DO ENVIRONMENTAL QUALITY AND HEALTH EXPENDITURE HARM ECONOMIC GROWTH? IMPLICATIONS FOR NIGERIA'S CLIMATE SENSITIVITY AND ECONOMIC STABILITY

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Abstract

Purpose: *The study examines the controversial relationship between environmental quality, health expenditure, and economic growth in Nigeria. It introduces an unconditional single-equation estimation model and identifies key environmental indicators, including temperature variability, carbon emissions, and nitrous oxide emissions, which have been previously overlooked in this context.*

Design/methodology/approach: *This study utilized a quantitative research design, analyzing macroeconomic data from Nigeria between 1991 and 2023. Data were sourced from the 2024 World Bank World Development Indicators, the 2023 Public Finance CBN Statistical Bulletin, and the IMF 2023 FAO Climate Change Indicators. The research applied the Auto-regressive Distributed Lag (ARDL), Error Correction, and Granger causality frameworks, extending its evidence on the Environmental Kuznets Hypothesis, also employing the Fully Modified Ordinary Least Squares (FMOLS) for model robustness.*

Findings: *Using the ARDL model, a long-term equilibrium relationship exists between the variables, with environmental quality variables and health expenditures showing a harmful and long-run delayed effect on economic growth. Likewise, carbon emissions promote economic growth in the short run, but changes in climatic temperature and health expenditures significantly harm economic growth, followed by no short-run predictive effect on economic growth under the Granger causality framework, which exhibits weakened economic-fiscal stability and high climate sensitivity.*

Research limitations and implications: *The study's findings indicate that there*

is climatic sensitivity and fiscal instability. Therefore, the study suggests that better-monitored institutional-fiscal reforms, effective financial management, and sustainable environmental funding remain crucial for leveraging health and environmental policies to drive growth in Nigeria's climate-sensitive economy.

Originality and recommendations: *To address these climatic sensitivity and human capital instability challenges, the Nigerian government should promote renewable energy, implement stringent regulations, and decrease reliance on fossil fuels to reduce emissions and meet climate targets. Proper management of health and environmental finances and anti-corruption measures are critical for public investment. Additionally, Nigeria requires adaptive strategies to manage climate-related issues impacting economic stability and public health.*

Keywords Environmental quality. Health expenditure. Climatic sensitivity. Economic growth. Carbon emissions

JEL Classification: Q53; Q54; I15; O55; Q58.

Introduction

Over the years, economic growth has remained a central concern for policymakers, scholars, and governments across the globe because it determines the overall welfare and prosperity of nations. For developing economies like Nigeria, the pursuit of sustained economic growth has become even more pressing amidst growing concerns about environmental quality and rising health expenditures. Nigeria's public health spending is relatively low at about 3.2% of gross domestic product (GDP), below the Abuja Declaration target of 15%, which has resulted in increased government health expenditures, higher life expectancy, and lower mortality rates (Orji et al., 2021; Oladosu et al., 2022; Bunyaminu et al., 2022). This has made the relevance of environmental quality and health expenditures imperative amidst erratic economic growth and increasing environmental pollution. For roughly over a decade now, there has been empirical debate on the relationship among environmental quality, health expenditure, and economic growth. These debates can be roughly divided into three categories. The first element is the connection between environmental quality and economic growth, with the majority of research concentrating on confirming a U-shaped relationship or refuting an N-shaped relationship (Egbetokun et al., 2020; Adejumo, 2020). Second is the connection between environmental quality and health expenditure (Nwani et al, 2018; Onyinyechi & Olasupo, 2022), and lastly is the nexus between health expenditures and economic growth (Udeorah et al., 2018; Ogunjimi, 2019; Ugochukwu & Oruta, 2021). This debate has made economic growth a persistent feature of human societies and environmental quality in Nigeria.

Despite this empirical evidence, in developing countries, the dynamics of environmental quality determine the sustainability of health finances, and economic growth. For every economy, increased economic activity leads to economic growth as well as increased

environmental quality and health consequences (Bu & Ali, 2022). Given these sustained increases in economic activity and growth, environmental quality has become an inevitable global issue (Ibrahim & Ajide, 2022). As part of the Sustainable Development Goals (SDGs), it was agreed that by 2020, at least 100 million rural residents' lives would have significantly improved as a result of efforts to address societal pressures, health issues, and climate change, clean water and sanitation, living well below the water, and a lower child mortality rate. The actualization of these goals has not been achieved in Nigeria. This is because the healthcare provision, expenditures, and environmental quality within the country remain insufficient and questionable. Particularly for emerging nations like Nigeria, health expenditures, whether public or private, are an essential investment in the development of human capital. Investments in human capital, such as health and education, increase worker productivity, which is crucial for maintaining long-term economic growth (Barro, 1991; Lucas Jr, 1988). Government health spending is a crucial instrument for boosting worker productivity, lowering disease burdens, and improving public health outcomes in Nigeria, since a sizable section of the populace lacks access to high-quality healthcare. Empirical studies like Olanubi et al. (2017) revealed that when the government invests a significant amount of money in health, life expectancy rises, absenteeism decreases, and mortality and morbidity rates decrease, all of which increase worker productivity. With this, citizens can participate in the economy more successfully when they are in good health, which boosts aggregate demand and productivity.

Apart from health expenditure as a driver of economic growth, another key factor in determining economic growth is environmental quality, particularly in developing nations like Nigeria, where large segments of the populace suffer from avoidable illnesses, carbon dioxide emissions, malnourishment, and unfavourable temperatures (Bedir, 2016; Adeleye et al., 2022). These factors represent aspects of the health system and the environment that have an impact on productivity and growth both directly and indirectly. The trajectory of Nigeria's growth is further complicated by environmental indicators like rising temperature change and carbon emissions (Egbetokun et al., 2020). Carbon dioxide emissions are a contributing factor to air pollution, which worsens cardiovascular and respiratory conditions and lowers working population productivity (Ofremu et al., 2024). Furthermore, a crucial industry in Nigeria, agriculture, may see a decline in output due to rising temperatures, which is partially caused by climate change. This would limit both food security and economic stability. Heat stress, waterborne illnesses, and vector-borne diseases like malaria, dengue, and Lyme disease are examples of climate-related health problems that are growing more common and are compromising both economic performance and health quality. This has proven that carbon dioxide emissions and temperature change are major drivers of environmental quality and declining health standards. As a result of this, evidence from the 2023 Central Bank of Nigeria shows that over 92% of Nigeria's exports come from the oil and gas sector, with about an 8.9% increase in 2023. With these indices, studies such as Sun and Wang (2021), Oyedele (2022), and

Adejumo (2020) have proved that economic growth and environmental pollution are positive due to increased commodity demand and industrial output, but with negative consequences on health expenditures.

These consequences, through labour-intensive has made the activities of carbon emissions harmful, leading to environmental pollution that poses a growing threat not just to human health but also to the health of other living things. This is also attributed to the increase in Nigeria's manufacturing output, whose production activities have polluted the air, causing harmful environmental inequalities and leading to the death toll (WHO, 2018). Also, with annual $PM_{2.5}$ emissions reaching 125 µg per cubic meter, carbon dioxide emissions of 73.22, and climatological temperature of 0.8^{o}C recommended greater threat to economic output. With this, increased economic growth has not just inflicted higher carbon dioxide emissions, but poses much pressure on health expenditures and extreme weather such as floods and temperature change. However, despite the growing macroeconomic certainty of increased economic growth, regretfully, the hope of actualizing the third sustainable development goal in Nigeria, the United Nations (UN, 2016) reports that Nigeria continues to have high rates of maternal death (120 per 100,000 live births) and under-5 mortality (estimated at 70 per 1,000), which is affected by environmental inequality. Thus, economic growth is unachieved through a weakened rise in respiratory disorders, waterborne infections, and other health issues brought on by poor environmental quality. Although economic indicators may indicate an increase, they frequently miss the underlying decline in health and environmental circumstances, creating a skewed perception of actual development. Therefore, comprehensive empirical research that measures the dynamic relationship among environmental quality, health expenditures, and economic growth needs thorough investigation in the Nigerian economy.

