Journal of Cleaner Production 295 (2021) 126373

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

The anthropogenic consequences of energy consumption in E7 economies: Juxtaposing roles of renewable, coal, nuclear, oil and gas energy: Evidence from panel quantile method

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A R T I C L E I N F O

Article history:
Received 6 October 2020
Received in revised form
30 January 2021
Accepted 10 February 2021
Available online 19 February 2021

Handling Editor: Dr Sandra Caeiro

Keywords:
CO_2 pollution
Environmental sustainability
Coal rents
Energy utilization
Regulatory quality and E7 countries

A B S T R A C T

The emerging industrialized seven (E7) economies are not excluded from the global warming issues which is a major problem for most economies. The E7 member countries have partaken in policies to mitigate against global warming in terms of decoupling CO_2 emission from economic growth trajectory in the highlighted economies. It is on this premise that the present study is motivated to consider the connection among economic growth, pollutant emissions, coal rent while accounting for the role of other co-variates such as CO_2 damage and energy from a nuclear energy source, oil gas energy between 1990 and 2016 on an annual frequency. This study adopts the use of panel ordinary least squares alongside panel quantile regression to explore the coal rent-energy and environment nexus. The empirical result shows a positive and significant effect of both real GDP and coal rent on CO_2 emissions. More precisely, a 1% increase in GDP growth increases pollution emission by 0.400% while for coal rent, an increase in coal consumption dampens environmental quality by 0.088% as reported by the panel regression which is resonated by the quantile regression estimations at different tails of the data. Nevertheless, we observe that 0.95 percentile GDP growth strongly contributes to environmental pollution while at the median tail i.e. 0.5 percentile renewable energy consumption dampens the adverse effect of environmental degradation. Additionally, renewable energy, on the other hand, was found a negative and significant impact on CO_2 emissions in E7 countries as a 1% increase in renewable energy consumption improves environmental quality by 0.588% Moreover, the estimated results indicate that regulation of coal consumption through the rent in addition to the cost of carbon damage will further increase the CO_2 emissions in E7 countries. This study implies that putting stringent regulations on coal consumption as it concerns the increasing cost of carbon damage will not be of help to environmental sustainability within the E7 economies. The adoption of renewable energy consumption, nuclear energy, oil energy will reduce CO_2 emissions in E7 countries. Thus, suggesting a paradigm shift for low-carbon energy sources which are more environmentally friendly.

1. Introduction

Pollutant emissions like CO_2 affect the global atmosphere, resulting in the challenge of global warming. To any viable economy, a stable supply and demand for energy are pertinent to its sustainable economic development (EIA, 2018). One of the banes of

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https://doi.org/10.1016/j.jclepro.2021.126373
0959-6526/

any developing/emerging economy is the pace of its development. The quest to economic growth comes with its environmental implications which gives rise to environmental commitments and treaties like the Kyoto Protocol, with signatory members like Brazil, Russia, India, Mexico, China, Indonesia and Turkey (E−7)[1] among others, highlighted climate change to be one of the significant challenges to sustainable development and economic growth (Sarkodie et al.,2020). This consensus comes with the commitment to ensure the reduction of pollutant emissions like greenhouse gas emissions by 2020 (Adedoyin et al., 2020).

Over the last decade's most economies have been working audaciously toward reducing their greenhouse gas emissions level (inter alia Shahbaz et al., 2019) because global interest in pollution and greenhouse gas emissions have risen. For instance, a review of the British Petroleum Global Energy Statistical Review (2017) report shows that most economies are making positive strides while the rest especially those in developing/emerging blocs are lacking behind on the global task to reduce CO_2 emission. A similar report emerged from the United States, which shows that the United State is found to have reduced its pollutant by almost 800 million tons, a feat which is five times more than the case of the United Kingdom which is second on the list. According to the British Petroleum Global Energy Statistical Review, the top achievers with a significant reduction in CO_2 emission includes the US, UK, Italy, Poland, Spain, Japan, the Russian Federation, France, Germany, and Greece among others. It appears from the list that, the Russian Federation emerged the only E7 member state to have successfully achieved a significant reduction in its pollutants over the last decade.

For the fight against ecological degradation which was to mitigate negative effects of climate change and global warming, the 21st session in Paris Conference for the Parties (COP21) emerges as a focal point to this objective (Esso and Keho, 2016). From the conference, participating countries would shift to renewable energies that produce less pollutant for not endanger the environment. Among the E7 member states, India emerges as one of the pioneers of world renewable energy producers and currently, it spends more on sustainable energy than on coal and oil. After achieving a 40% level of renewable energy generation in 2016, a target was set for 2030 for its renewable energy sustainability, its current success is so fast that this aim could be met ten years early. Climate experts estimate that India's plan is consistent with the two-degree Celsius rise, but it could be 1.5 °C incompatibility with its national energy plan if the country abandons plans to build new coal-fired plants. Moreover, China, another prominent member of the E7 states is also nearing the achievement of its renewable energy objectives agreed in Paris. However, these targets are exceedingly inadequate, and not realistic enough to reduce warming to below 2 °C or 1.5 °C, as stipulated in the Paris agreement, unless there is a considerably higher commitment by other countries to make substantially greater reductions. Although some current reports suggest, Chinese greenhouse gas emissions are expected to rise till at least 2030, it also expected that China can also make significant strides at peaking gains at reducing pollutants ten years earlier.[1]

Nevertheless, extant literature highlights several documentations on the connections between energy consumption-income and environment for blocs like G7, BRICS, OECD, and Sub-Saharan African (SSA) economies in addition to energy (coal, nuclear) consumption and sustainable development (Solarin & Shahbaz, 2013, 2015; Rauf et al., 2020). The energy consumption and economic development nexus established in literature has proven to be mixed with no consensus on the direction of causality flow, For instance, the study of Apergis and Payne (2010) and Cowan et al. (2014) shows uni-directional causality between energy and economic growth A practical implication of this assertion is that increase energy consumption drives economic growth and deplete the environment if the energy is from fossil-fuel based, although, this assertion raises a lack of consensus among researchers Bekun et al. (2019). For instance, Bekun et al. (2019) reveal that in South African which is heavily reliant on energy-intensive industries, as other industrialized nations across the globe considering fast population growth rates, technology, lifestyle changes and urbanization. These features facilitate the increased demand for energy consumption,[2] thus, posing significant threats to global warming. The increased demand for energy and its accompanying global environmental crises raises concerns with how nations pursue their environmentally friendly and sustainable development goals which are in line with the United Nations Sustainable Goals. In the light of economic, political, social diversity, and differing environment-friendly strategies, global concerns regarding the capacity of countries to keep pace with their energy demands and the rising rates of pollutants related to anthropogenic environmental warming, presents a significant problem. Issues as these require a continuous focus on the causal relationships between energy consumption, economic growth and CO_2 emissions by policymakers.

