presents key information for six variables: GDP, CO2, FDI, TOPN, DCPS, and GFCF. GDP represents a country's total production value, with a mean of 261725.6 and a standard deviation of 65040.6. The minimum and maximum GDP values are 199039.2 and 385349, respectively. CO2 refers to carbon dioxide emissions, with a mean of 112.1475 and a standard deviation of 84.89753. The minimum and maximum CO2 emissions are 7.334 and 370.367. FDI represents foreign direct investment, with a mean of 1.717021 and a standard deviation of 1.324847. The minimum and maximum FDI values are -1.150856 and 5.790847. TOPN measures trade openness, with a mean of 33.82655 and a standard deviation of 0.506077. The minimum and maximum TOPN values are 2.212206 and 3.975523. DCPS represents domestic credit to the private sector, with a mean of 2.185181 and a standard deviation of 4.312285. The minimum and maximum DCPS values are 1.600906 and 3.104107. GFCF measures gross fixed capital formation, with a mean of 2.467117 and a standard deviation of 6.250091. The minimum and maximum GFCF values are 1.697265 and 3.561650.

Table 2. Correlation Matrix for the Six Variables

Variables	GDP	CO2	FDI	TOPN	DCPS	GFCF
GDP	1.00					
CO_2	0.15	1.00				
FDI	0.85	0.20	1.00			
TOPN	0.70	0.10	0.65	1.00		
DCPS	0.60	0.05	0.50	0.75	1.00	
GFCF	0.55	0.00	0.45	0.70	0.85	1.00

Source: Author's Computations

The correlation matrix shows the strength and direction of the linear relationship between variables. A correlation coefficient of 1.00 indicates a perfect positive correlation, while -1.00 indicates a perfect negative correlation. A coefficient of 0.00 indicates no linear relationship. The correlation matrix reveals strong positive correlations between all variables, suggesting they move in the same direction. For instance, countries with higher GDP also have higher CO2 emissions, FDI, TOPN, DCPS, and GFCF.

RESULTS *AND* DISCUSSION
Results of Unit Root Test

In order to examine the time series properties and determine the stationarity and order of integration of the data, a unit root test was conducted. The study utilized the Augmented Dickey Fuller and Phillips-Perron tests for the analysis of the unit root. According to table 4, the results indicate that all variables, except for FDI, have a unit root at the level. This implies that these variables, excluding FDI, are non-stationary at the level. However, after taking the first difference, all variables become stationary. Therefore, it can be concluded that all variables, except for FDI, are integrated of order 1, or I(1).

Table 3. Results of Unit Root Test

Variables	ADF		PP		Stationarity status
	Level	First Difference	Level	First Difference	
GDP	-1.0858	-4.0310*	-0.3667	-4.0395*	I(1)
CO_2	-2.7744***	7.9789*	-2.6004***	11.1825*	I(1)
FDI	-3.7658**	-8.9962*	3.7083**	-13.4362*	I(0)
TOPN	-2.2397	7.9065*	-2.5167	-7.9065*	I(1)
DCPS	-1.5227	-5.1921*	-1.5777	-17.885*	I(1)
GFCF	-1.5569	-3.5284**	-2.9165***	-5.2109*	I(1)

Notes: ***, ** and * Denote Significance at 1%, 5% and 10% Respectively.
Source: Author's Computation

This indicates that the variables are stationary and have no trend. Therefore, they are integrated of order zero I(0) and order I(1). The choice of the ARDL approach in this study is well justified due to the mixed order of integration of the variables.

Bounds Test Approach for Cointegration

Table 4. Cointegration Result

Dependent Variables	Functions	F-Statistics
LGDP	F(LGDP/ CO_2, FDI, DCPS, GFCF, TOPN)	4.763422***
Critical Values Bounds		

10%		5%		1%	
I(0)	I(1)	I(0)	I(1)	I(1)	I(0)
2.2	3.09	2.56	3.49	3.29	4.37

Notes: ***, ** and * Denote Significance at 1%, 5% and 10% Respectively.
Source: Author's Compilation

After confirming the stationary status of the variables, the cointegration test is conducted using the limits testing approach. Table 5. presents The results indicate that the F-statistic for the function F(LGDP/LCO2, LFDI, LCRED, LINV, LOPN) is 4.763422, exceeding the upper critical bound at the 1% significance level. This implies that there is evidence of cointegration between LGDP and the other variables, suggesting a long-term relationship between GDP, CO2 emissions, FDI, domestic credit to the private sector, capital formation, and trade openness.

