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Moderating Role of Remittance Inflows in Testing the Validity of Ecological Footprint-Induced Environmental Kuznets Curve (EKC) Hypothesis in Nigeria: An ARDL bound testing approach

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Abstract. The paper tests the validity of ecological footprint induced-environmental Kuznets curve (EKC) hypothesis by considering the moderating role of remittance inflows in environmental quality - economic growth nexus in the context of Nigeria from 1980 to 2022. The study employed an ARDL bound testing approach, the results of both the short and long-run revealed that the coefficients of economic growth (GDP) and economic growth squared (GDP^2) is significantly positive and negative respectively. This indicates an inverted U-shaped relationship between environmental degradations and economic growth thereby authenticating the validity of the EKC hypothesis in Nigeria. Furthermore, remittance inflows exert a negative and significant impact on environmental quality in the short-run but the coefficient is insignificant in the long-run. The interactive term of GDP and remittance inflows exert a positive and significant impact on environmental degradations in the short-run thereby revealing a complementary role by both the two variables in deteriorating the environment in the short-run, although the coefficient is insignificant in the long-run. The interactive between squared GDP and remittance inflows revealed a negative significant impact on environmental pollution thereby indicating a substitutability role by the two variables in improving the quality of the environment. Based on the findings, it is recommended that government should invests in research and development (R&D) on green energies and environmentally friendly technologies. personal remittances received should be channeled toward financing environmentally friendly businesses for environmental sustainability in Nigeria.

Keywords: Ecological Footprint-Induced, Environmental Kuznets Curve, and Nigeria

1. Introduction

Environmental deterioration and global warming brought on by GHG emissions are currently the two main problems facing the world. The quest for economic growth has led to a sharp rise in GHG emissions had let to carbon emissions and global warming. Such changes have a significant impact on human well-being, the sustainability of forests, and the functioning of the ecosystem (Jakada, Mahmood, Ahmad, Farouq, & Mustapha, 2020). A number of global events has taken place to creates environmental awareness around the world among which includes the 1997 Kyoto Climate Change Conference.

Despite the fact that, GHG and carbon dioxide (CO2) emissions are thought to be the primary contributors to climate change and global warming, a number of other environmental issues, such as water pollution and forest degradation, also have a significant role. The ecological footprint, which measures the biologically productive regions required for human consumption, is a thorough indicator of environmental degradation. While EF denotes the number of resources demanded by humans, biocapacity refers to the biosphere's capacity to reproduce to provide this demand.

The state of economic development is a significant element in environmental degradation. More specifically, there is a concern about the ecological and environmental cost of economic progress. Grossman and Krueger (1991) conducted the first study to examine the inverted U-shaped link between

numerous environmental pollution indicators and economic development. The authors' research led to the conclusion that, the inverted U-shaped relationship (EKC hypothesis) holds true for suspended particles, dark matter, and sulfur dioxide. This link suggests that as development levels rise, environmental pollution initially climbs as well, and that after a certain point, as economic development increases, environmental deterioration decreases (Pata, 2021). While the notion of Environmental Kuznets Curve (EKC), which relates economic development to pollution, is well established, there is controversy about its shape, incidence and determinants.

On the other hand, remittances are another likely source that contributes to environmental degradation globally. Although a number has found conflicting results, remittance inflows, are noted to be a significant source of foreign direct investment (FDI) (Yoshino 2020), economic growth (Islam & Alhamad, 2022), and financial development (Donou-Adonsou et al. 2020), which are regarded as a key factor in determining the quality of the environment. Additionally, several academics have claimed that remittances assist financial development by increasing the available capital in a credit form for small businesses (Yoshino et al. 2020; Bhattacharya et al. 2018;). The relationship between remittances and CO2 emissions has been examined in a number of research. (Yang et al. 2020, 2021, Mahalik et al. 2021, Villanthenkodath & Mahalik 2022, Ahmad et al. 2019, Elbatanony et al. 2021). There are two main effects on the environment from the increase in remittances. According to Khan et al. (2020), Qingquan et al. (2020), Yang et al. (2021b) and Jamil et al. (2021), Remittances would have a negative impact on environmental quality due to large CO2 emissions if they were used to finance high-polluting industries and carbon-intensive goods, such as cars and air conditioners, among other things. In contrast, remittances would have a positive impact on environmental quality through low CO2 emissions if the influxes of remittances are used to finance green energy and ecologically safe technology (Li et al., 2022). More significantly, Usman & Jahanger (2021) discovered that remittances depend on how well the domestic countries' institution's function. Therefore, due to the technique impact of the EKC hypothesis, effective and stable political systems and institutions would receive more remittances that spur economic growth, thereby boosting the environmental quality.

There are limited studies that examines the moderating role of remittances' inflow on environmental sustainability using ecological footprints as a proxy for environmental degradation. Hence, it is imperious to study the moderating role of remittances inflow on the influence of economic growth on environmental quality in the context of Nigeria and help policymakers in more realistic ecological planning to enhance environmental performance.

Hence, the main purpose of this study is to test the validity of ecological footprint induced-environmental Kuznets Curve (EKC) hypothesis in the context of Nigeria and find out whether remittances inflow moderate the influence of economic growth on environmental degradation in Nigeria.

