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LINKAGES BETWEEN ECONOMIC GROWTH, HEALTH EXPENDITURES, EDUCATION, AND ENVIRONMENT: DYNAMIC ANALYSIS OF NIGERIA

*[1]Onwunali M.R.O., [2]Chima C.I. and [3]Ochigbo B.G.

[1]Department of Agricultural Education, Federal College of Education, Zaria
[2]Department of Economics, Federal College of Education, Zaria
[3]Department of Cultural and Creative Arts, Federal College of Education, Zaria

*Corresponding Author Email Address: martinroyal2002@yahoo.com

ABSTRACT:
The study comprehensively analyzed the nexus between economic growth, health expenditures, education, and the environment in Nigeria, using data obtained from Central bank of Nigeria and World Bank. By utilizing a robust dataset spanning from 1981 to 2021, the study employed autoregressive distributed lag (ARDL) approach to uncover intricate relationships. Results, both short-run and long-run analyses, reveal that health and education spending, and gross fixed capital formation positively correlated with economic growth. Conversely, the findings demonstrated that population growth and carbon dioxide emissions (CO_2) exerted detrimental effects on economic growth due to the negative impact on the health of the working population. Additionally, the inverted U-shaped relationship between the macroeconomic footprint and income confirms the validity of Nigeria's Environmental Kuznets Curve (EKC) phenomenon. Lastly, the findings of this study hold important policy implications, emphasizing the need for technological advancements and innovative solutions to address the challenges associated with economic growth, health expenditures, education, and the environment in Nigeria. Policy measures promoting birth control through contraception and family planning should be embraced to effectively manage the country's rapidly growing population.

Keywords: Nexus, economic growth, health, education, expenditures, environment, pollution, sustainable development

INTRODUCTION

The relationship between economic growth and various macroeconomic factors such as population, health conditions, carbon dioxide (CO_2) emissions, and education has been widely discussed (Abdullah, *et al.,* 2016; Lu *et al.*, 2017). Such factors play a crucial role in shaping a nation's economic progress (Sarwar *et al*., 2019; WHO 2022; European Environmental Agency, 2023). Air pollution, resulting from CO_2 emissions, is of global public health concern (Abdullah, *et al.,* 2016), which attracted international interest with the implementation of the Kyoto Protocol in 2005, now known as the United Nations Framework Convention on Climate Change (UNFCC) (Raihan, 2023). Industrialization and urban population growth have been identified as the primary driving forces of climate change, exacerbating air pollution levels (Raihan & Tuspekova, 2023). Greenhouse gas emissions, particularly CO_2 and sulfur dioxide (SO_2), stemming from human activities, have adverse environmental impacts (Mehfooz & Mansha, 2023).

The complex nature of climate change presents challenges related to uncertainty, consequences, vulnerabilities, and global power imbalances (Federal Ministry of Environment, 2021a). In Nigeria, the effects of climate change manifested in food insecurity, increased poverty rates, conflicts between herders and farmers, and overall insecurity, with consequent effects on economic development (Nigeria's Federal Ministry of Environment, 2019b; Onwunali *et al*., 2023). Projections suggested that Nigeria's GDP could decline by 2-11% by 2020 and potentially plummet by 6-30% by 2050 (Department for International Development, 2009). Necessitating Nigeria's commitment to the Paris Agreement to reduce its greenhouse gas emissions by 20 % by 2023 (Nigeria's Nationally Determined Contribution).

The study sought to investigate whether education should be integrated into policies addressing CO_2 emissions in Nigeria. The research focused on Nigeria, utilizing data from 1981 to 2021. The study examines two research questions: First, does the source of CO_2 emissions, whether consumption-based or production-based, affect economic growth in Nigeria? Secondly, does a long-run relationship exist among the variables under review? The research builds upon theoretical foundations, including the Environmental Kuznets Curve (EKC) theory, which suggests a notable relationship between environmental degradation and economic development, United Nations' Brundtland Commission Sustainable Development Theory, which strives for a harmonious equilibrium between social progress, economic growth, and environmental preservation and integrated Solow's theory, because it highlights education as a crucial socioeconomic determinant of growth (Jones & Schneider, 2006; Sarwar *et al*., 2019, Chima and Yusuf, 2023). This study aims to contribute to the existing body of knowledge by analyzing the impact of CO_2 emissions, population growth, health, and education on economic growth in Nigeria. In particular, it addressed a research gap related to the influence of fossil fuel use and carbon emissions on Nigeria's transition to a greener economic growth model.

Through an extensive literature review, it has been identified that limited research exists on this specific area in the context of Nigeria. To address this research gap, this study proposes to investigate "The Linkage between CO_2 Emissions, Health, Education, population, and Economic Growth in Nigeria". While previous studies have employed panel data analysis as their chosen methodology, it is important to note that this approach may not fully capture the unique characteristics of Nigeria given the current data set. Therefore, this study will employ an alternative methodology of the Auto-regressive Distributed Lag (ARDL) approach that can better account for the peculiarity of Nigeria's situation. The remainder of this paper is structured as follows: Section 2 provides a brief overview of supporting theories, followed

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by a description of the data and methodology used in Section 3. Section 4 presents the study's results, while Section 5 offers discussions and concluding remarks.