Yet, isolated efforts have been made to understand these dynamics. First, the nexus between environmental quality and economic growth; second, the link between environmental quality and health expenditures; and third, the relationship between health expenditure and economic growth (Egbetogun et al., 2020; Adejumo, 2020; Nwani et al., 2018; Onyinyechi & Olasupo, 2022; Udeorah et al., 2018; Ogunjimi, 2019; Ugochukwu & Oruta, 2021). Notwithstanding these previous efforts, this study remains sufficient by exploring two key research gaps. First is the explicit estimation of environmental indicators such as carbon dioxide emissions, nitrous oxide emissions, and temperature variations, which remains limited and largely unconditional rather than identified in previous studies. The second gap presented by the study is to provide policy-relevant elasticities and resilience framing by estimating the environmental-health nexus on economic growth, both in the short and long-run. As such, in order to establish whether there exists an environmental quality and health expenditures dynamic effect on Nigeria's economic growth, three research objectives were investigated. This study closes these gaps and generates resilience metrics that are empirically supported and useful for policy by employing an identification strategy that

explicitly considers the endogenous and dynamic nature of carbon emissions, nitrous oxide emissions, and temperature variability. Another gap is the estimation of the short- and long-run elasticities of the environmental-health nexus on economic growth. This further guides the objective of the study by achieving three unconditional single-equation estimations. First is to assess the short- and long-run effects of environmental quality on economic growth. Second is to investigate the role of health expenditures on economic growth, while the third objective is to identify causal relationships between environmental quality and health expenditures on Nigeria's economic growth.

The study is further divided into other sections. Section 2 reviews concepts, theoretical, empirical, and conceptual frameworks. Section 3 delves into the methodology, which entails clear information on the variables' description and econometric methodology. Section 4 presents results, robustness checks, and a discussion of findings, while concluding with Section 5, which entails policy implications for curbing the adverse effects of the environmental-health nexus on economic growth.

2. Literature Review

2.1. Conceptual review and conceptual framework

Environmental quality has become a crucial factor in development and environmental economics, particularly as worries about pollution, climate change, and the depletion of natural resources increase on a worldwide scale. The state or health of the environment, especially regarding the ecosystems and natural resources that sustain life, is referred to as environmental quality. It includes, among other things, biodiversity, soil fertility, air and water cleanliness, and climate stability. Environmental quality is a multifaceted concept that encompasses ecological integrity as well as the degree to which the environment satisfies human demands and expectations (Hariram et al, 2023). Environmental quality is the extent to which the environment promotes both individual and societal well-being (Krefis et al., 2018). In this regard, health expenditures have long been perceived as a critical determinant of economic growth, given their role in improving population health, labour productivity, and overall human capital development. However, the measurement of health expenditure varies considerably across studies, with different scholars and institutions proposing distinct definitions and proxies. According to the World Health Organization (WHO, n.d.), health expenditure can be defined as the total amount of financial resources allocated to health goods and services within a given period. Specifically, general government health expenditure is used as a proxy for health expenditures and is defined as the proportion of total government spending devoted to human existence, thereby reflecting the government's commitment to improving the health status of its population. This is perceived as the indicator that encompasses not only direct budgetary allocations but also health-related spending from parastatals, extra-budgetary agencies, and mandatory health insurance schemes. Capturing this as a proxy for health expenditures clearly tells the macro effects on economic growth. Similarly,

Aregbeshola and Khan (2018) highlighted financial risk protection, noting that health spending often becomes a burden when financed primarily through out-of-pocket payments, pushing many households into poverty, while Kastor and Mohanty (2018) added that health expenditure may also reflect reimbursement systems, where costs are partly or fully covered by insurance or third-party payers. These perspectives underscore the diverse ways in which health expenditure can be conceptualized, depending on whether the focus is on public, private, or household financing dimensions.

Although the aim of conceptualizing economic growth, it remains a controversial statement that connotes different perspectives. Economists globally have perceived the term as including total factor productivity (TFP), labour, and capital accumulation, and that, unless TFP varies, diminishing returns indicate convergence. This serves as a starting point for considering dynamics and trade-offs in the short- to medium-term and aids in organizing decomposition exercises (Pal, 2016). Conceptually, economic growth is a rise in an economy's output of goods and services during a given time frame, often a year, and is referred to as economic growth. The actual GDP, which is the entire worth of goods and services generated after accounting for inflation, is frequently used to measure it. In essence, it represents an increase in an economy's ability to generate the goods and services that people require and desire. However, in the field of environmental economics, Kuznets (1947) perceived economic growth as the study of biological units, which is the appropriate domain for the idea of growth, and its application in economics is an illustration of the common usage of analogies. In other words, He further argued that economic growth is quantitative in nature, which includes substantial growth. In the same vein, economic growth is also conceptualized as the consensus that the best way to assess economic growth is to look at how economic activity contributes to the attainment of better levels of human welfare.

2.1.1. Conceptual framework

Establishing the direct, indirect, linear, and non-linear link and relationship among economic growth, environmental quality, and health expenditure offers an organized perspective of the conceptual framework as presented in Figure 1. This diagram makes it more and clearer how environmental quality and health expenditure influence economic growth in a resource-rich yet environmentally challenged country like Nigeria. With this, it is shown that economic growth is consequently constrained by these health consequences, which also raise the expenses of both public and lower worker productivity, while environmental quality is directly related to the attainment of sustainable development, improved quality of life, and satisfying fundamental human needs (Živković & Milutinović, 2022).

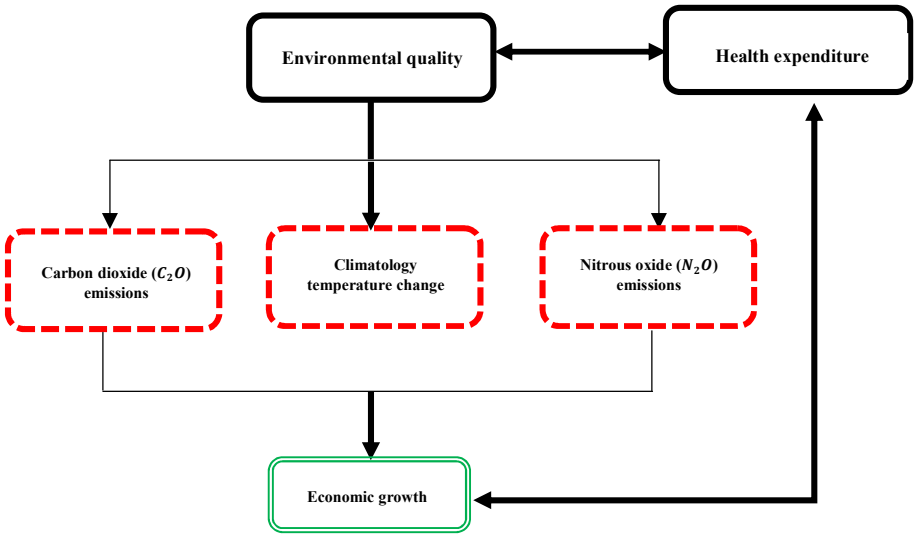

Figure 1. The link between environmental quality and health expenditure on economic growth. Source: Authors' compilation.

2.2. Theoretical review

In environmental economics, the Environmental Kuznets Hypothesis (EKH) is a critical paradigm that aims to explain the dynamic interplay between environmental degradation and economic growth. The EKH suggests that environmental degradation first gets worse during the early phases of economic expansion but gets better after a specific income threshold is exceeded. This idea is based on the larger Kuznets Curve, which was first put forth by Simon Kuznets in the 1950s to explain income disparity. This non-linear relationship, which is sometimes shown as an inverted U curve, implies that a nation will eventually invest more in cleaner technologies, stricter environmental laws, and sustainable development strategies as its wealth increases. Grossman and Krueger (1991, 1995), Shafik and Bandyopadhyay (1992), and Panayotou (1993) conducted groundbreaking research in the early 1990s that established the Environmental Kuznets Curve (EKC). They used cross-country data to investigate the correlation between per capita income and a number of pollutants, including carbon monoxide emissions, sulfur dioxide, and deforestation. The EKC has conflicting empirical support. The EKC pattern is followed by some pollutants, such as sulfur dioxide and particulate matter, but not by others, such as carbon dioxide and biodiversity loss. According to Grossman and Krueger (1995), the EKC applies to water pollutants and urban air pollution in middle-income nations. In Nigeria, there is still disagreement around the EKC. Likewise, Agboola et al. (2024) indicates to have a regenerative and unpredictable environmental of the EKC, exhibiting little support in Nigeria and has not yet crossed the tipping point where environmental improvement follows economic growth.

Unarguably, the EKC is developed on the assumption that economic growth increases as a result of an initial increase in environmental degradation but decreases as

the country experiences an increase in GDP per capita income. In clear terms, this substantial increase in economic growth and GDP per capita income reveals an inverted U-shaped relationship, as shown in Figure 2, implying that environmental degradation increases economic growth, especially in middle-income and higher-income countries. With this significant positive relationship, it is assumed that per capita income has an elastic impact on environmental quality. This asserts that as income per capita increases, the demand for environmental quality increases, leading to cleaner environmental support. The theory also assumes that it has a scale of developmental effect on economic growth. This assumption relies on the fact that at the initial stage of developmental growth, economic growth of any economy often relies on the state of resources through resource-capital intensiveness, which in turn leads to reduced pollution. This assumption implies that for any economy to grow, the production of industries should be increased as a result of an increase in resource growth. As such, since the industrialization of such a country increases, there would exist higher emissions of environmental pollution as a result of the increase in production. This shows that there is a scalar effect on environmental pollution as a result of an increase in industrial production.