2. Theoretical and Conceptual Framework

The Environmental Kuznets Curve (EKC) hypothesis postulates an Inverted-U-shaped relationship between different pollutants and per capita income, i.e., environmental pressure increases up to a certain level as income goes up; after that, it decreases. An EKC actually reveals how a technically specified measurement of environmental quality changes as the fortunes of a country change. Kuznets (1955) predicted that the changing relationship between per capita income and income inequality is an Inverted-U-shaped curve. As per capita income increases, income inequality also increases at first and then starts declining after a turning point. This relationship between income per capita and income inequality can be represented by a bell-shaped curve known as the environmental Kuznets curve (EKC). Grossman and Krueger (1991; Grossman and Krueger, 1993), pointed out that, an Inverted-U relationship between pollutants (SO2 and smoke) and income per capita. Kuznets' name was attached to the Inverted-U relationship between pollution and economic development.

2.1 Empirical Literature Review

2.1.1 Literature on the Environmental Kuznets Curve (EKC) hypothesis

In his study Pata (2018) found out that, there is a significant relationship between economic growth, urbanization and financial development, causes larger CO2 emissions. While consumption of renewable energy is insufficient for reduction in CO2 emissions. In the same vein, Ozigbou (2019) found the existence of a relationship between environmental degradation in Nigeria and growth-carbon dioxide emissions. This have revealed to have an inverted U-shape, supporting the validity of the EKC theory. On the other hand, Agala & Eke (2019) found no evidence of the Kuznets hypothesis in Nigeria using the ARDL technique, which suggests a monotonically growing link between

carbon dioxide emissions and economic development, especially in the short run. While kwuemeka et al. (2019) evaluate the macroeconomic factors influencing Nigeria's CO2 emissions and found that, the environment-economic relationship invalidates the validity of the EKC. furthermore, Adebayo (2021) looks into the long-term and causal impacts of trade openness, and economic growth on CO2 emissions and found economic growth and energy has positively influence CO2 emissions.

Furthermore, Iorember et al. (2020) in their study have found that, use of renewable energy and environmental quality show that, the use of renewable energy enhances environmental quality but financial development degrades it.

2.1.2 Remittances inflow and environmental Quality nexus

A study by Afawubo and Noglo (2019), argued that, remittances lessen deforestation in poor nations, with middle-income nations seeing the greatest effects. He submitted that, remittances and CO2 emissions have an asymmetric cointegrating relationship. Positive shocks increase emissions while negative shocks decrease them. In a similar study, Yang, Jahanger, and Khan (2020) found that, remittances and energy consumption boost CO2 emissions, but globalization has negative effects on CO2 emissions. In contrast, Khan, Ahmad, & Khan, (2020) revealed that, while FDI has a positive influence on the economics of these countries, remittances cause environmental damage in all except India where it shows an inverse relationship. Furthermore, Usman and Jahanger (2021) discovered a significant relationship between remittances and institutional has significant effect on environmental sustainability, financial development, energy consumption. While trade openness negatively affects environmental quality thereby authenticating the EKC theory. Elbatanony et al. (2021) study shows an inverted N-shaped EKC, indicating that remittances motivate households to switch to sustainable energy practices.

Salem (2021) used the NSD-ARDL model in the US from 1985 to 2020 and revealed that the EKC hypothesis is valid based on the results. Urbanization, globalization, energy use, and financial development are further factors that lower environmental quality. Instead, institutional quality improves environmental quality by reducing CO_2 emissions. Using AARDL and VECM techniques, Karasoy (2021) in the Philippines from 1977 to 2016 demonstrated a U-shaped relationship between income and environmental deterioration, showing how environmental issues are worsen by economic growth. Remittance inflows positively impact on environmental degradation but globalization has no discernible effect on the environment. In order to study the effect of remittances on CO2 emissions in five nations from 1980 to 2016, Wang et al. (2021) used ARDL to indicate that while improved financial systems and the, economic expansion result in higher CO2 emissions, increasing remittances, economic growth, and value-added agriculture assist reduce emissions. The influx of remittances and the value added to agriculture, in short-run, are associated with considerable increases in CO2 emissions, whereas the effects of financial development, economic expansion, and value added to industry are negligible. In a separate study, a second-generation technique is employed by Yang et al. (2021) to examine how remittances inflow affect environmental quality in BRICS economies from 1990 to 2016. They found that remittances inflow and financial development have a detrimental influence on environmental quality, whereas technological advancements have a positive impact on reducing ecological footprint. However, the interaction term reveals a significantly negative impact on EF.

Villanthenkodath and Mahalik (2022) demonstrated a long-term atmospheric emission in India from 1980 to 2018, while remittances and carbon dioxide emissions have a U-shaped association. Using FMOLS and PDOLS in G-20 nations from 1990 to 2019, Jamil et al. (2022) discovered that CO_2 emissions are favorably correlated with economic growth but negatively correlated with renewable energy, while trade openness has no effect on CO_2 emissions in G-20 nations, financial development and remittances significantly impact CO_2 emissions. The NARDL method is used by Kibria, (2022) to analyze how remittance inflows affected Bangladesh's environmental degradation between 1980 and 2016 utilizing foreign aid as a carbon dioxide multiplier. The findings indicate a long-run causal relationship between remittance and CO_2 emissions, with CO_2 emissions rising over time as a result of remittance shocks. Over time, foreign aid raises environmental standards.

