Applied Journal of Economics, Management, and Social Sciences, 2024, 39-50

Doi: 10.53790/ajmss.v5i2.9
ISSN: 2811-1613
Submitted: April, 2024; Revised: April, 2024; Accepted: May, 2024

ARTICLE

Asymmetric Effect of Financial Development and Urbanization on the Environment: Evidence from Nigeria

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Abstract
The study examines the influence of financial development (FD) and urbanization (URB) in the presence of economic growth (RGDP) on the environment – captured by ecological footprint – in the case of Nigeria over the period 1986-2022. This study employed the nonlinear autoregressive distributive lag (NARDL) model to capture the asymmetry that arises from positive or negative components of financial development, urbanization and economic growth. Our result confirms the existence of an asymmetric effect of URB, FD and RGDP on the ecological footprint in the short-run, while it was only FD and RGDP that impacted the ecological footprint in the long-run. Moreover, our empirical finding also suggests that RGDP has a significant contribution to ecological footprint in the short- and long-term, significantly supporting the existence of the EKC hypothesis both in the long and short terms and confirming the inverted U-shaped connection between RGDP and ecological footprint in Nigeria. Further, the error correction model (ECM) confirms a short-run relationship among the variables. Finally, we suggest that the implementation and use of clean energies and technologies are vital for controlling the environment in Nigeria.
Keywords: Ecological footprints, financial development, NARDL, Nigeria, urbanization.
JEL Classification: C22, O44, P346, Q56

Cite as: Akinpelumi, D. M., Aworinde, O. B., Onakoya, A., Rufai, A. A. (2024). Asymmetric effect of financial development and urbanization on the environment: Evidence from Nigeria. *Applied Journal of Economics, Management, and Social Sciences, 5(2), 39-*

1. Introduction

Economic activities that are targeted toward economic growth have led to environmental risks, leading to diverse research areas in environmental economics and sustainability that are controversial among environmental scholars. Economists and environmentalists globally have contributed to the literature to understand the different relationships that exist between economic growth, development, and the environment (**Shoaib et al., 2020**). Many research and inter-governmental initiatives are being made at the global level to provide answers to mitigate the effects of climate change and its inherent repercussions while boosting global development. The need to find solutions to many pressing international issues spurred the idea of the United Nations' Sustainable Development Goals (SDGs). The goals were developed during the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012. The 2030 Sustainable Development Timeline received approval at the United Nations Sustainable Development Summit in September 2015, validating the targets (UN General Assembly, October 2015).

Environmental deterioration and substantial environmental disruption to human existence and global economic growth is both caused by global warming. However, with increased economic activity and migration to cities as a result of urbanization and, by extension, globalization, the environmental effects might be disastrous if ignored or left unattended. Researchers claim that excessive greenhouse gas emissions are to blame for the issue of global warming. related variables, in an attempt to determine how to mitigate the challenge (**Adeleye et al., 2021**; **Jiang & Ma, 2019**). Global warming is a serious challenge encountered across all countries of the world and is not peculiar to one region.

Ecological footprints and carbon emissions are culprits of climate change or global warming while the responsibility of sanitizing the climate and truly realising a controlled - carbon economy remains farfetched. CO_2 emissions as a result of human activities are currently higher than it has been in the history of mankind as current facts exhibit proof that world CO_2 emissions became 150 times higher in 2011 than has been in 1850 (World Resource Institute, 2014). FD is a pertinent variable in a modern economy, as it is in every economy across the world. It is also a significant yardstick for measuring the progress of a state. It has a huge impact on CE. The influence of financial development (FD) on energy conservation is critical and should be investigated. On the one hand, via economic growth, industrial structure, technological innovation, and other variables, FD may have a direct influence on the process of energy saving and carbon emissions. Through its influence on growth, industrial structure, advancements in technology, and other factors, FD indirectly impacts preserving energy and carbon emissions (**Nasreen & Anwar, 2015**).

Scholars have contributed to the environmental impact of economic growth, with numerous conclusions highlighted. While some studies have found that FD has a negative influence on ecological footprints, many believe that financial development will raise carbon emissions. Various research, however, has found that FD has no substantial influence on carbon emissions (**Bekhet et al., 2017**; **Nasreen & Anwar, 2015**; **Uddin et al., 2017**). This study compensates for certain shortcomings in prior studies in the role of FD on CE in Nigeria systematically and thoroughly. The Financial Sector contributes to the overall expansion and improvement of the economy, promoting fair allocation of economic and monetary resources, the use of the channel of savings, assisting enterprise transactions, and monitoring resources for economic growth. Nigeria's economic quarter facilitates critical commercial transactions for progress.

