Asymmetric Cointegration of Trade Openness, Foreign Direct Investment (FDI) on Climate Change: Case of Manufacturing Sector in Nigeria

MUHAMMAD A. Muhammad[1]

And

KAMAL Tasiu Abdullahi[2]

[1]Department of Economics
Bayero University Kano, Nigeria
optimisticmuhammadam@gmal.com

[2]Department of Economics
Istanbul University
kmlts256@gmail.com

Introduction

Climate change and global warming become a leading issue of concern in recent times, due to their impact on human activities and the environment since the International Climate Conference in Copenhagen 2009.

Combustion of fossil fuels such as coal, oil and natural gas in the production of fuels for transport and other industrial relations which was established many years ago, attracts significant global concern as it releases greenhouse gases (GHG) particularly carbon dioxide (CO_2) into the atmosphere, (Cannaon and Sperling 2019).

Introduction cont.

Since 1980s developing countries start to open their economy to integrate with other countries of the world, the superiority of developed nations coupled with emerging multinational companies in 1960s played a vital role on the world trade openings.

The controversial relationship between trade openness, foreign direct investments, and climate change have been the topic of an impressive body of literature, international debates, and strategic agreements.

Introduction cont.

Open economies paved way for the import of new technologies and ideas from rest of the world which has led to a better division of labour, new method of production new products by enjoying comparative advantages.

FDI flow has increased during the last two decades in almost every nation of the world including Nigeria.

Literature reviews

The work of Onwuteaka (2019), offers empirical information regarding the effects of many factors, including the open market, market size, infrastructure, labor force, human capital, natural resources, exchange rate, and inflation rate (OLS), on Nigerian Foreign Direct Investment (FDI).

West Africa's persistent efforts to industrialize and catch up to the developed world are partly to blame for the subregion's rising emissions of greenhouse gases, particularly carbon dioxide. Yao and Ameyaw (2018).

Literature reviews cont..

Zugravu-Soilita (2017) asserts that the actions of multinational corporations (MNCs) through foreign direct investment (FDI) are primarily responsible for the rise in greenhouse gas and other pollutant emissions that contribute to climate change.

According to studies by Fankhauser and Mcdermott (2014), poor nations—particularly those in Africa—are more vulnerable to the consequences of climate change than developed industrial nations are in the current environmental issues.

Dataset and Econometrics Models

Dataset and Sources

Table 1 below provides a description of the data used in this study. The data is a set of yearly data for the years 1986–2023. The selection period is mostly explained by the data's accessibility. Prior to being estimated, all variables are transformed into natural logarithms.

Table 1. Data Variable Measurement

s/n.	Variable	Code	Definition	Source
1.	Carbon dioxide emission	$lCO_{2,t}$	is the proxy for the environmental quality variable, measured by CO2 emission per capita (CO2) in metric tons.	WDI
3.	Trade openness	$ltop_t$	The proportion of GDP that banks lend domestically to the private sector.	WDI
4.	Foreign direct investment	$lfdi_t$	represents foreign direct investment as a percentage of GDP.	WDI
5.	Manufacturing sector	$lman_t$	Manufacturing sector added value % of GDP	WDI
6.	GDP	$lgdp_t$	Growth of the economy	WDI

Notes: WDI is an acronym for world development indicators, It also worth noting that we interpolated for missing observation in lfdi, using Chow and Lin (1971) methods

Source: World Development Indicators (2022).

Model Specification

The structural equation that connects environmental contamination to its causes is often used in the literature about the effects of foreign direct investment on the environment (Stern 2004). CO2-FDI regression model is used in this investigation. According to the goal of this research, we design a model in which GDP, trade openness, foreign direct investment, are the regressors and C02 is the dependent variable;

$$C02_t = f(ltop_t, lfdi_t, lman_t, lgdp_t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Model Specification Cont.…

- ✓ The three stages of the econometrics approach used in this work are as follows: first, the stationarity status of the variables is assessed using the nonlinear Fourier based unit root test of Guris (2018) as well as the conventional ADF, PP, and KPSS tests.
- ✓ While the latter will test the variables' nonlinear stationarity, the traditional tests check the order of integration to make sure none of the variables are I(2). Second, we used the NARDL technique to investigate the asymmetric long and short run influence of the regressors on C02. Finally, we ran a few critical diagnostic tests on the model.