Li et al. (2022) employed a NARDL model and submitted that both positive and negative FDI shocks lower long-term CO_2 emissions but negative remittance shocks have a more negative environmental impact in China from 1981 to 2019. Using NARDL in China from 1981 to 2019, Afaq et al. (2022) revealed that a decrease in remittances provides both short- and long-term benefits for CO_2 emissions. We discovered that both positive and negative changes in FDI have a positive impact on

CO_2 emissions, with a positive change having a longer-term impact than a negative change. Islam (2022) Study uses panel data from the top eight remittance-receiving countries, the GLS method, and the PMG, according to GLS estimation remittances reduce CO_2 emissions, whereas FD increases pollution. PMG confirm the robustness by showing the same results. In order to investigate the dynamic link between remittance inflow, FDI, and EF in the top ten remittance-receiving counties using the EKC hypothesis, Zhang et al. (2022) used CUP-FM and CUP-BC estimators. outcomes suggest the PHH and inverted U-shaped EKC hypotheses are supported by remittances, foreign direct investment, and non-renewable energy, but renewable energy has a negative influence on EF. The N-shaped environmental Kuznets curve hypothesis is valid for all quantiles. Aljadani et al. (2023) examines environmental degradation and remittance inflows in top ten economies using panel quantile regression method from 1980-2018. Results from the PQR model reveal Rem, FD, and technology significantly impact environmental mitigation in top ten remittance-receiving economies. Interaction effects reveal negative effects on environmental degradation.

3. Methodology

3.1 Estimations Techniques

Autoregressive Distributions Lagged (ARDL) Model is used as the techniques for estimations and analysis.

3.2 Data Sources and Variables Measurements

This study uses ecological footprints (EF) as indicator of environmental quality and GDP which stands for gross domestic products indicate economic growth, while squared of gross domestic products (GDP2) is used to measure the validity of EKC hypothesis. The EKC hypothesis is only valid, if the coefficients of GDP and GDP squared is positive and negative respectively. Remittance inflows (RMI) as moderating variables on gross domestic product (GDP).

Time series data on the variables are secondary and is sourced from the followings:

Ecological footprints (EF) will be sourced from Global Footprint Network (GFN) while data on other variables are sourced from World Bank (1998) World Development Indicator (WDI).

3.3 Model specification

EF= f (GDP, GDP^2, RMI, GDP*RMI, GDP^2*RMI)

$$InEF = B_0 + B_1 InGDP_t + B_2 InGDP_t{}^2 + B_3 InRMI_t + B_4 InGDP_t * InRMI_t + lnGDP2 * lnRMI + \varepsilon_t$$

The above equation is used in testing the validity of the EKC hypothesis and the moderating role of remittances inflows on environmental degradation using ecological footprints as a proxy.

The ARDL framework for this study is formulated from equation (2) as follows:

$$\Delta EF = \beta_0 + \sum_{i=1}^{t} \beta_1 \Delta EF_{2t-1} + \sum_{i=1}^{t} \beta_2 \Delta GDP_{t-1} + \sum_{i=1}^{t} \beta_3 GDP^2{}_{t-1} + \sum_{i=1}^{t} \beta_4 RMI_{t-1} + \sum_{i=1}^{t} \beta_5 GDP * RMI_{t-1} + \sum_{i=1}^{t} \beta_6 GDP^2 * RMI_{t-1} + \beta_1 EF_{2t-1} + \beta_2 GDP_{t-1} + \beta_3 GDP^2{}_{2t-1} + \beta_4 RMI + \beta_5 GDP * RMI_{t-1}$$

Where the first difference is depicted by Δ. The variables coefficients in the long-run are illustrated by β_1……5. After the long-run relationship has been confirmed, the short-run linkage is examined by utilizing the error correction model (ECM) by Engle and Granger (1987) for the analysis of the short-run coefficients and the error correction term (ECT). This is achieved by incorporating the ECM to the ARDL framework for the model as follows:

$$\Delta EF_{2t} = \beta_0 + \sum_{i=1}^{t} \beta_1 \Delta EF_{2t-1} + \sum_{i=1}^{t} \beta_2 \Delta GDP_{t-1} + \sum_{i=1}^{t} \beta_3 GDP^2{}_{t-1} +$$

$$\sum_{i=1}^{t} \beta_4 \Delta RMI_{t-1} + \sum_{i=1}^{t} \beta_5 \Delta GDP * RMI_{t-1} + \sum_{i=1}^{t} \beta_6 GDP^2 * RMI_{t-1} + ECT_{t-1} + \varepsilon_t$$