Most of the economic activities take place in the urban centres or cities. Hence, the role of urbanization in stepping down on ecological footprint use and dirty environment (**Nasreen et al., 2017**). Urbanisation, according to the notion of ecological modernization, is a process of social transformation that serves as a sign of modernity. Economic expansion surpasses environmental sustainability as civilizations go from low to middle-stage development. As societies advance to higher degrees of development, the preservation of nature becomes increasingly important, and societies seek ways to become more environmentally sustainable. According to some, technical innovation, urbanization, and the transition from a manufacturing to a service economy might mitigate the negative effects of development on the environment (**Gouldson & Murphy, 1997**; **Mol & Spaargaren, 2000**). Furthermore, studies have explored the relationship that exists between urbanization and CE with diverse opinions. Urbanization may represent modernization and therefore the link between urbanization and CO2 varies from place to place (**Ehrhardt-Martinez et al., 2002**).

Studies on FD and the environment are considered to be in their early stages, and more research is needed to provide a full knowledge of the influence of FD on carbon emissions. The majority of previous research has focused on the linear influence of FD on emissions, but there may be a lack of empirical evidence on how FD moderates the growth and consumption of energy to affect CO2 emissions (**Cetin et al.,2018**; **Haseeb et al. 2018**). Examining the role of finance in Sub-Saharan Africa emissions is crucial because Africa contributes little to global carbon emissions. However, carbon emissions in the region have been increasing over time. As a result, it is necessary to evaluate the impact of global warming on the region. This resent study investigates the influence of financial development and urbanization on the ecological footprint in Nigeria.

The remainder of the study is as follows. Section 2 delves into an extensive literature review, encompassing both theoretical and empirical evidence. Section 3 elaborates on the data and methodology employed in the research. Section 4 is dedicated to presenting and analysing the results, while Section 5 concludes the study, emphasizing its policy implications.

2. Literature Review

2.1 Theoretical Issues

Grossman and Krueger (1991), proposed an inverted U-shaped link between growth and environment known as the EKC. The authors were interested in investigating the repercussions of ongoing economic expansion as being capable of causing greater harm to the earth's ecosystem. Furthermore, if increases in income and wealth plant the seed for the amelioration of environmental problems, the results will be essential in creating acceptable development plans for less developed nations. The principal premise is that income growth causes an increase in ecological footprint in the early stages of economic development. However, as development progresses, the reverse influence of wealth on pollution turns positive. In other words, an increase in wealth is caused by a decrease in ecological footprint, resulting in an inverted U- curve. It is significant because an inverted U-shaped EKC will prevent environment breakdown at a particular time during growth in economic terms, and the quality of the environment will improve as economies continue to rise. To put it another way, economic activities frequently cause environmental degradation, and at the start of economic expansion, individuals care less or are unable to maintain the environment.

According to the EKC model, during the early stages of expansion, pollution levels climb until they reach the previously indicated positive turning point, after which economies begin to see a decline in pollution. The consequence is that economic expansion has three effects on the environment: size impact, composition effect, and technological influence. The first asserts that a rise in the energy needs of the function of production leads to increased usage of fossil gas sources and, as a result, an increase in pollution. The composition effect is the shift away from capital-service sectors and toward knowledge-based economies, which employ cleaner strength techniques. Finally, the technological influence relates to the fact that rich economies devote more funds to energy.

According to **Torras and Boyce (1998)**, as economies push technological limitations, the pollution route increases owing to the scale effect, which imposes the influence of both the composition and the technical impacts. There is a consensus that when an economy reaches a certain level of affluence, regulatory measures and initiatives to protect the environment are desired. Recent research in environmental economics implies the possibility of an additional impact known as the technological obsolescence effect, which claims that when a certain second turning point is reached, the corresponding climbing emissions occur. Once the scale impact outweighs the composition and technical effects again, technical obsolescence is likely to lead to the return of pollution increase. The U-curve does not, but the N-shaped pattern produces a spike in pollution as soon as long-term high-income levels are achieved.

2.2 Empirical Evidence

Nasreen et al. (2017) conclude that the financial sector is crucial to mobilizing funds for commercial transactions, utilizing them, and keeping track of resources for economic growth. When the financial sector is completely developed, it encourages the efficient mobilization and distribution of resources, which is crucial for the economy to grow. Nigeria's financial industry aids in fostering economic growth. Therefore, it can be inferred that a successful financial sector will boost investment and encourage companies to employ green manufacturing techniques (**Mesagan & Nwachukwu, 2018**).