In pursuing this goal, the need to first consider climate change reports of major countries, as to whether they are reaching the globally acceptable target. Next, the need to ensure E7 countries (a group of emerging and industrialized nations), are not adversely affecting the global environment with their increased industrial operations. This is because in observing how the energy generated is consumed, consequential to environmental and social challenges such as pollution, and greenhouse gas emission indicates emissions mainly emanates from energy generation and utilization (IPCC, 2013). An energy source such as coal is mainly from fossil fuels, which is highlighted to influence pollutants, green and sustainable growth (Adedoyin et al., 2020). Ben-Amar (2013) asserted that energy is an essential factor for socioeconomically progress and other vital mankind action, however, the increased utilization of energy has increased ecological degradation consequences. While the requirements for socioeconomic revolution rests a crucial tool of government policy within a lot of nations, international pressures created by the threat of global warming and climate change continue to mount on countries. Thus far, the link between economic growth, energy consumption and pollution, particularly coal consumption, must be examined further (Rodionova et al., 2017). However, the current study of coal intake exists as an essential determinant of economic performance (Rodionova et al., 2017). Along with the fact that the examined blocs rely on coal consumption and further shows ample coal supplies and will possibly fulfil their existing and potential energy requirements in terms of socio-economic development and environmental changes. The heavy dependency of most E7 economies and several other developing economies on coal consumption and the subsequent strong pollutant emissions requires an awareness of the actual impact of rents in coal and environmental growth (Rodionova et al., 2017). Coal rent from coal energy offers benefits to coal-exploration firms to use coal to produce energy (Mehrara and Baghbanpour,

[1] E7 Countries: Group of seven global national emergency economies: Brazil, Russia, India, China, Indonesia, Mexico and Turkey, which are all mostly emerging and newly industrialized nations.

[2] Climate change report card: These countries are reaching the target. https://www.nationalgeographic.com/environment/2019/09/climate-change-report-card-co2-emissions/.

2015) an indication that coal production is mainly used for energy generation. It is estimated that coal rent in E7 economies accounts for some share of her energy mix precisely in Brazil 0.01%, China 0.41%, India 0.76%, Indonesia, 0.64%, Russia 0.37%, Mexico 0.02% and Turkey 0.02% and proportion of their GDP growth. This evidence suggests that coal rents play a crucial role in economic development, as with all other natural resources, including oil rents. It is crucial to demonstrate the impact that these natural resources have on environmental sustainability. (Lin and Wesseh, 2014).

For emerging markets, coal is still an important source of energy. The negative impact associated with coal use has raised criticisms from local and international agencies. This makes the need to reduce carbon footprints every nation's obligation. However, many developing economies as well as some developed ones are at crossroads with their energy, climate, and economic strategies Sarkodie et al. (2020). With the above highlights this study offers a five-fold contributions to the existing literature in terms of:

1. This study contributes to the extant literature by offering an understanding of the effect of energy consumption from (renewable, oil, and nuclear). Additionally, coal energy consumption on CO_2 emission in the E7 economies. The preference of the E7 economies is important to this examination since more than 70% of the energy supply in most of the E7 economies are generated from coal consumption.
2. Several studies exist on exploring the causal relationship between economic growth and energy utilization, in addition to other energy sources like coal rent, nuclear energy consumption which have received less documentation in the literature especially in the E7 context. Although several studies exist on supporting the economic expansion and energy emissions nexus, these studies have neglected the consideration of coal as an energy source, as such literature on coal rents, energy consumption and economic expansion among E7 economies is quite deficient.
3. This study is different from previous studies like (Cowan et al., 2014; Zakarya et al., 2015) that examined emission-energy determinants and other energy structures, including electricity. The current study leans toward the discussion on coal rents as well as nuclear energy and its connection to CO_2 emissions in the energy-emissions-growth debate.
4. The study also analyzes how carbon dioxide damage consistency in the E7 economies influences this connection, utilizing data from 1990 to 2016 and concentrating on relevant panel methods to rationalize the highlighted relationship.
5. Additionally, this sudsy relies on second-generation panel estimator that circumvent for cross-sectional dependency and as such offers more reliable and consistent results is employed to examine how the selected variables affect environmental degradation within the E7 economies.

The remainder of this study is structured as follows: a literature summary is provided in section two. Econometric methods and information are presented in the third section. The fourth section focuses on empirical results interpretation. Finally, the last section contains conclusion and policy implications.

2. Literature review

The literature on the correlation between coal output and sustainable development has produced a litany of mixed results. Prior examinations like Yang (2000) reported a negative causal association between coal utilization and sustainable development, while Wolde-Rufael (2004) contrary to the inverse association earlier reported, showed that coal utilization increases sustainable development. Similar differing findings are reported for coal utilization and economic development between OECD and non-OECD states (Jinke et al., 2008).

Mainly, much of the discussion on energy utilization have considered coal usage. As such, the analysis of the issue of coal usage and social development suggests the establishment of a one-way causality between social development and coal usage. For instance, Bhattacharya et al. (2013) confirm a one-way causality between social development and renewable energy in China and Japan, whereas no causality is identified in the cases of India, South Africa, and South Korea.

However, the association between coal output and sustainable development shows a positive connection in the long-term. For example, Wolde-Rufael (2010) earlier reviewed the effect of emissions on sustainable development among the top six coal using nations. India and Japan showed a unidirectional causality formed from coal usage to productivity expansion, while China and South Korea attained increased productivity gains from coal usage. However, between coal usage and social expansion in the case of South Africa and the United States, a bi-directional causality was found.

Further, Bhattacharya et al. again emphasize that, in the case of China, improving the productivity of the coal sector facilitated sustainable growth, while Shahbaz et al. (2015) perceive that the manufacture and use of industrial coal induce more CO_2 pollution for India, thus limiting social development in a comparative analysis between China and India.

In certain jurisdictions like South Africa, some studies established a causal one-way connection between coal usage to job creation, and a causal bidirectional connection between jobs and socio-economic development (Odhiambo, 2016). Indicating, an association between coal production and economic growth.