4. Results and Discussion

4.1 Tables or Figures showing results

Table 1: ADF and PP Unit root test results

	In Level		In first Difference		PP	ADF
Variables	ADF	PP	ADF	PP	Decision	
LNEF	-1.173617 (0.9031)	-1.07539 (0.9213)	-7.464415 (0.0000)	-7.416708 (0.0000)	I (1)	I (1)
LNGDP	-2.309777 (0.4193)	-3.783942 (0.0274)	-3.278670 (0.0227)	-4.20951 (0.0097)	I (0)	I (1)
$LNGDP^2$	-2.284820 (0.4321)	-3.751294 (0.0296)	-3.256876 (0.0239)	-4.19139 (0.0102)	I (0)	I (1)
LNRMI	-1.824515 (0.6749)	-1.82452 (0.6749)	-7.342951 (0.0000)	-7.290903 (0.0000)	I (1)	I (1)
LNGDP*RMI	-1.847520 (0.6635)	-1.84752 (0.6635)	-7.340447 (0.0000)	-7.289211 (0.0000)	I (1)	I (1)
$LNGDP^2$*RMI	-1.275632 (0.6320)	-1.871618 (0.6413)	-7.336533 (0.0000)	-7.303193 (0.0000)	I (1)	I (1)

Source: *Analysis, 2023*

Table 1 present the ADF and PP unit root test. from the results it clearly indicates that all the variables used in the investigations are stationary at mixed order, that is some are integrated of order I (0) while others are integrated at order I (1). When ADF unit root test is employed all the variables are stationary at level meaning series are integrated of I (1) but when phillips perron is used, two of the variables are stationary at level (lnGDP and lnGDP2). Since it has satisfied the pre-requisite conditions for ARDL, then the cointegration test is examined using the ARDL bound testing approach proposed by pesaran et al (2001). The results from the table 2 revealed a long-run relationship among the variables in the model estimated. This is true because the F-statistic value (4.83) is greater than the lower (3.06) and the upper (4.15) bound critical values at 1% level of significance.

Table 2: ARDL Bound Test

Model Estimated		
LNEF=f(lnGDP,lnGDP2, lnRMI,lnGDP*lnRMI,GDP2*RMI)	(1, 0, 0, 3, 2, 2)	
F-statistics	4.83	
Cointegration	Yes	
Significance Level	L-B I (0)	U-B I (1)
1%	3.06	4.15
5%	2.39	3.38
10%	2.08	3

Source: *Analysis, 2023*

Thus, the null hypothesis of no cointegration is rejected and the alternative view of the existence of a long-run nexus among the co-variates is validated. This result provides the ground for the estimations of the short and long-run ARDL outcomes in table three.

Table 3 depicts the ARDL short and the long-run estimations to verify the validity of the EKC hypothesis in the context of Nigeria. Based on the AIC, the number of lags for ecological footprint, economic growth, economic growth squared, the interactive terms of economic growth squared & remittance inflows and economic growth & remittance

inflows and the remittance inflows was 1, 0, 0, 3, 2 and 2 respectively. The natural logarithm form was used for each variable in this model, the coefficients reported in table 3 above indicated elasticity or the coefficients were interpreted as the percentage change in the dependent variable for each percentage change in the independent variables.
The speed of adjustment is negative and statistically significant, suggesting that any equilibrium distortion in ecological footprint would be corrected at the rate of 78.3%. The adjusted R- squared, which reached 98% indicated that the model constructed was sufficiently strong.

Table 3: ARDL short and long-run estimations.

Variables	Coefficient	Std.Error	t-statistic	Prob
SHORT RUN RESULTS				
D(LNGDP)	18.216418***	5.633076	3.233831	0.0033
D(LNGDP^2)	-0.782780***	0.247309	-3.165183	0.0039
(LNGDP^2_RMI)	-0.561512***	0.186983	-3.003019	0.0058
D(LNGDP^2_RMI)	-0.000146***	0.000049	-2.994495	0.0060
D(LNGDP_LNRMI)	12.657631***	4.208970	3.007299	0.0058
D(LNRMI)	-71.340539***	23.686486	-3.011867	0.0057
CointEq(-1)	-0.783075	0.125754	-6.227050	0.0000
LONG RUN RESULTS				
LNGDP	22.787870***	5.837058	3.903999	0.0006
LNGDP^2	-0.980875***	0.258089	-3.800526	0.0008
LNGDP^2_RMI	-0.172485	0.262816	-0.656298	0.5174
LNGDP_LNRMI	3.929445	5.895742	0.666489	0.5110
LNRMI	-22.353069	33.064543	-0.676044	0.5050
C	-124.119853	33.003227	-3.760840	0.0009

*Note: ***, ** and * represent significance at 1%, 5% and 10% respectively.*
Source: *Analysis, 2023*

4.2 Statistical Interpretation of Results

Ecological footprints were estimated by the model to grow by 18.21% in the short run for every 1% increase in economic growth (GDP). But environmental degradation rises by 22.78% in the long-run due to 1% increase in economic growth (GDP). These two coefficients were statistically significant at 1% level. Furthermore, for economic growth squared variable, in the short run, ecological footprint would be reduced by 0.78% in the short run for every 1% increase in economic growth squared at 1% level of significance, and in the long run ecological footprint will drop by 0.98% at 1% significance level.

