Environmental Science and Pollution Research (2022) 29:60426–60439
https://doi.org/10.1007/s11356-022-20180-7

RESEARCH ARTICLE

Impacts of globalization and energy consumption on environmental degradation: what is the way forward to achieving environmental sustainability targets in Nigeria?

Seyi Saint Akadiri[1] · Tomiwa Sunday Adebayo[2] · Musa Nakorji[1] · Wilfred Mwakapwa[1] · Eshiozemhe Micheal Inusa[1] · Oji-Okoro Izuchukwu[1]

Received: 5 October 2021 / Accepted: 6 April 2022 / Published online: 14 April 2022

Abstract

One of the major problems the world is currently facing is climate change. This is due to the use of fossil fuel combustion, which increases the presence of CO_2 emissions and other greenhouse gases in the atmosphere in several countries of the world, which Nigeria is not exempted from. Against this background, this study examines the impacts of globalization, real income, urbanization, and energy consumption on environmental degradation; and proffer way forward to achieving environmental sustainability targets in Nigeria, using quarterly frequency time series data over a period 1971–2018. To achieve our study objectives, this study makes use of quantile-quantile (Q-Q) approach, developed by Sim and Zhou J Bank Financ 55:1–8, (2015). This approach groups together non-parametric estimation and quantile regression. Empirical results show that, in all quantiles, globalization, real income, urbanization, and energy consumption impact positively on environmental degradation. Thus, we are of the opinion that for the nation to achieve any meaningful environmental sustainability targets, (i) it must shift from economic activities that are dependent and driven by non-renewable energy sources; (ii) enact environmental laws and regulations that prevent indigenous and multinationals firms from using non-renewable energy sources in production activities; (iii) discourage rural-urban migration by enacting policies that would improve life in the rural areas, such as diverting investment of indigenous and multinational companies to be situated in the rural areas; and lastly, (iv) learn from jurisdictional experiences that have successfully replaces non-renewable energy sources with renewable ones for an overall economic growth and environmental sustainability targets for both the immediate and future generations.

Keywords Environmental degradation · Globalization · Economic growth · Urbanization · Energy consumption · Quantile-on-quantile regression · Nigeria

Introduction

The goal of many nations is to increase economic growth through increased output, experience a low and stable inflation rate, increase the standard of living and maintain a favourable balance of payment. However, the environment plays a key role

Responsible Editor: Ilhan Ozturk

✉ Seyi Saint Akadiri
ssakadiri@cbn.gov.ng

Tomiwa Sunday Adebayo
tadebayo@ciu.edu.tr

Musa Nakorji
mnakorji@cbn.gov.ng

Wilfred Mwakapwa
mwilfred@cbn.gov.ng

Eshiozemhe Micheal Inusa
eminusa@cbn.gov.ng

Oji-Okoro Izuchukwu
ioji-okoro@cbn.gov.ng

[1] Research Department, Central Bank of Nigeria, Abuja, Nigeria

[2] Department of Business Administration, Faculty of Economics and Administrative Science, Cyprus International University, 99040 Nicosia, Turkey

in achieving these goals as the production of goods and services, climate changes and flooding in recent years have been the foremost causes of low output especially in the agricultural sector and Nigeria is not exempted from these environmental challenges (Adebayo 2022; Ayindea et al. 2011).

Rapid environmental degradation are not natural occurrence but are borne by human activities like urbanization, globalization and energy consumption. In most nations, urbanization is accompanied with strong real income growth, the agglomeration of secondary and tertiary industries in urban areas and population migration from rural to urban regions, all of which contribute to increased carbon emissions. The global urban population is estimated to be 1.52 billion in 1970 and grows to 4.6 billion people by 2030 and a large part of this will be in Asian and African cities (Yazdi and Dariani 2019). Similarly, according to Mabogunje (2002) in 1950s, urban centres represent less than 15 per cent of the population in Nigeria and rose to 23.4 per cent and 43.3 per cent in 1975 and 2000 respectively, having an annual urban population rate of 4.8 per cent. Several empirical studies have used urbanization as a factor of economic degradation and carbon emissions (Wu et al. 2016; Gasimli et al. 2019) this is because of the high movement of people in the urban areas and consumption of high-energy intensive goods. As a result of the switch in economic activity and changes in the population's behavioural patterns after migration from rural to urban regions, the process of urbanization impacts the environment by changing the levels of polluting emissions. This shows that the significance of the relationship between urbanization, globalization energy consumption, and environmental degradation varies across each country based on their levels of real income and development. In recent decades, through global economic and social development, attention has been drawn to the negative ecological and environmental consequences of urbanization. In addition to impacting the development of real income, health, education, and socialization of the populace, urbanization also affects environmental protection and remediation, along with the exploitation of natural resources through energy consumption. (Srinivasan 2017).

Globalization is without a doubt, a positive phenomenon in the present-day society, as it helps to enhance economic growth and development; however, it creates negative externality some of which are ecological contamination and environmental degradation Saint Akadiri et al. 2019a, b; Akadiri et al. 2021; Uzuner et al. 2020; Shahzadi et al. 2019). In the epoch of globalization, countries enhance their interdependence through international trade, capital flow, migration pattern and spread of technology. Globalization has, therefore, generated an increasing level of interdependence among several economies both of developing and developed status. This, however, translates that environmentally hazardous goods and pollution-intensive industries can easily concentrate more in the nation with little environmental laws and policies, which are found in developing countries. Karataş (2016) posited that globalization, a concept synonymous with raising international trade has advanced the development of goods, which has an undesirable and significant side effect on the environment. Some of this effect in Nigeria is evident in the Niger Delta region, dominated by multinational corporations due to its abundance of oil both offshore and onshore. Despite the region's natural wealth and vital contribution to the sustenance of the Nigerian government, the Niger Delta region is still home to Africa's poorest people and worst environmental destructions (Austine et al. 2014). Additionally, the multinational corporations have been associated with continuous environmental harm on the host nation, most especially oil-producing countries without adequate punishment or compensation like in Nigeria hence, the need to understand the relationship between globalization and environmental degradation.

Similarly, Alege et al. (2016) posited that in the current modern era, a large amount of the world's energy consumption needs is met through fossil fuel, thus, the increase in global trade has led to high CO_2 emissions. In Nigeria, due to poor infrastructure evident from the low electricity supply, fossil fuel consumption remains remarkably high and eminent in the country. According to Yusuf (2014) over 170 million Nigerians ration between 3000 MW to 6000 MW of electricity supply, while in countries like Libya, with a population of 5.5 million generate about 4600 MW. This is the reason Nigerians turn to fossil fuel as an alternative source of energy regardless of the environmental implication of CO_2 emitted through such alternative. According to the World Bank database, in 2000 only 43% of the population had access to electricity while in 2018, the number rose by 10.5 to 56.5% of the population. Similarly, in 2000, CO_2 emissions from fossil fuel consumption in the country contributes about 0.009 per cent of total CO_2 emissions, however, the value increased by more than 1000 per cent to 0.1 in 2016 indicating a substantial increase from fossil fuels. This illustrates the unchecked state of the country's environment with an increasing number of multinational corporations' environmental damage, oil spillage, flooding, deforestations, and the likes, it is not long before the country's ecosystem becomes inhabitable for the Nigerian citizens. With this in mind, it is also pertinent to understand how energy consumption, in the midst of raising income, globalization and urbanization affects environmental degradation in Nigeria, thus the study draws motivation from this.

There is literature evidence to suggest that existing studies have examined the relationship between the variables of interest in other developing and developed countries of the world (Shahzadi et al. 2019; Alam 2010; Karataş 2016; Nwagbara et al. 2012; Uzuner et al. 2020; Destek and Ozsoy 2015), however, little study exist that focus on Nigeria. Despite the

existence of literature studying the relationship between globalization and environmental degradation (Austine et al. 2014; Adesina 2012) or energy consumption and environmental degradation (Yahaya et al. 2019; Alege et al. 2016; Yusuf, 2014; Musa and Maijama'a 2020; Aiyetan and Olomola 2013), investigating the nexus between globalization, real income, urbanization and energy consumption on environmental degradation in Nigeria remains a gap in the literature that this study intends to fill.