Also, there is a unidirectional association between China's GDP and its coal usage. A related uni-directional causality link exists between coal usages to economic growth for India (Li and Li, 2011), Apergis and Payne (2010) disclosed that the causality involving economic development and coal intake being negative in the short and bidirectional. Studying the very identical base, Wassung (2010) on Water-Energy Connection in South Africa clarified that electricity production involves large volumes of clean aquatic for freezing and that the problem is expected to be further exacerbated as more solar energy plants will be constructed to solve South Africa's growing demand for energy.

Over the recent century, academics in the areas such as economics and climate had been charged with the issues to boost output in markets and progress on social deterioration, as a result of pollutants (CO_2) from industrial development, which is deemed the key cause of climate change. This illusion has been the subject of several studies primarily designed to examine the link involving socioeconomic progress and carbon pollution and to examine the Environmental Kuznets Curve (EKC) environmental theory and to implement interventions for environmentally-friendly management and effective development. For example, Odhiambo (2012) explained in South Africa that the causal relation flows unidirectionally from development to pollutant emissions, whereas Granger's energy usage causes both pollutant emission and productivity expansion. Results from Dinda (2009) vary from other reports for the OECD and non-OECD nations. Though CO_2 pollution may not stimulate economic growth, reports have shown that there could be improved economic development from the utilization of certain activities that facilitate CO_2 generation in non-OECD countries in OECD countries. Variables like trade, urbanization as well as globalization emerge as factors that facilitate pollutants (CO_2) pollution. For example, Sharma (2011) found a significant association between real GDP, trade accessibility and energy usage, whereas urban settlement is found to have established a negative relationship with low-income, middle-income as well as high-income panels. Similarly, oil use and increased electricity generation are statistically validated factors of pollutants, while electricity use has an adverse impact on pollution.

Besides, the connection of energy-demand-pollutants has been debated on a broad basis, involving cumulative as well as separate (sustainable energy and fossil fuel) energy, bringing various economic development measures and ecological degradation metrics into mixed-outcomes for regions and countries (Danish and Wang, 2018). Lately, researchers are paying considerable emphasis on the role of renewable technology in ecological degradation. Some scholars have proposed that renewable energy sources lead to CO_2 pollution mitigation (Dong et al., 2018). In comparison, some researchers concluded that renewable energy leads to ecological emissions (Bulut, 2017). In comparison, few contend that renewables are insignificantly impacting CO_2 pollution (Jebli et al., 2016). However, renewable energy has gained great study coverage like nuclear energy. Nuclear energy has a significant role to play in mitigating emissions. Moreover, Baek and Pride (26) concluded that nuclear energy mitigates pollution. Xu et al. (2018) discovered that even with carbon capture and storage (CCS) technology, nuclear energy generates lower emissions than coal.

The next team of scholars has the opposite results. E.g., Jin and Kim (2018) studied the connection between CO_2 pollution and nuclear energy in thirty nations. The findings revealed that nuclear technology had no role in lowering Pollution. The causal link between nuclear energy use and CO_2 emissions has been examined by Saidi and Mbarek (2016), in nine advance countries. Al-mulali (2014) has published mixed findings in a panel of thirty massive nuclear energy-intake countries investigating the intersection of energy-emissions. The factor of nuclear energy was optimistic but irrelevant for the final panel outcomes.

Furthermore, studies that analyzed the causality among economic growth and emissions in the E7 nations' financial parts of energy usage was also examined. Pao and Tsai (2010) examined the causal connection among the BRICS nations and identified that fossil fuel and real GDP causes emission. The connection between economic development, energy intake and pollutant (Wang et al., 2011) reported that only economic growth causes pollution which implies that the biggest sources of CO_2 pollution in China was economic growth. Moreover, according to the study of Farhani et al. (2014), coal intake and factory output in India were positively cause of CO_2 emissions, whereas the same result was found in China. Nevertheless, The determinants of CO_2 pollution from energy use in Brazil was analyzed by De Freitas and Kaneko (2011) and it reviewed that economic development and urbanization were the key factors explaining Brazil's pollutant increase.

The study on causality in some E7 nations indicated causal relations among all factors but vary in direction (Cowan et al., 2014). The presence of co-integration in China was established but was not established in India as presented in the analysis of Govindaraju and Tang (2013) although the same two countries had a causal unidirectional association involving economic development to CO_2 pollution. Pao et al. (2011), revealed a positive correlation between pollutant, energy intake and real GDP in Russia. In conclusion, considering the different causes, we find that there is a need for further examinations into the varying energy outlets, their growth and impact on pollutants particularly in the E7 blocks.

3. Data and methodology

3.1. Data and variables

Past studies have examined the energy consumption and environmental consequence nexus with different macroeconomic and energy variables (see, Adedoyin et al., 2020; BA Gyamfi et al., 2020). This current study explores the channels through which energy from carbon dioxide damage influence the relationship between coal rent, renewable energy, nuclear energy utilization and CO_2 emissions in E7 states. This study considers a data series spanning from 1990 to 2016, with second-generation estimation methods and the Dumitrescu and Hurlin panel causality test. Table 1 below offers detailed information on the variables used in this study.[3] In this current study, we allow for interactions of different environmental regulatory policies to identify how they can be effectively deployed to reduce carbon emissions in E7 countries.

3.2. Model and method

3.2.1. Methodology

To identify the right analytical technique(s) to employ, the authors used the cross-section dependency (CD) test. The outcome from the CD test helps in either going for the first-generation or second-generation panel data econometric technique. The analysis will be bias, meaningless and inconsistency if CD test is not carried out (Dong et al., 2018; Nathaniel et al., 2020). To make sure the mention problems do not occur, the authors employed 3 CD tests which are the Pesaran (2007) CD test and the Pesaran (2015) scaled LM test for the sake of robustness check. More attention was placed on the Pesaran (2015) scaled LM test because of how our dataset is shown i.e. the time frame (T) figure is larger than that of the cross-sections (N) number. The CD test equation is shown in Eq. (1) as:

$$CD = \left(\frac{TN(N-1)^{\frac{1}{2}-P}}{2} \right) \tag{1}$$

Whereas from equation (3), $P = \left(\frac{2}{N(N-1)} \right) \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} Pij$, Pij is the Pairwise cross-sectional correlation coefficient of the residual from the ADF regression. T and N are the sample and panel scope separately.