In the short run, the current, one-year and two-year lagged period values of remittances inflow has a negative and significant effect on environmental degradations. It shows that in every 1% increase in remittances inflow ecological footprint will drop by 71.34% at 1% significance level, but the coefficient of remittances inflow is positive and insignificant in the long run. Subsequently, the combined impact of economic growth and remittances inflow (GDP*RMI) on environmental quality is positive and significant in the short run. It implies that both variables contribute in increasing ecological footprint and that at every 1% increase in GDP*RMI, ecological footprint will rise by 12.65% with a significance level of 0.01. But the coefficient of GDP*RMI is negative and insignificant in the long run. Finally, the interactive term of squared GDP and remittance inflows exert a negative impact on environmental quality, it shows that at every 1% increase in (GDP^2*RMI) ecological footprint will decrease by 0.56% in the short-run at 1% significance level. This implies that the two variables play a substitutability role in improving the quality of the environment. But the coefficient of (GDP^2 *RMI) is insignificant in the long-run.

Table 4: Diagnostic Test Results

	Breusch-Godfrey Serial Correlation LM Test	
F-statistic	1.463068 Prob. F(2,26)	0.2500
Obs*R-squared	4.046355 Prob. Chi-Square(2)	0.1322
	Heteroskedasticity Test: Breusch-Pagan-Godfrey	

F-statistic	2.077863	Prob. F(11,28)	0.0581
Obs*R-squared	17.97725	Prob. Chi-Square(11)	0.0821
Scaled explained SS	8.659411	Prob. Chi-Square(11)	0.6533
Ramsey RESET Test t-statistic	Value	Df	Prob.
	0.374002	27	0.7113
F-statistic	0.139877	(1, 27)	0.7113

Source: *Analysis, 2023*

Testing for serial correlation, heteroskedasticity and stability of the model is paramount in time series analysis to ensure stable model and to avoid spurious inferences. The Breusch-Godfrey serial correlation LM test results in table 4 shows that the probability values (0.2500 and 0.1322) are greater than 0.05 levels of significance which imply that the null hypothesis of no serial correlation is accepted and it is concluded that the model has no serial correlation problem. Similarly, the Breusch-Pagan-Godfrey heteroskedasticity test result show that the probability values (0.0581, 0.0821 and 0.6533) are greater than 0.05 level of significance, and it implies that the null hypothesis of homoskedasticity is accepted and concluded that there is no problem of heteroskedasticity. The results of the CUSUM and CUSUMsq in figures 1 and 2 illustrate that the model is stable at a significance level of 5%.

Figure: 1

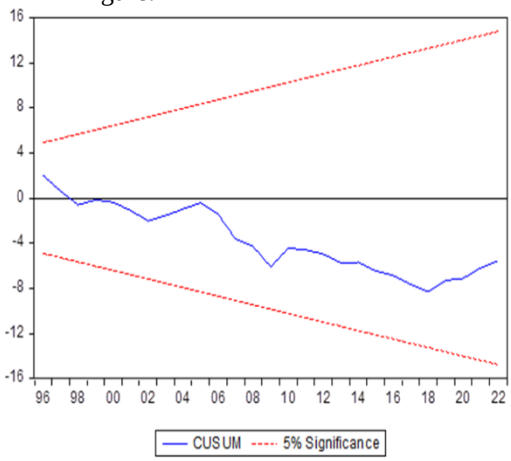
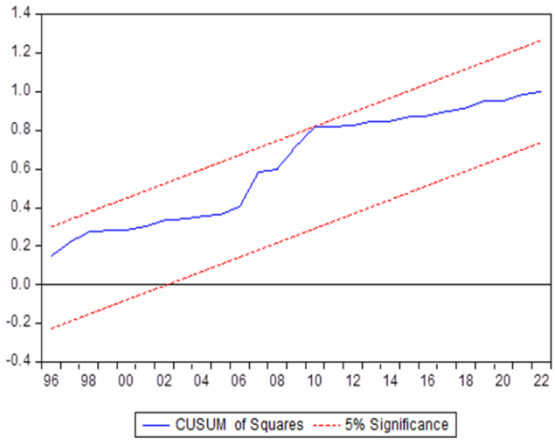


Figure 2



Source: *Analysis, 2023*

The result of Ramsey RESET test results reveal that the model is free of any specification errors.

5. Discussions of Findings

Using ARDL model, this study was conducted to investigate the validity of EKC hypothesis in Nigeria. Aside using GDP to measure economic growth relationship with environmental degradation, in this case referred to as ecological footprint. The study also examines the impact of remittances inflow and its moderating role on the influence of GDP on environmental quality.

Findings in both short and long run revealed that the coefficients of GDP and GDP2 is significantly positive and negative respectively indicating that environmental degradations are worsen with an increase in economic growth, but after a threshold of income environmental quality improves with an increase in economic growth. This result to an inverted U -shaped relationship between environmental degradation and economic growth in Nigeria, thereby validating the environmental Kuznets curve (EKC) hypothesis in Nigeria. This result is in line with the findings of Gokmenoglu & Taspinar (2018), Ozigbou (2019), Iorember et al. (2020), Musibau et al. (2021), Adebayo (2021), Pata (2021), Kahia et al. (2021), Adebayo (2021), Ali et al. (2021) and Yameogo & Dauda (2022). However, the result contradicts the findings of, Agala & Eke (2019), Koc & Bulus (2020), Yilanci & Pata (2020), Minlah & Zhang (2021) and Zhang (2021.