Non-Linear Autoregressive Distributed Lag Model

✓Recent studies have shown that macroeconomic factors are nonlinear. This means that asymmetric co-integration, or modeling co-integration, can be carried out using the framework of disassembled explanatory variables. It is used to find out if the independent variables' positive shocks have the same effect on the dependent variables as their negative shocks.

Although there are a number of approaches to modeling asymmetric interactions (Schorderet, 2003; Escribano et al., 2006), the two-step Engle-Granger method of asymmetric co-integration is the most commonly employed, as noted by Shin et al. (2014).

Non-Linear Autoregressive Distributed Lag Model Cont.

A clear shortcoming of the two-step Engle-Granger method of asymmetric cointegration is that, while it works well for short-term modeling, it is less efficient than the single-step ECM estimation of Shin et al. (2014), which models the long- and short-term asymmetries known as NARDL simultaneously.

As an extension of the framework created by Shin et al. (2001), NARDL meets the necessary conditions to be used with time series applications of ARDL. The primary one is that because of the stationary nature of variables, I(2) variables shouldn't be included.

Non-Linear Autoregressive Distributed Lag Model Cont.

As an extension of the framework created by Shin et al. (2001), NARDL meets the necessary conditions to be used with time series applications of ARDL. The primary one is that because of the stationary nature of variables, I(2) variables shouldn't be included.

Given this, we employed the traditional unit root tests of Augmented Dicky Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) to conduct a unit root test on the variables. Then, following Shin, Yu, and Greenwood-Nimmo (2014), we wrote (eq. 1).

Non-Linear Autoregressive Distributed Lag Model Cont.

$$\Delta lC02_t = \beta_0 + \sum_{i=0}^{m} \beta_1 \Delta lC02_{t-i} + \sum_{i=0}^{m} \beta_2 \Delta ltop_{t-i}^{+} + \sum_{i=0}^{m} \beta_3 \Delta ltop_{t-i}^{-} + \sum_{i=0}^{m} \beta_4 \Delta lfdi_{t-i}^{+} + \sum_{i=0}^{m} \beta_5 \Delta lfdi_{t-i}^{-} + \sum_{i=0}^{m} \beta_6 \Delta lman_{t-i}^{+} + \sum_{i=0}^{m} \beta_7 \Delta lman_{t-i}^{-}$$
$$+ \sum_{i=0}^{m} \beta_8 \Delta lgdp_{t-i}^{+} + \sum_{i=0}^{m} \beta_9 \Delta lgdp_{t-i}^{-} + \gamma_1 C02_{t-1} + \gamma_2 ltop_{t-1}^{+} + \gamma_3 \Delta ltop_{t-1}^{-} + \gamma_4 lfdi_{t-1}^{+} + \gamma_5 lfdi_{t-1}^{-} + \gamma_6 lman_{t-1}^{+} + \gamma_7 lmn_{t-1}^{-} + \gamma_8 lgdp_{t-1}^{+}$$
$$+ \gamma_9 lgdp_{t-1}^{-} + \psi_t DU_t + \in_t \qquad (2)$$

The first difference of the variable is indicated by the difference operator Δ. The lagged values are represented by i, the short run and long run coefficients are by β_1 to γ_9 and φ_1 to γ_9, respectively, and the disturbance term is by ∈_t.

Non-Linear Autoregressive Distributed Lag Model Cont.