3.2.2. Panel stationarity technique

The proof of CD made in the estimation brings out inefficiency in the first-generation stationarity technique (e.g., Im et al., 2003). Therefore, the authors employed a second-generation stationarity technique (CIPS) to solve the problem of inefficiency in the estimation. From the Pesaran (2007) the CIPS unit root test estimation is shown as;

$$\Delta Y_{it} = \Delta\phi_{it} + \beta_i X_{it-1} + \varrho_i T \sum_{j=1}^{n} \theta ij \Delta X_{i,t-}j, \varepsilon_{it} \tag{2}$$

Where ϕ_{it}, x_{it}, Δ, T, and ε_{it} represent the intercept, study variables, difference operator, time span, and disturbance term respectively. In the presence of stationary parameters of the first difference, a cointegration experiment of the second generation will be used. This is to decide whether the parameters to test have a long-term equilibrium association.

3.2.3. Panel cointegration test

The analysis used the Westerlund (2007) experiment to obtain

[3] More insight on basic statistics about Variance inflation factor on appendix A2.

Table 1
Description of variables.

Variables	Abbreviation	Definition	Data Source
CO_2 emissions (metric tons per capita)	CO_2	Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.	WDI
Renewable energy consumption (% of total final energy consumption)	REC	Renewable energy consumption is the share of renewable energy in total final energy consumption.	WDI
Energy from nuclear sources (% of total)	NPG	Sources of electricity refer to the inputs used to generate electricity. Nuclear power refers to electricity produced by nuclear power plants.	IEA Statistics
Economic Growth	GDP	GDP per capita (constant 2010 US$)	WDI
Coal rents (% of GDP)	CR	Coal rents are the difference between the value of both hard and soft coal production at world prices and their total costs of production.	WDI
carbon dioxide damage (% of GNI)	CD	Cost of damage due to carbon dioxide emissions from fossil fuel use and the manufacture of cement, estimated to be US$30 per ton of CO_2 (the unit damage in 2014 US dollars for CO_2 emitted in 2015) times the number of tons of CO_2 emitted.	WDI
Energy from oil, gas and coal sources (% of total)	OGC	Sources of electricity refer to the inputs used to generate electricity. Oil refers to crude oil and petroleum products. Gas refers to natural gas but excludes natural gas liquids. Coal refers to all coal and brown coal, both primary (including hard coal and lignite-brown coal) and derived fuels (including patent fuel, coke oven coke, gas coke, coke oven gas, and blast furnace gas). Peat is also included in this category.	IEA Statistics

Source: author's compilation

proof of cointegration between parameters. The error checking process can be represented as:

$$\Delta y_{it} = \delta_i d_t + \varphi_i y_{it-1} + \lambda_i x_{it-1} + \sum_{j=1}^{pi} \varphi_{ij} \Delta y_{it-j} + \sum_{j=0}^{pi} \gamma_{ij} \Delta x_{it-j} + e_{it} \quad (3)$$

Where $\delta_t = (\delta_{i1}, \delta_{i2})'$, $d_t = (1, t)'$, and φ are the vector of parameters, deterministic components, and the error correction parameter respectively. To identify cointegration existence, four tests were carried out. These techniques (4) were centred on the OLS technique of φi in Eq. (3). Group mean statistics was made up of two out of the four estimations and shown as;

$$G_\tau \frac{1}{N} \sum_{i=1}^{N} = \frac{\hat{\propto} i}{SE(\hat{\propto} i)} \quad \text{and } G_\alpha \frac{1}{N} \sum_{i=1}^{N} \frac{T \hat{\propto} i}{\hat{\propto} i(1)}$$

Where $\hat{\propto} i$ is denoted by $SE(\hat{} \propto i)$ as the standard error. The semiparametric kernel technique of $\propto i(1)$ is $\hat{\propto} i(1)$. Two of the four remaining panels mean estimations which proof that the whole panel is cointegrated is shown as;

$$P_\tau \frac{\hat{\propto} i}{SE(\propto i)} \text{ and } P_\alpha = T\hat{\alpha}$$

3.2.4. Ordinary least square (OLS) and quantile regression (QR)

The analysis uses the technique for OLS and QR. The existence of cointegration assesses a long-term connection utilizing the OLS econometrically rational. They use the OLS with standard errors made by Driscoll and Kraay (1998). This method allows (1) heteroscedasticity, (2) serial interaction and (3) cross-sectional dependency to be considered. Nevertheless, the QR was the chosen statistical tool based on its superior to the OLS for different reasons. The standard circulation, as well as the zero, mean approval of the OLS error concept, is rather unrealistic, since there may be multiple distribution models for socioeconomic measures (De Silva et al., 2016). The QR reinforces this deficit (Salman et al., 2019; Nathaniel et al., 2020). The methodology (QR) does not presume the function of the period (Zhu et al., 2016). In the case of outliers (Bera et al., 2016), forecasts remain robust. No predictions for distribution have been made. The model for QR is shown as

$$\text{Quant}_\theta (y_i/x_i) = x\beta_\theta + \mu_\theta, \ 0b\theta 1 \quad (4)$$

Where x is the exogenous factors, while y is the endogenous factors. The equilibrium place and disruption word of the explicit vector are θth and μ simultaneously. We use the contingent quantile regression that explores the effect of the regressors to be used in our econometric analysis on the foundation of the values of the preliminary factors. In the past, the QR-technology was utilized in (Hübler, 2017; Xu and Lin, 2018; Nathaniel et al., 2020).

3.2.5. Model

The Stochastic impact by regression on population, affluence and technology (STIRPAT) structure is the foundation of this analysis. The STIRPAT hypothesis notes that the destruction of the ecosystem is both economic and social.

$$I_t = \vartheta_o P_t^{\xi 1} A_t^{\xi 2} T_t^{\ \xi 3} \mu_t \quad (5)$$

From Eq. 7, I is a pointer of ecological deprivation, P, A, and T represents population, affluence, and technology respectively. $\xi 1 - \xi 3$ and μ are the factor evaluators and the error term respectively. T may be broken down based on the purpose of the study (Bello et al., 2018; Anser 2019; Nathaniel et al., 2020). Base on the analysis of Solarin and Al-Mulali studies (2018) I, identify the environmental factors in this analysis as stated earlier. From a different perspective, P and A are denoted by economic sustainability and economically globalization respectively. The authors then adopted Foreign Direct Investment (FDI) and renewable energy utilization as a proxy T. The extended layout is shown as:

$$I_t = \vartheta_o GDP_t^{\xi 1} REC_t^{\xi 2} NPG_t^{\ \xi 3} CR_t^{\ \xi 4} CD_t^{\ \xi 5} OGC_t^{\ \xi 6} \mu_t \quad (6)$$