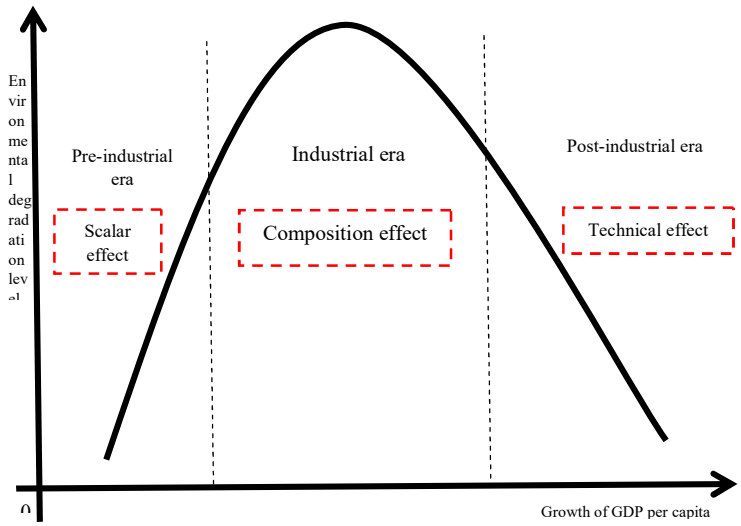

Figure 2. Representation of the Environmental Kuznets Curve (EKC) in low- and middle-income countries
Source: Author's compilation.

Despite these notable and practical assumptions, the EKC has faced numerous facets of criticism positing that the inverted U-shaped relationship between GDP per capita (economic growth) and environmental quality accounts for complexities in environmental problems and a significant decrease in consumption patterns. In clear terms, the major criticisms faced are oversimplification of the hypothesis, lack of focus on local pollution, lack of empirical evidence, and ignoring consumption patterns. As a result of oversimplification, the EKC disregards the

variety of environmental issues and the contextual elements that affect them by assuming a universal and uniform relationship between economic growth through the income of GDP per capita and environmental quality. Also, the EKC's lack of focus on local pollution and its role in ignoring the consumption patterns that influence the benefits of economic growth on environmental degradation is overlooked. To start with, the assumption that degradation can always be reversed by economic growth is risky since the EKC ignores the possibility of irreversible environmental harm and tipping points, where ecosystems collapse beyond a particular threshold. With this, the effect of global commerce and consumption trends on environmental quality is frequently overlooked by the EKC. Furthermore, the EKC ignores the environmental effects of consuming imported commodities and only considers production. As a result, technical advancements that benefit the environment will be counterbalanced by economic expansion, which will worsen environmental conditions. This contradicts the EKC's fundamental premise that changes in consumer behavior follow income increases. The EKC research does not take into account the relocation of polluting companies and the resulting movement of emissions, which may skew the emissions trajectory during the course of economic growth.

Conversely, the propounded inverted U-shaped growth route is inefficient, and the environmental harm caused during the initial stages of the EKC may not be reversible. Consequently, the EKC assessment may be enhanced by advancements in technology, climate financing, and energy transition. Apart from these, the EKC has also been criticized, indicating insufficient and controversial empirical evidence based on the scope. Studies such as Li (2023) assert that environmental degradation initially rises with economic growth through a scalar effect, but as economic growth increases, the economy starts to know and value environmental quality more and adopt cleaner technologies (composition and technique effect), which reduces environmental degradation, thereby assuming an inverted "U" shaped curve. Wang et al. (2024) show that income inequality alters the relationship between economic growth and carbon dioxide emissions, with low-income inequality increasing carbon dioxide emissions, while high-income inequality inhibits them. As income inequality increases, the impact shifts from inhibitor to promoter, altering the inverted "U" shaped curve to an "N" shaped curve.Yet, Egbetokun et al. (2020) assert that an economy turns around the inverted U-shaped EKC when pollution is effectively dampened by social, political, and economic factors; as such, an economy grows, implying that in Nigeria, the U-shaped curve of the EKC is not consistent, suggesting the need for strengthening Nigeria's institutional quality to limit environmental pollution. Also, examining the relationship between economic growth and environmental degradation in Nigeria, Adejumo (2020) found that factors like rainfall promote long-term environmental quality, while natural resource utilization depletes it, leading to increased economic growth but reduced growth per capita, suggesting a complementary Kuznets inverted U-hypothesis on the environment-growth relations.The EKC theory suggests

that as economies grow, environmental degradation worsens, but improves with further economic development.

2.3. Empirical review

2.3.1. Environmental quality and health expenditures

To establish the effects between environmental quality and health expenditures, there is first a need to carry out an empirical lens across other economies, as studies such as Anwar et al (2021) revealed that both carbon emissions and per capita health expenditures had a positive and significant relationship across the sampled nations. InBrazil, Russia, India, China, and South Africa(BRICS),Ganda (2021) concluded that health expenditures and current health expenditure levels were significantly and negatively associated with carbon emissions. Assertively, among 15 Economic Communities of West African States (ECOWAS) countries, Alimi et al. (2019) indicated that carbon emissions significantly and positively impacted both public and national healthcare expenditures, while environmental pollution and private healthcare spending had no relationship. Likewise, Anwar et al. (2022) suggested a positive effect of both air pollution and temperature change on health expenditure. However, they revealed that this effect is highest for government health expenditure, followed by private and total health expenditure. As such, flowing through to Nigeria,Omodero and Alege (2022) revealed that state fiscal expenditure has a minor destructive impact on haze secretion management. However, they further found that local government has a large deleterious impact on smoke decline, while on the other hand, federal government budgetary expenditure has a considerable and favorable influence on the control of carbon emissions.

In the same vein, Afolayan and Aderemi (2019),who found that carbon emissions and mortality rate were negatively but insignificantly related, while electricity consumption positively and significantly affected mortality at the 5% level. This leads the present study to conclude that existing literature has widely addressed the link among environmental quality, health expenditure, and economic growth across various countries and in Nigeria, yet the findings remain universal, as the findings of one differ from those of the other. Unlike Gövdeli (2019) revealed that both economic growth and carbon emissions had a causative effect on health expenditure. In the same vein,within Northern Africa and Southern Africa (NASA), Donkor et al. (2022) revealed that in Northern republics, government finance expenditure had a significant positive effect on environmental quality at 25%, 50%, and 75% quintile levels, while in the Southern republics, government finance expenditure had a significant negative impact on environmental quality at 25%. Without any special preference to an economy, Shahraki and Ghaderi (2021) revealed that the mean environmental performance index in very high and high human development index was 79.04 and 64.71, respectively; also, the elasticity of public health expenditures to gross national product, environmental performance index, physician supply, and urbanization ratio were 0.96, -2.41, 0.441, and 0.448, respectively. Wu et al. (2020) found that there exists co-movement and causality between environmental pollution

and healthcare expenditure at different frequencies and times.

In Nigeria, Ijuo et al. (2023) found that health risks significantly hindered economic growth and that government spending on health had a short-term negative effect. Simeon et al. (2021) found that there exists a long-run link between human capital development in health and economic growth, and in the short run, the average adult survival rate positively and significantly influenced economic growth. Similarly, Urhie et al. (2020) revealed that air pollution and government health expenditure significantly interact to influence health performance. Also, Nathaniel and Khan (2020)found that carbon emissions had no significant short-term impact on life expectancy. Olatayo et al. (2019) indicated that economic growth increased environmental degradation in the long run, and environmental degradation, on the other hand, reduced economic growth. Unlike Nwani et al. (2018), who revealed that in the short run, public spending has no impact on growth, while there exists a link in the long run. To have a summarized grasp of the methodological and empirical review, Table 1 presents the summary matrix of related literature of previous studies in the context of the stated research objectives.

2.3.2. Environmental quality, health expenditure and economic growth

Addressing a detailed knowledge of the standpoint of previous studies establishes the importance and significance of this empirical review. To start with, both the negative and positive consequences of health expenditure and environmental quality on economic growth are interrelated. The linear and non-linear relationships among these variables are not only captured by any single study but are widely referenced across various economies. Thus, this section reviews the various constituents of this dynamic relationship among economic growth, environmental quality, and health expenditure.Likewise, Ojo and Amassoma (2021) revealed that infrastructure development and environmental quality explain economic growth, and that environmental quality has both short- and long-run relationships, while population growth is positively significant to economic growth. Adejumo (2019)found that rainfall factors that improve environmental quality also promote long-term economic growth, both in per capita terms and GDP. In Nigeria, to examine the long- and short-run impacts of government expenditure on economic growth, Lawal et al. (2023) discovered that there exists a long-run relationship. Gukat and Ogboru (2017) revealed that while spending on administration positively and significantly affected economic growth, social and economic services expenditures showed a negative impact. In contrast, coefficients for administration and social services were negative and insignificant, while economic services were positive but not statistically significant.