The NARDL error correction equation that was previously formulated is as follows:

$$\Delta lC02_t = \beta_0 + \sum_{i=0}^{m} \beta_1 \Delta lC02_{t-i} + \sum_{i=0}^{m} \beta_2 \Delta ltop_{t-i}^{+} + \sum_{i=0}^{m} \beta_3 \Delta ltop_{t-i}^{-} + \sum_{i=0}^{m} \beta_4 \Delta lfdi_{t-i}^{+} + \sum_{i=0}^{m} \beta_5 \Delta lfdi_{t-i}^{-} + \sum_{i=0}^{m} \beta_6 \Delta lman_{t-i}^{+} + \sum_{i=0}^{m} \beta_7 \Delta lman_{t-i}^{-} + \sum_{i=0}^{m} \beta_8 \Delta lgdp_{t-i}^{+} + \sum_{i=0}^{m} \beta_9 \Delta lgdp_{t-i}^{-} + \vartheta_t ect_{t-1} + \in_t \quad (3)$$

Result Interpretation and Discussion

Table 2 provides a brief summary of the main characteristics of the observations of the yearly time series data that we used for the investigation, along with pairwise correlations between the variables. The results show that the dependent variable, LC02, and the four independent variables, LOP, LFDI, LMAN, and LGDP, have a substantial and positive relationship. The results of the pairwise correlation range from 0.65 to 0.95.

Result Interpretation and Discussion

Table 2. Descriptive Statistics and Pair-wise Correlations

	LCO2	LTOP	LFDI	LMAN	LGDP
Mean	11.3408	7.5892	2.1544	6.2236	10.3482
Std. Dev.	0.2361	0.0578	0.3423	3.1507	0.53524
Min.	11.6558	6.5201	1.5889	1.6093	9.7934
Max.	10.8101	6.7030	2.9767	11.5607	10.1857
JB	0.9391	3.2514	1.7547	3.9067	4.1976
Probability	0.5242	0.1967	0.4189	0.1516	0.1235
Observations	37	37	37	37	37
$LC0_2$	1.0000				
LTOP	0.9661	1.0000			
LFDI	0.6409	0.7210	1.0000		
LMAN	0.7427	0.9102	0.8403	1.0000	
LGDP	0.8496	0.9458	0.8289	0.9481	1.0000

Source: Researcher's computation using eviews10

Result Interpretation and Discussion Cont.…

Unit Root Test

When utilizing the NARDL asymmetric Cointegration technique, variables can be either I(0) or I(1); however, they cannot be integrated of the second order, I(2). Using the traditional techniques of ADF, PP, and KPSS, a unit root is carried out to verify that all variables are I(1). However, the NARDL estimate technique is supported by the absence of any 1(2) variables and is further encouraged by the mixed degrees of integration.

Result Interpretation and Discussion Cont.…

Table 3: Stationarity test results

Variables	ADF		PP		KPSS	
	level	1st difference	level	1st difference	level	1st difference
$LC0_2$	-1.6167	-9.7173**	-1.1779	-15.246**	0.7311*	
LTOP	-0.4665	-5.8336**	0.22810	-6.9620**	0.7345	0.3358**
LFDI	-1.7333	-5.8010**	-1.5843	-9.9777**	0.6549	0.5001*
LMAN	-0.4814	-4.7594**	-0.5012	-4.7798**	0.7523	0.1421**
LGDP	-1.0410	-3.7930**	0.4511	-3.7832**	0.7448	0.292893**

Source: Researcher's computation using eviews10

Result Interpretation and Discussion Cont.…

Güriş (2018), however, noted that testing for order of integration in nonlinear models is inadequate because standard unit root tests frequently exhibit no stationarity when addressing nonlinear variables.

Güriş (2018) presented a novel flexible Fourier form nonlinear unit root test to circumvent this problem. An exponential smooth threshold autoregressive (ESTAR) model is used to simulate the nonlinear adjustment in order to assess whether or not the variables are nonlinear stationary.