This study has the following contributions: methodologically, a gap exists in studying the relationship between the variables using quantile-on-quantile (Q-Q) approach most especially for Nigeria. The quantile-on-quantile (Q-Q) approach by Sim and Zhou (2015) is suitable because it takes into consideration low, median, and high quantiles of the variables involved. The result of this study provide insight for government, non-governmental organizations (NGOs) and private entities concerned about the environmental situation of the nation and help understand the interconnectedness of these variables when formulating environmental policies. Empirically, results show that in all quantiles, globalization, real income, urbanization and energy consumption impact positively on environmental degradation. Thus, we are of the opinion that, for the nation to achieve any meaningful environmental sustainability targets, (i) shift from economic activities that are dependent and driven by non-renewable energy; (ii) environmental laws and regulations that prevent indigenous and multinationals firms from using non-renewable energy sources in production activities should be put in place; (iii) government should discourage rural-urban migration by enacting policies that would improve life in the rural areas, such as diverting investment of indigenous and multinational companies to be situated in the rural areas; and lastly (iv) policymakers in Nigeria, should learn from jurisdictional experiences that have successfully replaces non-renewable energy sources with renewable ones for an overall economic and environmental sustainability target for both the immediate and future generations.

The rest of the paper is categorized as follows: the "Literature review" section discusses the literature review, while the "Material, theoretical framework and methods" section includes data and method of analysis of the study. Thereafter, the "Results and discussion of findings" section discusses the result while the "Conclusion and policy suggestions" section entails the conclusion and recommendations.

Literature review

The greatest challenge the world is faced with today is environmental degradation. The main factor that causes environmental degradation is CO_2 emission, which is caused by an increase in the use of energy.

Energy consumption, CO_2 emissions and economic growth

According to Menyah and Wolde-Rufeal (2010) and Bowden and Payne (2009), the use of energy is vital for achieving economic growth. Rahman (2017) and Hossain (2012) further established a direct nexus between CO_2 emission and economic growth, which is due to the fact that output growth requires more energy consumption which causes CO_2 emission. Khan et al. (2019a) found that energy consumption and economic growth have a positive impact on environmental degradation in pakistan both in the long and short-run.

The studies by Oh and Lee (2004), Chang 2010 and Solarin et al. (2016) found a bi-directional causality between energy consumption and economic growth. While Chang and Wong (2001), and Ozturk and Acaravci (2010) found uni-directional causality from economic growth to energy consumption. However, Cheng (1995), Cowan et al. (2014), and Rahman and Mamun (2016), found no relationship between energy consumption and economic growth. The relationship between economic growth and CO_2 emission tests the validity of the well-known Environmental Kuznet Curve (EKC) hypothesis, which explains the nexus between these two variables as a non-linear inverted U-shaped curve. According to the EKC, a positive nexus exists between these two variables at early stage of development initial, and after achieving a certain level of growth, CO_2 emission falls with the increase in GDP growth, as the country can afford the efficient technologies. Akbostanci et al. (2009) and Ozokcu and Ozdemir (2017) tested this hypothesis and confirmed the existence of a positive long-run nexus between CO_2 emission and economic growth.

Khan et al. (2020) examined the nexus between energy consumption, economic growth and CO_2 emissions in Pakistan. The results indicated that energy consumption and economic growth increase CO_2 emission in both the short and long-run. Furthermore, Khan et al. (2021) showed that energy consumption positively impacts CO_2 emmissions in 184 countries. However, most studies that tested this hypothesis supported the existence of the EKC such as Rahman (2017, 2020), Ertugrul et al. (2016), and Kasman and Duman (2015) among others. Furthermore, Apergis and Payne (2011), Hossain (2012), Shahbaz et al. (2013), Kasman and Duman (2015), Uddin et al. (2016), and Rahman and Kashem (2017) demonstrated causality from economic growth to energy consumption and CO_2 emission. In contrast, Soytas and Sari (2009), Ghosh (2010), and Lean and Smyth (2010) found a uni-directional causality from energy consumption and CO_2 emissions to economic growth.

Globalization, urbanization and environmental degradation

With enhanced globalization and industrialization, the global output is continuously growing. The integration of individual economies with the global economy in terms of trade, capital mobility and other socio-economic and political aspects is termed Globalization. Globalization could affect the quality of the environment through various channels. Shahbaz et al. (2017) argued that globalization is connected with several environmental problems. Many environmentalists are of the view that globalization increases global demand for goods and services which in turn increase economic activities and output. This results to the depletion of natural resources as well as environmental degradation. Lee and Min (2014), Dogan and Turkekul (2016) and Shahbaz et al. (2016) found positive effects of globalization on the environment. In addition, Sharif et al. (2020) found that globalization exerts negative environmental externalities. Furthermore, the analysis of Khan et al. (2019b) shows that political, social and economic globalization index have positive impact on CO_2 emissions while urbanization has a negative impact on CO_2 emission. However, Rahman (2020), and Dogan and Deger (2016) found a significant negative impact of globalization on CO_2 emission and emphasised that environmental quality can be improved with the transfer of technologies that are friendly to the environment, aided by globalization. Islam et al. (2021) also found a negative effect of globalization on CO_2 emissions which implies an improvement in the quality of the emvironment while urbanization has a positive impact on CO_2 emission both in the short and long-run.

This clearly shows a lack of consensus among researchers regarding the nexus between the interested variables and to the best of our knowledge, most studies that explain the relationship between some of the interested variables in Nigeria, mainly provided nexus between energy consumption and economic growth (see Omotor 2008; Odulari and Okonkwo 2009; Akpan and Akpan 2012; Olusanya 2012; Onakoya et al. 2013; Oyedepo 2013; Ogudipe and Apata 2013; and Chindo et al. 2014). Therefore, this study will provide further evidence using a robust methodology and improved data with the inclusion of the variable "globalization" to investigate the case for Nigeria and thus, effectively enrich the ongoing debate/literature on sustainable environment for policy makers.

Material, theoretical framework and methods

Data

The study employed quarterly frequency data covering the period 1961–2019 for Nigeria. The variables used in this study are CO_2 emission, economic growth, globalisation, energy consumption and urbanization. To obtain return series, the variables employed were transformed into logarithmic difference series to create comparable empirical findings (Battacharya et al. 2016). We sourced data for this current study from World Development Indicator online database.

Theoretical framework

Several factors that influence CO_2 emissions are recorded by prior studies, notably are (Akinsola et al. 2021; Ahmed and Le 2021; Udemba et al. 2021; Kraft and Kraft 1978; Sarkodie and Strezov 2019). Therefore, it is imperative to note, that the tremendous growth in the world economy in the last 40 years comprise a significant increase in the use of energy. This has caused Grossman and Krueger (1991), Panayotou (1997) and other famous economists specialized in the field of environment, in their various studies to examine the interactions among economic expansion environmental deterioration. In accordance with, their studies, they suggested that the growth and emission interrelationship can be classified into 3 distinct stages (the composite, the scale and procedure effects). First, the scale effect stage is linked to emerging economies (mostly low-income nations). Here, it is believed that, the use of fossil (nonrenewable energy) fuels enhance economic growth. At this stage, these countries pay little or no attention to the sustainability of the environmental degradation, causing the environment to suffer in the preliminary junctures of economic growth till it achieves a specific threshold, leading to a turning point where economic expansion will escalate environment quality. Second, the composite effect juncture appears to be related with the industrialized nations of the world, where economies are in the know of the cost and implication of environmental dilapidation (industrial economies). The technical effect juncture appears to be a stage, where economies of the world transit from industrial to service sector-based economies (see Adebayo and Rjoub 2021; Kirikkaleli and Adebayo 2021; Solarin et al. 2021).

Globalization is seen as one of the major factors that affect environmental degradation. The consequences associated to increase in energy consumption is a result of globalized economies. Progress in globalization leads to a fall in trade barriers, which increases a nation's revenue and output. To Kirikkaleli et al. (2021) recent patterns of globalization has led to various environmental worries, coupled with ozone layers depletion, deforestation and overutilization of assets. Intregration of thw world economies via globalization boosts economic activity, increase energy usage, and hence emissions per capita level. Globalization can induce clean environment, and improve environmental quality, if green

technologies are put in place (Adebayo et al. 2021; Ahmed et al. 2019).

In addition, interactions amid urbanization and economic expansion influence electricity consumption via many ways. For an instance, growth surges households purchasing power for making use of energy-efficient electrical machines. This impact on electricity consumption (Ozturk 2010). Urbanization on the other hand, is one of the key spectacles of development (Jones 1991). It touches the social and urban structure of a nation. Also, its impacts is felt via population migration, intensification of the industrial and service activities (Duan et al. 2008; Liu 2009; Xie et al. 2009) transport network extension and on the development of public conveniences; which includes education, health, among others for urban dwellers.

Lastly, theoretical framework explained above, would allows us to picture statistically the effects of globalization, urbanization, energy usage and economic growth on environmental degradation. We specify the relationship among the series as follows:

$$CO_{2_t} = f\left(GDP_t, GLO_t, URB_t, EC_t\right)$$

here GDP, GLO, URB, EC and CO_2 emissions are economic growth, globalization, urbanization, energy consumption and CO_2 emissions. To minimize skewness, the natural logarithm of the variables was taken.