The coefficient of remittances inflow is significantly negative on ecological footprint in the short run implying that the personal remittance received might have been invested on cleaner energies and environmentally friendly businesses that improved environmental quality. This finding is similar with Afawubo & Noglo (2019), Usman & Jahanger (2021), Wang et al. (2021), Afaq et al. (2022), Islam (2022), But remittance inflow plays no impact in the long run. Furthermore, the interaction effect of economic growth and remittance inflows shows an increasing

relationship with environmental degradations. personal remittances received plays a vital role in increasing economic growth but the money may not have been adequately enough to reduce environmental pollutions. However, the combined effect of remittance inflows and economic growth is insignificant in the long run. Finally, the interactive term of (GDP^2*RMI) shows that the two variables play a substitutability role in improving the quality of the environment, meaning that in the absence of squared economic growth remittance inflows can help in improving the quality of the environment. But the coefficient is insignificant in the long-run.

6. Conclusion

Amidst the debate over the validity of the EKC hypothesis which refers to the impetus of environmental damage that converses into environmental improvement as an economy develops, this study is conducted to validate this hypothesis for the case of ecological footprint and also examined the role played by remittance inflow in the EKC analysis in Nigeria from 1980 to 2022 using ARDL bound testing approach. This analysis concludes that the relationship between environmental degradation and economic growth is inverted U-shaped, thus authenticating the EKC hypothesis in Nigeria in both the short and long-run.

Moreover, a significant negative relationship between remittance inflow and environmental quality in the short-run exist, which implies that the personal remittances received by households in Nigeria might have been invested in cleaner energies and environmentally friendly technologies which improves the quality of the environment, the interaction effect of remittance inflow and GDP is significantly positive in the short-run suggesting that both personal remittances received and economic growth (GDP) are playing complementary role in increasing ecological footprint thereby deteriorating the environment, although coefficient is insignificant in the long run. But the coefficient of the interactive term between squared GDP and environmental pollution has a negative and significant impact on environmental quality. This reveals a substitutability role in by the two variables in improving the quality of the environment.

Based on the findings of this study, it is recommended that Nigerian government should concentrate more, on policies that will grow the economy because the validity of the EKC means that environmental issues to some extend will automatically be solved with continued increase in economic growth. Also, government should invest in research and development (R&D) on cleaner energies and environmentally friendly technologies. Concerning the role played by remittance inflows in reducing ecological footprint which in turns improves environmental quality, government should channel the personal remittances received toward investing them on ecologically safe technologies in order to enhance environmental sustainability. It is imperative to know that this study has contributed to the environment literature by examining the moderating role of remittance inflows on economic growth – environmental quality nexus in Nigeria using robust proxy of ecological footprint to measure environmental degradation. Furthermore, this study has some limitations, because it only considered Nigeria and used aggregates EF to capture environmental quality. Further studies can complement this research for other developing economies and also investigate the effect on the six sub-components of EF (disaggregated).

References

Adebayo, T. S. (2021): Testing the EKC Hypothesis in Indonesia: Empirical Evidence from the ARDL-Based Bounds and Wavelet Coherence Approaches, (November 2020).

Adebayo, T. S. (2020). Revisiting the EKC hypothesis in an emerging market: an application of ARDL-based bounds and wavelet coherence approaches. *SN Applied Sciences*, 2(12), 1–15. Retrieved from https://doi.org/10.1007/s42452-020-03705-y

Agala, F. B., & Eke, F. A. (2019). Income Inequality, Environmental Degradation and Economic Development Nexus in Nigeria: Reassessing the Kuznets Hypothesis. *International Journal of Innovation and Applied Studies*, 27(4), 1014–1023. Retrieved from https://www.ijias.issr-journals.org/

Ahmad, M., Ul Haq, Z., Khan, Z., Khattak, S. I., Ur Rahman, Z., & Khan, S. (2019). Does the inflow of remittances cause environmental degradation? Empirical evidence from China. *Economic Research-EkonomskaIstrazivanja*,32(1),2099–2121.Retrieved from https://doi.org/10.1080/1331677X.2019.1642783

Ahmad, M., Ul Haq, Z., Khan, Z., Khattak, S. I., Ur Rahman, Z., & Khan, S. (2019). Does the inflow of remittances cause environmental degradation? Empirical evidence from China. Economic Research-Ekonomska Istrazivanja, 32(1), 2099–2121. Retrieved

from https://doi.org/10.1080/1331677X.2019.1642783

Ali, M. U., Gong, Z., Ali, M. U., Wu, X., & Yao, C. (2021). Fossil energy consumption, economic development, inward FDI impact on CO2 emissions in Pakistan: Testing EKC hypothesis through ARDL model. *International Journal of Finance and Economics*, 26(3), 3210–3221. Retrieved from https://doi.org/10.1002/ijfe.1958

Aljadani, A., Toumi, H., & Hsini, M. (2023). Exploring the interactive effects of environmental quality and financial development in top ten remittance-receiving countries: do technological effect matter? Environmental Science and Pollution Research, 30(19), 56930–56945. Retrieved from https://doi.org/10.1007/s11356-023-26256-2

Bhattacharya M, Inekwe J, Paramati SR (2018) Remittances and financial development: empirical evidence from heterogeneous panel of countries. Appl Econ 50:4099–4112. https://doi.org/10.1080/00036846.2018.144151.