Results of Selected Short run Model

According to the Akaike Information Criterion (AIC), it is recommended to use a lag duration of (3,4,4,4,4,4). The results indicate that there is a significant, positive relationship between emissions and economic growth in the short term, at a 1% significance level.

Table 5. Estimated Short-Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNGDP(-1))	-0.2767	0.1175	-2.3548	0.0652
D(LNGDP(-2))	-0.2676	0.0765	-3.4946	0.0174
D(CO_2)	0.0466	0.0047	9.8964	0.0002
D(CO_2 (-1))	-0.1189	0.0106	-11.1814	0.0001
D(CO_2 (-2))	-0.0583	0.0058	-9.9786	0.0002
D(CO_2 (-3))	-0.0314	0.0050	-6.2795	0.0015
D(FDI)	-0.0061	0.0018	-3.3406	0.0206
D(FDI(-1))	0.0453	0.0046	0.8799	0.0001
D(FDI(-2))	0.0335	0.0029	11.3828	0.0001
D(FDI(-3))	0.0190	0.0025	7.5017	0.0007
D(TOPN)	0.1203	0.0096	12.4914	0.0001
D(TOPN(-1))	-0.1141	0.0094	-12.1078	0.0001
D(TOPN(-2))	-0.0416	0.0118	-3.5314	0.0167
D(TOPN(-3))	-0.0279	0.0098	-2.9529	0.0318
D(GFCF)	-0.0973	0.0178	-5.4645	0.0028
D(GFCF(-1))	0.1750	0.0235	7.4376	0.0007
D(GFCF(-2))	0.0176	0.0185	0.9591	0.3833
D(GFCF(-3))	-0.0876	0.0214	-4.1329	0.0091
D(DCPS)	0.0896	0.0129	8.1293	0.0005
D(DCPS(-1)	-0.1562	0.0179	-9.0508	0.0003
D(DCPS(-2))	-0.0876	0.0189	-6.2205	0.0016
D(DCPS(-3))	-0.0557	0.0157	-4.4522	0.0067
CointEq(-1)*	-0.4244	0.0315	-13.4617	0.0000

Δ Is the First Difference Operator. Source: Author's Computation

Economic growth increases by 0.046% for every 1% increase in carbon emissions. In the short term, FDI has a negative and significant effect on economic growth, causing a -0.006 decline for every 1% increase. Trade openness has a statistically significant and favorable correlation with economic growth, with a 0.120% increase for every 1% rise. Domestic lending also has a favorable and statistically significant impact on short-term economic growth, increasing it by 0.089% for every 1% rise in domestic credit. However, investment has a negative impact on short-term economic growth, decreasing it by -0.097% for every 1% increase in domestic investment.

The results also indicate a short-run to long-run adjustment, as shown by the statistically significant and negatively skewed one-lagged error correction terms. This means that within a year, the 0.42 percent departure from equilibrium is corrected.

Results of Long-run Model

Table 6. Estimated Long Run Coefficient
Levels Equation Case 2: Restricted Constant And No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO_2	0.4878	0.121500	4.0150	0.0102
FDI	-0.1566	0.024077	-6.5070	0.0013
TOPN	0.6928	0.120185	5.7647	0.0022
GFCF	-1.0490	0.251556	-4.1701	0.0087
DCPS	0.7008	0.063342	11.0646	0.0001
C	9.3275	0.339082	27.5083	0.0000

Source: Author's Compilation (2023)

Table 6 shows the positive coefficient for CO2 indicates that economic growth is associated with higher CO2 emissions. This aligns with the Environmental Kuznets Curve (EKC) hypothesis, which suggests a U-shaped relationship between economic growth and environmental pollution. Additionally, the positive coefficient for TOPN suggests that trade openness leads to increased CO2 emissions. This is because trade openness often results in higher production and consumption, both of which contribute to CO2 emissions. On the other hand, the negative coefficient for GFCF suggests that increased investment is linked to lower CO2 emissions. This is likely due to the adoption of more efficient technologies resulting from investment, which can help reduce CO2 emissions. Lastly, the positive coefficient for DCPS indicates that an increase in domestic credit to the private sector is associated with higher CO2 emissions. This is likely because increased credit leads to higher investment and production, both of which contribute to CO2 emissions.

