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INVESTIGATING THE ENVIRONMENTAL EFFECTS OF ECONOMIC GROWTH IN AFRICAN ECONOMIES

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ABSTRACT

Sustainable green environment, green innovation, and low-carbon economy are the top priorities of governments and global climate institutions. Indeed, the link between economic growth and environmental sustainability has been commonly discussed in the literature, with different outcomes. This paper endeavors to partly fill the research gap by using recent panel estimators to explore the long-run cointegration nexus between economic growth, trade openness, energy consumption, urbanization, and CO_2 emissions (pollution). In terms of decision making, we further grouped the specified 25 newly emerging African nations into oil-exporting and non-oil exporting economies. The data collected are annual and cover the period from 1990 to 2015. The panel cross-sectional dependency and homogeneity results indicated that our selected variables are heavily interdependent across the various cross-sections in the long-run. Similarly, the panel unit root test and bootstrap cointegration estimates showed evidence of stationarity and long-run equilibrium connection between the chosen variables for all panels. The long-run panel estimates using the common correlated effects mean group approach shows that economic growth, energy usage, trade openness, and urbanization depicted a positive and substantial impact on long-run carbon emissions for all panels. The Dumitrescu and Hurlin non-causality results indicated a bidirectional causal relationship between income and pollution, energy consumption and pollution, urbanization, and pollution for all three panels. Likewise, except for the 25-countries panel, there was evidence of a feedback causality between trade openness and pollution. Our outcome further verified the EKC framework but with distinct threshold points for all three panels. Various policy scenarios are discussed.

Contribution/Originality: This is one of the very few studies which have investigated the environmental effects of economic growth considering new emerging African economies. These nations were grouped into oil-exporting and non-oil exporting to enhance decision making and applying recent panel estimators while verifying the EKC framework within these economies.

1. INTRODUCTION

For decades now, scholars have been taking into account the trade-offs between economic expansion and its environmental impact. This revealed concerns about the strategy adopted by advanced nations during their early development phase "Grow now and clean up later". Every developing or developed economy in the world desire certain degree of sustainable development, but in the capacity of making choices to extract their natural resource for economic activities, bitter pills are left behind in the form of climate change, air pollution, destruction of water bodies, ozone depletion, etc. This continues to be the most prevalent controversy on the environment in this contemporary generation (Al-Mulali, 2014; Zaman, Shahbaz, Loganathan, & Raza, 2016). The elevated concentrations of pollutants that occur in the atmosphere generate several environmental challenges as proposed by (Shi, 2003). Regarding the ideology of "Grow now and clean up later," some studies indicate that, during the initial phases of economic development, emissions keep increasing until it reaches a turning point where a rise in Gross Domestic Product (GDP) per capita leads to a reduction in environmental pollution (Grossman & Krueger, 1991; Policy, 2008; Shafik & Bandyopadhyay, 1992). This idea is commonly referred to as the Environmental Kuznets Curve (EKC) framework; named after (Kuznets, 1955) who first modeled that income inequality rises to a peak and then begins to decline as per capita income rises. He and Richard (2010) revealed that most of the hypothetical and observational studies question the legitimacy of the EKC for pollutants like sulfur dioxide (SO_2) emissions, wastewater, and carbon monoxide (CO_2). This is to clarify that emissions, water pollution, deforestation, etc. are all indicators of environmental degradation, while per capita (GDP) is a proxy for economic growth. However, the presence of EKC for Carbon emission is still weak in the literature especially in this part of the globe (Africa) considering their level of development. Certainly, various measures and strategies, have been adopted by countries to control climate change and to achieve a green and low-carbon economy. The most recent plan was included by the United Nations as part of its Sustainable Development Agenda priorities: "Taking urgent actions to combat climate change and its impacts". Without a doubt, the poorest and vulnerable countries in the world are mostly affected by climate change activities. Therefore, knowing the adverse effect of climate change activities will significantly contribute to long-term policy development in the quest to combat climate change issues.

Africa with its endowed natural resources has played an imperative role in modern economic integration, with most nations moving from an agricultural-based economy to more of an industrialized economy. Thus, creating much concern with regards to energy efficiency and environmental pollution. Also, since economic advancement is worldwide, developed economies are setting up industries in this part of the globe due to their weak environmental legislation and cheap source of the labor force, hence, the continent is regarded as a pollution haven. Agreeing to the report by IPCC (2007) Africa is more defenseless to climate change and global warming problems. This can be evidenced by the resulting decrease in water accessibility from 30 to 50 percent and a reduction from 15 to 35 percent of agricultural yields throughout the previous years. According to Gunby, Jin, and Reed (2017) yearly air pollution contributes more than 6 million mortality each year globally, making it the single greatest environmental health hazard of our time.

There is developing literature concerning the nexus between energy, pollution, and income (Bölük & Mert, 2014). Nevertheless, there is still a lack of research on the significant role of urbanization in assessing the rate of environmental pollution. particularly, carbon dioxide emissions using panels from newly emerging economies in African. Africa as a whole is urbanizing rapidly: From 1950 to today, the share of urban residents has increased from 14 percent to 40 percent and is expected to reach 50 percent by the mid-2030s, therefore, this paper considered panels from newly emerging economies in Africa to empirical investigate the dynamic relationship between economic growth, trade openness, energy consumption, environmental pollution, and urbanization. To ensure that this research reflects the recent concerns and trends in environmental management, we adopted carbon dioxide emissions as the sole measure of environmental pollution based on the large dependency on primary energy for household and industrial consumption in this part of the globe. Our research will contribute to the existing literature in various ways. We employed current panel estimation techniques that are robust related to panel data analysis (cross-sectional independence and heterogeneity), thus, confirming the robustness and efficiency of our results. Again, to minimize the possibility of heterogeneity in panel causality analysis, we used the Dumitrescu and Hurlin (2012) Granger non-causality approach to investigate the direction of causality between carbon emissions and the independent variables. South Africa, Botswana, Namibia, Ghana, Gabon, Benin, Cote d'Ivoire, Senegal, Togo, Nigeria, Kenya, Mauritius, Mozambique, Tanzania, Zambia, Zimbabwe, Cameroon, Congo Dem. Rep., Congo

Rep., Algeria, Egypt, Libya, Morocco, Sudan, and Tunisia were the selected economies based on their socio-economic factors and natural environmental factors. Similarly, for a national, regional, and global policy perspective, we categorized the selected countries into oil and non-oil exporting countries to investigate the effects of the independent variables on the response variable within these two panels regarding the current fluctuation in global oil prices. This outcome will better inform policymakers when designing energy and environmental policies. Finally, we checked for the existence of the EKC framework within the three panels regarding Kuznets's original hypothesis for developed economies.

The rest of the paper is organized as follows: the next section highlights the literature review; the third section describes the models, data used and results; the fourth section presents and analyses the findings. Finally, the last section concludes with policy implications of the findings. Table 1 below describes details of the acronyms in the study.

Table-1. Description of Abbreviations/Acronyms.