Chukwuemeka, N., Chitedze, I., & Mourad, K. A. (2019). Science of the Total Environment An econometric analysis of the macroeconomic determinants of carbon dioxide emissions in Nigeria. *Science of the Total Environment*, 675, 313–324. Retrieved from https://doi.org/10.1016/j.scitotenv.2019.04.188

Donou-Adonsou F, Pradhan G, Basnet HC (2020) Remittance inflows and financial development: evidence from the top recipient countries in Sub-Saharan Africa. Appl Econ 52:5807–5820. https://doi.org/10.1080/00036846.2020.1776834.

Egbetokun, S., Osabuohien, E., Akinbobola, T., Onanuga, O. T., Gershon, O., & Okafor, V. (2020). Environmental pollution, economic growth and institutional quality: Exploring the nexus in Nigeria. *Management of Environmental Quality: An International Journal*, 31(1), 18–31. Retrieved from https://doi.org/10.1108/MEQ-02-2019-0050

Elbatanony, M., Attiaoui, I., Ali, I. M. A., Nasser, N., & Tarchoun, M. (2021). The environmental impact of remittance inflows in developing countries: evidence from method of moments quantile regression. *Environmental Science and Pollution Research*, 28(35), 48222–48235. Retrieved from https://doi.org/10.1007/s11356-021-13733-9

Haldar, A., & Sethi, N. (2021). Effect of institutional quality and renewable energy consumption on CO2 emissions−an empirical investigation for developing countries. Environmental Science and Pollution Research, 28(12), 15485–15503. Retrieved from https://doi.org/10.1007/s11356-020-11532-2

Islam, M. S. (2022). Do personal remittances cause environmental pollution? Evidence from the top eight remittance-receiving countries. Environmental Science and Pollution Research, 29(24), 35768–35779. Retrieved from https://doi.org/10.1007/s11356-021-18175-x

Islam, M. S., & Alhamad, I. A. (2022). Impact of financial development and institutional quality on remittance-growth nexus: evidence from the topmost remittance-earning economies. *Heliyon*, 8(12), e11860. Retrieved from https://doi.org/10.1016/j.heliyon.2022.e11860

Jakada, A. H., Mahmood, S., Ahmad, A. U., Farouq, I. S., & Mustapha, U. A. (2020). Financial development and the quality of the environment in Nigeria: An application of non-linear ARDL approach. *Research in World Economy*, 11(1), 78–92. Retrieved from https://doi.org/10.5430/rwe.v11n1p78

Karasoy, A. (2021). How do remittances to the Philippines affect its environmental sustainability? Evidence based on the augmented ARDL approach. Natural Resources Forum, 45(2), 120–137. Retrieved from https://doi.org/10.1111/1477-8947.12218

Khan, Z. U., Ahmad, M., & Khan, A. (2020). On the remittances-environment led hypothesis: Empirical evidence from BRICS economies. Environmental Science and Pollution Research, 27(14), 16460–16471. Retrieved from https://doi.org/10.1007/s11356-020-07999-8

Kibria, M. G. (2022). Environmental downfall in Bangladesh: revealing the asymmetric effectiveness of remittance inflow in the presence of foreign aid. Environmental Science and Pollution Research, 29(1), 731–741. Retrieved from https://doi.org/10.1007/s11356-021-15619-2

Koc, S., & Bulus, G. C. (2020). Testing validity of the EKC hypothesis in South Korea: Role of renewable energy and trade openness. *Environmental Science and Pollution Research*, 27(23), 29043–29054. Retrieved from https://doi.org/10.1007/s11356-020-09172-7

Koc, S., & Bulus, G. C. (2020). Testing validity of the EKC hypothesis in South Korea: Role of renewable energy and trade openness. *Environmental Science and Pollution*

Research, 27(23), 29043–29054. Retrieved from https://doi.org/10.1007/s11356-020-09172-7

Li, J., Jiang, T., Ullah, S., & Majeed, M. T. (2022). The dynamic linkage between financial inflow and environmental quality: evidence from China and policy options. Environmental Science and Pollution Research, 29(1), 1051–1059. Retrieved from https://doi.org/10.1007/s11356-021-15616-5

Li, K., Wang, X., Musah, M., Ning, Y., Murshed, M., Alfred, M., … Wang, L. (2022). Have international remittance inflows degraded environmental quality? A carbon emission mitigation analysis for Ghana. *Environmental Science and Pollution Research*, 29(40), 60354–60370. Retrieved from https://doi.org/10.1007/s11356-022-20094-4

Mahalik, M. K., Villanthenkodath, M. A., Mallick, H., & Gupta, M. (2021). Assessing the effectiveness of total foreign aid and foreign energy aid inflows on environmental quality in India. *Energy Policy*, 149(April), 112015. Retrieved from https://doi.org/10.1016/j.enpol.2020.112015