Methodology

Unit root test

To determine the order of integration of variables, the Augmented Dickey-Fuller (ADF) (Dicky and Fuller 1979) and Phillips-Perron (PP) (Phillips and Perron 1988) root tests were used.

Q-Q regression

This study employs the quantile-on-quantile (Q-Q) regression approach which is renowned for analysing the relationship between the various variables outside the mean of the data. Sim and Zhou (2015) pioneered the Q-Q technique, which combines nonparametric estimation and quantile regression. This, however, was contrary to the quantile regression approach introduced by Koenker and Bassett Jr (1978) and can be viewed as an addition to the basic simple linear regression model, it, therefore, gives an additional inclusive description of the associations among variables. Also, to evaluate the impact of a regressor on various quantiles of the dependent variable, the researchers utilized a traditional quantile regression model as an enhancement to the traditional least-squares method. The quantile regression investigates the impact of a variable not only on the conditional mean of the dependent variable but also on its quantiles and this provides a more complete connection as opposed to the least square approach. Furthermore, Cleveland (1979) and Stone (1977) suggested traditional linear regression is used to examine the impact of the precise quantile of the regressor variable on the regressand variable. Thus, to investigate the effect of different quantiles of the explanatory variable on different quantiles of the dependent variable, researchers can combine standard quantile regression with classic linear regression. The combination of these two techniques (linear regression and quantile regression) will improve the result of the model and help understand the relationship among the variables better.

To analyze the broad relationship between CO2 emission and economic growth, energy consumption, globalisation, and urbanization in Nigeria, a Q-Q approach is used which was adapted from the conventional quantile regression. Therefore, the nonparametric quantile regression model was employed to investigate the influence of different quantiles of X on the various quantile of Y. The model is expressed as follows:

$$Y_t = Y\hat{}\theta\left(X_t\right) + \varepsilon\_t\hat{}\theta \quad (1)$$

Where Y_t explains the dependent variables in period t and X_t represents the independent variables in time t. θ is the θth quantile on the distribution of X. Additionally, μ_t^θ represents quantile error term, where estimated θth quantile is equal to zero. Furthermore, ∝^θ(.) is unknown since there is no link function. However, under the standard regularity conditions on the link function ∝^θ(.) [see Sim and Zhou (2015)]. In addition, bandwidth selection is important when a nonparametric analysis is being done because it helps to simplify the target point and shifts the outcome's speed. If the bandwidth 'h' is wide, the variance will decrease while the estimate deviation would decrease and vice versa. This study thus utilized a bandwidth value of h = 0.05 as recommended by Sim and Zhou (2015).

Results and discussion of findings

Pre-estimation tests

The study commenced by presenting brief variables summary which is presneted in Table 1. The mean of GDP is the highest which is accompanied by energy utilisation (EC), globalization (GLO), urbanization (URB) and CO_2 emissions (CO_2) respectively. CO_2 emissions has more consistent score which is followed by GLO, URB, EC and GDP. Moreover, CO_2 and EC are skewed negatively whereas GFP, GLO and URB are skewed positively. All the variables-GDP,

GLO, EC, URB and CO_2 are leptourtic. Furthermore, all the series align with normal distribution. The stationarity outcomes is also depicted in Table 1 and outcomes disclosed that all the parameters are I(1). It is vital to understand the series nonlinearity feaures before further analysis. In doing so, we utilised BDS test to identify the nonlinearity attribute of the variables of research. The BDS result is depicted in Table 2 and the outcomes disclosed that the null hypothesis of "no linearity" cannot be rejected. Thus, utilising linear approaches such as ARDL, FMOLS, DOLS, CCR, VECM and OLS will produces misleading outcomes. Centered on this knowledge, we applied nonlinear techniques-quantile regression, quantile-on-quantile regression, and quantile causality techniques to assess the URB, GDP, EC, and GLO influence on CO_2 emissions in Nigeria.

Table 2 BDS test

	CO_2	EC	GDP	GLO	URB
M2	16.3692*	11.2582*	17.9816*	25.5154*	30.0180*
M3	16.8248*	11.5574*	17.5490*	26.0864*	30.9214*
M4	18.6471*	11.4538*	17.0112*	27.2983*	32.5237*
M5	20.1556*	11.5410*	17.7618*	29.2269*	35.3825*
M6	21.9183*	11.3451*	18.2577*	32.1701*	39.6029*

*P<0.01, **P<0.05 and ***P<0.10

QQR outcomes

This portion of the current research explores the influence of globalization, economic growth, and urbanization and energy consumption on CO_2 emissions at different quantiles. Figure 1 (a–d) outlined the outcomes of the QQR. The economic growth (GDP) influence on CO_2 emissions is illustrated by Fig. 1a and the findings revealed the followings: in all tails (0.1–0.90) of both GDP and CO_2 emissions a positive effect of GDP on CO_2 emissions is observed. However, in the lower tail (0.1–0.35) of both GDP and CO_2 emissions, the positive GDP effect on CO_2 is more pronounced. This implies that economic expansion in Nigeria triggers CO_2 emissions which result in environmental degradation. This empirical outcome is expected given the fact that the most of emerging nations that Nigeria is also part of favors continuous economic expansion. Therefore, Nigeria favors pro-growth initiatives at the expense of a sustainable environment. This result relates to the basic problem of the growth-growth paradox, which is discussed in UNESCAP (2019) report. Therefore, achieving SDG goals will be difficult for Nigeria due to its pro-growth initiates. The positive effect of GDP on CO_2 is confirmed by the studies of Adebayo et al. (2021) for South Korea, Gyamfi et al. 2021) for Mediterranean nations, Akinsola et al. (2021) for Brazil, and Su et al. (2021) for Brazil. However, the finding contradicts Rjoub et al. (2021) for Sweden and Usman et al. (2020) for the USA who reported negative CO_2-GDP interrelationship.

The globalization (GLOB) influence on CO_2 emissions is illustrated by Fig. 1b and the subsequent outcomes are disclosed: In the lower tail (0.1–0.35) of the combination of GLOB and CO_2 emissions, the influence of GLOB on CO_2 emissions is negative suggesting that in the lower tail (0.10–0.35) GLOB aid in abating degradation of the environment. However, in the middle and higher tails (0.40–0.90) of GLOB and CO_2 emissions, GLO, a positive effect of GLOB on CO_2 emissions is noticed. In summary, the positive effect of globalization on CO_2 emissions is more pronounced than the negative effect of globalization on CO_2 emissions. The explanation for this could be that certain developing nations, such as Nigeria, do not consider ecological problems. To increase their revenues from trade, they allow polluting industries in advanced nations to continue their operations.

Table 1 Descriptive statistics and unit root tests outcomes

Descriptive Statistics					
	CO_2	EC	GDP	GLO	URB
Mean	0.664077	699.1912	1777.527	44.77107	31.74902
Median	0.708895	694.3708	1757.235	42.86263	31.43650
Maximum	1.009958	798.6302	2550.470	57.52296	48.68300
Minimum	0.312014	579.0784	1317.360	32.25583	18.15100
Std. Dev.	0.187603	56.34513	393.1759	7.738225	9.168701
Skewness	-0.445312	-0.239253	0.411224	0.227148	0.201172
Kurtosis	2.292492	2.565811	1.894002	1.766360	1.884704
Jarque-Bera	2.479741	0.800187	3.641003	3.312483	2.694388
Probability	0.289422	0.670257	0.161945	0.190855	0.259969
Unit root tests Outcomes					
ΔADF	-7.8624*	-6.2199*	-5.2460*	-6.0521*	-3.2004***
ΔPP	-7.8624*	-6.6434*	-5.3409*	-6.0521*	-4.528*