Table 1. Summary matrix of related literature

Author (Year)	Method/Technique	Results/Findings
IJuo et al. (2023)	Autoregressive Distributed Lag (ARDL)	Health risk significantly retards economic growth, while government spending harms economic growth.
Anwar et al. (2021)	Generalized Method of Moments (GMM)	Carbon emissions and per capita health expenditures had a positive and significant relationship.
Ganda (2021)	FMOLS, VECM, Granger causality, and the Dumitrescu–Hurlin causality tests	Health expenditures and the level of current health expenditure have a significant but negative relationship with carbon emissions.
Simeon et al. (2021)	ARDL	Human capital development and economic growth have a positive relationship, while average adult survival rate had a positive and significant effect on economic growth.
Nathaniel and Khan (2020)	Bayer and Hanck cointegration test	Carbon emissions have no impact on life expectancy.
Urhie et al. (2020)	Moderated mediation model	Air pollution and public health expenditures have a significant interaction on health performance.
Adejumo (2019)	ARDL	Rainfall factors promote environmental quality and economic growth (per capita and GDP growth).
Alimi et al. (2019)	Pooled OLS, fixed effects and system GMM	Carbon emissions have a positive and significant impact on public healthcare, while environmental pollution has no relationship with private healthcare expenditure.
Gövdeli (2019)	Cointegration test	Carbon emissions and economic growth have a causal effect on health expenditures.
Afolayan and Aderemi (2019)	Dynamic Ordinary Least Squares (DOLS) and Granger causality technique	Carbon emissions and mortality rate are negatively and insignificantly related.

Source: Authors' compilations.

2.3.3. Gap in literature

Two important gaps emerged and captured the interest of the study due to the growing corpus of research surrounding the alignment of the research objectives. First, there hasn't been much empirical focus on identifying environmental indicators, such as temperature variability, carbon emissions, and nitrous oxide emissions. The majority of current research relies on unconditional, single-equation estimations that regard these variables as exogenous regressors, ignoring the cross-sectional dependence, endogeneity, and reverse causality that likely describe the link between the environment and growth. As a result, the trustworthiness of previous estimates for

policy design may be limited due to omitted variable bias and inconsistent parameter estimations. Second, despite a substantial amount of research looking at either the environment-growth or health-growth nexus separately, few studies jointly estimate the environmental-health-growth nexus within a consistent empirical framework that distinguishes short-run dynamics from long-run equilibrium correlations. This is a non-trivial omission: health channels, such as respiratory illness, heat-related mortality, and lost productivity, can both directly and indirectly transmit shocks to economic development, with consequences that differ greatly in timing and amplitude over time. The absence of horizon-specific, policy-relevant elasticities hinders policymakers' ability to design resilience-oriented interventions or activities tailored to whether environmental shocks cause transitory disruptions or chronic structural drag on growth.

2.4. Theoretical framework

This study is hinged on the Environmental Kuznets Hypothesis (EKH), propounded by Kuznets (1955), which outlines the relationship between environmental quality and economic growth. Based on the foregoing, the effect of health quality and environmental quality can be expressed through the endogenous growth model in equation (1) as,

$$EG_t = c + \pi_1 GDPPC_t \quad (1)$$

Where EG_t represents economic growth at time t, and $GDPPC_t$ represents GDP per capita at time t. With special reference to the hypothesis of Kuznets (1955), the linear and non-linear relationship between health expenditure and environmental quality on economic growth is specified in (2) as,

$$EG_t = c + \pi_1 GDPPC_t + \pi_2 (GDPPC)_t{}^2 + \pi_3 X_t \quad (2)$$

Where $(GDPPC)_t{}^2$ denotes the square of GDP per capita at time t, and X_t is the matrix vector of the control variable at time t. Thus, to measure the threshold coefficient of economic growth, it is necessary to find the first-order derivative as expressed in (3).

$$\frac{\partial (EG_t)}{\partial (GDPPC_t)} = \pi_1 + 2\pi_2 (GDPPC)_t \quad (3)$$

$$\pi_1 + 2\pi_2 (GDPPC)_t = 0 \quad (4)$$

$$\pi_1 = -2\pi_2 (GDPPC)_t \quad (5)$$

$$(GDPPC)_t = \frac{\pi_1}{-2\pi_2} \quad (6)$$

(6) measures the efficacy and efficiency of how environmental quality and health expenditure influence economic growth, outlining the transition from growth-induced degradation to growth-induced sustainability.

3.0. Methodology

3.1. Variables and data source

To investigate the dynamic effects of environmental quality and health expenditures on economic growth in Nigeria, time series data were sourced from 1991 to 2023 due to data availability. These periods prompted the limitation of data as a result of the availability of temperature change data, which is updated to 2023 as of the period of conducting the research problem and objectives. The dependent variable is economic growth, which is proxied by the GDP annual growth rate, and it's sourced from the 2024 World Bank World Development Indicators (WDI). The independent variables include GDP per capita, squared GDP per capita, carbon dioxide emissions, temperature change, nitrous oxide emissions, and public recurrent health expenditures. These explanatory variables were proxied by carbon dioxide (CO_2) emissions excluding land use, land use change, and forestry (LULUCF) per capita (t CO2e/capita), temperature change with respect to a baseline climatology ($TEMP_t$), the nitrous oxide ($N2O_t$) emissions from industrial processes (Mt CO2e), and the government recurrent expenditure on health. The government's recurrent expenditure on health was sourced from the 2023 Public Finance Central Bank of Nigeria (CBN) Statistical Bulletin. The data on annual growth rate of GDP, GDP per capita, carbon dioxide emissions excluding LULUCF per capita (t CO2e/capita), and the nitrous oxide emissions from industrial processes (Mt CO2e) were sourced from the 2024 World Bank WDI while the temperature change with respect to a baseline climatology were sourced from the International Monetary Fund (IMF) 2023 Food and Agriculture Organization (FAO) of the United Nations Climate Change, Climate Indicators. Table 2 further describes the variables and their respective code, sources, and expected signs.

Table 2. Variable code, source, and expected signs

Variable code	Variable source	Expected signs
Economic growth (EG_t)	2024 World Bank World Development Indicators (WDI)	NA
GDP per capita ($GDPPC_t$)	2024 World Bank WDI	-
Squared GDP per capita ($(GDPPC)_t^2$)	Authors' computations	+
Carbon dioxide emissions (CO_{2_t})	2024 World Bank WDI	-
Temperature change ($TEMP_t$)	International Monetary Fund (IMF) 2023; Food and Agriculture Organization (FAO) of the United Nations Climate Change, Climate Indicators	-
Nitrous oxide emissions ($N2O_t$)	2024 World Bank WDI	-

Recurrent health expenditures ($LHEXP_t$)	2023 Public Finance Central Bank of Nigeria (CBN) Statistical Bulletin	+

Source: Authors' compilations.

3.2. Empirical model specification and econometric modelling

Following the underpinning theoretical framework, the empirical model of Adejumo (2019) and Aluko and Marvellous (2018) were adapted to investigate the effect of environmental quality and health expenditure on economic growth. These studies were used as a benchmark for estimating the empirical implicit modelling in (7) as

$$EG_t = f\left(GDPPC_t, (GDPPC)_t^{\,2}, CO_{2_t}, TEMP_t, N2O_t, HEEXP_t\right) \quad (7)$$

Where EG_t represents economic growth, $GDPPC_t$ represents GDP per capita, $(GDPPC)_t^{\,2}$ signifies the squared GDP per capita, CO_{2_t} is carbon emissions, $TEMP_t$ is the temperature change, $N2O_t$ is the nitrous oxide emissions, and $HEXP_t$ represents recurrent health expenditures. However, to reduce the effect of outliers and improve interpretability, the recurrent health expenditure was converted into its natural logarithm form, resulting in a linear-log econometric model as expressed in (8) as,

$$EG_t = \pi_0 + \pi_1 GDPPC_t + \pi_2 (GDPPC)_t^{\,2} + \pi_3 CO_{2_t} + \pi_4 TEMP_t + \pi_5 N2O_t + \pi_6 InHEXP_t + \omega_t \quad (8)$$