In the order to attain the goal of this investigation, this section presents the models that show how each of the regulatory variables employed in the study affects the dependent variable (CO_2 emissions). All the variables are specified in their logarithmic forms (ln) to get more robust outcomes. By taking the logarithm of each of the variables, the formula is further formulated as;

$$lnI_t = \vartheta o + \xi_1 LnGDP_t + \xi_2 LnREC_t + \xi_3 LnNPG_t + \xi_4 LnCR_t + \xi_5 LnCD_{t+} \xi_6 LnOGC_{t+} \mu_t \quad (7)$$

Where GDP, REC, NPG, CR, CD and OGC denote economic growth, renewable energy consumption, energy from nuclear sources, coal rent, carbon dioxide damage and oil, gas and coal sources. I, on the other hand, represent the environmental indicator used in this analysis, thus, CO_2. To analysis the impact of GDP, REC, NPG, CR, CD, OGC and their regulatory policies on I at the selected quantile level, the authors formulated Eq (10) which is shown as;

$$Q\tau (LnCO_2) = \vartheta\tau + \xi_{1\tau} LnGDP_{it} + \xi_{2\tau} LnREC_{it} + \xi_{3\tau} LnNPG_{it} + \xi_{4\tau} LnCR_{it+} \xi_{5\tau} LnCD_{it+} \xi_{6\tau} LnOGC_{it+} \xi_{7\tau} Ln\,(CR{*}CD)_{\,it+} \xi_{9\tau} Ln\,(NPG{*}CD)_{\,it} \quad (8)$$

Whereas the remaining variables maintain their original description, CO_2 represent CO_2 emission. For the explicative variables, the reference point is τ. $Q\tau$ corresponds to the τth distributional point regression analysis that can be determined using the formulae in Eq. (9)

Nevertheless, pollutant controls, however, presume a substantial influence on decreasing pollutants. As seen in Table 1, this analysis deviates from recent research on the position of legislation and policy (Danish et al., 2019) by incorporating a separate regulatory quality measure that serves as a controlling and price-setting rule (carbon danger-CD) on pollution and how to resolve environmental issues from worry to practice. In this analysis, we engage with coal rents and nuclear energy to demonstrate the regulator's individual progress in addressing sustainable energy and green economy. Our purpose is to catch unique energy-related, emission-related procedural efficiency. According to Lange et al., carbon damage is measured as a multiplication of the increased social expense of pollution from a specific source of energy, multiplied by a rise in the supply of the number of tons of pollutant generated per year. Our insight is to connect this factor with the rents that result from the differential among world prices and the value of both hard as well as soft coal output is to catch the precaution that in the vicinity of increasing harm, E7 nations use this form of energy. We may not separate the direct impact of carbon damage pollution as caught in the relationship, but rather investigate how all groups of nations are driven in using this energy stream to meet climate change targets, determined by their emission levels.

$$Q_\tau = \arg\min \sum_{k=1}^{q} \sum_{t=1}^{T} \sum_{i=1}^{N} (|y_{it} - \alpha_i - x_{it} \cdot Q_\tau | H_{it}) \quad (9)$$

Where q, T, N and H_{it} shows the number of quantiles, years, cross-sections, and weight of the *i*th nations in the *i*th year respectively.

4. Results and discussions

4.1. Pre-estimation diagnostics

The study provided the summary of statistics of the variables of interest, which include the mean, median, standard deviation, minimum, maximum, skewness, Kurtosis, Jarque-Bera, probability values, the sum of deviation cum squared deviation and the total number of the observations are presented in Table 2. The outcome of the summary statistics reveals that all the variables of interest are negatively skewed except CO_2 emissions and the Jaque-Bera test confirms the normal distribution of the data series. Based on the average, real GDP has the highest average value of 8.901with a maximum and minimum of 9.620 and 8.450 respectively.

The correlation matrix is reported in Table 3 to show the level of multicollinearity among the variables of interest. It is discovered that CO_2 emissions have a strong and positive association with all the variables except with renewable energy consumption.

4.2. Estimated results

The results of the cross-sectional dependence are reported in Table 4, which depicts a signal for the rejection of the null hypothesis of an independent cross-section of the variables under investigation. In short, the analyzed variables of interest are dependently cross-sectional.

Instead of the results of the cross-sectional dependency test, we adopt Pesaran's IPS and CIPS panel unit root tests and of which the results are depicted in Table 5. The results of the panel unit root tests are presented at the level and first difference while considering the intercept and intercept cum trend. At level, only three variables (coal rent, carbon damage and oil, gas and coal energy sources) are stationary as demonstrated in the CIPS unit root test while other variables are found to be stationary at first difference. Thus, the mixed order arrangement of the variables between level and first difference requires more advanced estimation techniques that will be applied in the study The Westerlund (2007) Cointegration Test is thereby presented in Table 6 to confirm the existence of cointegration among the variables of interest. The cointegration test presents both the group statistics and panel statistics and the outcomes of both provide evidence for the existence of cointegration among the variables in the model. The results obtained from the cointegration test lead us to the application of the appropriate estimation techniques, that is, ordinary least square (OLS) and Quantile regression (QR).

The outcomes of the OLS and Quantile regressions for the long-run relationships between carbon emission and the independent variables are presented in Table 7 of which the study will focus more on the outcomes of the quantile regression. The OLS estimation shows that real GDP has significantly influenced carbon emission positively. Precisely a per cent increase in real GDP will cause an estimated 40% increase in carbon emission. Contrarily, increased renewable energy consumption negatively influences carbon emission in E7 economies such that, a 1% increase in renewable energy consumption attracts about a 59% reduction in carbon emissions. Additionally, nuclear energy sources also showed a significant influence on a coefficient of 0.138. Precisely, a 1% increase in energy generated from nuclear sources will increase carbon emission by about 14%. More so, coal rent exerts a positive and significant effect on carbon emissions. In that, a unit increase in coal rent will increase carbon emission by about 9%. The cost of carbon damage also exerts a significant effect, indicating a percentage increase cost of carbon damage will increase carbon emission by about 51%. Oil, gas and coal energy generation sources are showed a negative and statistically significant effect. Such that a 1% increase in the cost of carbon damage will decrease the carbon emission by about 11%. Furthermore, the OLS estimates show that the combined effect of coal rent and cost of carbon damage is positive and statistically significant. Contrarily, the combined effects of energy from nuclear sources and cost of carbon damage all exert negative effects on carbon emission and statistically significant at 1% (Table 8).

