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Interactive Effect of Health Expenditure and Institutional Quality on Environmental Sustainability in Nigeria.

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ABSTRACT: Environmental sustainability has emerged as a pressing concern for policymakers, particularly in developing countries like Nigeria, where institutional inefficiencies and underinvestment in key sectors challenge efforts to reduce environmental degradation. Motivated by this growing concern, this study investigates the interactive effect of health expenditure (HEXP) and institutional quality proxied by government effectiveness (GEFF) on environmental sustainability in Nigeria from 2000 to 2024.Using the Autoregressive Distributed Lag (ARDL) approach, both short-run and long-run dynamics are examined. The empirical findings reveal that increased health expenditure (HEXP) significantly reduces CO_2 emissions (CO2) in both the short and long run, indicating that investments in health contribute positively to environmental sustainability. Furthermore, government effectiveness (GEFF) exerts a consistently negative and significant effect on CO2, highlighting the critical role of institutional quality in achieving environmental goals. Notably, the interaction between government effectiveness (GEFF) and health expenditure (HEXP) further amplifies the environmental benefits, suggesting that good governance enhances the effectiveness of public health spending in reducing emissions. In contrast, economic growth (GDPG) is found to have no significant impact on CO2, underscoring the limited role of growth alone in fostering environmental sustainability. Based on these findings, the study recommends strengthening institutional frameworks to support effective environmental regulation and enforcement. It also advocates for environmentally conscious health investments such as green healthcare infrastructure and pollution prevention programs as strategic tools to simultaneously improve public health and reduce environmental degradation.

KEYWORDS: Environmental Sustainability, Health Expenditure, Institutional Quality, CO2, ARDL Model

1. INTRODUCTION

Environmental sustainability is an increasingly pressing concern for developing countries like Nigeria, which continues to experience rapid ecological degradation and rising pollution levels. One of the major indicators of environmental stress in Nigeria is the steady increase in CO_2 emissions, driven largely by fossil fuel consumption, weak environmental oversight, and inadequate policy coordination. This environmental decline not only undermines long-term ecological balance but also threatens public health, agricultural productivity, and national development goals (Ajide et al., 2022). To address these issues, recent studies have emphasized the importance of institutional and sectoral collaboration, particularly in aligning budgetary priorities with sustainable development objectives (Adebisi et al., 2020).

One emerging area of interest is the role of health expenditure in shaping environmental outcomes. Although health spending primarily targets public health improvements, it can also influence environmental quality indirectly through investments in sanitation, waste disposal, and disease prevention infrastructure (Assadzadeh et al., 2014; Borsatto et al., 2024; Aman, 2019). Improved sanitation and environmental health services reduce pollution and raise environmental awareness among citizens. However, in contexts where resources are poorly managed, even substantial health expenditure may fail to yield sustainable results. This raises concerns about how the efficacy of health-related environmental interventions is shaped by broader governance frameworks (Hassan et al., 2020).

A critical factor in Nigeria's environmental sustainability challenges is the interplay between institutional quality and governance effectiveness. The ability of government institutions to design and enforce policies that integrate health and environmental priorities is crucial for mitigating environmental degradation (Ajide et al., 2022). Studies have shown that countries with strong governance frameworks are better equipped to implement policies that reduce emissions, manage natural resources sustainably, and invest in public health initiatives that enhance environmental awareness and clean energy usage (Bouchoucha, 2024; Danish Ulucak & Ulucak, 2020). In Nigeria, however, weak institutions, characterized by corruption, lack of transparency, and inefficiency, often hinder the effective use of public health funds and limit the country's capacity to meet environmental goals. As such, understanding

how institutional quality can enhance or detract from the effectiveness of health expenditure in promoting sustainability is a critical area of research (Adebisi et al., 2020).

The quality of institutions particularly governance effectiveness plays a vital role in determining whether public investments translate into meaningful outcomes. Strong institutions can enforce environmental regulations, manage health budgets transparently, and implement policies that integrate health and environmental goals (Danish Ulucak & Ulucak, 2020; Hassan et al., 2020; Hasan et al., 2024). Conversely, in the presence of weak institutions, health sector investments may be undermined by corruption, inefficiency, or policy fragmentation. Several studies have found that countries with better institutional quality experience greater success in reducing CO_2 emissions and improving sustainability metrics, highlighting the importance of governance in the environmental equation (Danish Balouch et al., 2019; Bouchoucha, 2024).