*P<0.01, **P<0.05 and ***P<0.10

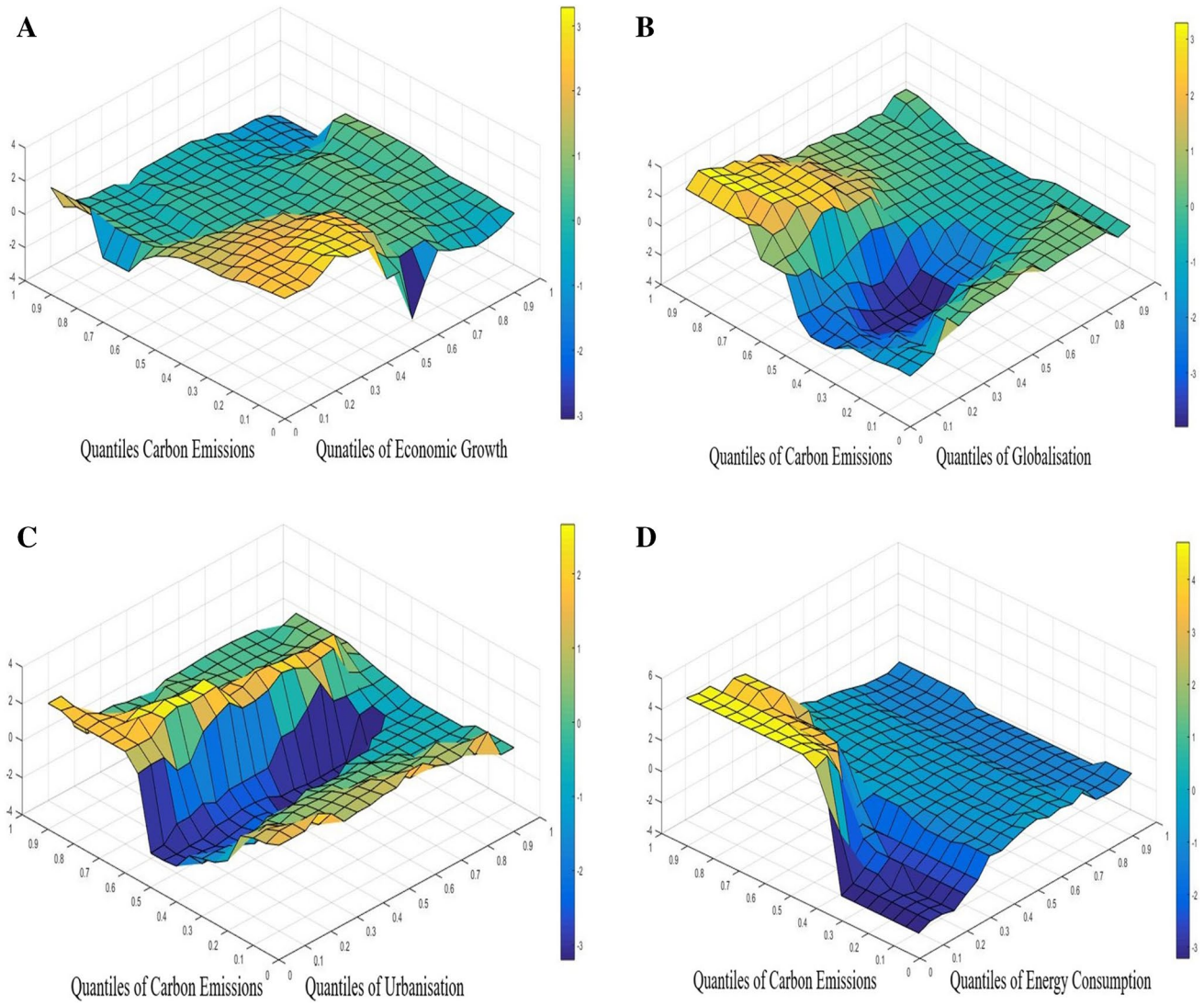

Fig. 1 **A** Effect of GDP on CO_2. **B** Effect of GLOB on CO_2. **C** Effect of URB on CO_2. **D** Effect of EC on CO_2

Furthermore, because industrial expansion puts additional pressure on the consumption of energy, fossil fuels are used at a rapid pace, resulting in increased emissions of CO_2 emissions (Kirikkaleli et al. 2021; Yuping et al. 2021). So, in a summary, it is obvious that Nigeria moving toward pollution caused by globalization. As a result, it becomes clear that strong environmental regulations are needed to decrease emissions. The positive effect of globalization on CO_2 emissions is confirmed by the studies of Kirikkaleli et al. (2021) for Turkey, and He et al. (2021) for Mexico. However, the study of Yuping et al. (2021) for Argentina and Kihombo et al. (2021) for WEMA contradicts this finding.

The urbanization (URB) influence on CO_2 is illustrated by Fig. 1c and the subsequent results are unveiled: In the middle tail (0.40–0.65) of the combination of CO_2 emissions and URB, the negative effect of URB on CO_2 emissions is observed. However, there is proof of positive effect of URB on CO_2 emissions in the lower and higher tails (0.10–0.35 and 0.70–0.90) of both CO_2 emissions and URB. The probable reason for this interrelationship is that number of job opportunities rises in tandem with the growth of the economy. Because Nigeria's industrial expansion is primarily concentrated in semi-urban and metropolitan regions, job opportunities are also concentrated in these places. As the number of employment vacancies increases, so does the expectation of a higher quality of life as overall wealth increases. This expectation entice people from rural regions to move to cities, leading to a rise in city dwellers. Because job opportunities are now divided according to skill level, the urban population were divided into skilled and semi-skilled laborers. Social and economic divides may grow as a result of this isolation, due to the creation of slum

districts and shadow cities in metropolitan centres. People in these areas lack access to clean cooking fuels, resulting in increased CO_2 emissions due to unsustainable energy use habits. This outcome complies with the works of Zhang et al. (2021) for Malaysia, and Ramzan et al. (2010) for Latin American nations.

Lastly, energy utilization (EC) influence on CO_2 emissions is illustrated by Fig. 1d and the following outcomes are unraveled: In the lower tail (0.1–0.30), EC impact on CO_2 emissions is negative which implies that in the lower tail, the energy usage is sustainable. This outcome is surprising given the fact that most developing nations' energy consumption is unsustainable. Moreover, in the middle tail (0.40–0.60) of combination of EC and CO_2 emissions, EC influence on CO_2 emissions is negative and weak. However, as we move into the higher tail (0.70–0.90) of CO_2 emissions, the influence of EC on CO_2 emissions is positive and significant. This implies that in the higher tail (0.70–0.90) the EC contributes to the degradation of the environment in Nigeria. The positive effect of energy utilization on CO_2 emissions is confirmed by the studies of Shan et al. (2021) for highly decentralized economies, Soylu et al. (2021) for China and Orhan et al. (2010) for India and Tufail e al. (2021) for emerging nations.

Robustness check

In a traditional quantile regression (QR), the QQ method is employed to allocate the coefficient. It allows the regressor's explicit coefficients at different quantiles to be obtained. The quantile regression (QR) model can be quickly constructed utilizing the quantile of X (Y) on Y (X), and the quantile regression coefficients can be indexed individually by σ. As noted previously, the QQ methods evaluate the th quantile effect of X (Y) on the quantile of Y (X) at various values of π and σ. As a result, this method elaborates more detailed information about X and Y with respect to the QR model. We applied the QR as a robustness check to the QQR. Figure 2(a–d) illustrates the robustness check of the study.

The GDP influence on CO_2 emissions is affirmed by Fig. 2a. In all tails (0.1–0.90), a positive effect of GDP on CO_2 emissions is observed. In addition, there is a strong resemblance between the slope coefficients of QRR and QR. Moreover, the globalization influence on CO_2 emissions is affirmed by Fig. 2b. In lower tails (0.1–0.30), the positive effect of globalization on CO_2 emissions is observed. However, in the middle and higher tails (0.5–0.90), a negative globalization effect on CO_2 emissions is noticed. In addition, there is a strong resemblance between the slope coefficients of QRR and QR. Furthermore, the urbanization influence on CO_2 emissions is affirmed by Fig. 2c. In lower tails (0.1–0.30), the positive effect of globalization on CO_2 emissions is observed. However, in the middle and higher tails (0.35–0.90), a negative urbanization effect on CO_2 emissions is noticed. In addition, there is a significant resemblance between the slope coefficients of QRR and QR. Lastly; the urbanization influence on CO_2 emissions is affirmed by Fig. 2d. In lower tails (0.1–0.30), the positive effect of energy use on CO_2 emissions is observed. However, in the middle and higher tails (0.35–0.90), a negative energy use effect on CO_2 emissions is noticed. In addition, there is a significant resemblance between the slope coefficients of QRR and QR.

Non-parametric causality-in-quantiles outcomes

We apply the nonparametric Granger causality in quantiles initiated by (Balcilar et al. 2016) to identify the causal influence of globalization (GLO), energy consumption (EC), economic growth (GDP) and urbanization (URB) on carbon emissions (CO2) in Nigeria. The variance and mean causal connection between CO_2 emissions and the regressors (GDP, URB, EC and GLO) can be assessed using this method. The non-parametric causality is depicted in Fig. 3(a–d) and Table 3, and the findings are as follows:

The EC causal effect on CO_2 emissions is illustrated by Fig. 3a and the result unveiled a causal interrelationship from EC to CO_2 emissions in the lower and middle quantiles (0.25–0.70) of CO_2 emissions provisional distribution. Also, Fig. 3a presents EC volatility and the result unfolds causal interconnection from GDP to CO_2 emissions lower and middle tails (0.1–0.90) of CO_2 emissions conditional distribution. Furthermore, the EC causal effect on CO_2 emissions is illustrated by Fig. 3b and the result unveiled a causal interrelationship from GDP to CO_2 emissions in the lower and middle tails (0.15–0.75) of CO_2 emissions provisional distribution. Also, Fig. 3b presents GDP volatility and the result showed causal interconnection from GDP to CO_2 emissions middle and lower tails (0.20–0.75) of CO_2 emissions conditional distribution. Moreover, the GLO causal effect on CO_2 emissions is illustrated by Fig. 3c and the result showed causal association from GLO to CO_2 emissions in the lower and middle tails (0.20–0.70) of CO_2 emissions provisional distribution. Also, Fig. 3c presents GLO volatility and the outcome showed a causal connection from GLO to CO_2 emissions middle and lower tails (0.20–0.80) of CO_2 emissions conditional distribution. Lastly, the URB causal effect on CO_2 emissions is illustrated by Fig. 3d and the result showed causal association from URB to CO_2 emissions in the lower and middle tails (0.10–0.70) of CO_2 emissions provisional distribution. Also, Fig. 3d presents URB volatility and the outcome showed a causal connection from URB to CO_2 emissions middle and lower tails (0.15–0.70) of CO_2 emissions conditional distribution.