Meanwhile, **Dasgupta et al. (2001)** stated that nations with constant financial systems probably have cleaner environments than nations with unstable financial markets. Additionally, empirical research backs up the idea that FDI is promoted in nations with secure financial markets. Given that there are several ways in which the financial sector influences the environment, there seems to be a fairly direct connection between their developments. The environmental Kuznets curve (EKC) says that investing can boost growth, which affects the environment. Second, promoting private sector investment in more advanced and secure technology is one method to enhance the banking industry. Furthermore, the allocation of loans to investments is affected by a country's level of financial development. Credits can enhance or deteriorate environmental quality. This is because financial institutions may consciously or accidentally reject credit facilities to enterprises with high carbon emissions, limiting funding to businesses with low carbon emissions. Consequently, various studies have demonstrated that the expansion of the financial sector may have a substantial influence on how successfully a country's environment is maintained through some channels (**Charfeddine & Khediri, 2016; Maji et al., 2017; Mahalik et al., 2017; Shahbaz et al., 2017; Salahuddin et al., 2018; Mesagan et al., 2018; Joseph, 2019**).

Purcel (2020), noted that one of the major concerns of nations centre around global warming, and particularly, the adverse effects that global warming produces on earth and on the quality of human life which could threaten human existence. The arrival of the Industrial Revolution, ushered in significant changes at the global level economically and socially, which affected the environment. Considering the factors influencing carbon emissions and using the multivariate non-linear ARDL to test for a non-linear and asymmetric relationship between CO2 emissions and its determinants, explains that climate change and its significant consequences are one of the modern world's most pressing problems. The NARDL model is useful because it integrates long and short-run asymmetric interactions of variables. Because of the complexities of economic systems and procedures that contribute to CO2 emissions and their drivers, asymmetric and nonlinear relationships between economic variables may occur (**Atil et al., 2019**).

Furthermore, studies agreed on a symmetrical relationship in the research, concentrating primarily on how FD influences CO2 emissions in Nigeria. Earlier studies' findings support the claim that the influence of FD on CO2 emissions in Nigeria warrants additional study. Empirical data from many countries suggests a nonlinear relationship, with asymmetric impacts of FD on CO2 emissions. The asymmetric impacts of financial sector development on CO2 emissions stem from the premise that the amount and impact of a positive change might differ in absolute value from the magnitude and impact of a negative change. In light of these considerations, this study provides a rigorous empirical examination of the influence of financial expansion and urbanization on CO2 emissions (**Ahmad et al., 2018**; **Gok, 2020; Karasoy, 2019**; **Shahbaz et al., 2016**)

The financial system in Nigeria has undergone metamorphosis throughout time in response to demands and changes in the economy. It is necessary to take into account asymmetries in the relationship between the growth of the financial sector and CO2 emissions because the depth of the Nigerian financial system has been impacted by a variety of strategic financial reforms and consolidation policies implemented in previous decades in response to globalization, technological advancement, changes in crude oil prices, and other systematic and non-systematic factors (**Karasoy & Akçay, 2019**). The study goes beyond linear connections by assessing the significance and consequences of positive and negative changes (asymmetries) in financial development on emissions using the recently established non-linear autoregressive distributed lag (NARDL) approach (**Shin et al., 2014**). In the instance of Nigeria, the research employed a longer sample period (1983-2021) than those used in earlier studies. The first empirical explanation of how differences in financial development affect Nigeria's CO2 emissions is presented.

Global economies have recently been confronted with the question of environmental sustainability, as the ultimate goal of humanity is to achieve economic progress and development, which entails some opportunity costs or alternatives foregone, as defined in economics (see **Everett et al., 2010**; **Panayiotou, 1994**). Finally, climate action, as defined in the United Nations Sustainable Development Goal 13, is a huge problem for the global economy, both developed and developing, as the SDGs document the unified global goal of environmental protection (**Danish et al, 2018**; **Haseeb et al., 2018**).

3. Methodology

3.1 Data and Sources

This study employed the time series secondary data spanning from 1986 to 2022, The variables adopted for the study include ecological footprint (EFP) measured in global hectares per capita– see **Altıntaş and Kassouri (2020)**, **Charfeddine (2017)**, **Kitzes et al. (2009) and Pata (2021)** – urbanization (urb) measured as Urban population (% of the total population), and real GDP $(rgdp)$ all sourced from World Bank Indicators (WDI) and financial development (fd) measured as depth, access, and efficiency of financial institutions and markets sourced from international Monetary Fund (IMF).