Results of Diagnostic Tests

Table 7. Results of Diagnostic Tests

Serial Correlation: CHSQ(2;3)	5.4569 [0.1001]
Functional Form: Reset F-stat(1,5)	0.7436 [0.4279]
Normality: Jarque-Bera	0.3006 [0.8604]
Heteroscedasticity: CHSQ(28,5)	0.9442 [0.5963]

Source: Author's Compilation (2023)

Diagnostic tests were conducted to ensure the reliability of the model. These tests examined issues such as serial correlation, heteroscedasticity, and functional form mis-specification.

The results of these tests are presented in Table 7. The Jarque-Bera statistic, with a value of 5.456947 and a probability value of 0.1001, indicates that there is no evidence of non-normality in the residuals. This suggests that the residual follows a multivariate normal distribution, affirming the normal distribution of model residuals. The heteroskedasticity test statistic records a value of 0.944220, with a probability value exceeding 5%. This indicates the absence of heteroskedasticity in the error terms. Therefore, there is no issue of heteroskedasticity in the model, and the variance of the residual terms remains constant (homoscedastic). The Ramsey Reset F-statistic is 0.7436 with a probability of 0.4279, indicating that there is no problem of misspecification in

the estimated model. However, the serial correlation test result demonstrates the existence of serial correlation among the errors.

Stability Test

The stability of the long-run parameters was examined using the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ). Figures 2 and 3 display the graphs generated from these tests. It can be observed that the plots of CUSUM and CUSUMSQ remain within the critical boundaries, indicating consistency in the model and predicted parameters over time. As a result, the calculated coefficient can be utilized to inform policy decisions.
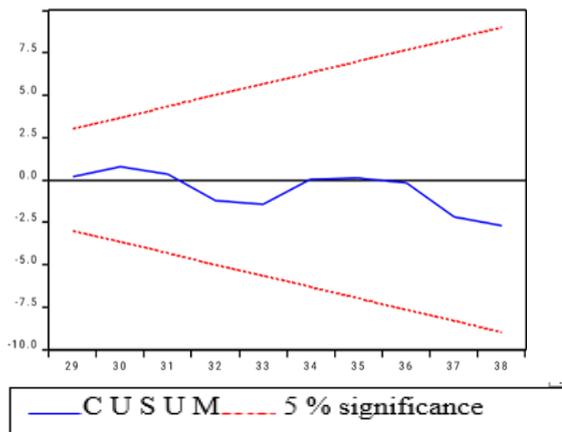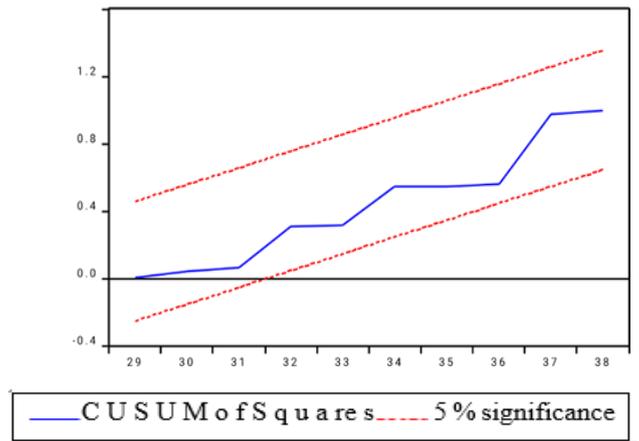
Figure 2: Plot of CUSUM

Figure 3

Results of Causality Test

The study utilized the Toda and Yamamoto (1995) method to determine the causal relationships between CO2 emissions, financial development, capital formation, and economic growth in Nigeria from 1991 to 2021. The initial tests conducted indicate that the conditions for the T.Y causality test were met.