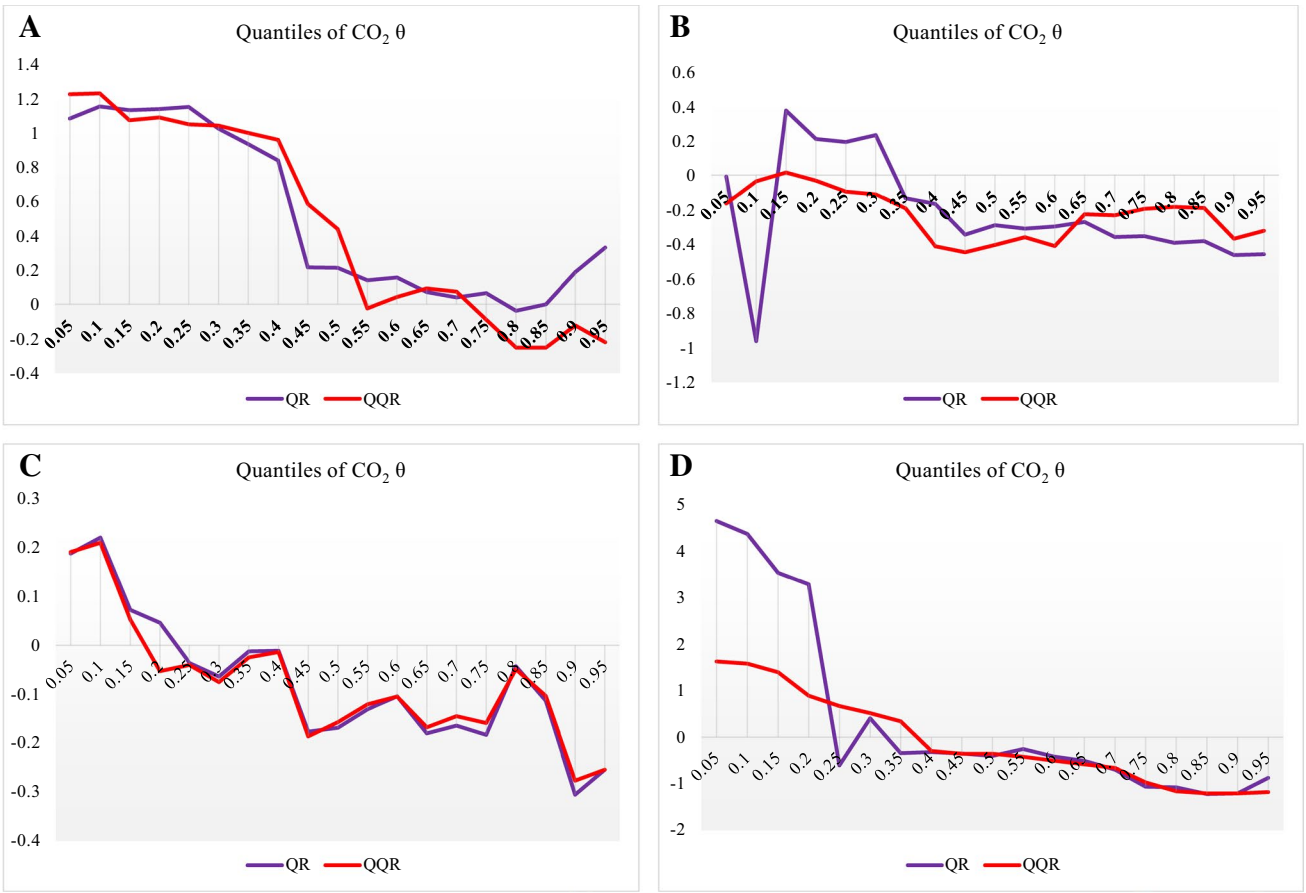

Fig. 2 **A** Effect of GDP on CO_2. **B** Effect of GLOB on CO_2. Effect of URB on CO_2. Effect of EC on CO_2

Conclusion and policy suggestions

In this paper, we examine the impacts of globalization, real income, urbanization, and energy consumption on environmental degradation; and proffer way forward to achieving environmental sustainability targets in Nigeria, using quarterly frequency time series data over a period 1971–2018. To achieve our study objectives, this study makes use of quantile-quantile (Q-Q) approach, developed by Sim and Zhou (2015). This aproach groups together nonparametric estimation and quantile regression. The Q-Q approach gives an additional inclusive description of the associations a mong variables. Also, for robustness check, this study used a conventional quantile regression to investigate the influence of an explanatory variables on various quantiles of the dependent variable. Combining these two approaches, rather than traditional techniques like OLS and ordinary quantile regression, can help us grasp the underlying relationship among variable under investigation.

Based on empirical estimations and findings, we found in the case of Nigeria that; first, in all tails (0.1–0.90) of both GDP and CO_2 emissions, a positive effect of GDP on CO_2 emissions is observed. From a policy perspective, for Nigeria economy to achieve any meaningful environmental sustainability targets, there must be a shift from economic activities that are dependent and driven by non-renewable energy sources to a more energy-savings and energy efficient technologies. We are of the opinion that, introduction of green economy should be considered and pursued vigorously by the authorities and policymakers in charge of environmental policies in other to achieve desirable and conducive environment for both the immediate and the future generation.

Second, empirical results show that in the majority of the quantiles, the effect of globalisation on CO2 emissions is negative. Based on this findings, since globalization have come to stay and its impact, it is obvious even from the COVID-19 pandemic around the globe, we suggest that, environmental laws and regulations that prevent