3.2 Model Specification and Estimation Technique

In previous studies, the financial development-ecological footprint nexus was majorly examined via the ordinary time series methods of the auto-distributive lag model (ARDL) cointegration analysis, followed by error correction (EC) modelling and Granger causality. However, econometric methods enable the evaluation of the existence of long-run relationships accompanied by short-run associations, taking the linkage among financial development, urbanization and ecological footprints symmetrically. For that reason, they are not sufficient to attain conceivable asymmetries among variables (see **Jan et al., 2023**; **Moghadam & Dehbashi, 2018**; **Sehrawat et al., 2015**). Recently, some studies were conducted exploring the comparative view of the symmetric and asymmetric effect of urbanisation and financial development on ecological footprint in a time series or panel data framework (see **Ahmed et al., 2021**; **Ahmad et al., 2018**). As ample of these studies expanded the ARDL model developed by **Pesaran et al. (1999)** as an asymmetric extension of a linear ARDL cointegration procedure (ARDL) to capture long-run and short-run asymmetries in the desired variables, birthing the nonlinear ARDL (NARDL). This modelling methodology is employed here.

Before presenting the full depiction of the NARDL model, the relationship among financial development, urbanization, economic growth and ecological footprint is shown in the following asymmetric long-run regression:

$$lnefp_t = \delta_0 + \delta_1 lnurb_t + \delta_2 lnfd_t + \delta_3 lnrgdp_t + \varepsilon_t \quad (1)$$

where efp is ecological footprint, urb_t represents urbanisation, fd_t indicates financial development, and $rgdp_t$ depicts real GDP. It should be of note that all series are in their respective logarithms transformation form to elasticities interpretation.

The above relationship carried out the linear relationship among the variables, meanwhile, the primary objective of this study is to explore the non-linearity among EFP, URB, FD and RGDP by employing the nonlinear Autoregressive distribute lag (NARDL) model presented by **Shin and Greenwood-Nimmo (2014)**. The NARDL model has the following form:

$$lnefp_t = \sum_{j=1}^{p} \partial lnefp_{t-j} + \sum_{j=0}^{q} \left(\pi_j^+ lnx_{t-j}^+ + \pi_j^- lnx_{t-j}^- \right) + \in_t \quad (2)$$

In equation (2) $lnx_t = [lnURB_t, lnFINDEV_t, lnRGDP_t]$ which is the vector of all the explanatory variables, defined such that $lnx_t = Inx_0 + Inx_t^+ + Inx_t^-$, ∂_j is the autoregressive parameter, π_j^+ and π_j^- are the asymmetric distributed lag parameters, and $\in_t$ is the *iid* – independent and identical distributed – random variables process with zero mean and constant variance, $\sigma_\in^2$. x_t is decomposed around a zero threshold, allowing us to distinguish between the effect of positive and negative changes of x. Following the work of **Pesaran et al., (2001)**, the model in equation (2) could be written in error correction form as follows:

$$lnefp_t = \mu + \rho_{co2} lnefp_{t-1} + \rho_{urb}^+ lnurb_{t-1}^+ + \rho_{urb}^- lnurb_{t-1}^- + \rho_{fd}^+ lnfd_{t-1}^+ \rho_{fd}^- lnfd_{t-1}^- + \rho_{RGDP}^+ lnrgdp_{t-1}^+ + \rho_{Rrgdp}^- lnrgdp_{t-1}^- + \sum_{i=1}^{p-1} \gamma_i \Delta lnefp_{t-i} + \sum_{j=0}^{q-1} \left(\alpha_j^+ \Delta lnurb_{t-j}^+ + \alpha_j^- \Delta lnurb_{t-j}^- \right) + \sum_{j=0}^{r-1} \left(\delta_j^+ \Delta lnfd_{t-j}^+ + \delta_j^- \Delta lnfd_{t-j}^- \right) + \sum_{j=0}^{s-1} \left(\theta_j^+ \Delta lnrgdp_{t-j}^+ + \theta_j^- \Delta lnrgdp_{t-j}^- \right) + \varepsilon_t \quad (3)$$