The quantile regression estimations results (presented in Table 7) showed that real GDP positively affects carbon emission across all the quantiles. This implies that increased economic growth experienced in E7 economies is a culprit of economic degradation in the region and the implication of this can be found with the uncontrolled growth rate of the industries that contribute more to the deterioration of the environment as they expand. These results align with the findings of Ozcan et al. (2019) on 35 OECD

Table 2
Summary statistics.

VARIABLES	LnCO2	LnGDP	LnREC	LnOGC	LnNPG	LnCR	LnCD
Mean	1.105	8.450	2.967	4.042	0.839	−2.334	0.602
Median	1.032	8.901	3.188	4.358	0.757	−1.966	0.588
Maximum	2.637	9.620	4.071	4.504	2.926	1.576	2.416
Minimum	−0.343	6.355	1.171	1.503	−3.856	−11.776	−1.053
Std. Dev.	0.774	0.908	0.914	0.765	1.001	2.452	0.743
Skewness	0.279	−0.795	−0.643	−2.234	0.074	−0.918	−0.027
Kurtosis	2.253	2.295	2.165	6.538	4.823	4.026	2.198
Jarque-Bera	7.343	25.616	19.879	274.873	28.309	37.422	5.4529
Probability	0.025	0.000	0.000	0.000	0.000	0.000	0.065
Sum	224.472	1715.393	602.311	820.623	170.475	−473.897	122.306
Sum Sq. Dev.	121.040	166.828	168.819	118.300	202.519	1215.451	111.528
Observations	189	189	189	189	189	189	189

Table 3
Correlation matrix.

	LnCO2	LnGDP	LnREC	LnOGC	LnNPG	LnCR	LnCD
LnCO2	1						
P-value	–						
LnGDP	0.638*	1					
P-value	(0.00)	–					
LnREC	−0.952*	−0.565*	1				
P-value	(0.00)	(0.00)	–				
LnOGC	0.184*	−0.354*	−0.300*	1			
P-value	(0.00)	(0.00)	(0.00)	–			
LnNPG	0.631*	0.275*	−0.692*	0.147**	1		
P-value	(0.00)	(0.00)	(0.00)	(0.03)	–		
LnCR	0.101**	−0.509*	−0.141**	0.664*	0.180*	1	
P-value	(0.04)	(0.00)	(0.04)	(0.00)	(0.01)	–	
LnCD	0.275*	−0.511*	−0.309*	0.595*	0.345*	0.733*	1
P-value	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	–

NOTE: *, **, *** represents 1%, 5% and 10% significant levels.

countries and Sharif et al. (2019) on 74 nations selected globally. Also, the outcomes discovered for the clean energy intakes are negative and statistically substantial across the observed quantiles. This means that increase in the consumption of renewable energy will reduce the environmental degradation experienced in E7 economics. This is another policy direction for policymakers to adopt cleaner energy sources in place of the traditional non-renewable energy sources in a way to promote environmental quality and sustainable development in the region. These results concur with the findings of Danish et al. (2019) and Hanif et al. (2019) for BRICS and Asian economies respectively. Additionally, nuclear energy sources are observed to be positive in 5th and 25th quantiles but only significant in the 25th quantile while other quantiles show a negative and insignificant impact of nuclear energy sources on the environmental deterioration in E7 economies. This implies that the adoption of low nuclear energy sources as

Table 4
Cross-sectional dependency test results.

	Pesaran (2007) CD Test	Pesaran (2015) LM Test
$LnCO_2$ = f (LnGDP, LnREC, LnNPG, LnCR, LnCD, LnOGC)	4.483*	−2.444**

NOTE: *, **, *** represents 1%, 5% and 10% significant levels.

Table 5
Panel IPS and CIPS unit root test.

Variables	IPS				CIPS			
	Intercept		Intercept & trend		Intercept		Intercept & trend	
	Levels	1st Diff	Levels	1st Diff	Levels	1st Diff	Levels	1st Diff
$LnCO_2$	−1.008	−4.707*	−2.210	−4.638*	−2.826	−4.468*	−2.237	−4.456*
LnGDP	−0.160	−3.765*	−2.032	−3.877*	−1.753	−3.041*	−1.345	−3.323*
LnREC	−0.592	−5.034*	−2.632	−4.958*	−2.657**	−4.672*	−2.657	−4.794*
LnNPG	−1.950	−2.070***	−2.570	−2.930**	−1.889	−3.327*	−2.607	−3.668*
LnCR	−2.027	−5.776*	−2.493	−5.668*	−2.623*	−5.011*	−2.872***	−5.591*
LnCD	−1.868	−4.509*	−2.220	−4.435*	−2.087	−4.925*	−2.808***	−4.981*
LnOGC	−2.164	−6.285*	−3.0348	−6.217*	−2.968*	−5.643*	−3.124*	−5.735*

NOTE: *, **, *** represents 1%, 5% and 10% significant levels.

Table 6
Westerlund (2007) Cointegration test.

Model/dependent	Group statistics		Panel statistics	
	$G\tau$	$G\alpha$	$P\tau$	$P\alpha$
$LnCO_2$ = f (LnGDP, LnREC, LnNPG, LnCR, LnCD, LnOGC)	−1.841**	−3.529***	−6.959*	−6.159***

NOTE: *, **, *** represents 1%, 5% and 10% significant level.

Table 7
OLS and Quantile Regression Result for a long-run relationship.

Dependent variable: $LnCO_2$	OLS	Q.05	Q.25	Q.50	Q.75	Q.95
LnGDP	0.400*	0.321*	0.376*	0.468*	0.499*	0.547*
LnREC	−0.588*	−0.593*	−0.636*	−0.564*	−0.575*	−0.479*
LnNPG	0.138*	0.314*	0.079	−0.096	−0.055	−0.042
LnCR	0.088*	0.315	0.086**	0.068***	0.101*	0.054
LnCD	0.508*	0.341*	0.522*	0.642*	0.693*	0.711*
LnOGC	−0.107*	−0.019	−0.130**	−0.140**	−0.250*	−0.128**
LnCR*LnCD	0.072*	0.078*	0.085*	0.061*	0.033**	0.029***
LnNPG*LnCD	−0.096*	−0.022	−0.082*	−0.128*	−0.128*	−0.108*
Constant	−0.290*	−0.124	0.060***	−0.858**	−0.535**	−1.658*
F-Statistic	651.72*					
Wald test	5171.33*					
R2/Pseudo R2	0.9704	0.8369	0.8445	0.8517	0.8561	0.8502
Adj R-square	0.9689					
Observation	189	189	189	189	189	189

NOTE: *, **, *** represents 1%, 5% and 10% significant levels.