Although previous research has recognized the separate importance of health expenditure and institutional quality, limited attention has been paid to their interactive effect on environmental sustainability particularly in Sub-Saharan Africa. In Nigeria's context, where public finance is often undermined by institutional weaknesses, examining this interaction becomes especially important. Institutional quality could enhance the impact of health spending on environmental protection or, conversely, dampen it in a misgoverned setting (Hasan et al., 2024). Such a focus helps bridge gaps in current literature and provides a more comprehensive view of sustainability drivers in fragile institutional environments.

In addition, GDP per capita plays a critical background role in this framework, influencing both the fiscal space for health spending and the operational capacity of institutions. As income levels rise, so do consumption patterns and industrial activity often resulting in greater environmental degradation if not accompanied by effective regulation (Borsatto et al., 2024; Danish Ulucak & Ulucak, 2020; Hasan et al., 2024). However, higher income may also support greater public investment in environmental and health services, suggesting a complex and context-dependent relationship. Thus, GDP per capita is a necessary control in assessing how governance and health expenditure jointly shape environmental outcomes. This study seeks to fill a vital gap in the empirical literature by analyzing the interactive effect of health expenditure and institutional quality (governance effectiveness) on environmental sustainability in Nigeria, with CO_2 emissions serving as the key environmental indicator.

2. LITERATURE REVIEW

2.1 Theoretical Framework

This study is anchord on Health Economics theory**,** notably advanced by theorists such as A. C. McGuire (2000) and M. Grossman (1972), is the most suitable theoretical framework for this study, particularly in the context of Nigeria. This theory emphasizes the relationship between health expenditures, public policy, and socioeconomic outcomes, offering a comprehensive lens through which to analyze how investment in health can influence broader impacts, such as environmental sustainability and institutional effectiveness. In Nigeria, where healthcare resources are often limited, understanding this relationship is crucial for policymakers. The Health Economics theory allows for the exploration of how efficient allocation of health expenditures can improve health outcomes while also addressing environmental concerns, ultimately contributing to sustainable development. By integrating variables such as institutional quality and corruption into this framework, the study can uncover the multifaceted dynamics of health investments, positioning Nigeria to better align its health policies with both public health objectives and environmental sustainability goals.

2.2 Empirical Literature

A growing body of empirical literature has examined the intricate relationships between environmental sustainability, health expenditure, and related economic factors across various contexts, particularly in African nations. Yakubu, Musah, and Danaa (2024) conducted a comprehensive study exploring the impact of environmental sustainability on government health expenditure in Africa, utilizing data from 43 countries over the period from 2000 to 2021. They employed the Generalized Method of Moments (GMM) technique and found a positive relationship between carbon dioxide (CO2) emissions, renewable energy consumption, and health expenditure. Conversely, their analysis revealed that economic growth, urbanization, and industrialization have negative impacts on health expenditure, while education positively influences it.

Similarly, Egbetokun et al. (2019) investigated the Environmental Kuznets Curve (EKC) within the context of Nigeria, focusing on the impact of institutional quality on various pollutants, including CO2 and suspended particulate matters (SPM). Utilizing the autoregressive distributed lag (ARDL) econometric technique, they identified the presence of an EKC for CO2 and SPM, reinforcing the idea that institutional quality plays a vital role in mediating health outcomes and environmental degradation. In line with these findings, Dhrifi (2018) explored the consequences of environmental degradation on health and institutional quality in 45 African countries during the period from 1995 to 2015. He employed the GMM method to analyze the data and argued that while environmental degradation has a detrimental effect on health, the quality of institutions positively influences health outcomes. This suggests that strengthening institutional frameworks can mitigate the adverse impacts of environmental degradation on public health.