Terms	Description	Terms	Description
ADF	Augmented Dickey-Fuller	IPS	Im-Pesaran-Shin
AMG	Augmented Mean Group	LLC	Levin-Lin-Chu
CADF	Cross-sectional Augment Dickey-Fuller	LM	Lagrangian Multiplier
CCEMG	common correlated effects mean group	MENA	The Middle East and North Africa
CD	Cross-sectional Dependency	NO	Nitrous Oxide
CIPS	Cross-sectional Im-Pesaran-Shin	OECD	Organization for Economic co-operation and Development
CO2	Carbon dioxide	OLS	Ordinary Least Squares
(D-H)	Dumitrescu-Hurlin	PM10	Particulate Matter 10
EKC	Environmental Kuznets Curve	R&D	Research and Development
FDI	Foreign Direct Investment	SO2	Sulfur dioxide
GDP	Gross Domestic Product	USD	United State Dollars
IPCC	Intergovernmental Panel on Climate Change	WDI	World Development Indicators

2. BRIEF REVIEW OF LITERATURE

There have been several cross-country and single-nation study on the pollution-growth nexus. But these researches failed to find common grounds in their outcomes. The research on pollution and economic growth is commonly related to the Environmental Kuznets Curve (EKC) hypothesis proposed by Kuznets (1955). During which he suggests that as income increases, pollution also increases, but subsequently declines at a turning point if growth proceeds far enough. In a study by Sulemana, James, and Rikoon (2017) they provided empirical evidence on the environmental Kuznets curve for air pollution in Sub Sahara African and developed countries by exploring the turning point, incomes and the role of democracy. Their evidence shows that the EKC hypothesis holds for both CO_2 and Particulate Matter (PM10) emissions for Sub Sahara African and OECD countries. According to Wang et al. (2017) using multivariate analysis on CO_2 emissions, energy consumption, and economic growth, confirmed that economic growth contributes to increased emission. Another study by Boamah et al. (2017) examined carbon emission and economic growth of China covering the period 1970-2014 in a multivariate framework, they confirmed the presence of a long-run relationship between economic growth and carbon emission, under the estimated Kuznets curve framework. During a country's growth phase, the fast and unprecedented migration of individuals from rural to urban areas is one of the most attainable mechanisms of the demographic pattern. The number of residents in the cities was 3.943 billion, more than half of the world's population (53.86%) in 2015. Indeed, the connection amid CO_2 emissions and urban growth is still considered an academic conflict. Generally, several empirical works of literature such as Al-Mulali, Sab, and Fereidouni (2012); Martínez-Zarzoso and Maruotti (2011); Parikh and Shukla (1995) have produced comparable outcomes that urbanization has a beneficial impact on environmental quality. Conversely, Sharma and Joshi (2013) pointed out the contrary. Similarly, Sadorsky (2014) and Rafiq, Salim, and Nielsen (2016) also stated that urbanization had an adverse effect on environmental quality. The social process of human migration from rural to urban regions is what we call urbanization. From a conceptual perspective, Poumanyvong and Kaneko (2010) highlighted the impacts of urbanization on the environment in three categories: ecological transformation, urban environmental change, and standardized city concepts. Shahbaz, Loganathan, Muzaffar, Ahmed, and Jabran (2016) described the theoretical correlation between urbanization and environmental quality. Madlener and Sunak (2011) summarized some processes of the impact of urban growth on energy usage, which may affect environmental quality. Finally, the authors also pointed out that the effects varied amid emerging and industrialized economies.

Das Neves Almeida, Cruz, Barata, and García-Sánchez (2017) revealed that economic growth alone is not enough to improve environmental quality hence the EKC hypothesis is not proved. Also, many studies argued that there is no guarantee that economic growth will lead to an improved environment hence do not support the Kuznets hypothesis. Grossman and Krueger (1991) EKC's proponent claim that the connection between economic growth and environmental quality follows an inverted-U shaped curve, hence their findings shows a negative relationship between economic growth and environmental quality in the long-run. Panayotou (1993) also gave further credence to the validity of the EKC hypothesis, by adding that economic growth has a positive impact on environmental quality. Hu, Xie, Fang, and Zhang (2018) confirmed the EKC hypothesis. Studies by Kaika and Zervas (2011) and Sanglimsuwan (2011) also found an inverted U-shaped relationship between CO_2 emissions and economic development in a cross-country analysis. The different empirical evidence from previous works (U-shaped, inverted U-shaped, and no relationship) creates an avenue to further probe into the subject especially among low-income economies considering the recent trends in economic development and integration.

Some studies have been conducted on the impact of technology on carbon emissions with emphasis on the EKC theory but the method adopted varies from one another. Hence, differences in their findings. A study by Jin, Duan, Shi, and Ju (2017) on the impact of technological progress in the energy sector on carbon emission using time series data from China, concluded that there is a reduction in carbon emissions with hysteresis through the impacts of technological progress in the energy sector. This was also confirmed by Mensah et al. (2018). Some studies also argued that trade openness can be a measure of technological progress because of its role in ensuring sustainable innovation and economic growth in the long term. A related result depicts that technological innovation is substantial in helping to reduce carbon emission (Samargandi, 2017). Moreover, Jaffe, Newell, and Stavins (2005) assume that research and development (R&D) investment is the main cause of technological progress, moreover, the impact of carbon emission is not certain. Further, researchers concluded that the impact of technology on carbon emissions has both long and short term difference. Our study does not only tests the impact of economic growth on environmental quality by adopting the EKC theory but also included international trade as a proxy for technological innovation when developing our model. An inquiry conducted by Apergis and Payne (2009), utilizing information from six central American economies, inspected the connections between energy usage, economic development, and CO_2 emission. Their outcome unveiled that, there existed a bidirectional connection between energy usage and CO_2 emissions. On comparable grounds, Soytas, Sari, and Ewing (2007) depicted that there is a long run connection between energy usage and carbon emissions. An investigation by Omri (2013) concerning the same notion for (MENA) economies by employing a simultaneous equation model show proof of unidirectional causality from energy usage to carbon emissions without any critical impacts. Wang, Zhou, Zhou, and Wang (2011) discovered that a correlation exists between their chosen variables in the long-run by researching the linkage between consumption of energy and CO_2 emissions. Similarly, a study on the environmental effects of foreign direct investment for less developed countries was conducted by Zeng and Eastin (2012). Their findings depicted that, a rise in environmental stewardship is caused by FDI. Shao (2018) also explored the interaction between CO_2 emission and foreign direct investment by applying a panel of data set from 188 nations spanning from 1990-2013. They unveil that foreign direct investment has negative significant effects on carbon emission.

Furthermore, an investigation of FDI effects on CO_2 emission by implementing the EKC assumption in Turkey from 1974-2013 by Koçak and Sarkgüneşi (2018). Their results show that in the long-term evaluation, FDI has a beneficial impact on CO_2 emissions. The extreme objective of policymakers and global organizational entities is to promote a low-carbon economy. On this note, this study is to help regional and global organizational bodies in their quest to promote a green and low-carbon economy by developing feasible and efficient environmental policies.