The topic of linkages between economic growth, health expenditures, education, and the environment in Nigeria can be examined through multiple theoretical perspectives, the theoretical background of this study is anchored on the Simon Kuznets' Environmental Kuznets Curve (EKC). According to the theory, as countries undergo economic growth, environmental deterioration initially worsens. Kuznets' Environmental Kuznets Curve (EKC) theory, first proposed in 1992, suggests that there is a notable relationship between environmental degradation and economic development. This is mainly due to increased industrialization, urbanization, and greater pollution resulting from intensified production processes. However, once a certain level of income or development is achieved, the trend starts to reverse. Environmental degradation begins to improve as countries advance technologically, prioritize environmental awareness, and implement more stringent regulations and policies. As economies become more advanced and efficient, they are better equipped to adopt innovative measures that reduce pollution and promote sustainable practices. It's important to recognize that the EKC may not be universally applicable to all environmental issues. Some problems, such as climate change, require global cooperation and comprehensive solutions beyond the scope of the EKC. Nevertheless, understanding this theory can empower policymakers to strike a balance between economic growth and environmental sustainability.

The concept of Sustainable Development Theory (SDT) was proposed by the United Nations' Brundtland Commission in 1987. The theory strives for a harmonious equilibrium between social progress, economic growth, and environmental preservation. At its core, SDT recognizes that meeting the needs of the present generations should not compromise the ability of future generations to meet their own needs. It urges us to take conscious actions today, ensuring that development is pursued in a manner that safeguards natural resources, promotes social equity, and secures the well-being of both people and the planet. By advocating for sustainable practices, this theory provides a framework for decision-makers to consider the long-term consequences of their actions. It encourages a shift towards renewable energy sources, responsible consumption, and waste reduction. Furthermore, it emphasizes the importance of inclusive and equitable development, striving to bridge gaps between different socioeconomic groups and promoting equal opportunities for all.

The possible outcomes of embracing Sustainable Development Theory are promising in the area of harmonizing communities and nature, accessible clean air and water, and reduction of poverty and inequality (Kopnina, 2015). Incorporation of sustainability into policies and practices fosters innovation, promotes green technologies, and creates new job opportunities (Kriselda *et al*., 2023). However, achieving these outcomes requires collective action. Governments, businesses, and individuals must come together to embrace sustainable lifestyles, implement green initiatives, and support policies that prioritize the well-being of both current and future generations. Such will pave the way for a balanced and prosperous future. SDT offers us a road map toward a more sustainable and equitable world, and the interconnections between economic growth, social progress, and environmental preservation will reduce challenges for a brighter and more sustainable future for all.

Studies on the relationships between carbon emissions, education, health, and population are uncommon (Long *et al*., 2015), even though the topic of global warming has been debated for many years. Researchers used many macroeconomic indices and varied methodologies to tackle the nexus. Reports have also shown linkages between carbon emissions affecting population, health, and economic growth (Lu *et al.*, 2017; Mardani *et al*., 2019). Carbon emissions have an impact on growth through a variety of channels. These channels can be split into two categories. First, air pollution spreads through and second through the spillage on the land and water surfaces. Thus, in both ways, the growth of the economy will be affected by the health of the population. Perhaps surprisingly, attempts were made to quantify health's impact on the level and growth of GDP, in a study that established the determinants of long-run economic growth and longevity (Barro, 1997; Barro & Lee, 1994; Xavier *et al*., 1995). Similarly, reports have also revealed a positive impact of longevity on various measures of GDP and GDP growth (Bloom *et al.*, 2004; Bloom *et al*., 2018; Farahani *et al*., 2009; Nguyen, *et al*., 2017). Derindag *et al*., (2023) reported that foreign direct investment and trade openness have three threshold effects on industrial carbon emissions.

Several researchers have demonstrated a positive link between education and economic growth in diverse nations using the appropriate models. (Sheehan and Shi, 2019; Brown *et al*., 2004; Chima and Yusuf, 2023; Havea & Mohanty, 2020. Using the Johansen Cointegration test, Duppati *et al*., (2023) reported that, New Zealand's economic growth and CO_2 emissions are sensitive to the changes in renewable, fossil fuels, Brent, and Australian coal prices in the long run. They further explained that renewable energy has the flexibility and potential to correct the short-run inconsistencies in economic growth at a significant speed to ensure equilibrium in the long run. But the Brent and Australian coal is likely to cause discrepancies in the short term after which the error corrections in the long-term equilibrium are unlikely to happen. Abdel-Gadir, (2020), examined the Energy Consumption, CO_2 Emissions, and Economic Growth Nexus in Oman using an ARDL Approach to Cointegration and Causality Analysis. The bound test, as well as the Johansen Cointegration, test both reveal the existence of a long-run relationship between CO_2 emissions and its determinants. This long-run relationship indicates that CO_2 in Oman is positively influenced by economic growth and energy consumption. Ali *et al*., (2022) in South Asia confirmed that both globalization and economic growth increased CO_2 emissions in their developing economies while renewable energy consumption significantly improved environmental quality with an inverted U-shaped environmental Kuznets curve (EKC).