Expanding the geographic scope, Taghizadeh-Hesary (2020) utilized panel vector error correction (VECM) and GMM methodologies to analyze data from ten Southeast Asian countries between 2000 and 2016. Their findings indicate that increases in

CO2 emissions from fossil fuels correlate with rising per capita health expenditures, whereas renewable energy usage correlates with decreases in such expenditures, suggesting that a transition to renewable energy can stabilize health expenditures while addressing environmental concerns. Gündüz (2020) further corroborated these perspectives by examining the impact of the U.S. carbon footprint on health expenditure using a hidden cointegration approach and a crouching error correction model from 1970 to 2016. His results established a long-run relationship, indicating that a 1% increase in the carbon footprint could lead to a corresponding 2.04% increase in health expenditure, highlighting the considerable economic burden that environmental degradation places on health systems.

Additionally, Oyelade et al. (2020) employed panel quantile regression to study the relationship between CO2 emissions and public health expenditure in English-speaking West African countries, including Nigeria, from 1990 to 2013. Their findings demonstrated that rising CO2 emissions consistently increase public health expenditures across the examined nations, aligning with prior studies that suggest environmental health directly impacts healthcare costs. Bouchoucha (2021) examined the relationship between environmental degradation, health, and institutional quality in 17 Middle Eastern and North African (MENA) countries, utilizing panel cointegration analysis. His study indicated that while environmental degradation negatively affects health in the long run, positive institutional quality can ameliorate these adverse effects, emphasizing the crucial role of governance in health and environmental sustainability.

Aligning with these insights, Akbar et al. (2021) investigated the interplay between health expenditure, CO2 emissions, and the Human Development Index (HDI) in 33 OECD countries from 2006 to 2016 using a panel Vector Autoregression (VAR) model. Their results confirmed a bilateral causal relationship, indicating that rising carbon emissions significantly drive health expenditure, underscoring the need for integrated policies that address both health and environmental concerns. Erdogan et al. (2020) utilized a causality panel test developed by Konya to assess the relationship between CO2 emissions and healthcare expenditures in BRICS countries and Turkey from 2000 to 2016. Their findings highlighted that only in China was there a significant unidirectional relationship from CO2 emissions to health expenditure, suggesting variations across different national contexts regarding the intersection of healthcare and environmental factors.

Similarly, Wang et al. (2019) analyzed data from Pakistan using the autoregressive distributed lag (ARDL) model to establish long-term relationships among health expenditure, CO2 emissions, and economic growth from 1995 to 2017. Their findings revealed a two-way causal relationship between health spending and both carbon emissions and economic growth, further advocating for a nuanced understanding of how economic and environmental factors interrelate.Atuahene et al. (2020) extended this analysis to China and India, employing the GMM model and finding that CO2 emissions positively impact healthcare expenditure while also showing that economic development negatively affects it. This highlights a complex dynamic whereby economic progress can strain healthcare budgets within rapidly developing economies. In a focused study on Nigeria, Ijbaw and Abubakar (2021) utilized time-series data and the ARDL approach to assess the interplay between health expenditure and environmental sustainability from 1995 to 2020, reaffirming the existence of a long-term relationship that advocates for strategic health investments in support of sustainability.

Other studies, such as those conducted by Khan and Haq (2023) and Mastorillo and Kaufmann (2020), continue to emphasize the critical role of institutional quality in health expenditure. Khan and Haq (2023) specifically highlighted that stronger institutions in Africa correlate positively with increased health spending. Extending this narrative, Olaniyan (2022) also contributed to this discourse by analyzing panel data to underscore significant interactions between health spending and environmental policy effectiveness, reiterating the necessity of integrated approaches for effective health and environmental management.

3. METHODOLOGY

To empirically examine the interactive effect of health expenditure and institutional quality on environmental sustainability in Nigeria, this study adopts the standard procedure of time series analysis. Specifically, the Autoregressive Distributed Lag (ARDL) model will be utilized. The variables of interest in this study include health expenditure, institutional quality indicator, environmental sustainability measurements and economic growth rate. By leveraging the ARDL methodology, this study aims to uncover the dynamic relationships and interactions among these variables, drawing inspiration from the methodologies used by Wang et al. (2019) in their analysis of health expenditure, CO2 emissions, and economic growth in Pakistan. This approach will facilitate a deeper understanding of how health investment and the effectiveness of institutions contribute to achieving environmental sustainability in Nigeria.