3. EMPIRICAL MODEL DEVELOPMENT

In examining the relationships among the variables, the study adopted the model used by Adu and Denkyirah (2019) which is set out in a linear form in Equation 1 as below:

$$CO_{2it} = \alpha + \sum_{k=1}^{k} \beta_k X_{it}^{k} + \varepsilon_{it} \tag{1}$$

To decrease the menace of heteroscedasticity, we toke the natural logarithms of the linear equation. This model is used to estimate the elasticity or coefficients of the various explanatory variables within the panels. From the equation above; CO_{2it}, represent carbon emission (environmental quality) of the countries i at time t, with t =1….. N; i =1…. T; α is a constant parameter, X_{it} and k are the explanatory variables and ε_{it} is the disturbance or stochastic term. The dependent and independent variables were logarithmized to allow the parameters to be interpreted as elasticities. The model is further estimated in Equation 2 as follows:

$$lnCO_{2it} = \alpha_0 + \beta_1 lnY_{it} + \beta_2 lnEC_{it} + \beta_3 lnTR + \beta_4 lnUrb + \varepsilon_{it} \tag{2}$$

The environmental Kuznets curve, which is mostly termed as the EKC model by Kuznets (1955) is used in assessing the effect of economic growth on environmental pollution. Our study tested for the presence of the EKC framework in assessing the impact of economic growth on environmental quality. The empirical model to assess the existence of EKC and its determinants is indicated in Equation 3:

$$InCO_{2\,it} = \alpha_0 + \beta_1 InY_{it} + \beta_2 InY_{it}^2 + \beta_3 InEC_{it} + \beta_4 InTR_{it} + \beta_5 lnUrb_{it} + \varepsilon_{it} \tag{3}$$

Where InY_{it}^2 denotes the square of GDP, in the quest to investigate whether there is the presence of an inverted U-shape relationship between economic growth and environmental quality for the selected African economies. ε_{it} represent the unobserved country-specific effect by following the works of Afzal, Farooq, Ahmad, Begum, and Quddus (2010) and Dao (2012). We expect positive elasticities for income, energy consumption, and urban population following previous studies. Based on the development stages of our selected countries, we expect either positive or negative coefficients for trade openness. Finally, we expect both a positive or negative elasticity for the square of GDP, in this case, the positive coefficient will violate the EKC framework and the later (negative) will confirm evidence of the EKC hypothesis.

3.1. Empirical Analysis and Techniques

All data for the empirical analysis were sorted directly from the World Development Indicators. The data gathered are annual and cover the period between 1990 and 2015 for 25 emerging economies within Africa. These include nations from East Africa, the Middle and Central Africa, North Africa, South Africa, and West Africa. We further classified the following countries into oil and non-oil exporting countries for reliability and policy insight. Table 2 below gives information about the variables for the study.

Table-2. Definition of variables.

Variable	Definition	Units of Measurement	Source
CO_2	Carbon Emissions per metric tons	Metric tons	WDI
Y	GDP per Capita	Constant 2010 USD	WDI
EC	Energy Consumption per Capita	Kg of oil equivalent per Capita	WDI
TR	(Import +export) percentage of GDP	Constant 2010 USD	WDI
UrB	Urbanization	Urban Population	WDI

The figures below thus Figure 1, Figure 2, Figure 3, Figure 4, and Figure 5 indicates the growth pattern of selected macro-economic indicators from 1990-2015.

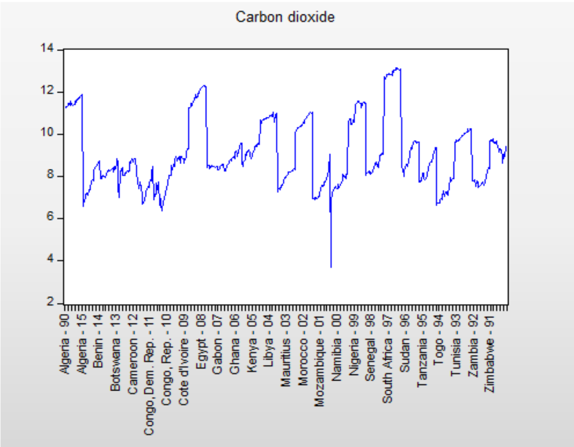

Figure-1. CO2 emissions.

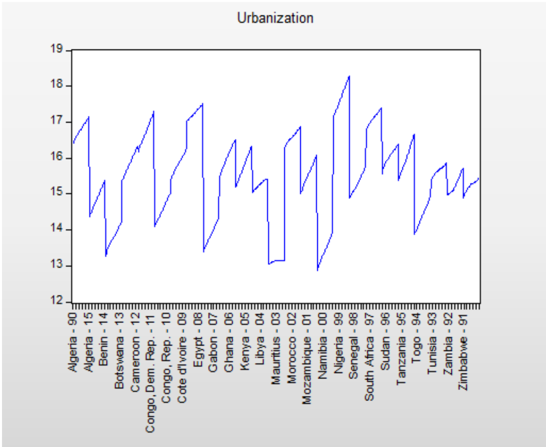

Figure-2. Urbanization.

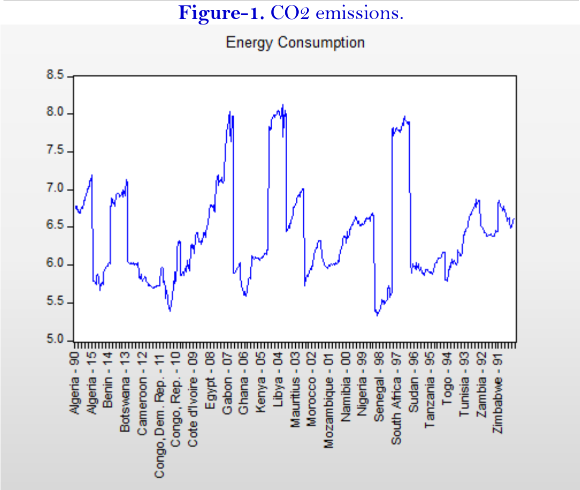

Figure-3. Energy consumption.

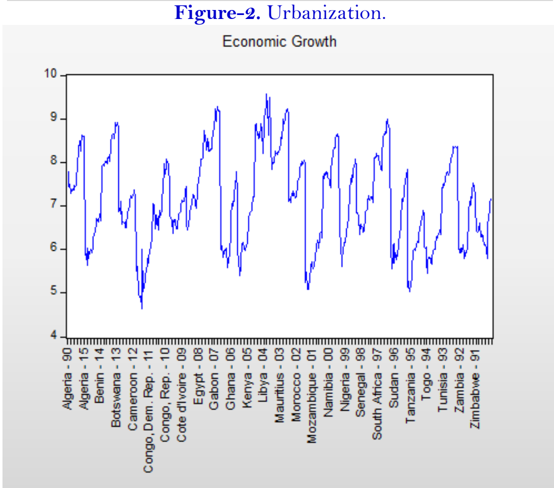

Figure-4. Economic growth.