Mehmood, U., Tariq, S., Ul-Haq, Z., & Meo, M. S. (2021). Does the modifying role of institutional quality remain homogeneous in GDP-CO2 emission nexus? New evidence from ARDL approach. *Environmental Science and Pollution Research*, 28(8), 10167–10174. Retrieved from https://doi.org/10.1007/s11356-020-11293-y

Minlah, M. K., & Zhang, X. (2021). Testing for the existence of the Environmental Kuznets Curve (EKC) for CO2 emissions in Ghana: evidence from the bootstrap rolling window Granger causality test. *Environmental Science and Pollution Research*, 28(2), 2119–2131. Retrieved from https://doi.org/10.1007/s11356-020-10600-x

Musibau, H. O., Shittu, W. O., & Ogunlana, F. O. (2021). The relationship between environmental Zdegradation, energy use and economic growth in Nigeria: new evidence from non-linear ARDL. *International Journal of Energy Sector Management*, 15(1), 81–100. Retrieved from https://doi.org/10.1108/IJESM-04-2019-0016

Pata, U. K. (2021). Renewable and non-renewable energy consumption, economic complexity, CO2 emissions, and ecological footprint in the USA: testing the EKC hypothesis with a structural break. *Environmental Science and Pollution Research*, 28(1), 846–861. Retrieved from https://doi.org/10.1007/s11356-020-10446-3

Pata, U. K., & Aydin, M. (2020). Testing the EKC hypothesis for the top six hydropower energy-consuming countries: Evidence from Fourier Bootstrap ARDL procedure. *Journal of Cleaner Production*, 264, 121699. Retrieved from https://doi.org/10.1016/j.jclepro.2020.121699

Pata, U. K., & Caglar, A. E. (2021). *Investigating the EKC hypothesis with renewable energy consumption, human capital, globalization and trade openness for China: Evidence from augmented ARDL approach with a structural break. Energy* (Vol. 216). Elsevier Ltd. Retrieved from https://doi.org/10.1016/j.energy.2020.119220

Rana, R., & Sharma, M. (2018). Dynamic causality testing for EKC hypothesis, pollution haven hypothesis and international trade in India. *The Journal of International Trade &Economic Development*, 0(0), 1–17. Retrieved from https://doi.org/10.1080/09638199.2018.1542451

Solarin, S. A., & Al-Mulali, U. (2018). Influence of foreign direct investment on indicators of environmental degradation. *Environmental Science and Pollution Research*, 25(25), 24845–24859. Retrieved from https://doi.org/10.1007/s11356-018-2562-5

Usman, M., & Jahanger, A. (2021). Heterogeneous effects of remittances and institutional quality in reducing environmental deficit in the presence of EKC hypothesis: A global study with the application of panel quantile regression (Environmental Science and Pollution Research, (2021), 28, 28, (37292-37310), 10.1007/s11356-021-13216-x). *Environmental Science and Pollution Research*, 28(28), 37311. Retrieved from https://doi.org/10.1007/s11356-021-13791-z

Usman, O., Iorember, P. T., & Olanipekun, I. O. (2019). Revisiting the environmental kuznets curve (EKC) hypothesis in India: The effects of energy consumption and democracy. *Environmental Science and Pollution Research*, 26(13), 13390–13400. Retrieved from https://doi.org/10.1007/s11356-019-04696-z

Villanthenkodath, M. A., & Mahalik, M. K. (2022). Technological innovation and environmental quality nexus in India: Does inward remittance matter? *Journal of Public Affairs*, 22(1). Retrieved from https://doi.org/10.1002/pa.2291

Wawrzyniak, D., & Doryń, W. (2020). Does the quality of institutions modify the economic

growth-carbon dioxide emissions nexus? Evidence from a group of emerging and developing countries. Economic Research-Ekonomska Istrazivanja, 33(1), 124–144. Retrieved from https://doi.org/10.1080/1331677X.2019.1708770

Yameogo, C. E. W., & Dauda, R. O. S. (2022). The effect of income inequality and economic growth on environmental quality: A comparative analysis between Burkina Faso and Nigeria. *Journal of Public Affairs*, 22(3). Retrieved from https://doi.org/10.1002/pa.2566

Yang, B., Jahanger, A., & Ali, M. (2021). Remittance inflows affect the ecological footprint in BICS countries: do technological innovation and financial development matter? *Environmental Science and Pollution Research*, 28(18), 23482–23500. Retrieved from https://doi.org/10.1007/s11356-021-12400-3

Yoshino, N., Taghizadeh-hesary, F., & Otsuka, M. (2020). Determinants of international remittance inflow in Asia-Pacific middle-income countries. *Economic Analysis and Policy*, 68, 29–43. Retrieved from https://doi.org/10.1016/j.eap.2020.08.003

Zhang, J. (2021). Environmental Kuznets Curve Hypothesis on CO2 Emissions: Evidence for China. *Journal of Risk and Financial Management*, 14(3), 93. Retrieved from https://doi.org/10.3390/jrfm14030093