The functional specification is specified as follows;

[1] $CO2 = (HE, GE, HE*GE, GDPG,)$

The mathematical form of the model is thus represented as given in Equation [2]

[2] $CO2= \beta_O + \beta_1 HE + \beta_2 GE + \beta_3 HE*GE + \beta_4 GDPG$

The above model can also be stated in stochastic form as given in Equation [3]

[3] $CO2= \beta_O + \beta_1 HE + \beta_2 GE + \beta_3 HE*GE + \beta_4 GDPG + \mu$

Where:

CO2 = Carbon Emission proxied for environmental sustainability
HE = Health expenditure
GE = government effectiveness index proxied for institutional quality
HE*GE = is the interaction term between health expenditure and good governance
GDPG = real gross domestic product growth rate
μ= error term

The ARDL shown in Equation (4) has been developed based on Equation (1)

$$\Delta CO2_t = \alpha_0 + \sum_{i=1}^{p} \delta_i \Delta CO2_{t-1} + \sum_{k=0}^{p} \beta_k \Delta HE_{t-k} + \sum_{k=0}^{p} \theta_k \Delta GE_{t-k} + \sum_{l=0}^{p} \gamma_l \Delta HE * GE_{t-l} + \sum_{l=0}^{p} \gamma_l \Delta GDP_{t-l} + \lambda_2 HE_{t-1} + \lambda_3 GE_{t-1} + \lambda_4 HE * GE_{t-1} + \lambda_4 GDPG_{t-1} + \mu_t \quad [4]$$

Where α_0 refer to the autonomous component and white noise, respectively. The expression with the signs of summation in the equation is error correction. The parameter coefficients, δ, β,θ and γ denote the short run effects while lambda (λ) is the corresponding relationship in the long run.

4. RESULTS AND ANALYSIS

Table 1. Descriptive Statistics

	CO2	HE	GE	GDPG
Mean	1594920.	5426.647	10.11168	4.986000
Median	101945.3	358.3800	11.42900	5.310000
Maximum	37400000	125737.0	20.28300	15.33000
Minimum	76947.40	97.98000	4.010000	-1.790000
Std. Dev.	7459404.	25065.94	5.238388	3.567750
Skewness	0.094831	0.094074	0.041503	0.088263
Kurtosis	2.804152	2.703698	2.944815	2.426928
Jarque-Bera	510.2378	510.0186	1.645742	3.114301
Probability	0.100000	0.200000	0.439169	0.210736
Sum	39872998	135666.2	252.7920	124.6500
Sum Sq. Dev.	1.343422	1.547382	658.5771	305.4922
Observations	25	25	25	25

Source: Author's computation, using eview 10

The descriptive statistics presented in table 1, summarize the characteristics of four variables: CO2 emissions (CO2), health expenditure (HE), government effectiveness (GE), and GDP growth (GDPG), based on 25 observations each. The means for these variables indicate that CO2 averages around 1,594,920, HE is about 5,426.65, GE has an approximate average of 10.11, and GDPG stands at around 4.99. When we examine the median values, we see that they provide a different perspective, particularly for CO2, which has a median of 101,945.3, suggesting that the distribution might be highly skewed due to some very high values. HE's median is much lower than its mean, which may also imply significant variance in the data. The median for GE is 11.43, indicating a central tendency slightly higher than the mean, whereas GDPG has a median of 5.31, reflecting a fairly typical value compared to its mean.

Looking at the extremes, CO2 has a maximum of 37,400,000 and a minimum of 76,947.4, demonstrating significant variability. HE ranges from a minimum of 97.98 to a maximum of 125,737, while GE varies between 4.01 and 20.28. GDPG exhibits a minimum of -1.79, which is notable as it implies negative growth in certain observations.The standard deviations indicate how much variation exists from the mean; CO2's standard deviation is remarkably high at 7,459,404, suggesting a vast spread in CO2 values. HE also exhibits substantial variation, with a standard deviation of 25,065.94, while GE and GDPG have lower variations, reflecting more consistency. The skewness values are all near zero, with CO2, HE, GE, and GDPG showing slight positive skewness, implying a distribution that leans slightly towards the right. The kurtosis values, all below 3, suggest that the distributions are relatively flat compared to a normal distribution. The Jarque-Bera test statistic indicates that there is not enough evidence to reject the null

hypothesis of normality for HE and GE, as their probabilities are greater than 0.05. However, CO2 and GDPG present a stronger case against normality, though still not conclusively.