Dong *et al*., (2018) investigated the nexus among CO_2 emissions, economic and population growth, and renewable energy across regions over 24 years, using panel data for 128 countries, and confirmed significant cross-sectional dependence and heterogeneity. They further reported that population size and economic growth positively and significantly influence CO_2 emission levels at both regional and global levels. Similarly, Hsiao-Tien and Chun-Chih (2018) explored the affiliation between CO_2 emissions, energy resources, and economic growth in 25 years in the G20 countries. The results established an absolute decoupling effect with a drop in environmental-related pressure and the continuation of economic growth. Results also affirmed a long-run equilibrium relationship between carbon emissions, fossil fuel, real GDP, and the different types of clean energies like renewable

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energy, hydro-power, and nuclear energy, hence validating the existence of the Carbon Kuznets Curve (CKC) hypothesis. Additionally, the emanation of CO_2 was positively elastic to fossil fuel and negatively inelastic to renewable energy, hydro-power, and nuclear energy. Based on their results, renewable energy's average per capita compound annual growth rate was 14%, which indicated that, among others, the use of nuclear energy was a key means of dealing with carbon emissions. Satterthwaite, (2009) investigated the CO_2 emission levels in various nations for the periods 1950–1980 and 1980–2005 and established little association between rapid population growth and high emission increase because low emissions per capita are associated with a high population growth rate. Yeh and Liao (2017) investigated the Impact of population and economic growth on carbon emissions in Taiwan, the result affirmed the urgent need to address how such factors as population and economic growth impact the emission of carbon dioxide in any developing country

Examining the Impact of Demographic Factors on Air Pollution, Cole and Neumayer (2004) reported that, CO_2 emission was proportional to population increase while high urbanization rate and low average household size increased emissions. Contrary to CO_2 emission, SO_2 emissions gave a U-shaped relationship, indicating that population-emissions elasticity increased with high population levels, while urbanization and average household size were not significant determinants of SO_2 emissions. However, they concluded that developing countries will account for an increasing share of global emissions of CO_2 and SO_2. Similarly, reports on the impact of air pollution have shown that air pollution has negatively impacted the health of African children, with high risk for children under the age of five due to exposure to high levels of ambient air pollution, hence lowering total life expectancy to an average of 4–5 years (Adebayo *et al*., 2022a; Adebayo *et al*., 2022b; Mlambo *et al*., 2023)

In the USA however, the spatial patterns of carbon emissions linking Population, Affluence, and Technology framework revealed strong evidence of spatial heterogeneity in the estimated elasticity of emissions (Videras, 2014). In the nexus of CO_2 emissions, renewable energy, and economic growth, Bouyghrissi *et al*. (2021) established that gross domestic product (GDP), CO_2 emissions, and RENEC were stable in the long term, with a bidirectional relationship between GDP and CO_2 emissions, RENEC and GDP but not between CO_2 emissions and RENEC in Morocco. In China, Chen, *et al*. (2019) studied the effect of economic growth (EG), renewable energy consumption (REC), and non-renewable energy consumption (NREC) on CO_2 emissions (CE) in different regions in 17 years and reported that inverted U-shaped EKC hypothesis was not supported in the central and western regions, but was barely supported in the eastern region. They also revealed positive variation in the effects between NREC and CE, with greater impact in Central, Western, and Eastern regions, respectively.

In conclusion, the comprehensive analysis of existing literature has yielded invaluable insights into the intricate interplay between carbon emissions, education, health, and population dynamics. The research sheds light on the multifaceted effects of carbon emissions on economic growth, underscoring the pivotal role played by factors such as education, trade openness, and the utilization of renewable energy sources in shaping intricate relationships. It is important to note, however, that none of the studies reviewed specifically focused on Nigeria, and the majority of investigations relied on panel data and cross-country analyses, which pose challenges in gauging the presence of the environmental Kuznets curve theory within individualistic nations. The study addressed the gap discovered in other literature about the model, period of study, and region. The findings highlighted the significance of implementing sustainable policies and embracing environmentally conscious practices to effectively mitigate carbon emissions and promote environmental quality. Nonetheless, it is crucial to emphasize the need for further research to delve deeper into these complex dynamics, as this will not only enhance our understanding but also inform the development of evidence-based policy interventions.

MATERIALS AND METHODS

Data Sources

The study used an Autoregressive Distributed Lag (ARDL) data set covering 40 years from 1981 to 2021. Data were sourced from the World Bank database and the Central Bank of Nigeria statistical bulletin.

Data and Estimation Techniques

Using annual time series data from 1981 to 2021, the study examined the relationship between economic growth, health, education, population, and CO_2 emission in Nigeria. In this study, existing data were used to generate empirical conclusions with no problems utilizing a statistical technique and a descriptive research design. The World Bank (WB) and the Central Bank of Nigeria (CBN) statistical databases were employed as a source of secondary data for the study. Such data were the dependent variable, the gross domestic product (GDP), and the independent variables, which included population (POP), carbon dioxide emissions (CO_2), health expenditure (HLT), education expenditure (EDU), and gross fixed capital formation (GCF). Table 1 provides a comprehensive summary of the study variables. Data on the GDP, HLT, EDU, POP, and CO_2 were collected in millions of Naira (nominal forms) and log-transformed to reduce the variance of the series and enable percentage interpretation while the GCF maintained its percentage form. Data analysis was done using the statistical application E-views version 12.