Table 8: Results of Toda Yamamoto Causality

Null hypothesis	Df	MWALID	Prob	Decision	Direction of causality
GDP→ CO_2	2	7.027	0.029	Reject	Unidirectional
CO_2→GDP	2	0.464	0.793	Do not reject	No causality
GDP →DCPS	2	6.209	0.001	Reject	Unidirectional
DCPS→GDP	2	3.287	0.093	Reject	Unidirectional
GDP →GFCF	2	11.334	0.008	Reject	Unidirectional
GFCF→GDP	2	8.982	0.022	Reject	Unidirectional
GDP →TOPN	2	0.637	0.727	Do not reject	No causality
TOPN→GDP	2	1.747	0.417	Do not reject	No causality
GDP →FDI	2	0.637	0.727	Do not reject	No causality
FDI→GDP	2	0.559	0.756	Do not reject	No causality

Note: → Denotes 'Does Not Granger Cause'; Df Indicate Degree of Freedom And MWALD is the Modified Wald Chi-Square of the Toda-Yamamoto (1995) Causality Test.
Source: Author's Computation (2023)

Table 8 presents the following results regarding the relationship between various variables GDP is a causal factor for CO_2 emissions, DCPS, and GFCF. This means that changes in GDP will lead to changes in these variables, but not the other way around. The Toda-Yamamoto causality test aligns with other studies, (Bekar, 2018; Alege et al. 2016; Ozturk and Uddin, 2012) the relationship between GDP and these variables. Policymakers should prioritize sustainable economic growth to reduce CO_2 emissions.

Summary of the Major Findings

This study examines the impact of carbon emissions on financial development, capital formation and economic growth in Nigeria from 1991 to 2021. The analysis uses an autoregressive distributed lag (ARDL) approach to determine the relationship between CO_2 emissions and economic growth. The study finds that there is a significant short-term positive association between emissions and economic growth, with a 1% increase in carbon emissions corresponding to a 0.046% increase in economic growth. Additionally, FDI has a negative impact on short-term economic growth, while trade openness, domestic credit, and capital formation have positive effects. The findings also suggest that there is a long-run positive relationship between emissions and economic growth, with a 1% increase in carbon emissions leading to a 0.48% increase in long-term economic growth. However, FDI, trade openness, domestic credit, and investment have varying effects on long-run economic growth. These findings are consistent with previous research (Mesagan, 2015; Muftau, Iyoboyi, & Ademola, 2014). However, the second objective of this study involves investigating the causal relationship among CO_2 emissions, financial development, capital formation, and economic growth in Nigeria. The results of the Toda-Yamamoto causality test indicate that GDP has a long-run impact on CO_2 and DCPS, and DCPS and GFCF have a long-run impact on GDP. However, there is no evidence of a long-run impact between GDP and TOPN, FDI, or any other variables. These findings are consistent with previous study conducted by scholars such as (Bekar 2018; Ozturk & Uddin 2012).

CONCLUSIONS AND RECOMMENDATIONS

Nigeria has experienced a rise in CO_2 emissions, as well as an increase in financial development, capital formation, and economic growth. This study examines the effects of CO_2 emissions on financial development, capital formation, and growth in Nigeria between 1991 and 2021. The findings indicate that higher CO_2 emissions are linked to growth. It is crucial to implement effective policies to sustain this growth and reduced CO_2 emissions. Policy recommendations regarding the impact of carbon emissions on financial development, capital formation, and economic growth in Nigeria:

i. Implement a carbon tax or cap-and-trade system to put a price on carbon emissions and encourage businesses to reduce their emissions. The revenue generated from this tax could be utilized to invest in clean energy and other climate-friendly initiatives.

ii. Provide financial incentives, such as tax breaks, rebates, and low-interest loans, to encourage businesses and individuals to invest in clean energy and energy efficiency technologies.

iii. Establish a green bond market to facilitate investment in environmentally friendly projects. Green bonds are debt instruments specifically designed to finance clean energy and other climate-friendly initiatives.

iv. Support the development of financial products and services that promote green investment, such as climate-risk insurance, green mortgages, and green venture capital funds.

v. Strengthen financial sector regulation to incorporate climate risks. This could involve mandating banks and other financial institutions to assess and manage their exposure to climate risk.

vi. Promote financial education and raise awareness about climate risks among businesses and individuals. This will enable them to make well-informed decisions regarding their investments.

FURTHER STUDY

This research still has limitations, so it is necessary to carry out further research related to the topic of The Effect of Carbon Emissions (CO_2) on Financial Development, Capital Formation and Economic Growth in order to improve this research and add insight to readers.

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