Where Δ is the first difference operator and ε_t is the error term. $urb_t^+, urb_t^-, fd_t^+, fd_t^-, rgdp_t^+$ and $rgdp_t^-$ are obtained through the decomposition of urb_t, fd_t and $rgdp_t$, respectively into positive and negative partial sums as follows:

$$urb_t^+ = \sum_{j=1}^{t} \Delta urb_j^+ = \sum_{j=1}^{t} \max(\Delta urb_j, 0); \; urb_t^- = \sum_{j=1}^{t} \Delta urb_j^- = \sum_{j=1}^{t} \min(\Delta urb_j, 0)$$
$$fd_t^+ = \sum_{j=1}^{t} \Delta fd_j^+ = \sum_{j=1}^{t} \max(\Delta fd_j, 0); \; fd_t^- = \sum_{j=1}^{t} \Delta fd_j^- = \sum_{j=1}^{t} \min(\Delta fd_j, 0) \quad (4)$$
$$rgdp_t^+ = \sum_{j=1}^{t} \Delta rgdp_j^+ = \sum_{j=1}^{t} \max(\Delta rgdp_j, 0); \; rgdp_t^- = \sum_{j=1}^{t} \Delta rgdp_j^- = \sum_{j=1}^{t} \min(\Delta rgdp_j, 0)$$

Furthermore, we employed the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests to establish the order of integration.

4. Results and Discussion

4.1 Summary Statistics

From Table 1, the ecological footprint, urbanization, FD and RGDP have a mean value of 1.792 global hectares per capita, 39.157 % of the total population,49.6534 and 291.147 billion USD depicting that on average, during the 38 years periods studied, Nigerian ecological footprint, urbanization, financial development and real GDP was 1.792 global hectares per capita, 39.157 % of the total population,49.6534 and 291.147 billion USD with a dispersion of 0.1999 global hectares per capita, 8.101 % of the total population, 11.660 and 147.783 billion USD, respectively, establishing that the volatility in Nigerian energy use was still manageable, as it clustered around the average value, suggesting that the series are less susceptible to change over time. Meanwhile, the EFP, URB, FD and RGDP were positively skewed to the right, portraying a long-right tail, while FD was negatively skewed. At the same time, all the peakedness was platykurtic, showing that the series' extreme values characteristics are similar to that of the normal distribution. Finally, all the series were normally distributed during the study period at a 0.05 significant threshold.

4.2 Stationary Tests

Precursory to the estimation of the NARDL model, the researcher checked for the stationarity properties of the series using the augmented Dickey-Fuller (ADF) and Philip Perron (PP) tests to determine the integrating order of each variable, and Table 4.3 is the output of the estimates.

Table 1: Summary Statistics

	EFP	URB	FD	RGDP
Mean	1.7922	39.1571	49.6534	291.1470
Std. Dev.	0.1999	8.1009	11.6606	147.7833
Skewness	0.2959	0.2095	-0.3222	0.3950
Kurtosis	1.9205	1.8155	1.4808	1.5271
Jarque-Bera	2.3996	2.4994	4.3119	4.4231
Probability	0.3013	0.2866	0.1158	0.1095
Observations	38	38	38	38

Source: Authors' Computation

Table 2: Stationarity Tests

	Level		First Difference	
Variable	ADF	PP	ADF	PP
$lnefp$	-2.6782	-2.8487	-7.9657***	-11.0484***
$lnurb$	-3.4283*	-3.4283*	-8.7503***	11.7067***
$lnfd$	-3.5788**	-3.2581*	-4.6482***	-6.7042***
$lnrgdp$	-3.6036**	-1.5168	-3.8129**	-3.7043**

Source: Authors' compilation
Notes: * Significant at 10%; ** Significant at 5%; *** Significant at 1%.

From Table 2, the stationarity test result using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) show that under the ADF, three variables – $lnfd$, $lnurb$ and $lnrgdp$ – were stationary at the level without differencing [I(0)], while $lnefp$ was stationary at first difference [I(1)] after differencing. Additionally, under the PP unit root tests, two (2) variables exhibited stationary at level [I(0)] – $lnfd$ and $lnurb$ –without differencing, while the remaining two (2) – $lnefp$ and $lrgdp$ – were stationary at first difference [(1(1)] after the first differencing. This implies that the order of integration of the series is mixed, signifying and necessitating the use of the Nonlinear Autoregressive Distributed Lag (NARDL) as proposed by **Shin et al. (2014)**, which allows mutually co-integrated series.