Code	Variable	Variable Types	Data Measurements	Data Sources	
GDP	Gross Domestic Product	Dependent Variable	Millions of Naira	WB	HLT
	Health Expenditure	Independent Variable	Millions of Naira	CBN	EDU
	Education Expenditure	Independent Variable	Millions of Naira	CBN	POP
	Population Growth	Independent Variable	Millions of People	WDI	CO2
	Carbon Dioxide	Independent Variable	Kiloton	WDI	GCF
	Gross Capital Formation	Independent Variable	% of GDP	WDI	

GDP = Gross domestic product, HLT = Health expenditure, EDU = Education expenditure, POP = population growth, CO_2 = Carbon dioxide, GCF = Gross capital formation, WB = World Bank, CBN = Central Bank of Nigeria, WDI = World development index

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Theoretical specification of this study followed the empirical studies of Apergis and Ozturk 2015; Al-Mulali *et al*., 2016; and Jebli *et al*., 2016, who have included various explanatory variables in the growth-emission nexus under the scheme of the EKC hypothesis. This study follows these equations Carbon emission:

Yit = β0 + β1X1it + β2X2it + β3X3it + Uit (1)

Carbon emission it = β0 + β1X1it + β2X2it + Uit (2)

Carbon emission *i*t = β0 + β1X1*i*t + β2X2*i*t + β3X3*i*t + β4X4*i*t + U*i*t (3)

from which all tests and estimations were developed and specified as follows:

$$\Delta LnGDP_t = \phi_0 + \phi_1 LnPOP_t + \phi_2 LnHLT_t + \phi_3 LnEDU_t + \phi_4 LnCO2_t + \phi_5 LnGCF_t + \sum_{i=0}^{n} \beta_1 \Delta LnGDP_t + \sum_{i=0}^{n} \beta_2 \Delta LnPOP_t + \sum_{i-0}^{n} \beta_3 \Delta LnHLT_t + \sum_{i=0}^{n} \beta_4 \Delta LnEDU_t + \sum_{i=0}^{n} \beta_5 \Delta LnCO_{2t} + \sum_{i=0}^{n} \beta_6 \Delta GCF_t + ECT_{t-1} + \varepsilon_t$$

where: $\phi 0$ = intercept and i is the lag indicator. ϕ_1, ϕ_2, ϕ_3, ϕ_4, and ϕ_5, represent the long-run multipliers which show the long-run effects of the identified measures on economic growth calculated. Δ = signifies the first difference operator, t = deterministic time trend comprising the years from 1981 to 2021. β_1, β_2, β_3, β_4, β_5, and β_6, are the short-run dynamic coefficients that assist the error correction model's convergence to equilibrium. k is representative of the number of explanatory variables, and ξ is the disturbance term that is uncorrelated with the x's. ECTt-1 is the error correction term's one-period lag value and the speed adjustment parameter that measures how quickly the variables, in the event of a disturbance, returned from short-run disequilibrium to long-run equilibrium. The coefficient must be negative, less than one, and statistically significant to achieve long-run equilibrium. A test of the disturbance term, εt, can confirm that the regression includes an adequate lag length. If the error series is serially uncorrelated and indicative of a white noise process, the lag lengths included are sufficient. Theoretically, ϕ_1, ϕ_2, ϕ_3, and ϕ_4, are all expected to produce negative coefficients except ϕ_5 to suggest the relationship between the explaining dependence on the economic growth.

Estimation Procedures

It is essential to practically conduct a unit root test approach to determine the series' stationary qualities before testing for co-integration. Running stationarity tests is necessary because, if a series is stationary, the mean, variance, and autocorrelations may be accurately estimated using long-time averages based on a single set of realizations (Enders, 2004). This stage is also important to determine whether the ARDL methodology should be used because the ARDL limits test demands that the dependent variable be integrated into order one and the explanatory variables be I (0) or I (1) stationary. The approach will be invalidated by the inclusion of any I (2) variable, and the F test will yield biased and unreliable findings. This was accomplished by utilizing the well-known augmented Dickey-Fuller (1981) and Phillips-Perron (1988) tests. While PP tests serve to alleviate the bias brought on by ADF tests due to omitted autocorrelation, ADF tests use parametric auto-regression to approximate the autoregressive moving average (ARMA) structure of the errors in the test regression. Accordingly, serial correlation and heteroscedasticity in the errors are the main ways that the Phillips-Perron (PP) unit root tests and ADF tests differ from one another (Qiang *et al*., 2023). Further, the study analysis was an integrated period that included global health challenges of the COVID-19 pandemic, the general economic meltdown that affected production, increased inflation and unemployment rates, and global oil price volatility which endangers Nigeria's economic stability.

The Zivot-Andrews (ZA) unit root test, created by Zivot and Andrews (1992), was additionally used in the current study to get around this problem because it can identify a single unknown structural break as well as the series' stationary behavior characteristics. Keep in mind that the traditional unit roots tests are considerably distorted in the presence of structural breaks. In this study, the Akaike information criterion (AIC) was used as this better fits data from small sample numbers and determines the ideal lag length for each variable should consider a maximum of two lag lengths. As a result, a maximum lag length of 2 was applied to the conditional ARDL model in Eq. 1, which was then used in this investigation. It is vital to apply this automatic lag length selection to get accurate results and conclusions because the significance of the F test results significantly depends on the selection of the proper lag length (Pesaran & Shin, 2001). After the optimum lag length has been established, the F-statistic is calculated using the Wald test, and co-integration is then tested by comparing the F-statistic with the lower and upper bound critical values suggested by Pesaran & Shin (2001), the link between the various factors. If the computed F-statistic at the 5% level of significance is greater than the upper bound critical value, the null hypothesis is disregarded postulating a long-run relationship. Finally, in this work, the model was diagnosed using tests for serial correlation, heteroscedasticity, normality, and functional form. In addition, the study followed the recommendation of Pesaran & Shin (2001) by calculating the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) to test the estimated model's goodness-of-fit and assess how stable the model is over the sampled periods.

RESULTS AND DISCUSION

Preliminary analysis of the study variables

By outlining the key characteristics of the study variables in our model, this preliminary analysis gave a basic overview of the nominal data set and determined whether the data series are normally distributed and appropriate for using the OLS regression. The fundamental or distributional characteristics of the data in a study are described using descriptive statistics in nominal form and presented in Table 2.