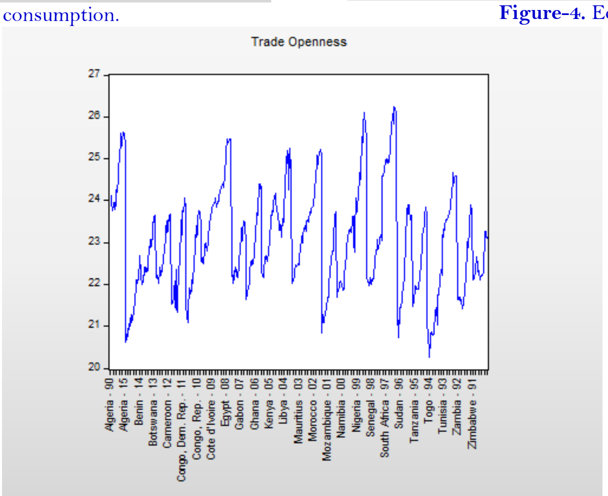

Figure-5. Trade Openness.

3.1.1. Slope Homogeneity Test

The research used recent panel estimation techniques to examine the environmental footprint of economic growth on carbon emissions. Panel data analysis offers better comprehension and precise information than cross-sectional and time-series data. Cross-sectional reliance and heterogeneity, however, are significant issues connected with panel data analysis. In an attempt to minimize such occurrences, this study utilizes the slope homogeneity test established by Pesaran and Yamagata (2008) to examine whether or not the variables are homogenous, based on the computed values of the delta tilde (Δ) and adjusted delta tilde (Δ) Table 3 we failed to accept the null hypothesis of the slope coefficients being homogenous (significant at 1%). As reported by Breitung (2005) supposing slope homogeneity will result in inaccurate predictions if the panels are perhaps heterogeneous. Hence, cross-sectional homogeneity must be regulated when performing empirical studies with panel data. The slope homogeneity test statistics are calculated using Equation 4 and 5 as indicated below:

$$\bar{\Delta}= \sum_{i=1}^{N}(\delta_i - \delta_\sigma)' \frac{x_i' M_\tau x_i}{\vartheta_i^2}(\delta_i - \delta_\sigma) \tag{4}$$

$$\Delta= \sqrt{N}\left[\frac{N^{-1}(s-X)}{\sqrt{2X}}\right] \tag{5}$$

Where ($\bar{\Delta}$) and (Δ) indicate the test statistics, δ_i represent the elasticity of the pooled ordinary least squares (OLS), (σ) show the weighted fixed effect pooled estimator, (x_i) is the matrix with regressors in derivations from the mean, M_τ signify the identity matrix, (ϑ_i^2) denotes the calculated value of (ϑ), and (X) shows the number of regressors. Equation 6 depicts the adjusted (Δ) test.

$$\Delta_{adj}.= \sqrt{N}\left(\frac{N^{-1}(s-X)}{\sqrt{\frac{2X(T-X-1)}{T+1}}}\right) \tag{6}$$

3.1.2. Cross-Sectional Dependency

Similarly, we used the Pesaran scaled LM test and Pesaran cross-sectional dependence test suggested by Pesaran (2004) to explore whether or not the series is cross-sectional dependent. Cross-sectional dependence is also a significant problem in econometrics, specifically when working with panel data. Assuming cross-sectional independence would probably generate unreliable estimations (Grossman & Krueger, 1995). Based on the outcome, we failed to accept the null hypothesis of no cross-sectional dependence. Therefore, we can firmly conclude that the variables are cross-sectionally dependent. The result of the test is reported in Table 4. In an attempt to justify various environmental costs, cross-sectional dependency and homogeneity tests are important when developing global and regional economic policies. Given the possibility of cross-sectional dependence and homogeneity in cross-country panels, we employed second generation panel unit root test methods that are robust to homogeneity and cross-sectional dependence. The Breusch-Pagan LM test is valid for small N and T (Breusch & Pagan, 1980), and as shown in Equation 7 can be calculated as follows:

$$LM_1 = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} T_{ij}\hat{\rho}_{ij}^2 \rightarrow x^2 \frac{N(N-1)}{2} \qquad (7)$$

The limitation of the Breusch-Pagan LM test contributed to the development of the Pesaran scaled LM test. This test is an extension of the LM statistics designed by Breusch and Pagan (1980) and is robust to big N and T. That is, it operates fairly under large N and T. and is estimated using Equation 8:

$$LM_{scaled} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N} \sum_{j=i+1}^{N-1} (T_{ij}\hat{\rho}_{ij}^2 - 1) \rightarrow N(0,1) \qquad (8)$$

To solve concerns related to the Breusch-Pagan LM test and the Pesaran scaled LM test, a more advanced test statistic was developed by Pesaran is known as the Pesaran CD test; as depicted in Equation 9, this statistic is efficient for bigger N and stationary T and is stated as follows:

$$CD = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (T_{ij}\hat{\rho}_{ij}^2) \rightarrow N(0,1) \qquad (9)$$

Where $\hat{\rho}_{ij}$shows the correlation elasticities of the regression model attained from the stochastic errors. This model is asymptotically standard normally distributed with the null hypotheses of $T_{ij} \rightarrow \infty$ and $N \rightarrow \infty$.

3.1.3. Panel Unit Root Test

Several methods for estimating stationarity are reported in the literature. These techniques include the (Levin-Lin-Chu (LLC), Im, Pesaran, and Shin (2003) Philips-Perron (Fishers-PP) (Phillips & Perron, 1988) augmented Dickey-Fuller (Fisher-ADF), cross-sectional IPS (CIPS) and cross-sectional ADF (CADF), etc. However, most of these tests fail to address the issues of cross-sectional dependence and homogeneity within cross-country panels. Thus, spurious results are generated when used. In other to minimize such circumstances, this research adopted a second-generation approach to estimating unit root. These tests are robust to both cross-sectional dependency and heterogeneity concerns available in panel data. The application of CIPS and CADF test developed by Pesaran (2007) was adopted to test whether or not the variables are stationary in the long-run. The empirical outcome of both approaches Table 5 shows that the selected variables are non-stationary at levels for all panel groups. However, at the first difference, we failed to accept the null hypothesis of non-stationarity. This implies that there is proof of stationarity between the variables at the first difference. Having established their level of stationarity, we employed (Westerlund & Edgerton, 2007) panel bootstrap cointegration test to investigate whether or not there exists a long-term relationship between the variables. The CADF statistics can be calculated as below:

$$\Delta y_{it} = \alpha_i + \gamma_{i,t-1} + \delta_i \bar{y}_{t-j} + \sum_{j=0}^{n} \vartheta_{ij} \Delta\bar{y}_{t-j} + \sum_{j=1}^{n} \sigma_{ij} \Delta y_{i,t-j} + \varepsilon_{it} \qquad (10)$$

Where $\bar{y}_{t-j}$ and $\Delta\bar{y}_{t-j}$ represents the cross-sectional means of the lagged levels and first differences of each specific variable, correspondingly. Knowing the values of the CADF estimates we can compute, the CIPS statistics using Equation 11:

$$CIPS = N^{-1} \sum_{i=1}^{N} CADF_i \qquad (11)$$

Where $CADF_i$ depicts the t-statistics in the CADF model; Equation 10.