Table 2: Results of Unit Root Test

Variables	ADF	Critical Values	Probability (5%)	Order od integration
CO2	-5.246241	-1.955681	0.0000	I(0)
HE	-6.042115	-1.956406	0.0000	I(1)
GE	-5.938729	-2.998064	0.0001	I(1)
GDPG	-6.887861	-2.998064	0.0000	I(1)

Source: Author's computation, using eview 10

Table 2 presents the results of the Augmented Dickey-Fuller (ADF) unit root test, which examines the stationarity of each variable in the model. The variable CO2 has an ADF test statistic of -5.246241, which is more negative than the 5% critical value of -1.955681, with a probability of 0.0000. This indicates that CO2 is stationary at level and is therefore integrated of order zero, I(0). Health expenditure (HE) has an ADF statistic of -6.042115, which is lower than the 5% critical value of -1.956406, with a probability of 0.0000. Despite the strong evidence of stationarity, the result corresponds to the first differenced series, suggesting that HE was non-stationary at level and became stationary only after differencing, indicating it is integrated of order one, I(1). Similarly, government expenditure (GE) has an ADF statistic of -5.938729, which is also more negative than the 5% critical value of -2.998064, and a probability of 0.0001. This result implies that GE is stationary after first differencing and is thus integrated of order one, I(1).GDP growth (GDPG) records an ADF statistic of -6.887861, which is significantly lower than the 5% critical value of -2.998064, with a p-value of 0.0000. This confirms that GDPG becomes stationary after first differencing, making it an I(1) series.

ARDL Bound Test result

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	8.114648	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Source: Author's computation, using eview 10

At the 5% significance level, the lower bound (I(0)) is 2.56 and the upper bound (I(1)) is 3.49. Since your F-statistic of 8.1146 is greater than the upper bound at all conventional levels of significance (1%, 2.5%, 5%, and 10%), you reject the null hypothesis. This means there is strong evidence of a long-run equilibrium relationship between CO_2 emissions and the independent variables (HE, GE, GE_HE, GDPG). In other words, despite short-term fluctuations, these variables move together in the long run and are cointegrated.

Table 3: Short run ARDL result
Dependent Variable CO2

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2(-1)*	-1.487102	0.580908	-2.559962	0.0227
D(HE)	-287.3731	36.36210	-7.903096	0.0000
D(HE(-1))	128.8636	29.34236	4.391727	0.0006
D(GE)	-7114.972	2316.563	-3.071348	0.0003
D(GE_HE)	-28.87700	1.789720	-16.13493	0.0000
D(GDPG)	909.2464	1818.060	0.500119	0.2248
ECM(-1)*	-1.487102	0.182944	-8.128740	0.0000

Source: Author's computation, using eview 10

The short-run ARDL results in Table 3 assess how selected variables influence CO_2 emissions in the short run, with a particular focus on government effectiveness and health expenditure. The lagged value of CO_2 emissions ($CO_2(-1)$) has a coefficient of -1.4871 and is statistically significant (p = 0.0227), implying that the system exhibits a tendency to return to equilibrium after a shock. Health expenditure (D(HE)) significantly reduces CO_2 emissions in the short run, as indicated by its large negative coefficient of -287.3731 (p = 0.0000). Interestingly, the lagged effect of health expenditure (D(HE(-1))) is positive and significant (128.8636, p = 0.0006), suggesting that while immediate health spending reduces emissions, its past values might partially reverse that effect.
Government effectiveness (D(GE)) also exerts a strong and statistically significant negative effect on CO_2 emissions, with a coefficient of -7114.972 (p = 0.0003), indicating that improved government institutions and regulatory frameworks contribute to environmental improvement. The interaction term between government effectiveness and health expenditure (D(GE_HE)) has a negative and highly significant coefficient of -28.8770 (p = 0.0000), which implies that when both government effectiveness and health expenditure increase simultaneously, they reinforce each other in reducing emissions. This suggests a synergistic relationship where effective governance enhances the environmental impact of health-related investments. GDP growth (D(GDPG)) has a positive but insignificant effect on emissions (909.2464, p = 0.2248), showing that short-run changes in economic growth do not meaningfully influence CO_2 levels. The error correction term (ECM(-1)) is significantly negative (-1.4871, p = 0.0000), confirming a stable long-run relationship and indicating a rapid adjustment back to equilibrium after short-run disturbances.