Table 2 Descriptive statistical evidence about the study variables

	GDP	HLT	EDU	POP	CO_2	GCF
Mean	37488.78	79.17829	148.2	131.9	73966.19	35.65
Median	8234.500	16.64000	57.96	125.3	88767.70	33.00
Maximum	173527.7	388.3700	646.7	211.4	119544.1	89.39
Minimum	139.3	103.2	41.60	75.44	81.60	14.17
Std. Dev.	502.611	111.822	193.8	40.37	403.95	18.95
Skewness	1.272	1.376	1.238	0.387	0.965	1.087
Kurtosis	2.407	2.758	3.330	1.966	2.261	1.929
J. Bera	11.353	13.920	10.665	2.848	7.302	9.557
J.B. Porb.	0.342	0.094	0.048	0.240	0.051	0.084
Obs.	41	41	41	41	41	41

GDP = Gross domestic product, HLT = Health expenditure, EDU = Education expenditure, POP = population growth, CO_2 = Carbon dioxide, GCF = Gross capital formation

In the Table above, the kurtosis revealed that policy variables were normally distributed, however with considerable drift of the standard deviation from mean values. In particular, GDP, HLT, POP, CO_2, and GCF. indicated kurtosis values less than 3, suggesting that these variables produced outliers that are less frequent and less extreme than those found in the normal distribution. Furthermore, EDU indicated leptokurtic distribution with a kurtosis value exceeding 3, indicating higher than usual kurtosis of the variable and larger than usual population density function's tail weight. The skewness values, which depict the asymmetry of the data, revealed that the variables were favorably skewed, however were heavier right tail. Kurtosis and skewness values revealed data fitness into the normal distribution, following Jarque-Bera statistics. Consequently, the null hypothesis of GDP, HLT, POP, $CO_{2,}$ and GCF variables was widely accepted in its nominal form. On the other hand, the EDU series exhibited significant Jarque-Bera probabilities of less than 0.05, which clearly showed the absence of normality in the residuals. This indicates that these variables are quite vulnerable to shocks and other economic challenges facing the nation at the current period resulting in residual non-normality. However, the ARDL co-integration method utilized in this study can be applied without the data distribution being normally distributed (Chima and Duruh, 2022).

Spearman Correlation Analysis Test
The study evaluated the degree of linear dependency and the level of multi-collinearity problems among the explanatory variables stated in the empirical model using the Spearman rank-order correlation coefficient to determine the threshold level of the variables. Table 3 shows the nominal form of the explanatory variables' Spearman rank-order correlation coefficient.

Table 3 Spearman's Correlation coefficients for explanatory variables

	HLT	EDU	POP	CO_2	GCF
HLT	1.00				
EDU	0.614	1.00			
POP	0.585	0.591	1.00		
CO_2	0.697	0.693	0.705	1.00	
GCF	0.726	0.558	0.524	0.697	1.00

HLT = Health expenditure, EDU = Education expenditure, POP = population growth, CO_2 = Carbon dioxide, GCF = Gross capital formation.

Because the correlation coefficients of the explanatory variables are discovered to be below the acceptable dependence threshold of 0.80, Table 3 demonstrated that the variables tested in the model do not have multi-collinearity, indicating that the model is good for policy recommendation. Similarly, reports have shown that multi-collinearity may not always constitute a problem and that the frequently employed approach to resolving multi-collinearity issues in regression analysis can result in more issues than they aim to overcome (Abdulkarim and Mohamed 2021; Chima and Duruh, 2022).

Stationarity Properties of variables
To check the data stationary properties of the variables, unit root tests were conducted. The outcomes of the traditional and structural breakdown unit root tests conducted for the study are shown in Table 4.

Table 4 ADF, PP, and Zivot-Andrew's stationarity test results

Variable	**ADF**		**PP Test**			**Z.A. Test**			
	Level	Δ	Level	Δ	Rmk	Break-date	Level	Δ	Rmk
GDP	-1.421^{n}	-3.433^{a}	-1.063^{n}	-3.358^{a}	I (1)	2017	-2.422n	-10.31a	I(1)
HLT	-2.862^{c}	-2.339^{a}	-1.552^{b}	-18.29^{a}	I (0)	2018	-2.713a	-9.162a	I(1)
EDU	-2.963^{b}	-5.248^{a}	-1.486^{b}	-10.49^{a}	I (1)	2018	-5.255a	-9.255 a	I(1)
POP	0.597^{n}	-2.793^{c}	0.538^{n}	-10.61^{a}	I (1)	2012	-7.112n	-12.15a	I(1)
CO_2	-1.466^{n}	-5.563^{a}	-1.493^{n}	-5.557^{a}	I (1)	2008	-4.241a	-6.314a	I(1)
GCF	-3.5979^{a}	-4.4217^{a}	-3.6629^{a}	-4.3029^{a}	I (0)	2014	-5.036b	-6314a	I(1)

a, b, and c = rejection of the null hypothesis at 1%, 5%, and 10% levels, respectively, n = not significant, Δ = first difference, Rmk = remark, GDP = Gross domestic product, HLT = Health expenditure, EDU = Education expenditure, POP = population growth, CO_2 = Carbon dioxide, GCF = Gross capital formation, ADF = augmented Dicky-Fuller, PP =Philip-Perron, ZA = Zivot-Andrews tests