Where π_i is the coefficient of the explanatory parameters, ω_t is the stochastic white noise of the model at time t, while π_0 is the stochastic white noise. To achieve the stated research objectives, the study employs the ARDL Bounds test, otherwise known as the ARDL Cointegration. This is decided due to the mixture of the variables' stationarity using the Phillips-Perron (PP) unit root test results. The ARDL model, as developed by Pesaran, Shin, and Smith (2001) and empirically put forward by Shrestha and Bhatta (2018), the ARDL model is used to determine the short- and long-term dynamic impact between non-cointegrated and mixed unit root stationary variables at order I(0) and I(1). However, in the case of this study, the ARDL is employed because of its dynamic regression model that checks for the impact of both the short-term and long-term dynamics by incorporating the lagged values of the variables. Secondly, it makes it possible to estimate both short-term dynamics and long-term equilibrium at the same time, allowing for a thorough comprehension of how variables interact over time (Anagun et al., 2024; Anagun & Agosu, 2024). Second, even with small sample sizes, it is reliable, which makes it very beneficial for research projects with limited time series observations. Thirdly, the ARDL remains suitable due to its dependability over other conventional cointegration procedures (Pesaran et al., 2001). These methodological justifications guarantee the precise cointegration adaptability irrespective of the data's stationarity characteristics, except for I(2). As such, the unrestricted ARDL bound test model is estimated in (9) as,

$$EG_t = \pi_0 + \pi_1 EG_t + \pi_2 GDPPC_t + \pi_3 (GDPPC)_t^{\,2} + \pi_4 CO2_t + \pi_5 TEMP_t + \pi_6 N2O_t + \pi_7 LHEXP_t + \sum_{i=1}^{a} \epsilon_1 EG_{t-i} + \sum_{j=1}^{b_1} \epsilon_2 GDPPC_{t-j} + \sum_{j=1}^{b_2} \epsilon_3 (GDPPC)^2{}_{t-j} + \sum_{j=1}^{b_3} \epsilon_4 CO2_{t-j} + \sum_{j=1}^{b_4} \epsilon_5 TEMP_{t-j} + \sum_{j=1}^{b_5} \epsilon_6 N2O_{t-j} + \sum_{j=1}^{b_6} \epsilon_7 LHEXP_{t-j} + \omega_t \quad (9)$$

Where π_0 is the constant parameter, $\pi_1 - \pi_7$ are the coefficients of the estimated long-run parameters, $\epsilon_1 - \epsilon_7$ are the coefficients of the estimated short-run parameters, and ω_t is the stochastic white noise or error term. Therefore, the ability to estimate long-run relationships between the non-stationary and theircointegrated variables without the need for pre-estimation for the order of integration or cointegration is one of the main benefits of the ARDL model (Abdulkadr, 2024). As such, to investigate the presence of a dynamic long-run relationship among the dependent and independent variables, the ARDL bound test hypothesis of no cointegration is specified in (10) as,

$$H_0: \epsilon_1 = \epsilon_2 = \epsilon_3 = \epsilon_4 = \epsilon_5 = \epsilon_6 = \epsilon_7 \quad (10)$$

Therefore, the rejection of the ARDL bound test null hypothesis in (10), using the F-statistic rule of thumb, indicates that if the F-statistic is greater than the 5% critical value of the upper bound, then there exists a dynamic long-run relationship, which calls for the employment of the dynamic short-run impact of the Error Correction Mechanism (ECM). The ECM framework is estimated in (11), where ECT_t represents the error correction term, ρ captures the adjustment speed, and Δ denotes the operator of the first difference.

$$\Delta EG_t = \pi_0 + \sum_{i=1}^{a} \epsilon_1 \Delta EG_{t-i} + \sum_{j=1}^{b_1} \epsilon_2 \Delta GDPPC_{t-j} + \sum_{j=1}^{b_2} \epsilon_3 \Delta (GDPPC)^2{}_{t-j} + \sum_{j=1}^{b_3} \epsilon_4 \Delta CO2_{t-j} + \sum_{j=1}^{b_4} \epsilon_5 \Delta TEMP_{t-j} + \sum_{j=1}^{b_5} \epsilon_6 \Delta N2O_{t-j} + \sum_{j=1}^{b_6} \epsilon_7 \Delta LHEXP_{t-j} + \rho ECT_{t-1} + \omega_t \quad (11)$$

4.0. Results and discussion of findings

4.1. Descriptive statistics

Table 3 presents the summary of descriptive statistics, revealing that Nigeria's economic growth rate has experienced a best rate of 15% and a worst rate of 2.03%, which implies that the economic growth rate over this period exhibits a growth path, perhaps due to industrial productivity and an increased labour force. Likewise, since Nigeria experienced a significant growth path, the GDP per capita has also undergone an increase, lying between a maximum value of 12.21% and a lower value of 4.59%. The mean threshold for economic growth is averaged at 4.02%, coupled with GDP per capita at 1.36%. However, the squared (sq.) of the GDP per capita was pegged at 13.92% per capita sq. This shows an increasing rate of Nigeria's environmental degradation issues. Also, over the sampled period, on average, Nigeria emits 39.06 tonnes of carbon dioxide per capita, which indicates an increase in industrial production but causes more threats to health expenditures and the labour force. Moreover, this threat is further posed by the average emission of 2.75 metric tonnes of nitrous oxide from industrial processes alongside a climatic temperature that averaged at 0.94 degrees Celsius. With this, it is evident that to curb these health expenditures and the labour force, the Nigerian government has spent an average of N138 billion on recurrent health expenditures. Considering the variability of the standard deviation of the series to its respective mean values, it was also revealed that government health expenditure exhibits a higher variability, while economic growth rate, emissions of carbon dioxide, emissions of nitrous oxide from industrial processes, the initial and latter forms of GDP per capita, and temperature reveal a lower variability.

Assessing the directional position and the symmetry of the series around the mean, it was revealed that economic growth, the initial and former periods in the growth rate of per capita gross domestic product, carbon dioxide emission, nitrous oxide emission from industrial processes, and government health expenditures exhibit a positively skewed distribution, while temperature shows a negatively skewed distribution. The implication is that economic growth and the initial and former periods in the growth rate of GDP per capita, carbon dioxide emission, nitrous oxide emission from industrial processes, and government health expenditures have a flat tail of distribution. This further revealed that carbon dioxide emission, nitrous oxide emission from industrial processes, and government health expenditures do not just exhibit flat-tail distribution but are also platykurtic. This clearly showed that the distributions of carbon dioxide emissions, nitrous oxide emissions from industrial processes, and government health expenditures are broadly humped. However, Nigeria's climatic temperature is mesokurtic in nature, exhibiting an evenly distributed value around its mean. Thus, economic growth, the initial period, and the former period of the growth rate of GDP per capita exhibit a leptokurtic distribution. This indicates that the values of economic growth, the initial and the former periods of the growth rate of

GDP per capita, possess a relatively high peak and a narrowly humped distribution.

Table 3. Summary of descriptive statistics results

Variables	EG_t	$GDPPC_t$	$(GDPPC)_t^2$	CO_{2_t}	$TEMP_t$	N_2O_t	$HEEXP_t$
Unit	**%**	**%**	**% per capita sq.**	**Capita tonnes of CO_2 emi.**	**°C**	**Metric tonnes of CO_2emi.**	**₦' Billion**
Maximum	15.3292	12.21039	149.0935	74.3928	1.6470	3.8630	468,638,800,000
Minimum	-2.0351	-4.5972	0.0001	7.70778	-0.0670	1.6903	150,161,000
Mean	4.0175	1.3601	13.9228	39.0683	0.9463	2.7529	138,895,200,000
Std. Dev.	3.7288	3.5285	26.0137	21.2289	0.3851	0.7000	149.8333
Skewness	0.5185	0.5124	4.4369	0.2187	-0.3618	0.0940	0.889413
Kurtosis	3.9007	4.0869	23.5498	1.7915	3.0076	1.6408	2.481633
Obs.	33 years	33 years	33 years	33 years	33 years	33 years	33 years

Std. Dev. = Standard Deviation, Obs. = Number of sampled years, % = Percentages, % per capita sq. = Percentage of per capita square, °C = Degree Celsius, ₦' Billion = Billion naira. Source: Authors' compilations.

4.2. Correlation results

Table 4 presents the correlation results exhibiting a statistically significant and positive relationship between economic growth and GDP per capita ($r = 0.998$, $p < 0.000$), and the square of GDP per capita ($r = 0.611$, $p < 0.000$). This significant positive relationship shows that the initial development period of the growth rate of GDP per capita is associated with the economic growth rate by 0.99, which indicates a stronger association. Thereafter, the squared development period of the growth rate of GDP per capita indicates a moderate, positive, and statistically significant association with the economic growth rate in Nigeria. This contradicts the postulations of the 1955 environmental Kuznets curve and was later supported by Okon (2021) and Egbetokun et al. (2020).