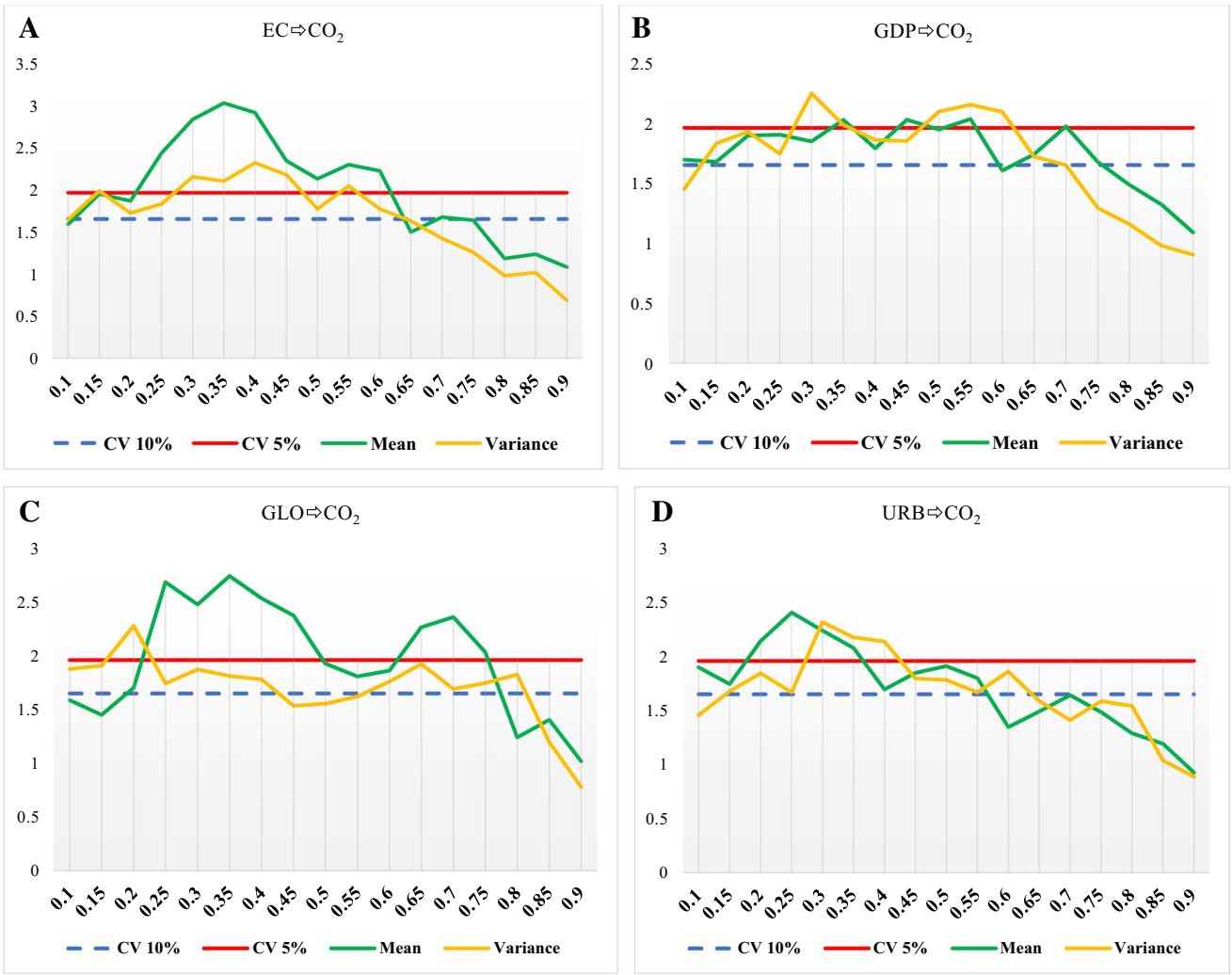

Fig. 3 **a** Causality in mean and variance from EC to CO_2. **b** Causality in mean and variance from EC to CO_2. **c** Causality in mean and variance from GLO to CO_2. Causality in mean and variance from URB to CO_2

indigenous and multinationals firms from using non-renewable energy sources in production activities should be put in place. Non-renewable energy sources should be replaced by more friendly renewable energy sources in order to curb and control at least to a minima the ravaging impact as a results of globalization on the host country, most especially in Nigeria.

Third, empirical findings show a proof of positive effect of urbanization on CO_2 emissions. Based on this finding, we are of the opinion that, government should discourage rural-urban migration by enacting policies that would improve life in the rural areas, such as diverting investment of indigenous and multinational companies to be situated in the rural areas. This would improve infrastructure facilities and create job opportunities for the rural dwellers. This in one-way or another would reduce congestion in the urban centres, hence reduction in environmental degradation. By so doing, the nation would achieve its environmental sustainability targets in the long run.

Empirical results show that, in the majority of the quantiles, the effect of energy consumption on CO_2 emissions. Based on this finding, we are of the opinion that, policymakers in Nigeria, should learn from jurisdictional experiences of nations that have successfully control non-renewable energy sources to renewable ones for an overall economic and environmental sustainability targets for both the immediate and future generations.

Conclusively, this current study is without limitation. Our research uses carbon emissions to proxy environmental degradation. However, future authors could focus on other environmental metrics such as the load capacity factor and other key drivers of environmental degradation. Also, future

Table 3 Nonparametric granger causality in quantiles outcomes

			Energy Consumption		Economic Growth		Globalization		Urbanization	
	CV 5%	C 10%	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance
0.10	1.96	1.65	1.5869	1.6419	1.6941**	1.4516	1.5865	1.8769**	1.4998	1.6587**
0.15	1.96	1.65	1.9467**	1.9827**	1.6780**	1.8291**	1.4514	1.9083**	1.6546**	1.6881**
0.20	1.96	1.65	1.8651**	1.7197**	1.8962**	1.9266**	1.7026**	2.2800*	2.1438*	1.8456**
0.25	1.96	1.65	2.4315*	1.8278**	1.9023**	1.7455**	2.6865*	1.7425**	2.4063*	1.6692**
0.30	1.96	1.65	2.8301*	2.1499*	1.8475**	2.2462*	2.4783*	1.8733**	2.2412*	2.3193*
0.35	1.96	1.65	3.0256*	2.0999*	2.0260*	1.9849*	2.7442*	1.8133**	2.0798*	2.1766*
0.40	1.96	1.65	2.9122*	2.3168*	1.7892**	1.8601**	2.5359*	1.7822**	1.6951**	2.1390*
0.45	1.96	1.65	2.3390*	2.1744*	2.0275*	1.8515**	2.3766*	1.5360	1.8481**	1.7967**
0.50	1.96	1.65	2.1263*	1.7702**	1.9466**	2.0958*	1.9269**	1.5542	1.9117**	1.7829**
0.55	1.96	1.65	2.2938*	2.0413*	2.0324*	2.1519*	1.8086**	1.6214	1.8006**	1.6683**
0.60	1.96	1.65	2.2215*	1.7695**	1.6041	2.0941*	1.8630**	1.7606**	1.3481	1.8602**
0.65	1.96	1.65	1.4950	1.6269	1.7392**	1.7206**	2.2667*	1.9249**	1.4903	1.5885
0.70	1.96	1.65	1.6726**	1.4195	1.9726**	1.6488	2.3604*	1.6911**	1.6430	1.4129
0.75	1.96	1.65	1.6346	1.2549	1.6760**	1.2919	2.0349*	1.7469**	1.4846	1.5864
0.80	1.96	1.65	1.1816	0.9775	1.4846	1.1576	1.2412	1.8264	1.2902	1.5433
0.85	1.96	1.65	1.2326	1.0144	1.3215	0.9786	1.4051	1.1969	1.1929	1.0375
0.90	1.96	1.65	1.07847	0.6837	1.0901	0.9043	1.0201	0.7792	0.9263	0.8886

*P<0.05 and **P<0.10

authors may also investigate blocs' of countries that is, in panel format or time series studies, with more same or more advance econometric techniques.

Author contribution Tomiwa collected data and analyzed the data. Micheal and Wilfred wrote the introduction and literature review. Oji-Okoro work on the methodology and Seyi Saint Akadiri wrote the conclusion and policy suggestion, Nakorji work on study development and proofreading.

Data availability Corresponding authors can provide data used in the study on appropriate request.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

References

Adebayo TS (2022) Environmental consequences of fossil fuel in Spain amidst renewable energy consumption: a new insights from the wavelet-based Granger causality approach. Int J Sustain Dev World Ecol 6(4):1–14

Adebayo TS, Rjoub H (2021) A new perspective into the impact of renewable and nonrenewable energy consumption on environmental degradation in Argentina: A time–frequency analysis. Environ Sci Pollut Res. https://doi.org/10.1007/s11356-021-16897-6

Adebayo TS, Awosusi AA, Kirikkaleli D, Akinsola GD, & Mwamba MN (2021) Can CO 2 emissions and energy consumption determine the economic performance of South Korea? A time series analysis. Environ Sci Pollut Res 1–16

Adesina OS (2012) The Negative Impact of Globalization on Nigeria. Int J Humanit Soc Sci 2(15):193–195

Ahmed Z, Le HP (2021) Linking Information Communication Technology, trade globalization index, and CO2 emissions: Evidence from advanced panel techniques. Environ Sci Pollut Res 28(7):8770–8781. https://doi.org/10.1007/s11356-020-11205-0

Ahmed Z, Wang Z, Mahmood F, Hafeez M, Ali N (2019) Does Globalization Increase the Ecological Footprint? Empirical Evidence from Malaysia. Environ Sci Pollut Res 26(18):18565–18582. https://doi.org/10.1007/s11356-019-05224-9

Aiyetan IR, Olomola PA (2013) Environmental degradation, energy consumption, population growth and economic growth: Does Environmental Kuznets curve matter for Nigeria? Econ Policy Rev 16(2)

Akadiri SS, Uzuner G, Akadiri AC, Lasisi TT (2021) Environmental Kuznets curve hypothesis in the case of tourism island states: The moderating role of globalization. Int J Financ Econ 26(2):2846–2858

Akbostanci E, Türüt-Asik S, Tunç GI (2009) A decomposition analysis of CO2 emissions from energy use: Turkish case. Energy Policy 37(11):4689–4699

Akinsola GD, Adebayo TS, Kirikkaleli D, Bekun FV, Umarbeyli S, Osemeahon OS (2021) Economic performance of Indonesia amidst CO2 emissions and agriculture: A time series analysis. Environ Sci Pollut Res. https://doi.org/10.1007/s11356-021-13992-6

Akpan GE, Akpan UF (2012) Electricity consumption, carbon emissions and economic growth in Nigeria. Int J Energy Econ Policy 2(4):293–308