In both the conventional (ADF and PP) and structural break (ZA) unit root tests, the results in Table 4 showed that the variables were stationary at levels I(0) and the first difference I(1) and none at the second difference I(2). The dependent variable (GDP) did not become stationary until after the first difference, demonstrating that the prerequisites for using the ARDL approach were met. The unit root test results of ADF and PP in Table 4 above, depicted that all series (GDP, HLT, EDU, POP, CO2, and GCF) maintained stationarity after the first difference. More so, HLT, EDU, and GCF were stationary at levels in both ADF and PP. This indicated a mixed order of integration of I(0) and I(1). Further, the outcome of the ZA unit root test revealed that GDP, HLT, EDU, POP, CO2, and GCF were stationary at first difference. The break dates for GDP, HLT, EDU, POP, CO2, and GCF are 2017, 2018, 2018, 2012, 2008, and 2014. However, HLT, EDU, CO2, and GCF are stationary at this level. These outcomes indicate that none of the parameters are stationary at I (2), and so the ARDL simulation model can be deployed to assess the short- and long-term interactions (Chima and Duruh, 2022).

Bounds testing for co-integration

Upon verifying the integration order and optimal lag length selection with assigned figures of 1, 0, 1, 1, 1, 0, the study undertakes the analysis of the cointegration test by employing the bounds testing approach. The sample size of the study was 41, with 6 variables, while the observations were annual. An ideal lag length of 1 was chosen and imposed on the dependent variable because of the few observations and the necessity for preserving degrees of freedom. This ensured that the model dynamics were optimally fitted and that the selected model was serial correlation-free. In the study, the presence of a long-run link between the study variables was determined using F-statistics, and the model's joint significance was also tested. Table 5 contains the findings from the estimated F test and the ARDL bounds testing method.

Table 5: Cointegration results of the bounds test

Model	F-statistics	K	Critical values			Decision	
LnGDP=f (LnHLT, LnEDU, LnPOP, LnCO2, GCF)	5.812899	5	**%**	**≤**	**≥**	**H_0**	**H_a**
						No Co-int.	Co-int.
			1%	3.06	4.15	Series are co-integrated	
			2.5%	2.7	3.75		
			5%	2.39	3.38		
			10%	2.08	3.0		

≤ = Lower bound, ≥ = upper bound values, K = constant, Ho = Null hypothesis. Ha = Alternative hypothesis, LnGDP=f (LnHLT, LnEDU,LnPOP, LnCO2, GCF) = model

The computed F-statistics is 5.812 exceeded the critical value of 4.15 at the 1% significance level' demonstrating the necessity for a long-run approach by showing that there is strong evidence of a long-run correlation between economic growth and selected variables that could slow down economic growth expansion. Additionally, according to the study's findings, these factors move together over the long run, and any short-run deviation in their interaction would eventually return to equilibrium. Therefore, following Pesaran *et al*. (2001) and Narayan's critical values (2005), the results in Table 5 showed that the null hypothesis of no cointegration is rejected.

Dynamic ARDL results

After validating the cointegration relationship, the study computed the coefficients of the determinant of the economic growth variables through the dynamic ARDL in the long run and it is exhibited in Table 6.

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Table 6. Long-run Coefficients of links between economic growth and the estimated variables

Variables	Coefficients	Std. error	*t*-Stat.	*P*. Value
LnHLT	0.214345	0.084959	2.522910	0.017
LnEDU	0.124969	0.060841	2.054043	0.049
LnPOP	-2.481791	0.690276	-3.595358	0.001
LnCO_2	-0.335121	0.099315	-3.374318	0.002
GCF	0.018369	0.007559	2.430123	0.021
C	7.588356	3.469602	2.187097	0.036

Coefficients were measured in percentage Error correction representation for the selected ARDL model. ARDL (1, 0, 1, 1, 1, 0)

From the dynamic ARDL long-run results in Table 6, the study showed a positive and significant relationship between economic growth and the health condition of the people. Suggesting that a percentage increase in health spending *ceteris paribus*, stimulated an increase of about 0. 21% in GDP. Therefore, improved access to quality healthcare services can positively affect a healthy lifestyle and consequently increase production activity levels in Nigerians. By implication, healthcare will promote the longevity of Nigeria's populace which is paramount for economic growth. Earlier, reports have identified the positive impact of longevity on the measurement of GDP and GDP growth (Bloom, *et al*., 2004; Nguyen, *et al*. 2017; Bloom *et al*., 2018).

The estimated coefficient for Government Expenditure on Education (LnEDUS) revealed a significant positive relationship with long-run GDP. As shown in Table 6, a percentage increase in education spending is expected to stimulate a corresponding 0.12% increase in GDP. Such results recognized the significance of education across all sectors, including its impact on economic growth. The implication is twofold. First, it suggested that an educated population enjoys a better quality of life than those without access to education. Secondly, investing in improved quality education is a *sine quo non* to the creation of a higher-quality labor force that will, consequently improve productivity. These findings aligned with Brown *et al*. (2004), Ziolo *et al*., (2017), Johnson and Koyama (2017); Sheehan and Shi (2019); and Chima and Yusuf (2023) who reported that investment in education is a precursor to improved productivity and long-term economic growth. They established a positive relationship between government expenditure on education and GDP, as observed in this study.