Also, the correlation results revealed that economic growth and carbon dioxide emission have a weak, negative, and statistically insignificant relationship ($r = -0.102$, $p > 0.571$), while the association between economic growth and nitrous oxide emission from industrial processes is also insignificantly negative ($r = -0.025$, $p > 0.889$). This stands in tandem with Afolayan and Aderemi (2019) and Anwar et al. (2021). On the other hand, temperature changes exhibit a weak, positive, and statistically insignificant relationship with economic growth rate ($r = 0.053$, $p > 0.771$) over the sampled period. This is supported by Alimi et al. (2019). Lastly, government recurrent health expenditures have a weak, positive but insignificant association with economic growth ($r = 0.145$, $p > 0.420$). These results indicate that the increase in the economic productivity of Nigeria is a result of the good healthcare system under the purview of Nigerians, and are corroborated by Ogundipe and Anagun (2024) and contradict the results of Ijuo et al. (2023).

Table 4. Correlation matrix results

Variables	EG_t	$GDPPC_t$	$(GDPPC)_t^2$	CO_{2_t}	$TEMP_t$	$N2O_t$	$LHEEXP_t$
EG_t	1.000 [------]						
$GDPPC_t$	0.998* [97.717]	1.000 [------]					
$(GDPPC)_t^2$	0.611* [4.300]	0.610* [4.291]	1.000 [------]				
CO_{2_t}	-0.102 [-0.573]	-0.058 [-0.323]	-0.197 [-1.117]	1.000 [------]			
$TEMP_t$	0.053 [0.294]	0.080 [0.448]	-0.069 [-0.385]	0.503* [3.241]	1.000 [------]		
$N2O_t$	-0.025 [-0.141]	0.014 [0.079]	-0.167 [-0.942]	0.857* [9.266]	0.691* [5.317]	1.000 [------]	
$LHEEXP_t$	0.145 [0.818]	0.175 [0.989]	-0.011 [-0.063]	0.716* [5.713]	0.723* [5.826]	0.914* [12.522]	1.000 [------]

Values in [] are t-Statistics, while * represents the 1% significance probability value.Source: Authors' compilations.

4.3. Unit root test results

Employing the Phillip and Perron (1988) unit root test using the trend and intercept-only estimation, Table 5 presents the results of testing each of the variables' null hypothesis at a 5% level of critical test against an alternative hypothesis. Thus, in comparison of the PP unit root test at intercept to that of the PP unit root test at trend and intercept, the PP unit root test revealed that the squared GDP per capita growth rate, climatic temperature change, and nitrous oxide emission from industrial processes were stationary at level, that is, they are stationary at $I_t \sim (0)$. On the other hand, economic growth, the growth rate of GDP per capita, carbon dioxide emissions, and government recurrent health expenditures were stationary at first difference, that is, $I_t \sim (1)$. The implication is that the variables used in the model are of mixed order of stationarity, which indicates that in the trend and intercept test equation of the PP unit root test, the series are both stationary at the level and stationary at the first difference.

Table 5. Results of the PP test at the trend and intercept test equation

Variables	Level			1st difference			$I_t \sim (d)$
	PP test statistic	Test the critical value at the 5% level	Prob.	PP test statistic	Test the critical value at the 5% level	Prob.	
EG_t	-2.8473	-3.5577	0.1920	-16.5001	-3.5628	0.0000	$I_t \sim (1)$
$GDPPC_t$	-2.9638	-3.5577	0.1575	-16.7401	-3.5628	0.0000	$I_t \sim (1)$
$(GDPPC)_t^2$	-5.0820	-3.5577	0.0014	-	-	-	$I_t \sim (0)$
CO_{2_t}	-2.5276	-3.5577	0.3137	-6.4238	-3.5628	0.0000	$I_t \sim (1)$
$TEMP_t$	-5.5861	-3.5577	0.0004	-	-	-	$I_t \sim (0)$
$N2O_t$	-4.0637	-3.5577	0.0164	-	-	-	$I_t \sim (0)$
$LHEEXP_t$	-2.9039	-3.5577	0.1746	-16.0375	-3.5628	0.0000	$I_t \sim (1)$

$I_t \sim (d)$ = Order of stationary, $I_t \sim (0)$ = stationary at levels, $I_t \sim (1)$ = non-stationary at first difference.

Source: Authors' compilations.

4.4. ARDL bound test

Nevertheless, since the results of Table 5 revealed a mix of variable stationarity, there is a need to determine the existence of a short-run or long-run cointegration between economic growth and the independent variables, which warrants the necessity of running a cointegration test using the ARDL bound test to avoid a misleading estimation technique. This is done to know the cointegration among the variables. Therefore, to test the level of relationship or cointegration between economic growth, environmental quality, and health expenditure in Nigeria, it is tested upon a one-lag period as shown in equation 3.6. That is, the F-statistic value is tested against a long-run relationship against a one-lag-period null hypothesis of no cointegration between economic growth, environmental quality, and health expenditure in Nigeria. However, the ARDL bound test results are tested around two sets of critical bounds, namely the upper bound of I(1) and the lower bound of I(0), against an F-statistic value. The critical bounds are tested to validate whether the computed F-statistic supports the rejection of the null hypothesis.

Thus, to ascertain a rejection of the null hypothesis, the F-statistic value must exceed the respective upper bound significance values to show that at least one of the long-run estimates is non-zero. Table 6 presents the results of the ARDL bound test, indicating that the value of the F-statistic is greater than the upper bound values at the respective levels of significance of 10%, 5%, 2.5%, and 1%. Summarily, the results show that the F-statistic value of 4.562 is greater than the upper-bound 10% significance value of 2.94, the upper-bound 5% significance value of 3.28, the upper-bound 2.5% significance value of 3.61, and the upper-bound 1% significance value of 3.99. This result establishes the rejection of no cointegration, indicating that there exists a long-run cointegration between economic growth, environmental quality, and health

expenditure in Nigeria, revealing a long-run economic imbalance between economic growth, environmental quality, and health expenditure in Nigeria. This can only be corrected using the Error Correction Model (ECM) through the ARDL framework.

Table 6. ARDL bound test results

Selected model	Test Statistic	Value	Significance level	Lower bound	Upper bound
ARDL (2, 2, 2, 2, 1, 0, 2)	F-statistic	4.562	10%	1.99	2.94
	K	6	5%	2.27	3.28
			2.5%	2.55	3.61
			1%	2.88	3.99

K = Number of variables minus 1 (that is, N-1).Source: Authors' compilations.

4.5. ARDL-ECM estimation and discussion of findings

Based on the results of the ARDL bound tests, Table 7 presents the results of the dynamic ARDL long-run and ECM short-run estimates based on the model's automatic selection. The growth rate of GDP per capita has a positive statistical effect on economic growth. As such, a one-unit increase in the growth rate of GDP per capita brings about a 1.08% increase in economic growth. Despite a long-run positive effect of the linear GDP per capita effect, the squared growth rate of GDP per capita shows an insignificant and negativeeffect on economic growth in the long-run.This shows that the growth rate of GDP per capita has a long-run non-linear effect on economic growth in Nigeria, exhibiting a non-linear U-shape EKC in Nigeria, and is supported by the empirical work of Musibau et al. (2021).Unlike the results of the long-run estimates, the short-run estimates reveal that the increase in the growth rate of GDP per capita has a statistically positiveeffect on economic growth in the current period, but when lagged by one period, economic growth is statistically decreased. This implies that a unit increase in the growth rate of GDP per capita brings about a 1.03% increase in the current period, followed by a 0.65% decrease in the lagged period. However, in the short-run, GDP per capita squared has a positive effect, though only significant when lagged by one period. This suggests that, in the short-run, the growth rate of GDP per capita is increased, followed by a fathomless increase in the squared GDP per capita. This implies that, only in the long run does the non-linear inverted U-shape of the EKC hold, and not in the short run.

In the long run, carbon dioxide emissions negatively but significantly affect economic growth in Nigeria, implying that a unit increase in carbon dioxide emissions yields a 0.01% decrease in economic growth. This relationship suggests that increased carbon emissions lead to a minimal decrease in economic growth, indicating that the impact, although negative, is not substantialin the long-run (Yusuf et al., 2023).Although in the short-run, carbon dioxide emissions have a statistical effect both in the current period

and when lagged by one period. At the current period, carbon dioxide emissions have a fathomless negative effect on economic growth, followed by a fathomless positive effect when lagged. This suggests that, in the short-run, economic growth is only affected when lagged, but both at the current period and in the long-run, carbon dioxide emissions distort the performance of Nigeria's economy. The change in climatic temperature has a negative and insignificant effect on economic growth in the long-run, revealing that a unit increase in climatic temperature change yields a 0.07% decrease in economic growth. Explicitly, this demonstrates that changes in Nigeria's climatic temperature distort economic growth. However, in the short-run, climatic temperature change significantly but negatively affects economic growth, showing a negative effect in the current short-run period. In the current short-run period, a one-unit increase in climatic temperature change reduces economic growth by a 0.05% effect, indicating a spontaneous effect over time. This is supported by Olatayo et al. (2019) and Nwani et al. (2028).