Table 3 presents the results of the long-run and the short-run estimates of the NARDL model. Starting with the short-run result, there is evidence that positive and negative URB shocks have a significant negative relationship with EFP, respectively. This portrays that in the short run, increases in URB led to a decrease in ecological footprint (EFP), while the decrease in URB brought about an increase in Nigerian ecological footprint. These imply that the increase and decrease in urbanisation are significant factors influencing changes in the ecological footprint in Nigeria. Furthermore, the short-run coefficient of negative shocks in financial development is positive. The estimates further expose that financial development decrease decreases Nigeria's ecological footprint, hence decrease in FD is a significant factor influencing changes in the ecological footprint in Nigeria. Finally, in the short-run, the positive and negative shocks in real GDP exhibited a significant negative and positive nexus on EFP, respectively. The estimates show that as real GDP increases, ecological footprints decrease, while a decrease in real GDP declines Nigeria's ecological footprint. Thus, positive and negative shocks in real GDP are a significant factor partially contributing to the ecological footprint in Nigeria.

The nonlinear ARDL cointegration test relies on the joint F-statistics test for long-run relationships (see **Shin et al., 2014**). Table 4 presents the F-statistics test results and shows that the F-statistic is greater than the upper critical bound at a 5% significance level. The null hypothesis is thus rejected, suggesting that long-run nexus exists among financial development, urbanisation and carbon emission in Nigeria. Hence, the hypothesis of long-run cointegration among variables is firmly accepted, leading to the interpretation of the long-run coefficient estimates.

Table 3: NARDL estimation results for financial development, urbanisation and ecological footprint nexus in Nigeria.

	$lnurb^{+}$	$lnurb^{-}$	$lnfd^{+}$	$lnfd^{-}$	$lnrgdp^{+}$	$lnrgdp^{-}$
$\delta^{lnurb^{+}}$	-0.0192*** (0.0065)					
$\delta^{lnurb^{-}}$		-0.0121** (0.0054)				
$\delta^{lnfd^{+}}$			-0.0121 (0.0114)			
$\delta^{lnfd^{-}}$				0.0744*** (0.0141)		
$\delta^{lnrgdp^{+}}$					0.1121*** (0.0202)	
$\delta^{lnrgdp^{-}}$						-0.0697*** (0.0176)
$\lambda^{lnurb^{+}}$	0.4889*** (0.1666)					
$\lambda^{lnurb^{-}}$		0.3480* (0.1976)				
$\lambda^{lnfd^{+}}$			0.7842*** (0.1550)			
$\lambda^{lnfd^{-}}$				0.3658*** (0.1256)		
$\lambda^{lnrgdp^{+}}$					1.3444* (0.2187)	
$\lambda^{lnrgdp^{-}}$						0.4495** (2.0725)
γ^{ect}	-0.4792*** (0.0971)					

Source: Authors' work

Note: The values in parentheses are the standard errors. The $\delta s'$ are for the short run while the $\lambda s'$ are for the long run. ***, ** & * imply significance at the 1%, 5% and 10% levels, respectively

Table 4: Post-Estimation Diagnostic Tests

Diagnostic Tests
$R^2 = 0.8189$ $\bar{R}^2 = 0.6854$ $DW = 2.6088$
$X^2_{LM} = 4.5515[0.1623]$ $X^2_{BGP} = 15.3210[0.4286]$ $X^2_{JB} = 0.3186[0.8527]$ $X^2_{RS} = 2.8482[0.1097]$
$F-statistic = 6.1359[0.0002]$ STABILITY=CUSUMSQ
NARDL bound test
$F-statistic = 11.1105[I(0) = 2.27, I(1) = 3.28 @ 5\%]$

Notes: DW: Durbin Watson statistics. statistics. $X^2_{LM}, X^2_{BGP}, X^2_{RS}, X^2_{JB}$ represent LM test for serial correlation, Breusch-Pagan Godfrey test for heteroscedasticity, Ramsey rest test for model specification and Jarque-Bera normality test, respectively. I(0) and I(1) represent lower and upper bound, respectively. [ ] indicate respective probability values.