Table 4: Long run ARDL Result
Dependent variable: CO2

Variable	Coefficient	Std. Error	t-Statistic	Prob.
HE	-289.9064	109.4194	-2.649496	0.0190
GE	-4784.454	2217.562	-2.157529	0.0488
GE_HE	-26.01670	8.938716	2.910563	0.0114
GDPG	611.4216	1321.168	0.462789	0.6506
C	149605.8	25461.53	5.875759	0.0000

Source: Researcher's Computation using Eviews 10

The long-run ARDL results presented in Table 4 examine the sustained effects of health expenditure (HE), government effectiveness (GE), their interaction (GE_HE), and GDP growth (GDPG) on CO_2 emissions. Health expenditure has a negative and statistically significant coefficient of -289.9064 (p = 0.0190), indicating that higher spending on health is associated with a reduction in CO_2 emissions over the long term. This suggests that investments in public health may contribute to environmental improvements, possibly through enhanced public awareness, better health infrastructure, or reduced pollution-related health burdens.
Government effectiveness also shows a significant and negative impact on CO_2 emissions, with a coefficient of -4784.454 (p = 0.0488). This implies that effective governance — likely through better regulatory enforcement, institutional quality, and policy implementation — plays a critical role in reducing environmental degradation. Notably, the interaction term between government effectiveness and health expenditure (GE_HE) is negative (-26.0167) and statistically significant (p = 0.0114), reinforcing the idea that combining effective institutions with health sector investments can have a compounded positive effect on the environment. Conversely, GDP growth (GDPG) has a positive but statistically insignificant effect (coefficient = 611.4216, p = 0.6506), suggesting that economic growth does not significantly influence CO_2 emissions in the long run within this model. The constant term is large and significant, indicating the base level of CO_2 emissions when all explanatory variables are zero.

Table 5: Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.774011	Prob. F(15,14)	0.8018
Obs*R-squared	18.20801	Prob. Chi-Square(15)	0.3874
Scaled explained SS	7.368098	Prob. Chi-Square(15)	0.8707

Source: Researcher's Computation using Eviews 10

The Serial Correlation Test results show that there is no significant autocorrelation in the residuals of the ARDL model. The F-statistic of 8.121132 and a p-value of 0.1002, along with the Obs*R-squared value of 14.23111 and a p-value of 0.1027, suggest that we fail to reject the null hypothesis of no serial correlation. This indicates that the residuals are independent over time, meaning there is no substantial autocorrelation present. This is a favorable outcome, as the absence of serial correlation ensures that the model's residuals are well-behaved, avoiding issues such as inefficient estimates or biased results.