Likewise, nitrous oxide emissions from industrial processes revealed a negative and insignificant impact on economic growth. This shows that the emissions of nitrous oxide from industrial processes in Nigeria significantly harm the growth of the Nigerian economy in the long run. This shows that, with an increase in nitrous oxide emissions from industrial processes, economic growth is reduced by 0.10%. Therefore, this implies that the more the nitrous oxide emissions as a result of industrial processes, the lower the economic growth in Nigeria. This finding stands in tandem with Urhie et al. (2020).Government health expenditures reveal a negative and statistically insignificant effect on Nigeria's economic growth in the long-run. This implies that a one-percent increase in public health expenditures brings about a 0.06% decrease in long-run economic growth. However, in the short-run, government health expenditure negatively affects economic growth, exhibiting a 0.06% decrease in the current period, followed by a 0.08% decrease when lagged. Therefore, while immediate and one-period effects are negative, the long-run results also support that increased health expenditures cannot marginally boost economic growth. This suggests that while health expenditure may harm short-term growth, it also does not significantly influence long-term economic growth considering other structural and environmental quality factors (Gukat & Ogboru, 2017; Ijuo et al., 2023; Omodero & Alege, 2022).

Thus, to correct the model's disequilibrium, the result of the dynamic long-run bound cointegration test reveals the speed at which the model is corrected by the coefficient of the error correction term. Thus, the error correction term of -0.2196 revealed that the model is adjusted back to normal in 4 years and 5 months with a speed of 21.9%, *ceteris paribus*. To support the findings, the model's R-squared and adjusted R-squared show that the dynamic short-run model of the environmental quality-health expenditure on the growth rate of the Nigerian economy is stable and good for policy implementation.

Table 7. Results of the dynamic ARDL-ECM estimates

Long-run estimates: ARDL				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	3.3473*	0.3003	11.1469	0.0000
$GDPPC_t$	1.0778*	0.0161	66.7578	0.0000
$(GDPPC)^2{}_t$	-0.0028	0.0017	-1.6872	0.1154
CO_{2_t}	-0.0060**	0.0024	-2.5551	0.0240
$TEMP_t$	-0.0677	0.1080	-0.6265	0.5418
$N2O_t$	-0.1039	0.2219	-0.4682	0.6474
$LHEXP_t$	-0.0611	0.1665	-0.3668	0.7197
Short-run estimates: Error correction model				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ΔEG_{t-1}	0.6263**	0.1837	3.4093	0.0047
$\Delta GDPPC_t$	1.0252*	0.0033	315.0860	0.0000
$\Delta GDPPC_{t-1}$	-0.6532**	0.1880	-3.4740	0.0041
$\Delta(GDPPC)^2{}_t$	0.0004	0.0003	1.6010	0.1334
$\Delta(GDPPC)^2{}_{t-1}$	0.0008**	0.0003	3.0659	0.0090
ΔCO_{2_t}	-0.0002	0.0006	-0.2758	0.7870
$\Delta CO_{2_{t-1}}$	0.0007	0.0005	1.4586	0.1684
$\Delta TEMP_t$	-0.0542**	0.0196	-2.7621	0.0162
$\Delta LHEXP_t$	-0.0643*	0.0318	-2.0203	0.0644
$\Delta LHEXP_{t-1}$	-0.0854**	0.0234	-3.6544	0.0029
ECT_{t-1}	-0.2196*	0.0293	-7.4934	0.0000
R-squared	0.9999	Adjusted R-squared		0.9999
Mean dependent variable	4.1158	Durbin-Watson stat		2.4077
F-statistic	69905.15	F-statisticProbab.		0.0000

*, **, and *** denotes level of significance at 1%, 5%, and 10% respectively. Source: Authors' compilations.

4.6. Model stability and FMOLS Robustness check

4.6.1. Model stability

Diagnostic tests were conducted to confirm the authenticity of the dynamic ARDL long-run and short-run ECM dynamic models. This is also to ensure that the models are free from econometric problems. As such, the results of the model stability checks as shown in Table 8 indicate that there are no issues with serial autocorrelation, functional dependency, normality, and heteroscedasticity in the estimation of the long-run and short-run models (Mills, 2014). Figure 3 also depicts that the cumulative sum test (CUSUM) and the cumulative sum of squares test (CUSUM of Squares) lines lie within the 5% significance bounds throughout the sample period, and that the histogram normality test presents a normal bell-shaped curve, validating the ARDL estimates stability (Pesaran & Pesaran, 1997).

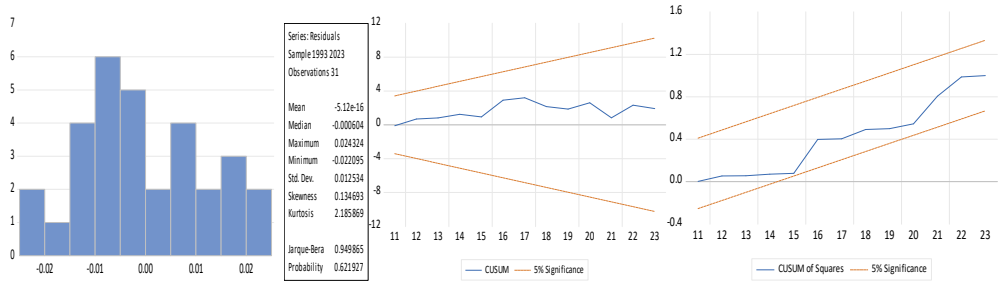

Figure 3. Model stability thresholds. Source: Authors' compilations.

Table 8. Model stability checks

Diagnostic Test	Null hypothesis	Df	F-statistic	Prob.
Breusch-Godfrey Serial correlation LM test	No serial correlation at up to 2 lags	2, 11	1.3856	0.2906
Breusch-Pagan-Godfrey Heteroskedasticity test	Homoskedasticity does not systematically change the variance of the unobserved shocks to economic growth	17, 13	0.7818	0.6879
Ramsey RESET test	Internal contradiction across test measures does not exist	1, 12	1.9862	0.1841

Source: Authors' computation.

4.6.2. FMOLS Robustness check

Table 9 presents the model's robustness test using the Fully Modified Ordinary Least Squares (FMOLS) technique. The FMOLS was conducted to check robustness in the model's long-run cointegration in view of correcting for endogeneity and serial correlation, especially in the Ordinary Least Squares cointegrating systems (Phillips & Hansen, 1990; Stock & Watson, 1993). Specifically, the FMOLS was conducted to adjust the non-parametric OLS by correcting any endogeneity and serial correlation in the long-run results (Pedroni, 2001). FMOLS is deemed more efficient for small samples (Li, 1995; Masih & Masih, 1996; Pedroni, 2001). As revealed in the FMOLS robustness results, the growth of GDP per capita has a significant positive effect on economic growth. It revealed that a 1% increase in GDP per capita brings about a 1.05% increase in economic growth, indicating a strong long-run elasticity in Nigeria's economic growth. However, the square of GDP per capita showed a negative and insignificant effect on economic growth, exhibiting a 1% increase, bringing about a 0.001% decrease in the long-run elasticity in Nigeria. These results ascertained the robustness of the nonlinearity in the EKH.

In the long run, FMOLS elasticity results show that the proxies for environmental quality hurt the elasticity of Nigeria's long-run economic growth. As such, carbon

emissions have a negative and significant impact on economic growth. This indicates that a 1% increase in carbon emissions implies a 0.01% decrease in the elasticity of Nigeria's long-run economic growth. Climate temperature change has a negative and insignificant effect on the long-run elasticity of economic growth in Nigeria. This shows that a 1% increase in temperature brings about a 0.13% decrease in the elasticity of long-run economic growth in Nigeria. Also, the emissions of nitrous oxide from industrial processes have a negative and significant effect on economic growth, indicating that a 1% increase in the emissions of nitrous oxide from industrial processes implies a 0.29% decrease in the elasticity of Nigeria's long-run economic growth. Contrarily, government health expenditures have a positive and significant effect on long-run economic growth elasticity. Therefore, this implies that a 1% increase in government health expenditures brings about a 0.20% increase in economic growth. Results from the FMOLS robustness test revealed that while well-managed health investments promote growth, environmental degradation impedes it. Thus, this implies that the FMOLS is the long-run cointegrating equilibrium of the ARDL long-run model.