3.1.4. Panel Co-Integration Test

Concerning the presence of cross-sectional dependence and homogeneity in cross-country panel data. This research employed a panel cointegration approach that is robust to the above-stated concerns. The panel bootstrap cointegration test Westerlund and Edgerton recommended by Westerlund and Edgerton (2007). Based on the outcomes as reported in Table 6, we failed to accept the null hypothesis of no cointegration for all three panels with carbon emissions as the dependent variable in all three cases (significant at 1%). This indicates that the variables are strongly related in the long-run.

3.1.5. Panel Long-Run Estimates

The traditional long-run panel estimation techniques such as the dynamic OLS and fully-modified OLS fail to consider slope homogeneity and cross-sectional independence statistics during their estimations, thus, producing spurious and biased estimates (Pesaran & Smith, 1995). This study aims to considerably decrease these circumstances by employing a panel common correlated effects mean group (CCEMG) estimator that enables slope homogeneity and cross-sectional independence of the different coefficients by comparing the measured outcomes from the two tests. The panel CCEMG estimator was first proposed by Pesaran (2006) and then extended by Kapetanios, Pesaran, and Yamagata (2011); this estimator takes into account concerns related to slope heterogeneity and cross-sectional independence during estimation Table 7. The linear arrangements of the cross-sectional mean of the prevalent impacts reported along with the various factors are used in this estimator (Atasoy, 2017; Kapetanios et al., 2011). We test the robustness of the panel CCEMG estimator using the panel augmented mean group (AMG) estimator following the work of Dong et al. (2018). In Equation 12, the panel CCEMG estimator is shown below:

$$Y_{it} = \tau_{1i} + \delta_i x_{it} + \gamma_i f_t + \alpha_i \bar{y}_{it} + \beta_i \bar{x}_{it} + \varepsilon_{it} \qquad (12)$$

Where (Y_{it}) and (x_{it}) represents our target variables; (δ_i) is the country-specific estimates of elasticity; (f_t) shows the undetected common factor with unrelated features; τ_{1i} and ε_{it} indicates the constant and stochastic term, correspondingly.

3.1.6. Panel Causality Test

One merit for undertaking empirical research is to assist policymakers and organizational bodies in designing and implementing domestic, regional, and global economic policies. The investigation of causality among the chosen economic indicators will, therefore, assist policymakers to design effective environmental policies. Consequently, this study adopted the Granger non-causality approach by Dumitrescu and Hurlin (2012) (D-H) to empirically examine the direction of causalities between the selected variables. The D-H panel non-causality test was created based on the average non-causality across the cross-sectional units of the individual Wald Statistics (Granger, 1969). This test statistic is computed in Equation 13:

$$Y_{it} = \alpha_i + \sum_{n=1}^{n} \beta_m^n (Y_{i(t-n)}) + \sum_{n=1}^{n} \delta_m^n (X_{i(t-n)} + \varepsilon_{it} \qquad (13)$$

Where (Y) and (X) represents the response and independent variables, respectively. (β_m^n) and (δ_m^n) are the autoregressive parameters and coefficients of the variables, respectively. Accordingly, the null of no causal relationship for any of the subgroups ($H_o: \delta_i = 0 \; i = 1,2,\ldots,N$) and the alternative hypothesis that causal relationships occur for at least one subgroup of the panel($H_1: \delta_i = 0 \; i = 1,2,\ldots,N_1;: \delta_i \neq 0 \; i = N_1+1, N_2+2,\ldots.N$) in the D-H panel causality test can be tested based on an average Wald statistic. The mean of each Wald statistics generated by the D-H Panel Granger non-causality test can, therefore, be estimated in Equation 14 as below:

$$W_{N,T}^{HNC} = N^{-1}\sum_{i=1}^{N} W_{i,T} \tag{14}$$

Where $W_{i,T}$ is the individual Wald statistic for each cross-section unit.

4. RESULTS AND DISCUSSIONS

4.1. Slope homogeneity and Cross-sectional Dependency Results

The empirical outcomes of the slope homogeneity and cross-sectional dependence tests are reported in Table 3 and Table 4 respectively. For the 25-countries panel, we failed to accept the null hypothesis of slope homogeneity (significant at 1%). This suggests that the selected series are heterogeneous across the various cross-sectional unit. Similarly, we failed to accept the null hypotheses for the other two subpanels. The estimated values for the delta and the adjusted delta provide sufficient proof not to accept the null hypothesis of the test. Thus, based on our outcome we confidently reject the null hypothesis of the slope homogeneity test. In particular, we conclude by supporting the fact that the variables are categorically different and normally distributed across the various panel groups.

Table-3. Results of Slope homogeneity test.

Description	Test	All (25 countries) Statistics/ P-value	Oil Exporting Statistics/ P-value	Non-Oil Exporting Statistics/ P-value
P-Y	$\tilde{\Delta}$	386.6 (0.0005) ***	101.8 (0.0365)***	115.6 (0.0002)***
	$\tilde{\Delta}_{Adj}$.	-10.15 (0.000) ***	2.651 (0.0080)***	8.84 (0.000)***

Note: *** signifies 1% significance level, $\tilde{\Delta}$ and $\tilde{\Delta}_{Adj}$. Indicates delta and adjusted delta respectively; P-Y indicates Pesaran-Yamagata.

Table-4. Results of cross-sectional dependency.

		All(25 countries)		Oil Exporting		Non-Oil Exporting	
Test	Series	Statistics	P-values	Statistics	P-values	Statistics	P-values
CD	$lnCO_{2it}$	50.243	0.000***	4.995	0.000***	11.744	0.000***
	lnY_{it}	71.476	0.000***	36.358	0.000***	33.575	0.000***
	$lnEC_{it}$	22.215	0.000***	7.658	0.000***	12.247	0.000***
	$lnTR_{it}$	47.76	0.000***	41.266	0.000***	35.698	0.000***
	$lnUrb_{it}$	87.086	0.000***	44.806	0.000***	40.396	0.000***

Note: *** represents significance level at 1%.