Result Interpretation and Discussion Cont.…

Table 4. Güriş (2018) Nonlinear Unit Root Test

Variables	Lags	Test statistics	Decision	Critical values K=1	
$LC0_2$	2	17.22687**	Stationary	1%	20.31
LTOP	2	15.97637**	Stationary	5%	13.72
LFDI	2	6.293270	Nonlinear unit root	10%	11.42
LMAN	2	13.88877*	Stationary		
LGDP	2	17.42102**	Stationary		

Note: the signs of ***, ** and * refers to the rejection of unit root hypothesis at 1%, 5% and 10% level respectively. lag method (AIC), Maximum lags (3).

Source: Researcher's computation using eviews10

Result Interpretation and Discussion Cont.…

All other variables, with the exception of manufacturing sector, which displays a unit root, are stable and exhibit nonlinearity with breaks at unknown dates at a significance level of 5%, according to Guris's (2018) nonlinear unit root test.

Short and Long-run NARDL Results

To investigate the impact of economic growth, trade openness, foreign direct investment, and on Nigeria's CO2 emissions, we performed both short- and long-term NARDL estimations. These conclusions were supported by the unit test results shown in Tables 3 and 4, which confirmed that NARDL was applicable.

Short and Long-run NARDL Results

Table 5. Short and long-run NARDL results

NARDL Short-Run Result; Dependent Variable: LC0,							
Regressors	Lags 0 1						
Δ LTOP⁺	0.225846 (0.2041)	0.435727 (0.0966)***					
Δ LFDI⁺	0.055626 (0.0260) **	-1.247151 (0.0018)*					
Δ LMAN⁻	-0.061575 (0.5217)	-0.629001 (0.0418)**					
Δ LGDP⁺	0.193647 (0.8508)	-2.245438 (0.0048)*					
NARDL Long-Run Result							
LTOP⁺	LTOP⁻	LFDI⁺		LFDI⁻	LMAN⁻	LGDP⁺	LGDP⁻
-0.2905 (0.0010) *	-0.2138 (0.7696)	-0.3177 (0.3055)	2.0970 (0.0757) ***		-0.3856 (0.0673) ***	7.4869 (0.1124)	9.6556 (0.0967) ***
Diagnostics							
Bound test	ECM_{t-1}	Adj. R^2		Hetero. Test	LM Test		
4.152410	-0.863618 (0.0000) *	0.739170		(0.1280)	(0.1277)		
$LTOP_{LR}$	$LFDI_{LR}$	$LMAN_{LR}$		LGD_{LR}			
25.18963 (0.0000)	14.77864 (0.0006)	17.56625 (0.0002)		5.79223 (0.0161)			

( ) = Probability values, LR=Long-run Wald test. *, **, *** mean significance at 1% , 5% and 10% respectively

Source: Research's computation using eviews10

Short and Long-run NARDL Results cont..

The results of the estimation of equation (2) are shown in Table 5. The short-term outcome indicates that a 1% increase in LTOP from the previous year will result in a 0.40% emission increase in the present short-term period, but the positive shock of LTOP in the current period is positive but statistically insignificant. Put another way, the present foreign direct investment may have a favorable impact on emission levels, but it won't become noticeable until a year from now.

The overall outcome, a shock to LTOP+ will decrease emissions by 0.21. The outcome may be suggesting that people and businesses are using more environmentally friendly or renewable energy-powered products in the manufacturing sector, even though this was not anticipated beforehand. This result is consistent with research undertaken in the west Africa economies, (Bediako, et al., 2022; Mordi, et al., 2022).

Short and Long-run NARDL Results Cont..

It is shown that a positive shock in foreign direct investment does not have the anticipated good effect on emission; instead, it lowers emission by 2.09. This is the case because a negative shock to foreign direct investment causes the manufacturing sector to contract, which impairs the industry's capacity to produce.