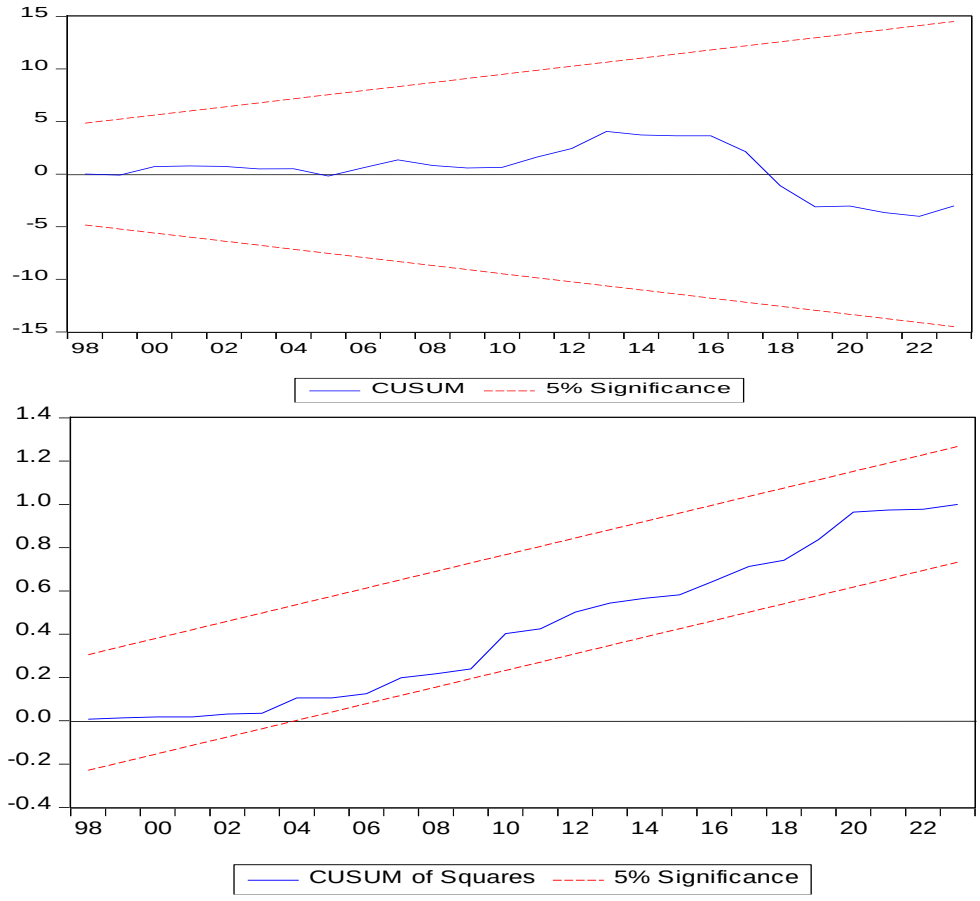
Table 6: Serial Correlation Test

F-statistic	8.121132	Prob. F(2,12)	0.1002
Obs*R-squared	14.23111	Prob. Chi-Square(2)	0.1027

Source: Researcher's Computation using Eviews 10

The results from the Serial Correlation Test indicate that there is no significant autocorrelation in the residuals of the ARDL model. The F-statistic of 8.121132 with a p-value of 0.1002 and the Obs*R-squared value of 14.23111 with a p-value of 0.1027 both suggest that the null hypothesis of no serial correlation cannot be rejected. This implies that the residuals of the model are independent over time, which is a positive outcome, as serial correlation in residuals could lead to inefficient estimates and biased inferences. Therefore, the model's residuals appear to be well-behaved in terms of autocorrelation.

Fig 1 Stability test



The results from the stability test (Figure 1) indicate that the ARDL short-run model is stable and has passed all diagnostic tests. Both the CUSUM (Cumulative Sum) and CUSUMSQ (Cumulative Sum of Squares) tests show no evidence of autocorrelation at the 5 percent level of significance. This suggests that the model's parameters remain stable over time, and the residuals do not exhibit systematic patterns, ensuring reliable and consistent estimates for both short-run and long-run relationships.

5. CONCLUSION AND RECOMMENDATION

The empirical findings from both the short-run and long-run ARDL models highlight the critical role of health expenditure and government effectiveness in reducing carbon dioxide (CO_2) emissions. In both the short and long term, increased health expenditure significantly lowers emissions, suggesting that public health investments contribute to environmental sustainability. Similarly, government effectiveness has a consistent negative impact on CO_2 emissions, emphasizing the importance of institutional quality and efficient governance in environmental protection. The interaction between government effectiveness and health expenditure further strengthens these effects, indicating that good governance enhances the environmental returns of health-related spending. However, economic growth appears to have no significant impact on CO_2 emissions in either the short or long run, suggesting that growth alone is insufficient to drive environmental improvements without complementary institutional and sectoral support. This therefore recommend that government should Strengthen institutional frameworks to ensure that governance structures effectively

support environmental regulation and enforcement, thereby maximizing the environmental benefits of public sector investments, particularly in health as well as Prioritize environmentally conscious health investments, such as green healthcare infrastructure and pollution prevention initiatives, to leverage the dual benefits of public health improvement and emission reduction.

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