Similarly, the empirical evidence for the Pesaran cross-sectional dependence test as reported in Table 4 shows the existence of strong interdependency amid the five selected macroeconomic indicators for all three panels. This implies that at a significance level of 1%, the selected variables strongly depend on each other across the various cross-sectional unit in the long-run. One cause for this may be that, over the last few decades, we have seen an ever-increasing economic and financial integration of nations and financial institutions, implying robust interdependencies between cross-sectional units. In microeconomic applications, the tendency of people to react similarly to common "shocks" or common unobserved variables can be theoretically explained by social norms, community impacts, group activity, and truly interdependent preferences. Strong evidence of cross-sectional reliance and heterogeneity in panel data econometrics necessitates the use of second generational panel stationarity and long-run equilibrium relationship estimators. Following their studies, (Soytas et al., 2007) revealed that strong evidence of heterogeneity and cross-sectional reliance on panel data statistics will possibly result in spurious outcomes. However, the techniques adopted in this research are robust to slope homogeneity and cross-sectional independence.

4.2. Panel Unit Root Test Result

The empirical evidence from the panel stationarity test using the Pesaran CIPS and CADF with both tests controlling for cross-sectional dependence and heterogeneity are stated in Table 5. The tests seek to disclose and exploit the possible unknown characteristics of the selected macroeconomic indicators, hence we used the constant plus trend estimators. As per the results, we fail to reject the null hypothesis of non-stationarity (panel unit root) at levels for all panel groups. However, at the first difference, we cannot accept the null hypothesis of non-stationarity. This indicates that there exists strong evidence of stationarity between the five selected variables in the long-run. In particular, at first difference, there is ample proof to support stationarity conditions amid the various series across the three-panel groups. The outcome does not account for the prospect that some variables contain unit roots while others do not have unit roots across various countries.

Table-5. Panel unit root test results.

		All(25 countries)		Oil Exporting		Non-Oil Exporting	
Test	**Series**	**Level**	**First difference**	**Level**	**First difference**	**Level**	**First difference**
CADF	$lnCO_{2it}$	-2.295	-3.973 ***	-2.546	-3.377***	-2.344	-3.615 ***
	lnY_{it}	-1.846	-4.075 ***	-2.515	-3.301***	-2.812**	-3.591 ***
	$lnEC_{it}$	-2.178	-3.655 ***	-1.713	-3.716 ***	-2.207	-3.429***
	$lnTR_{it}$	-2.299	-3.871 ***	-2.154	-4.108 ***	-2.473	-3.187***
	$lnUrb_{it}$	-1.955	-3.214 ***	-2.200	-3.067 ***	-2.080	-2.922 **
CIPS	$lnCO_{2it}$	-2.333	-5.146 ***	-2.249	-5.484 ***	-2.382	-5.128 ***
	lnY_{it}	-2.724	-5.107 ***	-2.491	-5.249 ***	-2.590	-4.726 ***
	$lnEC_{it}$	-2.431	-4.828 ***	-2.492	-4.928 ***	-2.362	-4.785***
	$lnTR_{it}$	-2.680	-5.006 ***	-2.226	-5.156 ***	-2.531	-4.605***
	$lnUrb_{it}$	-1.834	-3.223 ***	-1.643	-3.040***	-1.991	-3.072 ***

Note: ***,**,* represents significance level at 1%, 5%, and 10% respectively.

4.3. Result of Panel Cointegration Test

In an attempt to investigate time series variables using classical approaches, a basic assumption is made as follows: The variance and means of the macroeconomic variables should be constant and independent over time (stationary). However, non-stationary variables (i.e. unit-roots variables) do not meet this assumption, therefore, the findings from any hypothesis test are considered bias and misrepresentative. Thus, we perform a panel cointegration test to minimize such occurrences.

The strong evidence of stationarity condition at first difference amid the five selected macroeconomic variables is proceeded by using the appropriate panel cointegration estimator to investigate the presence of a long-run equilibrium relationship between the stationary variables. Table 6 reports the empirical highlights from the Westerlund-Edgerton bootstrap panel cointegration test with carbon dioxide emissions as the explained or dependent variable. Concerning the robust probability values, we fail to accept the null hypothesis of no cointegration for all three-panel groups at 1% and 5% significant levels. Our outcome, therefore, implies that in the very long-term, the macroeconomic variables are strongly related.

Table-6. The result from the bootstrap panel cointegration test.

	G_t	G_a	P_t	P_a
Panels	**Statistics/ Robust P-values**	**Statistics/ Robust P-values**	**Statistics/ Robust P-values**	**Statistics/ Robust P-values**
All 25 countries	-4.299 (0.000)***	-3.141 (0.990)	-88.299 (0.000)***	-21.563 (0.010)***
Oil Exporting	-3.163 (0.000)***	-7.428 (0.030)**	-8.899 (0.040)**	-6.892 (0.008)***
Non-Oil Exporting	-5.121 (0.000)***	-5.969 (0.980)	-82.465 (0.000)***	-26.875 (0.020)***

Note: ***, ** represents significance level at 1%, and 5% respectively.

4.4. Result of Panel Long-Run Estimates

The outcome from the panel CCEMG estimates is presented in Table 7 for all three-panel groups, showing the various coefficients of the panel long-run cointegrated macroeconomic series for the response variable (Carbon dioxide emissions). Our empirical outcome indicates a positive significant elasticity for economic growth, energy consumption, trade, and urbanization per the 25-countries panel. Likewise, the other two subpanel groups recorded a positive significant coefficient for the four economic indicators. This implies that economic growth, energy consumption, trade openness, and urbanization will significantly increase environmental pollution within the various panel groups. Similar results were confirmed by the panel AMG approach but with different elasticities and p-values.

Table-7. Results of Panel long-run estimates.

		Dependent Variable: $lnCO_2$					
	Independent	**All(25-countries)**		**Oil Exporting**		**Non-Oil Exporting**	
Test	**Variables**	**Coefficient**	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
CCEMG	lnY_{it}	0.0692	0.010 **	0.0545	0.056*	0.0759	0.015**
	$lnEC_{it}$	0.8565	0.000***	0.4196	0.000.***	2.4019	0.004 ***
	$lnTR_{it}$	0.0147	0.042 **	0.0205	0.0809*	0.0451	0.037**
	$lnUrb_{it}$	1.1393	0.004 ***	1.0087	0.017**	0.3908	0.0460**
	RMSE	(0.0742)		(0.0661)		(0.0825)	
AMG	lnY_{it}	0.0153	0.039**	0.0637	0.060*	0.0616	0.028**
	$lnEC_{it}$	1.3084	0.002***	0.5259	0.000***	1.9543	0.000***
	$lnTR_{it}$	0.0245	0.034**	0.0477	0.057*	0.0346	0.027**
	$lnUrb_{it}$	0.7331	0.000***	0.2899	0.000***	0.5006	0.0180**
	RMSE	(0.0463)		(0.0153)		(0.0337)	

Note: ***,**,* represents significance level at 1%, 5%, and 10% respectively, CCEMG is common correlated effects mean group, AMG is augmented mean group and RMSE is the root mean square error.