Based on the results in Table 6, the estimated coefficient of population (LnPOP) showed a negative but highly significant relationship with long-run economic growth. This means that an increase in population does not necessarily lead to economic growth as observed currently. A percentage decrease in population growth, all things being equal, is likely to result in a reduction in economic growth. Additionally, the effects of population on carbon emissions are related to production and consumption behaviors, which are influenced by population size and structure. Rapid population growth can lead to increased environmental deterioration, resulting in a decline in ecosystem quality. This finding is supported by previous studies that have shown a weak association between rapid population growth and high emission increases. Overall, this interpretation suggests that while population growth may not directly lead to economic growth, it can have adverse effects on the environment, potentially contributing to increased carbon emissions and environmental degradation (Martínez-Alier *et al*., 2010, United Nations Department of Economic and Social Affairs (UN DESA), Zhanga *et al*, 2023, Bloom *et al*., 2020, Yeh, and Liao, 2017).

The long-run coefficient of Carbon Dioxide emission (LnCO2) showed a significant negative impact on economic growth at a one percent level. According to the findings in Table 6, a one percent point increase in carbon dioxide emission, while keeping other explanatory variables constant, led to a decrease of approximately -0.335% in long-run economic growth. Environmental pollution induces health challenges, leading to reduced productivity hence the need for Nigeria to key into the implementation of "pollution tax" or "carbon tax" policies, often proposed as solutions in the field of environmental economics. The theory of environmental economics suggests that increased CO2 emissions result in negative externalities like air pollution and climate change. The negative coefficient observed implied that CO_2 emissions increased with a corresponding decrease in economic growth and a negative impact on health. The results contradicted the findings of Raza and Shah (2018) who affirmed that renewable energy consumption reduces CO_2 emission in the long run and supported environmental Kuznets curve theory in G7 countries. However, the results were consistent with the principles of environmental economics theory and reports of Edoja *et al*., (2017), Hsiao-Tien and Chun-Chih (2018), Akif (2021), Dogan *et al*. (2022) who reported negative externalities with increased CO_2 emission which negatively affects economic growth and health.

The estimated long-run coefficient of gross fixed capital formation (GCF) indicated a positive significant relationship with economic growth. High domestic capital formation is an increased investment in economic activities and growth. From the results in Table 6, a unit increase in gross capital formation will prompt 0.018% in economic growth. Furthermore, investment in fixed capital plays an important role in driving economic growth in the long run, hence efficient allocating of resources toward capital formation will enhance the production capacity, technological advancements, and overall economic development. The results are supported by both economic theories and empirical evidence reported by Solow, (1957), Romer (1986), Rosenstein-Rodan, (2013), Liu *et al.* (2018), Ngo *et al.* (2022), Chima and Yusuf (2023) who revealed a positive relationship between gross fixed capital formation and GDP growth.

Short-run Dynamics results from the link between economic growth and the estimated variables

After estimating the long-run coefficients, the ARDL model used the lagged values of all variables in Eq. (1) (a linear combination denoted by the error-correction term (ECT)) to estimate the model's short-run dynamics associated with the long-run relationship and was presented in Table 7.

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Table 7 Short- run Coefficients of links between economic growth and the estimated variables

	Variables	Coefficient	Std.Error	t-Statistics	P-value
Error correction representation for the selected ARDL model. ARDL (1, 0, 1, 1, 1, 0)	D(LnHLT)	0.047125	0.017479	2.696151	0.0116
	D(LnEDU)	0.049510	0.018296	2.706144	0.0113
	D(LnPOP)	-13.284986	1.107482	-11.995667	0.0000
	D(LnCO2)	-0.096808	0.035089	-2.758956	0.0099
	D(GCF)	0.006810	0.002562	2.657640	0.0127
	CointEq (-1)	-0.340357	0.044021	-7.731615	0.0000***
	Cointeq=LnGDP–(0.2143*LnHLT+0.1250*LnEDU-2.4818*LnPOP - 0.3351*LnCO2+0.0184*GCF+7.5884)				

According to Table 7, the model's error-correction term is highly significant and appropriately signed. The error-correction term coefficient of −0.340357, implied that 34% of the deviation from the long-run growth rate in output caused by previous years' shocks converge back to long-run equilibrium in the present year. It was also negative, significant, and less than one, implying that the predicted coefficients from this study can be used to make policy choices on economic growth. The result supports the presence of a long-run relationship between economic growth and the analyzed enablers of economic growth in Nigeria, suggesting that expenditure on health, education, improved healthy environment fosters long-term growth.

Results (Table 7) indicated that the current level of health spending D(LnHLT), was positively significant on long-run economic growth, and therefore empirically supported the hypothesis that increased investment in health sectors contributes to sustained economic development over time. By confirming the long-run impact, this study reinforces the notion that adequate allocation of resources towards health services and infrastructure has the potential to yield substantial societal benefits, including improved well-being and productivity.

The coefficient education spending D(LnEDU)) was found to be positive and statistically significant, indicating that increased investment in education has a significant impact on short-term economic growth. This finding implied that the allocation of more resources to educational sectors will immediately improve productivity and human capital development. Furthermore, in the long-run analysis, the positive and significant coefficient for education spending is also a good signal that sustained investment in education is imperative for long-term economic development. The significant positive effect of short-term and long-term presents education as a driving force to economic growth.