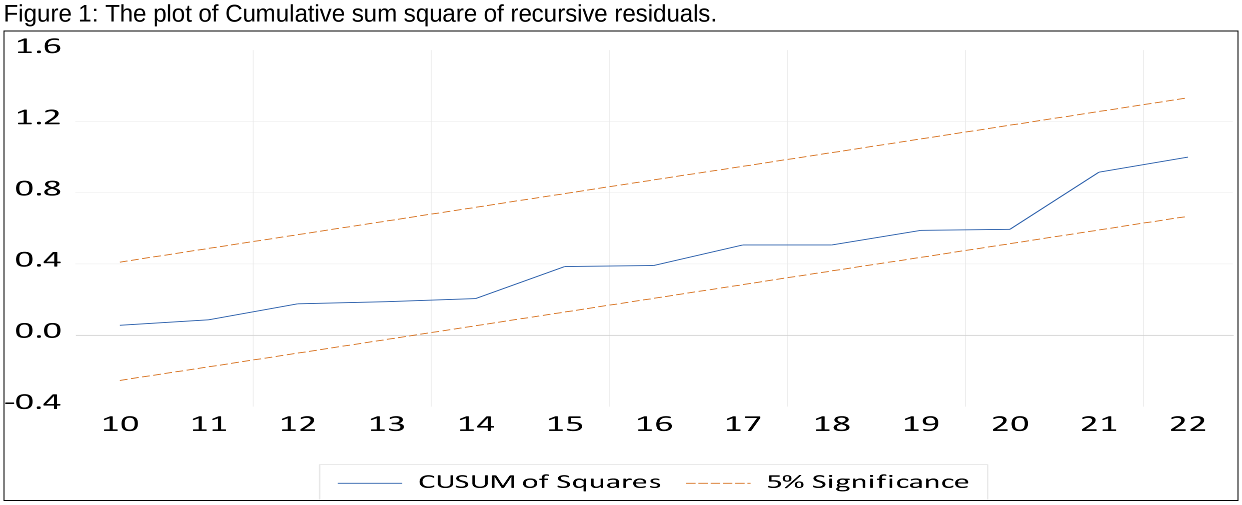
In the long run, there is evidence that the increase (decrease) in urbanisation has a significant positive (positive) association with ecological footprint in Nigeria, implying that urbanisation increase (decrease) leads to ecological footprint increase (decrease), hence, positive and negative shocks in urbanisation are significant factor partially influencing fluctuations in ecological footprint in Nigeria. Additionally, the long-run coefficient of positive (negative) shock in financial development is significantly positive (positive), declaring that as financial development increases (decreases), it will lead to an increase (decrease) in ecological footprint. Finally, in the long run, the coefficient of positive and negative shocks in real GDP is positive, as the estimates show that as real GDP increases (decreases), it will lead to a rise (fall) in Nigeria's ecological footprint. This connotes that positive and negative shocks in real GDP are a significant factor influencing fluctuations in ecological footprint in Nigeria.

The striking finding about the long-run result is a confirmation of dissimilar effects of tight and loose financial development, urbanisation and real GDP shocks on ecological footprint. Likewise, the response of EFP to negative shocks in real GDP is significantly higher than to positive shocks in real GDP. That is, low productivity through easing or decreasing real GDP by a certain magnitude causes a decrease in ecological footprint than loosening or increasing real GDP. On the contrary, discouraging rural-urban migration has a lower impact than encouraging, as revealed via the 0.35 per cent significant contribution of URB Negative shock on ecological footprint against the 0.49 per cent significant impact of the URB positive shock on ecological footprint (see Table 3). On the contrary, it was the positive shock of RGDP that had the highest significant impact – in magnitude – on ecological footprint, as it exerted a whopping 1.344 per cent impact on ecological footprint as against 0.784 per cent recorded by FD increase.

For the error correction term (ECT), the speed of adjustment coefficient is negative and statistically significant as required. The coefficient of -0.479 indicates that about 47.9% of the short-run deviations from the long-run equilibrium are corrected annually. Alternatively, the adjustment is calculated by taking the inverse of the absolute value of the ECT to show how long it takes for the deviations from equilibrium to return to equilibrium (**Pao & Tsai, 2010**). Therefore, the adjusted speed for this study is 1.7 years (i.e., $1/0.4792$), which implies that it would take about 2 years and 2 months for short-run deviations from the long-run to be corrected.

Some post-estimation diagnostics tests were conducted (see Table 4) to ascertain that the estimated model is free from multicollinearity, autocorrelation, serial correlation, and heteroscedasticity, as they were all confirmed absent. Autocorrelation, serial correlation, and heteroscedasticity are established as absent from this analysis with Durbin Watson's (DW) values. Furthermore, the normality and linearity of the residuals were diagnosed with the Jarque-Bera test and the Ramsey Reset test. Non-normality and non-linearity are all confirmed absent from the estimated model.

Figure 1: The plot of Cumulative sum square of recursive residuals.



Source: Authors' compilation

Note: The blue line is the solid line, while the red lines that bounded the blue line are the critical bounds at 0.05.