4.5. Results of Panel Causality

Having established evidence of a long-run relationship between the response variable and the instrumental variables, the (D-H) Granger non-causality technique was used to examine the direction of the long-term causal relationship between the selected variables. The evidence as stated in Table 8 depicts a significant causal relationship between the response variable and the various independent variables for all the 25-countries panel and the two sub-panels. The outcome shows evidence of a bidirectional causal relationship between economic growth and carbon emissions, energy consumption, and carbon emissions, and urbanization and carbon emission. Likewise, proof of a unidirectional causal relationship was discovered from carbon emissions to trade for the 25-countries panel.

The findings for the oil-exporting panel demonstrate a two-way causality between economic growth and carbon emissions, power consumption and carbon emissions, trade openness and carbon emissions, urbanization, and carbon emissions, but with different elasticities. High long-run elasticity indicates a higher degree of carbon emissions. A similar response was shown in the non-oil exporting panel. The findings suggest a bidirectional causality between economic growth and carbon emissions, energy use and carbon emissions, trade openness and carbon emissions, and urbanization and carbon emissions.

Table-8. Results for Granger non-causality test Dumitrescu and Hurlin (2012).

Test	Null Hypothesis	All(25 economies)	Oil Exporting	Non-Oil Exporting
D-H	$CO_2 \neq Y$	6.165 (0.000)***	3.093 (0.000)***	13.422(0.000)***
	$Y \neq CO_2$	3.574 (0.000)***	4.416 (0.000)***	5.247(0.000)***
	$CO_2 \neq EC$	7.645 (0.000)***	5.581 (0.000)***	16.836(0.000)***
	$EC \neq CO_2$	2.040(0.0413)**	5.409 (0.000)***	2.596(0.0094)***
	$CO_2 \neq TR$	7. 193 (0.000)***	4.491 (0.000)***	15.366(0.000)***
	$TR \neq CO_2$	1.416 (0.1568)	3.921 (0.0001)***	6.393(0.000)***
	$CO_2 \neq UrB$	11.920 (0.000)***	4.129 (0.000)***	12.607(0.000)***
	$UrB \neq CO_2$	9.7347 (0.000)***	28.682 (0.000)***	11.672(0.000)***

Note: *** represents the significance level at 1%.

4.6. Result of the Environmental Kuznets Curve (EKC)

The negative coefficients of the squared GDP indicate the existence of an inverted U-shaped relationship between income and environmental pollution. This outcome as shown in Table 9 supports the assumptions behind the Environmental Kuznets Curve (EKC). Hence, indicating the presence of the EKC hypothesis within the various panels. The various panels recorded variant turning or threshold points. A higher turning point implies that countries within these panels require a lesser time to reach the optimum threshold level. Similarly, pollution levels are higher for nations with smaller turning points as they may take more years to achieve the limit point where environmental pollution starts to decline.

Generally, the study endeavors to examine the interconnectedness between economic growth, energy consumption, trade openness, urbanization, and carbon emissions for a panel of 25 newly emerging African nations group into two sub-panels (oil and non-oil exporting economies). During this process, the study adopted the Pesaran cross-sectional dependence test and Pesaran-Yamagata homogeneity test to make certain evidence of heterogeneity and cross-sectional dependence concerning the selected variables.

Table-9. Environmental Kuznets Curve (EKC).

		Dependent Variable: CO_2					
		ALL(25 countries)		Oil Exporting		Non-Oil Exporting	
Test	Series	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
	lnY_{it}	3.5767	0.000***	4.6646	0.000 ***	1.8758	0.000 ***
	lnY_{it}^2	-0.2216	0.000***	-0.3209	0.000***	-0.1080	0.001***
	$lnEC_{it}$	1.1737	0.000 ***	1.4896	0.000 ***	0.5758	0.000 ***
	$lnTR_{it}$	0.1668	0.0200 ***	0.1484	0.064 ***	0.1978	0.080 ***
	$lnUrb_{it}$	0.2100	0.000 ***	0.7615	0.000 ***	0.7493	0.000 ***
Turning points		USD3197.65		USD 1433.67		USD5909.16	

Note: *** represents significance at 1%.

The proof of heterogeneity and cross-sectional dependence explains the regional interaction of the selected variables across the various cross-sections. These outcomes support the findings of Mensah et al. (2019) and Dogan and Aslan (2017). Likewise, the outcome of the CADF and CIPS panel unit root test implies that the chosen variables have a unique order of stationarity. That is, they are integrated of the same order (I (1)). These findings confirmed the outcomes of Dogan, Seker, and Bulbul (2017) as they investigate stationarity for economic growth, carbon emissions, energy usage, and tourism in OECD countries.

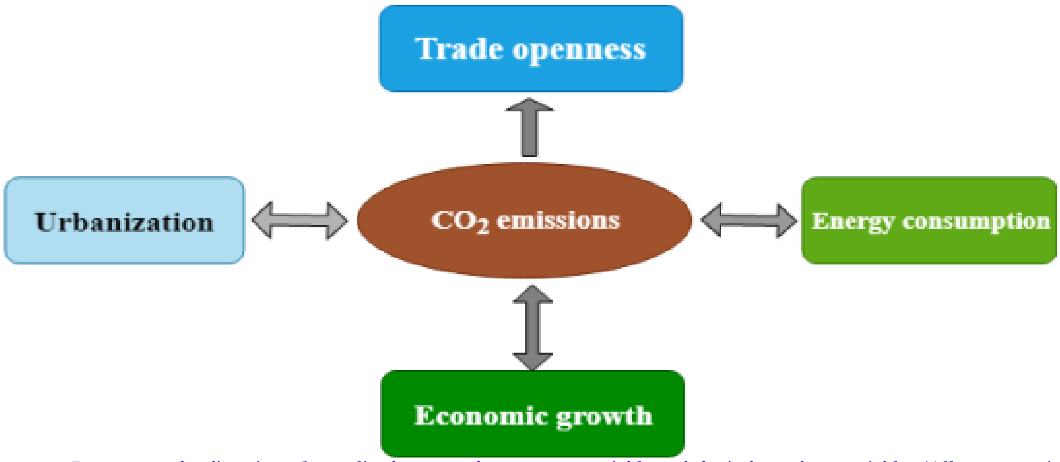

Figure-6. Represents the direction of causality between the response variable and the independent variables (All 25-countries).