The coefficient of the population growth D(LnPOP) showed a significantly negative effect on economic growth, which conformed with the long-run results of economic growth. This implied that population growth had a detrimental effect on economic growth, indicating that population exerts pressure on infrastructure, resources, and employment prospects. For maintaining sustainable economic growth and minimizing the effects of population growth, methods like urban planning and infrastructural investments are essential

In the short-run result (Table 7), the coefficient for the variable D(LnCO2) was statistically significant. This implied that there is an adverse correlation between short-term economic performance and carbon dioxide emissions (CO_2). It is important to take effective steps to minimize greenhouse gas emissions to ensure sustainable economic development as a 1% increase in CO_2 emission generated a 0.096% reduction in economic growth implying higher CO_2 emissions are linked to slower economic growth.

Gross fixed capital formation in the current period D(GCF) is in harmony with the long-run results which activated a significantly positive impact on the present level of growth. The coefficient of 0.068 suggests that for every 1% increase in GCF, economic growth rises by 0.068%. This suggests that a sizable investment in infrastructures and capital goods may have a positive impact on economic growth. and it is statistically significant.

Post-estimation diagnostic tests

Different econometric diagnostic tests were used to validate the study's findings, including serial correlation, heteroscedasticity, functional form, and stability test. The test's outcome is shown in Table 7 below.

Table 8: ARDL Model Diagnostics Test Indicators

Test	**Null hypothesis**	**F-statistics**	**P-value**
Breusch Godfrey LM Test	No Serial Auto-Correlation	1.509804	0.3711
Breusch-pagan-Godfrey	No Heteroscedasticity	0.412638	0.5527
Ramsey RESET	No Misspecification	0.646099	0.6360

According to the diagnostics test, the model's residuals are normally distributed, and there is no solid proof of multi-collinearity, serial correlation, heteroscedasticity, or model misspecification error. The model has the aforementioned desirable traits of OLS models and was described correctly. The estimated model parameters are within the 5% critical value, accepting the null hypothesis that all coefficients and the ECM are dynamically stable, and the estimated findings are accurate and sufficient for forecasting and policy making, according to the results of the CUSUM and CUSUM of squares tests (Figs. 1 and 2).

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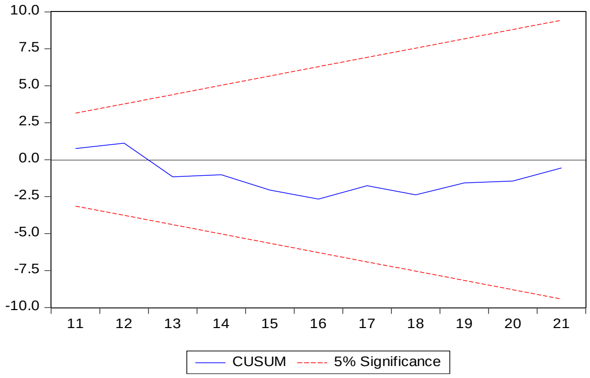

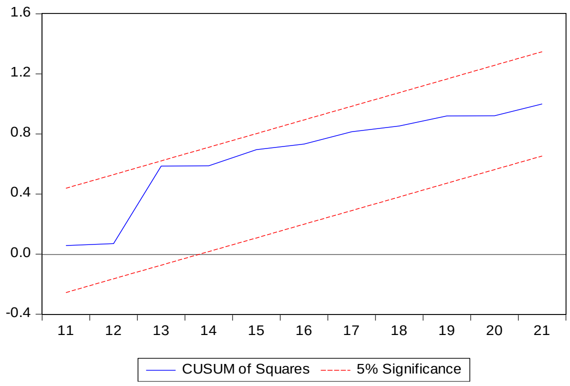

Conclusion

This study provided valuable insights into the complex interrelationships between economic growth, health expenditures, education, and the environment in Nigeria. Through the utilization of a comprehensive data set and the application of an autoregressive distributed lag (ARDL) approach, the study established positive associations between health spending, education spending, and gross fixed capital formation with economic growth in both the short-run and long-run. Exposing the crucial nature of such sectors in economic development in Nigeria. By prioritizing adequate funding for healthcare, education, and infrastructure, policymakers can create an environment conducive to sustainable economic growth. Furthermore, the study also uncovered the adverse effects of population growth and carbon dioxide emissions on economic growth. The negative impact of such factors on the health of the working population, which drives economic activities, demands the need for effective measures to address the challenges. In particular, policies aimed at curbing population growth through birth control, contraception, and family planning can contribute to managing the country's rapidly growing population and reducing associated strains on resources and infrastructure. Additionally, our findings confirm the existence of the Environmental Kuznets Curve (EKC) phenomenon in Nigeria, as evidenced by the inverted U-shaped relationship between the macroeconomic footprint and income. This underscores the significance of implementing sustainability practices and environmental conservation measures as integral components of economic development strategies. Technological advancements and innovative solutions should be encouraged to mitigate the harmful effects of carbon emissions and promote a more sustainable path of economic growth.

Recommendations and Policy Implication

1. Increase healthcare, education, and infrastructure investments to drive economic growth, improve health outcomes, and enhance human capital.
2. Promote effective population management strategies such as birth control, contraception, and family planning to stabilize the population and support sustainable development.
3. Foster technological advancements and innovation across sectors to enable more efficient resource utilization and reduce environmental impact, paving the way for sustainable economic growth.
4. Raise awareness and promote environmental conservation through education and initiatives emphasizing environmental sustainability's importance. Encourage responsible behavior and eco-friendly practices among individuals and businesses to contribute to a greener and more sustainable future.

By incorporating these policy recommendations into Nigeria's development framework, policymakers can effectively tackle the challenges posed by economic growth, health expenditures, education, and the environment. This comprehensive approach will pave the way for a more sustainable, inclusive, and prosperous future for the country.

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