Table 8
Results of causality tests.

NULL HYPOTHESIS	F-STATISTICS	P-Value	CAUSALITY FLOW
LnCR ↗ $LnCO_2$	4.18337**	(0.0422)	LnCR → $LnCO_2$
$LnCO_2$ ↗ LnCR	0.00426	(0.9480)	
LnGDP ↗ $LnCO_2$	1.26118	(0.2628)	$LnCO_2$ → LnGDP
$LnCO_2$ ↗ LnGDP	3.10253***	(0.0798)	
LnNPG ↗ $LnCO_2$	1.16505	(0.2818)	$LnCO_2$ → LnNPG
$LnCO_2$ ↗ LnNPG	5.93176**	(0.0158)	
LnREC ↗ $LnCO_2$	0.05665	(0.8121)	$LnCO_2$ → LnREC
$LnCO_2$ ↗ LnREC	4.26515**	(0.0402)	
LnCD ↗ LnCR	12.3992*	(0.0005)	LnCD → LnCR
LnCR ↗ LnCD	3.9E-05	(0.9950)	
LnGDP ↗ LnCR	2.08027	(0.1508)	LnCR → LnGDP
LnCR ↗ LnGDP	4.99611**	(0.0266)	
LnOGC ↗ LnCR	8.07409*	(0.0050)	LnOGC → LnCR
LnCR ↗ LnOGC	1.81411	(0.1796)	
LnGDP ↗ LnCD	1.95802	(0.1633)	LnCD → LnGDP
LnCD ↗ LnGDP	7.10912*	(0.0083)	
LnNPG ↗ LnGDP	2.77912***	(0.0971)	LnNPG → LnGDP
LnGDP ↗ LnNPG	0.86123	(0.3546)	
LnREC ↗ LnNPG	7.06945*	(0.0085)	LnREC ↔ LnNPG
LnNPG ↗ LnREC	5.07429**	(0.0254)	

NOTE: *, **, *** represents 1%, 5% and 10% significant levels.

observed for the 5th quantile tends to contribute immensely to environmental degradation in E7 economies. This evidence is supported in the study of Sarkodie and Adams (2018) on the economy of South Africa.

Furthermore, the outcomes for coal rent are found to be positive across all the observed quantiles but only statistically significant in the three median quantiles, that is, 25th, 50th and 75th quantiles. This indicates that the introduction of moderate rent on coal consumption in E7 economies observed in the median quantiles increases environmental degradation among the E7 states. This finding is in contrast with findings from Adedoyin et al. (2020) who found no causal relation between coal rent and carbon emission in BRICS. More so, the results for cost carbon damage show a positive effect across all the observed quantiles. This intuitively provides evidence parallel to the claim that increasing the cost of carbon emitted in E7 economies further deteriorates environmental quality if adequate policy measures are not put in place. Energy generation from oil, gas and coal sources showed a negative influence across all the observed quantiles, except the 5th quantile where the estimated effect was insignificant. This implies that more energy generated from oil, gas and coal sources reduces the level of carbon emission. However, Pata (2018) found contradictory findings with evidence from Turkish.

In the bid for more clarification, the analysis further sought to investigate the effect of some expected regulatory measures on carbon emissions in E7 economies. The outcome of the regulatory measures including coal rent and cost of damage showed positive effects across the observed quantiles. This implies that increasing rent on coal consumption alongside increasing cost of carbon damage increases environmental deterioration. Additionally, the generation of energy from nuclear sources alongside the increasing cost of carbon damage has negative effects on carbon emission across all the observed quantiles except at 5th quantile. This implies that the regulatory measure that involves nuclear energy sources and cost of carbon damage reduces environmental degradation in E7 economies.

4.3. Dumitrescu and Hurlin causality test

The panel causality test (Dumitrescu and Hurlin causality test) is necessitated by the need to assess the Granger non-causality moving from the explanatory variables to the explained variable as conceptualized in the study of Dumitrescu & Hurlin (2012) in a non-heterogeneous panel dataset. A causal link occurs among two factors if one variable is a better predictor of the other that is, say A has a prediction power over B. The first one is considered as the source, while the other is the impact. A two-factors correlation does not mean causality. However, if two variables are causality that indicates somewhat level of association. Causality, therefore, means one variable influence the other to occur.

An uni-directional association running from coal rent to CO_2 emission is observed in the study. This implies that regulations on coal consumption may further affect the activities of industries, which emit high amounts of carbon dioxide into the atmosphere. In other terms, regulations of demand and supply of coal resources will lead to more environmental deterioration in E7 countries and a way to get rid of this as suggested in the literature is to adopt clean energy sources as an alternative for the coal energy consumption to keep the global economy safe from environmental degradation and climate change. A unidirectional relationship exists involving CO_2 pollution and economic progress in the study. The implication of this is that, activities that are more productive favour the economy but the channels of the growth fuel environmental degradation in E7 countries. A similar result is reported for CO_2, nuclear energy and renewable energy sources moving from the former to each of them separately. This is in line with the recent climate policy that focuses on the adoption of alternative energy sources that will reduce the CO_2 emission in the global world. In other words, this means that environmental degradation in E7 economies will prompt the government to adopt nuclear energy and renewable energy sources as viable alternatives for fossil fuels to reduce CO_2 emissions in E7 countries.

Additionally, a one-way directional relationship is also observed between the cost of coal damage to coal rent; coal rent to real GDP; oil, gas and coal sources coal rent; the cost of carbon damage to real GDP; nuclear energy sources to real GDP and from renewable energy consumption to nuclear energy sources. The Quantile Regression analysis shows that coal rent has a positive effect on CO_2 emissions, while the cost of carbon damage triggers CO_2 emission. Thus, the use of coal rent as a regulatory measure will increase the cost of producing coal and then accelerate the cost attached to polluting the environment. From another angle, the theoretical basis for these outcomes is that the search for economic transformation through coal consumption will prompt governments and policymakers to map out regulations, which may inform the introduction of coal rent to reduce the carbon dioxide emission. Consequently, industrialists would look for alternatives for non-renewable energy sources that deteriorate the environment as claimed in the majority of the previous studies found in the literature (see Bekun et al., 2019) by adopting renewable energy and nuclear energy consumption that tend to reduce the CO_2 emissions in E7 countries. However, this has generated a lot of debate in the literature. In this regard, the transition from carbon-intensive technologies to modern clean technologies will promote sustainable development and reduces the experience of environmental deterioration in E7 economies.