Positive and negative shocks to the manufacturing sector cause CO2 to rise and fall by 0.38 and 0.81, respectively. Lastly, a 9.65% drop in CO2 emissions is the consequence of a decline in GDP brought on by the effects of human production. The long run Wald test of the regressors often validates the nonlinear asymmetries in our model.

Short and Long-run NARDL Results Cont..

The results of the post-estimation demonstrate that: the bound test verifies the cointegration of the variables, demonstrating the existence of a long-term relationship between them; The ECM is statistically significant, negative, less than unity, and has the ability to reverse any shock that causes disequilibrium at a rate of 86% per second.

The model's fitness is supported by the corrected R2 of 0.73. The Heteroskedasticity test and Breusch-Godfrey serial correlation (LM Test) probability values of (0.1280) and (0.1277) show that there is no serial correlation and that the residual errors of the model are homoscedastic. The CUSUM and CUSUM squares tests demonstrate the stability of the model's parameters.

Table 6. NARDL Results

NARDL Long-Run Result Dependent Variable: $LC0_2$							
TOP^+	TOP^-	LFDI	LGDP				
-0.0340 **(0.3939)**	-0.1621 (0.0007) *	2.7916 (0.0469) **	-0.3266 (0.3785)				
Diagnostics							
Bound test	ECM_{t-1}	Adj. R^2	Heteroskedasticity test	LM Test			
2.5837	-0.9179 (0.0000) *	0.5757	(0.8095)	(0.5445)			

( ) = Probability values, * means significance at 1%.

Source: Research's computation using eviews10

NARDL Results

A positive TOP shock is not statistically significant, while a negative shock will result in an increase in LC02 emission of 0.16. The results show that LFDI and LGDP have no long-term asymmetric influence on LC02, even though a unit increase in FDI (LFDI) will cause an increase in emission of 0.04. This is understandable given that LFDI is the means via which TOP affects LC02.

Conclusion

Several studies are conducted on the impact of trade openness and the quantum of $C0_2$ emission in several countries across different regions of the globe. However, with the exception of a very few, all works assumed symmetric and linearity in relationship among variable.

This work explored the possibility of nonlinear relationship with the assumption of asymmetric cointegration within the NARDL for Nigeria from 1986-2023. Findings revealed that, trade openness had a positive and significant impact on foreign direct investment (FDI), and on environmental degradations, suggesting that FDI improves as trade openness opened up. Trade openness is a determinant of FDI inflows since it positively affects FDI inflows.

Conclusion cont..

Based on the above assertions, its not far from the difference in the methodology employed. While we employed nonlinear asymmetric cointegration technique of NARDL, they employed a linear and assumed symmetrical relationship. Our result about the existence of asymmetric relationship between CO2 and trade openness. CO2 emission is found to be more responsive to negative shocks of trade openness and foreign direct investment than it is for positive shocks.

Conclusion cont..

Contrariwise is the case for manufacturing sector. With this revelation of $C0_2$ been more responsive to negativity than positive shocks to trade openness variables, and which linear models don't account for, it therefore means that symmetrical models have ignored this very important part of the discuss in the CO2-trade openness and foreign direct investment nexus, the inclusion of which herein appears to be a value addition.

Recommendations

It is therefore recommended that, the federal government, through its ministries and agencies, should strengthen its investment strategy by collaborating with both local and multilateral sectors in order to improve trade policies and increase FDI inflows.

The government should utilize its monetary authority to ensure that the value of the Nigerian naira in relation to the US dollar is stronger and more stable, since foreign direct investment inflows have a favorable impact on exchange rates.

Recommendations cont.

The use of green energy be financed and encouraged by the government, environmental laws be strengthened and pollution taxes be introduced in order to mitigate the increasing level of $C0_2$ released through the consumption spree for energy demanding and $C0_2$-emitting goods aided by the increasing level of Nigeria's trade development.

Thank You

FOR LISTENING