Table 5: Results of the asymmetry Wald test

	Long run		
Variables	$X^2 Chi-Square$	$[prob]$	**Is there asymmetry?**
$lnurb$	0.0279	0.8673	No
$lnfd$	5.1969**	0.0226	Yes
$lnrgdp$	12.1787**	0.0212	Yes
	Short run		
$lnurb$	4.719**	0.0298	Yes
$lnfd$	16.222***	0.0003	Yes
$lnrgdp$	14.325***	0.0473	Yes

Source: Authors' compilation

Note: ***, ** and * denotes rejection of the null hypothesis at 1%, 5% and 10% significance level, respectively.

The Wald test output in Table 5 shows a significant short-run asymmetric relationship among the variables at 1%, 5% and 10% for urbanisation (URB), financial development (FD) and real GDP (RGDP). Meanwhile, in the long run, other variables exerted long-run asymmetric except URB with long-run symmetric association.

Empirically, in comparison with existing literature, there is a alignment with studies such as **Baloch et al. (2019), Majeed and Mazhar (2019)** and **Nasreen et al. (2017)** which suggest that financial development can have both positive and negative effects on ecological footprint. Additionally, the long-run positive association between urbanization and ecological footprint is consistent with findings by **Huang et al. (2024)**. On the other hand, **Baabou et al. (2017)** and **Pan et al. (2023)** conclude that financial development has no significant impact on the ecological footprint or the environment as sustained in this study. The empirical findings of this study contribute to the growing body of literature on the asymmetric impact of financial development and urbanization on ecological footprint as an indicator of environment (see **Bagliani et al., 2008; Uddin et al., 2017**). The results emphasize the need for a nuanced understanding of these relationships, considering both short-run and long-run dynamics, as well as the asymmetry in the impact of positive and negative shocks. The findings align with and extend the insights provided by previous research (see **Altıntaş & Kassouri, 2020; Charfeddine, 2017; Kitzes et al., 2009; Mesagan et al., 2018**), shedding light on the complexity of the interactions between financial development, urbanization, and ecological footprints in the Nigerian context.

The Wald test results further support the presence of short-run and long-run asymmetry in the relationships, corroborating findings from various studies that have explored the non-linear and asymmetric nature of the relationship between financial development, urbanization, and ecological footprint in different countries (see **Ahmad et al., 2018; Atil et al., 2019; Nathaniel, 2021; Shahbaz et al., 2016**).

Theoretically, the finding is in tandem with the Environmental Kuznets Curve Hypothesis as identified in the study. **Grossman and Krueger (1991)**, proposed an inverted U-shaped link between growth and ecological footprint known as the EKC. The focus is on the repercussions of ongoing economic expansion as being capable of causing greater harm to the earth's ecosystem. Furthermore, if increases in income and wealth plant the seed for the amelioration of environmental problems, the results will be essential in creating acceptable development plans for less developed nations. The principal premise of the EKC is that income growth causes an increase in ecological footprints in the early stages of economic development.

However, as development progresses, the reverse influence of wealth on pollution turns positive. In other words, an increase in wealth is caused by a decrease in ecological footprint, resulting in an inverted U- curve. Countries with strong financial development can invest in cleaner energy sources. It is significant because an inverted U-shaped EKC will prevent environment breakdown at a particular time during growth in economic terms, and the quality of the environment will improve as economies continue to rise. To put it differently, economic activities frequently cause environmental degradation, and at the start of economic expansion, individuals care less or are unable to maintain the environment. However, when people's income grows, they tend to increase their expenditure on pollution-reduction efforts. Consumers increasingly prefer to buy hybrid automobiles or new houses with modern heating systems over dwellings that utilize filthy fuels such as coal (**Maiti & Agrawal, 2005; Morinière, 2012**).

5. Conclusion and Policy Implications

This study investigated financial development, urbanization, economic growth and ecological footprint in Nigeria using the NARDL technique over the period 1986-2022. The evidence has indicated the existence of short- and long-run asymmetric for the variables except urbanization, which opted for a symmetric association with ecological footprint in the long- run. Consistent with the findings, this study offers some key policy implications. First, given the short-run asymmetric impact of urbanization on ecological footprint, policies aimed at managing urbanization processes should be implemented to mitigate the potential increase in ecological footprint.

However, a comprehensive and sustainable approach that integrates urban planning and financial development strategies is recommended to address the long-run positive relationships observed. Pigouvian taxes are targeted on businesses that create negative externalities in Nigeria. Furthermore, policymakers should focus on integrated sustainable development planning. Initiatives that balance urbanization and financial development while considering ecological footprints. Strategies that promote eco-friendly urban development, efficient resource utilization, and sustainable financial practices should be prioritized. Collaborative efforts between urban planning authorities and financial institutions are essential to ensure a harmonized approach towards achieving ecological sustainability in the long run.

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