5. Conclusion and policy recommendations

The main objective of this study is to examine the influence of economic growth, coal rent, nuclear energy, coal CO_2 damage and energy from oil gas energy on carbon emissions. It employs a panel dataset of E7 member states from 1990 to 2016. The study uses OLS and Quantile regression analyses to understand the dynamics of the hypothesized relationships. The quantile regression approach aids to get rid of the bias of the OLS estimator. The results from the estimation techniques reveal a positive effect of real GDP on carbon emission. Increasing economic activities recorded in the region as a result in industrialization and the adoption of more advanced production techniques have led to more environmental depletion. Thus, uncontrolled growth is seen as a driver of environmental degradation in E7 economies. Additionally, renewable energy is found to have a negative and significant impact on $C0_2$ emissions in E7 countries. This confirms the transition of countries from non-renewable energy (fossil fuels, coal) consumption to renewable energy consumption as a viable way to combat the rising CO_2 emissions and to meet the expectation of growing demand for energy resources.

Furthermore, nuclear energy sources exert a positive effect on carbon emission in E7 economies but only when energy consumption from nuclear sources is low whereas found to have insignificant negative coefficients when more energy is generated from nuclear sources. This implies that environmental degradation could be reduced if more energy can be generated from nuclear energy sources in E7 economies. The results for coal rent show a positive and statistically significant impact of coal rent on carbon emission in E7 economies. However, the influence is most prevalent where coal rent consumption is moderately charged. Also, the cost of carbon damage shows a positively significant effect on carbon emission. This implies that the rising carbon emissions in E7 economies are because of the increasing economic activities compounding pressure on the environment. Energy generation from oil, gas and coal sources is found to benefit the environment, as the findings show a negative impact on environmental degradation in E7 economies. Finally, the study also incorporated some regulatory measures to gain more insight into the effect of some energy policies in CO_2 emissions in E7 countries. As such, the estimated results indicate that regulation of coal consumption through a rent in addition to the cost of carbon damage will increase CO_2 emissions in E7 countries. The implication of this is that putting stringent regulations on coal consumption at par with the rising cost of carbon damage will not be of help to environmental sustainability.

Additionally, commanding adherence to the environmental policy could be a good way to reduce CO_2 emissions in E7 countries. However, it could be more effective in circumventing the environmental degradation produced from the generation of energy supply from oil, coal and gas sources. This implies that putting regulations on coal consumption at par with oil, coal and gas consumption will be a vital means to promote environmental quality and sustainable development in E7 economies. Also, strict adoption of nuclear energy sources, as well as more cost of carbon damage, will reduce CO_2 emissions in E7 countries significantly. This is pointing towards the resistant of nuclear energy sources to produce air pollutants while operating, unlike fossil fuel energy sources. Lastly, Energy generation from nuclear sources as well as increasing cost of carbon damage is found to give a mixed result as it is found that lesser environmental degradation is attached to the lesser regulatory measure.

Based on the results obtained from this study, this study recommends several policies to reduce the CO_2 emissions embattling the environmental sustainability of E7 economics. It is evident from the study that the adoption of renewable energy can be an effective way to enhance green growth and sustainable development. The policy implication is that renewable energy makes use of clean technologies that can offset the emissions set out by non-renewable energy consumption. Thus, E7 economies should put more effort into more consumption of renewable energy and less of the traditional non-renewable energy to reduce the level of CO_2 emissions experienced in the region. Meanwhile, the reduction of the consumption of the carbon-emitting non-renewable energy does not have a significant effect on the economies. To achieve this feat at a low transaction cost, research and development should become a sector of interest to policymakers in a way to make the energy resources produced from renewable energy sources cheaper.

Furthermore, policies should be focused on aggravating the cost of production for coal exploitation vis-a-vis the introduction of coal rents. The study found that charging lower rent on coal consumption might put the carbon-emitting firms to overlook the impact of their activities on the environment, as their revenue seems to be affected when lower rent is charged. Therefore, the findings from this study have shown that the introduction of more stringent environmental regulations and policies that will enforce the transition of industries from carbon-emitting energy sources to cleaner energy sources that improve the environmental quality and encourage sustainable development.

Finally, the study shows that research and developmental efforts of the governments to improve the climate condition may not be enough to curb environmental degradation in the region. The study recommends that governments and policymakers should look towards the direction of infrastructural developments by increasing the yearly capital expenditure. Theoretically, more capital expenditure attracts more investment, thus, this policy will make a turnaround as more FDI will flow into the countries and importance of the FDI is found in the need to adopt clean technologies that will save the masses from the menace of CO_2 emissions. This strengthens the blocs of environmental quality and sustainable development. Further research can be conducted for other emerging blocs like Sub Saharan African, BRICS, countries to explore the energy-growth- environmental nexus while accounting for demographic indicators like population, democracy and the likes to either validate or refute the current study findings as a gap exist to explore or need further insight needed in the extant literature.

Funding

I hereby declare that there is no form of funding received for this study.

Compliance with ethical standard

I wish to disclose here that there are no potential conflicts of interest at any level of this study.

CRediT authorship contribution statement

Bright Akwasi Gyamfi: Writing – review & editing, Conceptualization, Formal analysis. **Festus Fatai Adedoyin:** Writing – review & editing, Conceptualization, Formal analysis. **Murad A. Bein:** Writing – review & editing, Conceptualization, Formal analysis. **Festus Victor Bekun:** Writing – original draft, Validation, Visualization. **Divine Q. Agozie:** Data curation, Writing – original draft, Investigation, Methodology, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

Author gratitude is extended to the prospective editor(s) and reviewers that will/have spared time to guide toward a successful publication.

Appendix

Table A.2
VIF Estimations

Variables	VIF	1/VIF
LnGDP	7.20	0.108662
LnREC	6.81	0.113549
LnCD	5.62	0.177864
LnCR	2.75	0.364046
LnOGC	2.58	0.388111
LnNPG	2.28	0.438534
Mean VIF	4.54	

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