Table 9. FMOLS results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$GDPPC_t$	1.0562*	0.0086	122.6307	0.0000
$(GDPPC)^2{}_t$	-0.0017	0.0012	-1.4982	0.1466
CO_{2_t}	-0.0064*	0.0023	-2.7658	0.0105
$TEMP_t$	-0.1384	0.0891	-1.5532	0.1329
$N2O_t$	-0.2892**	0.1280	-2.2603	0.0328
$LHEXP_t$	0.2028**	0.0798	2.5403	0.0177
Constant	3.4419*	0.1922	17.9040	0.0000
R-squared		0.9990		
Adjusted R-squared		0.9987		

Source: Author's computation

4.7. Results of the short-run predictive estimates

Table 10 reveals the Results of the range causality tests, which reveal the results of the short-run predictive estimates. The results revealed that economic growth is Granger-caused by GDP per capita at the 10% significance level (F = 2.9230, p > 0.0716). This result implies that historical variations in GDP per capita do not have a substantial short-run predictive effect on economic growth, suggesting a unidirectional causal relationship from GDP per capita to economic growth. This finding is consistent with the theoretical prediction

that increases in per capita income incite the accumulation of human capital, aggregate demand, and productive capacity, which contribute to economic growth in Nigeria. On the other hand, the reverse causality between economic growth and GDP per capita was negligible at the 10% level ($F = 2.6100$, and $p > 0.0927$), indicating that economic growth does not have a short-run dynamic impact on GDP per capita. This is further indicated by a statistically insignificant impact. This modest feedback effect suggests that Nigeria's economic growth hasn't been inclusive enough to result in widespread gains in people's quality of life. Thus, assessing the effects at both levels of economic growth and GDP per capita, there exists no causality between them. The results further showed that neither direction of significant causality was found for the square of GDP per capita, which represents the nonlinear relationship between GDP per capita and economic growth, perhaps reflecting the Environmental Kuznets Curve hypothesis. In both directions, the F-statistics showed 0.3151 and 0.8101 at probability levels of 0.7324 and 0.4557, respectively. This further indicates that there is no predictive dynamic short-run impact between economic growth and the squared GDP per capita. This suggests that the induced structural changes of GDP per capita may take a longer period to manifest since nonlinear income impacts may not significantly impact growth dynamics in the short term. Therefore, it implies that the square of GDP per capita does not Granger-cause economic growth, and vice versa.

Also, with reference to assessing the short-run dynamic direction between carbon dioxide emissions and economic growth, there is a lack of substantial causality in either direction ($F = 0.3911$, $p > 0.6803$), and vice versa ($F = 1.6089$, $p > 0.2194$). This suggests that, in the short run, carbon emissions and economic growth are dynamically independent. Environmental quality changes do not immediately feed back into growth dynamics, and growth-induced environmental pressures or pollution abatement methods may not be immediate. Similarly, there is no discernible causal relationship between climatic temperature change, nitrous oxide emissions, and economic growth. The F-statistics validate that there is no causal relationship between these environmental indicators and growth, and vice versa ($F = 0.5809$, $p > 0.5665$; and $F = 0.8337$, $p > 0.4457$, respectively). Thus, due to adaptation mechanisms, inadequate climate monitoring, or the predominance of non-agricultural sectors in GDP composition, this conclusion suggests that climate change and greenhouse gas emissions have not yet had a noticeable short-term impact on Nigeria's economic performance. Furthermore, there was no statistically significant dynamic relationship between health expenditures and economic growth in either direction at respective F-statistics of 0.1402 and 0.0279 and respective probability values of $p > 0.8698$ and $p > 0.9726$. This lack of causality implies that short-term changes in economic growth are neither caused by nor influenced by health expenditures. The findings demonstrate the poor relationship between Nigeria's health sector and economic growth, highlighting inefficiencies in public health expenditures and the minimal short-term impact of health outcomes on productivity. Summarily, the Granger causality results revealed that among GDP per capita, squared GDP per

capita, carbon emissions, temperature, emissions of nitrous oxide from industrial processes, government health expenditures, and economic growth in Nigeria, there does not exist a short-run dynamic direction at any level of no causality, unidirectional causality, or bidirectional causality.

Table 10. Granger causality test results

Null Hypothesis:	F-Statistic	Prob.	Decision
$GDPPC_t$ does not Granger cause EG_t	2.9230	0.0716	No short-run predictive cause
EG_t does not Granger cause $GDPPC_t$	2.6100	0.0927	
$(GDPPC)^2{}_t$ does not Granger cause EG_t	0.3151	0.7324	No short-run predictive cause
EG_t does not Granger cause $(GDPPC)^2{}_t$	0.8101	0.4557	
CO_{2_t} does not Granger cause EG_t	0.3911	0.6803	No short-run predictive cause
EG_t does not Granger cause CO_{2_t}	1.6089	0.2194	
$TEMP_t$ does not Granger cause EG_t	0.5809	0.5665	No short-run predictive cause
EG_t does not Granger cause $TEMP_t$	0.2509	0.7800	
$N2O_t$ does not Granger-causeEG_t	0.8337	0.4457	No short-run predictive cause
EG_t does not Granger-cause$N2O_t$	0.2191	0.8047	
$LHEXP_t$ does not Granger-causeEG_t	0.1402	0.8698	No short-run predictive cause
EG_t does not Granger-cause$LHEXP_t$	0.0279	0.9726	

Source: Authors' computation.

5. Conclusion and recommendations

This study investigated the effects of environmental quality and health expenditures on Nigeria's economic growth between 1991 and 2023 by employing the ARDL, ECM, Granger causality, and the FMOLS to ensure the robustness of the model. The results revealed that environmental quality and health expenditures have an association with economic growth, which suggests that long-run economic prosperity is fostered by changes in environmental conditions and health financing. Using the ARDL model, the findings demonstrated a long-term equilibrium relationship between the variables, with health expenditures showing a positive but delayed impact on growth and environmental deterioration, especially on climatic temperature change and carbon emissions, having negative long-term consequences. The short-run model is adjusted by 22% of short-run disequilibrium toward the long-run equilibrium. Likewise, the Granger causality revealed that environmental quality and health expenditures have no short-run predictive effect on economic growth, exhibiting that short-term interactions are weak because of institutional and structural inefficiencies.

In conclusion, institutional reforms, efficient financial management, and sustainable environmental plans are necessary for Nigeria to realize its significant potential to use health and environmental policies for growth. Based on the results, the following recommendations were made. First, the Nigeriangovernment should encourage the use of renewable energy, strengthen the enforcement of environmental protection legislation, and lessen reliance on fossil fuels. These actions will assist in lowering emissions, reducing pollution, and bringing Nigeria into compliance with international climate goals. Secondly, sustainable funding of climate adaptation initiatives should be encouraged so as to implement budgets for irrigation and early warning, especially targeting the agricultural sector.Another recommendation is thatthe Nigerian government needs to manage health and environmental finances more effectively, transparently, and accountably. Prioritizing anti-corruption initiatives can help guarantee that public investments in environmental and health infrastructure projects provide the desired results. Also, another recommendation is that, to deal with factors that affect environmental quality, such as temperature swings, flooding, and other climate-related disruptions that jeopardize economic stability and health consequences, Nigeria has to create adaptive strategies. Furthermore, investments in renewable energy, green technologies, and healthcare facilities should be promoted to the private sector. With this, increasing project delivery efficiency and mobilizing resources would be achieved. Also, the Nigerian government should strengthen the immediate environment of its citizens from environmental pollution by bringing back the monthly environmental sanitation exercise. With this, the increased health expenditures would be reduced and reallocated for other forms of human capital investments. Lastly, to ensure the development of human capital, consistent and focused health expenditure is essential. Thus, the Nigerian government should guarantee fair budget distribution between capital and ongoing medical expenses and provide access to high-quality healthcare services, particularly in rural areas.

Furthermore, this study highlights the importance of fiscal restraint and institutional quality in determining how health and environmental spending impact economic growth. It suggests that politicians create long-run plans that combine environmental protection with sustainable health finance. In order to confirm causation and policy links, future research should concentrate on sector-specific determinants, including sophisticated econometric techniques like structural Vector Autoregressive (SVAR) or dynamic panel analysis, as well as institutional quality as a moderating variable. Essentially, Nigeria's sustainable economic route necessitates conscious efforts to strike a balance between social investments in human capital and health and environmental management. When properly controlled, the combined effects of these factors can promote resilient, inclusive, and ecologically conscious economic growth.

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