Alam S (2010) Globalization, Poverty and Environmental Degradation: Sustainable Development in Pakistan. J Sustain Dev 3(3):103–114
Alege PO, Adediran OS, Ogundipe AA (2016) Pollutant Emissions, Energy Consumption and Economic Growth in Nigeria. Int J Energy Econ Policy 6(2):202–207
Apergis N, Payne JE (2011) A dynamic panel study of economic development and the electricity consumption-growth nexus. Energy Econ 33:770–781
Austine E, Sunday E, Raymond AO (2014) Globalization and Environmental Degradation of the Niger Delta. Res Humanit Soc Sci 4(13):142–154
Ayindea OE, Muchiea M, Olatunji GB (2011) Effect of Climate Change on Agricultural Productivity in Nigeria:A Co-integration Model Approach. J Hum Ecol 35(3):189–194
Balcılar M, Demirer R, Hammoudeh S, Nguyen DK (2016) Risk spillovers across the energy and carbon markets and hedging strategies for carbon risk. Energy Econ 54:159–172
Battacharya M, Paramati SR, Ozturk I, Bhattacharya S (2016) The effect of renewable energy consumption on economic growth: evidence from top 38 countries. Appl Energy 162:733–741
Bowden N, Payne JE (2009) The causal relationship between US energy consumption and real output: a disaggregated analysis. J Policy Model 31(2):180–188
Chang C-C (2010) A multivariate causality test of carbon dioxide emissions, energy consumption and economic growth in China. Appl Energy 87:3533–3537
Chang Y, Wong JF (2001) Poverty, Energy, and Economic Growth in Singapore. Working Paper. Department of Economics. National University of Singapore, Singapore
Cheng BS (1995) An investigation of cointegration and causality between energy consumption and economic growth. J Energy Dev 21(1):73–84
Chindo S, Abdulrahim A, Waziri SI, Wong MH, Abdulfatah AA (2014) Energy consumption, CO2 emission and GDP in Nigeria. Geo J 80:315–323
Cleveland WS (1979) Robust locally weighted regression and smoothing scatterplots. J Am Stat Assoc 74(368):829–836
Cole MA, Elliott RJ (2003) Determining the trade-environment composition effect: The role of capital, labor and environmental regulations. J Environ Econ Manag 46:363–383
Cowan WN, Chang T, Inglesi-Lotz R, Gupta R (2014) The nexus of electricity consumption, economic growth and CO2 emissions in the BRICS countries. Energy Policy 66:359–368
Destek MA, Ozsoy FN (2015) Relationships between economic growth, energy consumption, globalization, urbanization and environmental degradation in Turkey. Int J Energy Stat 3(4):1550017
Dicky DA, Fuller WA (1979) Distribution of the estimators for autoregressive time series with a unit root. J Am Stat Assoc 74:427–431
Dogan B, Deger O (2016) How globalization and economic growth affect energy consumption: panel data analysis in the sample of Brazil, Russia, India, China countries. Int J Energy Econ Policy 6(4):806–813
Dogan E, Turkekul B (2016) CO2 emissions, real output, energy consumption, trade, urbanization, and financial development: testing the EKC hypothesis for the USA. Environ Sci Pollut Control Ser 23:1203–1213
Duan J, Yan Y, Zheng B, Zhao J (2008) Analysis of the relationship between urbanisation and energy consumption in China. Int J Sustain Dev World Ecol 15:309–317
Ertugrul HM, Cetinb M, Sekerc F, Dogan E (2016) The impact of trade openness on global carbon dioxide emissions: evidence from the top ten emitters among developing countries. Ecol Indic 67:543–555
Gasimli O, Haq IU, Naradda Gamage SK, Shihadeh F, Rajapakshe PS, Shafiq M (2019) Energy, Trade, Urbanization and Environmental Degradation Nexus in Sri Lanka: Bounds Testing Approach. Energies, 1-15
Ghosh S (2010) Examining carbon emissions economic growth nexus for India: a multivariate cointegration approach. Energy Policy 38(6):3008–3014
Grossman GM, Krueger AB (1991) Environmental impacts of a North American free trade agreement. In Papers (No. 158; Papers). Princeton, Woodrow Wilson School - Public and International Affairs. https://ideas.repec.org/p/fth/priwpu/158.html. Accessed 4 Jan 2022
Gyamfi BA, Adebayo TS, Bekun FV, Agyekum EB, Kumar NM, Alhelou HH, Al-Hinai A (2021) Beyond environmental Kuznets curve and policy implications to promote sustainable development in Mediterranean. Energy Rep 7:6119–6129
He X, Adebayo TS, Kirikkaleli D, Umar M (2021) Consumption-based carbon emissions in Mexico: an analysis using the dual adjustment approach. Sustain Prod Consump 27:947–957
Hossain S (2012) An econometric analysis for CO2 emissions, energy consumption, economic growth, foreign trade, and urbanization of Japan. Low Carbon Econ 3:92–105
Islam MM, Khan MK, Tareque M, Jehan N, Dagar V (2021) Impact of globalization, foreign direct investment and energy consumption on C02 emission in Babgledesh: Does institutional quality matter? Environ Sci Pollut Res 28:48851–48871
Jones D (1991) How urbanization affects energy-use in developing countries. Energy Policy 19:621–630. https://doi.org/10.1016/0301-4215(91)90094-5
Karataş A (2016) Environmental Impacts of Globalization and a Solution Proposal. Am Int J Contemp Res 6(2):64–71
Kasman A, Duman YS (2015) CO2 emissions, economic growth, energy consumption, trade, and urbanization in new eu member and candidate countries: a panel data analysis. Econ Model 44:97–103
Khan MK, Teng JZ, Khan MI (2019a) Effect of energy consumption and economic growth on carbondioxide emission in pakistan with dynamic ARDL simulations approach. Environ Sci Pollut Res 26(23):23480–23490
Khan MK, Teng JZ, Khan MI (2019b) Impact of globalization, economic factors and energy consumption on C02 emission in Pakistan. Sci Total Environ 688:424–436
Khan MK, Khan MI, Rehan M (2020) The relationship between energy consumption, economic growth and carbondioxide emissions in pakistan. Finance Innov 6:1
Khan S, Khan MK, Muhammad B (2021) Impact of financial development and energy consumption on environmental degradation in 184 countries using a dynamic panel model. Environ Sci Pollut Res 28:9542–9557
Kihombo S, Ahmed Z, Chen S, Adebayo TS, Kirikkaleli D (2021) Linking financial development, economic growth, and ecological footprint: what is the role of technological innovation? Environ Sci Pollut Res 28(43):61235–61245
Kirikkaleli D, Adebayo TS (2021) Do public-private partnerships in energy and renewable energy consumption matter for consumption-based carbon dioxide emissions in India Environmental Sci Pollut Res 1–14
Kirikkaleli D, Adebayo TS, Khan Z, Ali S (2021) Does Globalization Matter for Ecological Footprint in Turkey? Evidence from Dual Adjustment Approach. Environ Sci Pollut Res 28(11):14009–14017. https://doi.org/10.1007/s11356-020-11654-7
Koenker R and Bassett Jr G (1978) Regression quantiles. Econometrica: Journal of the Econometric Society 33–50
Kraft J, Kraft A (1978) On the relationship between energy and GNP. J Energy Dev 3(2):401–403
Lean HH, Smyth R (2010) CO2 emissions, electricity consumption and output in ASEAN. Appl Energy 87(6):1858–1864

Lee KH, Min B (2014) Globalization and carbon constrained global economy: a fad or a trend? J Asia Pac Bus 15(2):105–121
Liu Y (2009) Exploring the relationship between urbanisation and energy consumption in China using ARDL (autoregressive distributed lag) and FDM (factor decomposition model). Energy 34:1846–1854. https://doi.org/10.1016/j.energy.2009.07.029
Mabogunje A (2002) Re-constructing the Nigerian city: The new policy on urban development and housing. National conference on the city in Nigeria, Ile Ife
Menyah K, Wolde-Rufeal Y (2010) Energy consumption, pollutants emissions and economic growth in South Africa. Energy Econ 32:1374–1382
Musa KS, Maijama'a, R. (2020) Economic Growth, Energy Consumption And Environmental Pollution In Nigeria: Evidence From ARDL Approach. Energy Econ Lett 7(2):61–73
Nwagbara EN, Abia RP, Uyang FA, Ejeje JA (2012) Poverty, Environmental Degradation and Sustainable Development: A Discourse. Global J Human Soc Sci 12(11):1–8
Odulari GO, Okonkwo C (2009) Does energy consumption contribute to economic performance? Empirical evidence from Nigeria. J Econ Int Finance 1(2):044–058
Ogudipe A, Apata A (2013) Electricity consumption and economic growth in Nigeria. J Bus Manag Appl Econ 11(4):1–14
Oh W, Lee K (2004) Causal relationship between energy consumption and GDP revisited: the case of Korea 1970–1999. Energy Econ 26(1):51–59
Olusanya SO (2012) Long-run relationship between energy consumption and economic growth: Evidence from Nigeria. J Human Soc Sci 3(3):40–51
Omotor DG (2008) Causality between energy consumption and economic growth in Nigeria. Pak J Soc Sci 5(8):827–835
Onakoya AB, Onakoya AO, Jimi-Salami O, Odedairu BO (2013) Energy consumption and Nigerian economic growth: An empirical analysis. Eur Sci J 9(4):25–40
Orhan A, Adebayo TS, Genç SY, Kirikkaleli D (2010) Investigating the linkage between economic growth and environmental sustainability in India: do agriculture and trade openness matter?. Sustainability 13(9):4753
Oyedepo SO (2013) Energy in perspective of sustainable development in Nigeria. Sustain Energy 2:14–25
Ozokcu S, Ozdemir O (2017) Economic growth, energy, and environmental Kuznets curve. Renew Sust Energ Rev 72:639–647
Ozturk I (2010) A literature survey on energy-growth nexus. Energy Policy 38:340–349. https://doi.org/10.1016/j.enpol.2009.09.024
Ozturk I, Acaravci A (2010) CO2 emissions, energy consumption and economic growth in Turkey. Renew Sust Energ Rev 14:3220–3322
Panayotou T (1997) Demystifying the environmental Kuznets curve: turning a black box into a policy tool. Environ Dev Econ 2(4):465–484. https://doi.org/10.1017/S1355770X97000259
Phillips PB, Perron P (1988) Testing for a unit root in time series regression. Biometrika 75:335–346
Rahman MM (2017) Do population density, economic growth, energy use and exports adversely affect environmental quality in Asian populous countries? Renew Sust Energ Rev 77:506–514
Rahman MM (2020) Environmental Degradation: The role of electricity consumption, economic growth growth, and globalization. J Environ Manag 253:109742
Rahman MM, Kashem MA (2017) Carbon emissions, energy consumption and industrial growth in Bangladesh: empirical evidence from ARDL cointegration and granger causality analysis. Energy Policy 110:600–608
Rahman MM, Mamun SAK (2016) Energy use, international trade trade, and economic growth nexus in Australia: new evidence from an extended growth model. Renew Sust Energ Rev 64:806–816
Ramzan M, Iqbal HA, Usman M, Ozturk I (2010) Environmental pollution and agricultural productivity in Pakistan: new insights from ARDL and wavelet coherence approaches. Environ Sci Pollut Res 4(9):1–20
Rjoub H, Akinsola GD, Adebayo TS, Oladipupo SD (2021) The asymmetric effects of renewable energy consumption and trade openness on carbon emissions in Sweden: New evidence from quantile-on-quantile regression approach. Environ Sci Pollut Res 1–12
Saint Akadiri S, Alola AA, Akadiri AC (2019a) The role of globalization, real income, tourism in environmental sustainability target. Evidence from Turkey. Sci Total Environ 687:423–432
Saint Akadiri S, Lasisi TT, Uzuner G, Akadiri AC (2019b) Examining the impact of globalization in the environmental Kuznets curve hypothesis: the case of tourist destination states. Environ Sci Pollut Res 26(12):12605–12615
Sarkodie SA, Strezov V (2019) (2019) Empirical study of the environmental Kuznets curve and environmental sustainability curve hypothesis for Australia, China, Ghana Ghana, and USA. J Clean Prod 201:98–110. https://doi.org/10.1016/j.jclepro.2018.08.039
Shahbaz M, Hye QMA, Tiwari AK, Leitão NC (2013) Economic growth, energy consumption, financial development, international tradetrade, and CO2 emissions in Indonesia. Renew Sust Energ Rev 25:109–121
Shahbaz M, Bhattacharya M, Ahmed K, (2016). CO2 emissions in Australia: economic and non-economic drivers in the long-run. Appl Econ 1–14
Shahbaz M, Khan S, Ali A, Bhattacharya M (2017) The impact of globalization on CO2 emissions in China. Singap Econ Rev 62(4):929–957
Shahzadi A, Yaseen MR, Anwar S (2019) Relationship between Globalization and Environmental Degradation in Low Income Countries: An Application of Kuznet Curve. Indian J Sci Technol 12(19):1–13
Shan S, Ahmad M, Tan Z, Adebayo TS, Li RYM, Kirikkaleli D (2021) The role of energy prices and non-linear fiscal decentralization in limiting carbon emissions: Tracking environmental sustainability. Energy 234:121243
Sharif A, Afshan S, Chrea S, Amel A, Khan SAR (2020) The role of tourism, transportation and globalization in testing environmental Kuznets curve in Malaysia: new insights from quantile ARDL approach. Environ Sci Pollut Res 27(20):25494–25509
Sim N, Zhou H (2015) Oil prices, US stock return, and the dependence between their quantiles. J Bank Financ 55:1–8
Solarin SA, Nathaniel SP, Bekun FV, Okunola AM, Alhassan A (2021) Towards achieving environmental sustainability: environmental quality versus economic growth in a developing economy on ecological footprint via dynamic simulations of ARDL. Environ Sci Pollut Res 28(14):17942–17959
Solarin SA, Shahbaz M, Sahzad SJH (2016) Revisiting the electricity consumptioneconomic growth nexus in Angola: the role of exports, imports import, and urbanization. Int J Energy Econ Policy 6(3):501–512
Soylu ÖB, Adebayo TS, Kirikkaleli D (2021) The imperativeness of environmental quality in China amidst renewable energy consumption and trade openness. Sustain 13(9):5054
Soytas U, Sari R (2009) Energy consumption, economic growth, and carbon emissions: challenges faced by an EU candidate member. Ecol Econ 68:1667–1675
Srinivasan V (2017) Decreasing, not increasing, leaf area will raise crop yields under global atmospheric change. Glob Chang Biol 23(4):1626–1635
Stone M (1977) An asymptotic equivalence of choice of model by cross validation and Akaike's criterion. JR Stat Sco Ser B Methodol 39(1):44–47

Su ZW, Umar M, Kirikkaleli D, Adebayo TS (2021) Role of political risk to achieve carbon neutrality: Evidence from Brazil. J Environ Manag 298:113463

Tufail M, Song L, Adebayo TS, Kirikkaleli D, Khan S (2021) Do fiscal decentralization and natural resources rent curb carbon emissions? Evidence from developed countries. Environ Sci Pollut Res 28(35):49179–49190

Uddin MGS, Bidisha SH, Ozturk I (2016) Carbon emissions, energy consumption, and economic growth relationship in Sri Lanka. Energy Sources B Energy Econ Plan Policy 11(3):282–287 UN, 2017

Udemba EN, Adebayo TS, Ahmed Z, Kirikkaleli D (2021) Determinants of consumption-based carbon emissions in Chile: An application of non-linear ARDL. Environ Sci Pollut Res. https://doi.org/10.1007/s11356-021-13830-9

UNESCAP (2019) United Nations Economic and Social Commission for Asia and Pacific. https://www.unescap.org/publications/asiaand-pacific-sdg-progress-report-2019. Accessed 5 Jan 2022

Usman O, Akadiri SS, Adeshola I (2020) Role of renewable energy and globalization on ecological footprint in the USA: implications for environmental sustainability. Environ Sci Pollut Res 27(24):30681–30693

Uzuner G, Akadiri SS, Lasisi TT (2020) The asymmetric relationship between globalization, tourism, CO 2 emissions, and economic growth in Turkey: implications for environmental policy making. Environ Sci Pollut Res 27:32742–32753

Wu J, Wu Y, Guo X, Cheong T (2016) Convergence of carbon dioxide emissions in Chinese cities: A continuous dynamic distribution approach. Energy Policy:207–219

Xie P, Tan Z, Hou J-C, Wang M (2009) Analysis on dynamic relationship between urbanization and electricity consumption level in China. Power Syst Technol 33:86–92

Yahaya NS, Jali MR, Raji JO (2019) Energy consumption and environmental pollution in Nigeria. Acad J Econ Stud 5(1):24–30

Yazdi SK, Dariani AG (2019) CO2 emissions, urbanisation and economic growth: evidence from Asian countries. Econ Res-Ekon Istraživanja 32:510–530

Yuping L, Ramzan M, Xincheng L, Murshed M, Awosusi AA, BAH SI, Adebayo TS (2021) Determinants of carbon emissions in Argentina: The roles of renewable energy consumption and globalization. Energy Rep 7:4747–4760

Yusuf SA (2014). Impact of Energy Consumption and Environmental Degradation on Economic Growth in Nigeria. MPRA Paper No. 55529

Zhang L, Li Z, Kirikkaleli D, Adebayo TS, Adeshola I, Akinsola GD (2021) Modeling CO2 emissions in Malaysia: an application of Maki cointegration and wavelet coherence tests. Environ Sci Pollut Res 28(20):26030–26044