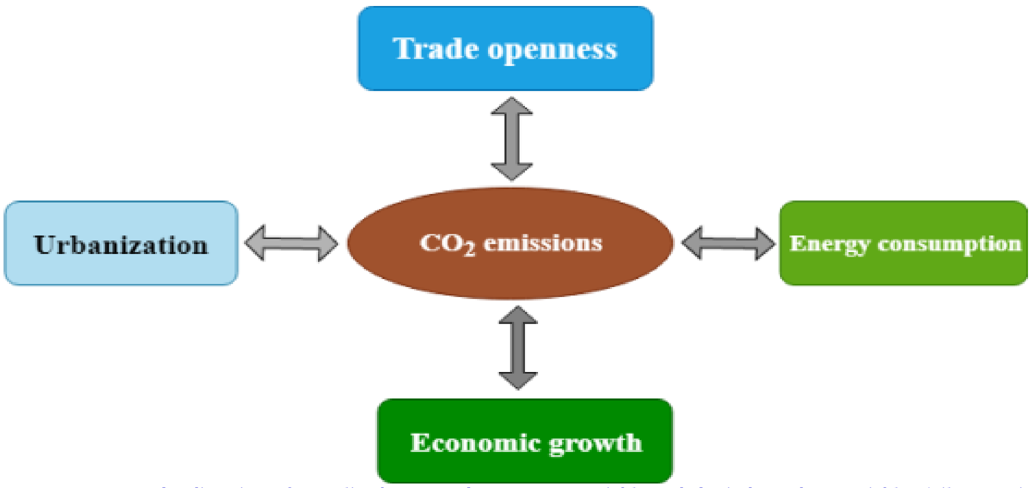

Figure-7. Represents the direction of causality between the response variable and the independent variables (oil-exporting and non-oil exporting panels).

Similarly, an application of the Westerlund-Edgerton bootstrap panel cointegration test technique was adopted to investigate the reality of the long-term cointegration relationship between the chosen variables. The findings showed evidence of cointegration between the variables in the long-run. This result provides support for the study conducted by Mensah et al. (2019) on the long-term equilibrium interaction between carbon emission, fossil fuel energy consumption, economic growth, and oil price in Africa. In contrast, Ozturk, Aslan, and Kalyoncu (2010) failed to provide evidence of strong long-term nexus between economic growth and demand for energy among 51 countries from 1971 to 2005. Our results imply that the elasticities of the various independent variables are environmentally and empirically beneficial.

The estimates for the panel long-run coefficients or elasticities of the selected independent variables for all 25-countries panel and the two sub-panels (oil-exporting and non-oil exporting economies) as reported in Table 7 using the panel CCEMG approach indicates that the coefficients of economic growth, energy consumption, trade openness, and urbanization are positive and strongly significant for the 25-countries panel. Specifically, in the long-run, a 1% increase in economic growth will increase the level of emissions in the atmosphere by the magnitude of the growth elasticity (significant at 1%). This outcome supports the findings of Apergis and Payne (2009). Similarly, a 1 % increase in energy consumption in these nations will increase environmental pollution by a percentage of the energy consumption coefficient (significant at 1%). These findings are in line with the outcome of Apergis and Payne (2009). Likewise, a 1% increase in trade is associated with a percentage increase in carbon emissions equal to the trade elasticity (significant at 5%). This result confirms the outcome of Sun, Attuquaye, Geng, Fang, and Clifford (2019). Finally, as urbanization expands any 1% increase is associated with a percentage rise in carbon emissions equivalent to the magnitude of urbanization coefficient (significant at 1%). These findings are in line with the outcome of Zhang, Yi, and Li (2015). Similar references are reported in the oil-exporting and non-oil exporting countries but with different coefficients or elasticities. In addition, the same outcomes were obtained using the panel augmented mean group (AMG) technique for all three panels but with varying coefficients of elasticity. This test was performed to check the robustness of our outcomes.

The feedback causal relationship from the cointegrated panel variables are illustrated in Figure 6 and Figure 7. Concerning these results, we uncovered the path of causality of the variables through different panels, which are established by numerous factors according to Chou (2013). The outcomes are particularly helpful in establishing specific policies to curb CO_2 emissions and promote economic growth and trade expansion. A bidirectional Granger causality from energy usage to CO_2 pollution implies that, along with steadily growing energy needs, global CO_2 pollution can be successfully alleviated in a lifetime. This observation is in agreement with previous studies by Mensah et al. (2019); Ssali, Du, Mensah, and Hongo (2019). The causation also suggests that CO_2 emissions and energy usage are strongly interdependent across the various panel groups. This progress clarifies that a rise in energy use is correlated with an increase in pollution rate, particularly carbon emissions and vice versa, which is also valid. In opposition to our findings, a study by Kahouli (2017) concluded that in the long term energy usage Granger causes carbon emissions.

Similarly, the bidirectional causality among environmental quality and economic development confirms the claim that CO_2 emissions may not be a restricted driver of economic growth. The conclusion supports the earlier study by Mensah et al. (2019). A possible explanation of the response hypothesis is the trend of economic development within this region. This shows that widening economic operations within these panels will lead to greater emission levels, especially carbon emissions. Similarly, any efforts to attain a low-carbon economy should lead to a decline in economic development. Creating serious concerns when designing green environmental policies.

The link between urbanization and pollution indicates the existence of a bidirectional causal connection between urbanization and carbon emissions. This emphasizes that these variables are interdependent in the longer term. This, however, demonstrates that the result of reducing the amount of urbanization would decrease the level of carbon emissions without factoring the alternative role of urbanization growth patterns and technological advancement. This discovering is, however, incompatible with the outcomes of Wang et al. (2016).

The path of causality between trade openness and carbon emission varies within the various panels. Evidence of a unidirectional causality was discovered moving from carbon emission to trade openness for the 25-countries panel. This explains that increasing emissions level is strongly linked to the volume of trade. This, however, depends on the origin of energy consumption. Similarly, there was evidence of bidirectional causality between trade and emissions for the oil and non-oil exporting panels. This suggests that trade and carbon emissions are strongly interdependent. Higher emission levels are combined with a greater amount of trade and vice versa. By comparison, any effort to minimize carbon emissions will adversely impact the quantity of trade. These results are consistent with the results of Sun et al. (2019).

There was a proof of an inverted U-shaped connection between real income and environmental quality in the framework of our EKC estimates. That is our results support the EKC concepts for all three panels; at the initial phase of economic development, there will be some form of deterioration in the environment. However, at some point on the development curve, the level of emissions begins to fall when the threshold income level is reached.

5. CONCLUSIONS AND POLICY IMPLICATIONS

The empirical research contributes to the emerging literature that focuses on researching the environmental impacts of economic growth and carbon emissions. Unlike most past research, our empirical research applies a causality structure involving panel unit root, cointegration, causality tests, and distinct geographical locations during our data sampling that enable heterogeneity, cross-sectional reliance, and non-stationarity to define the connection between factors and evaluate the causal impact of economic growth on carbon emissions. A panel of data from 25 African countries with emphasis on geographical location (North, East, West, and South) covering 1990-2015 was used in this study to investigate empirically the vibrant linkages between CO_2 emissions, economic growth, energy consumption, trade openness, and urbanization while accounting for time-invariant differences across distinct areas.

The main outcomes of this research are listed below. To begin with, the results of the slope homogeneity and cross-sectional dependence tests indicate robust interdependencies concerning the selected variables in the long run due to the growing level of globalization. Also, there was evidence that economic growth, energy consumption, trade openness, and urbanization positively and significantly affect the level of environmental pollution. Similarly, this evidence explained that the proof of substantial positive consequence of energy usage on pollution is autonomous of the geographical setting and the economic growth level of the various regions. This implies that irrespective of the level of economic development in the various region, the relationship between energy consumption and CO_2 emissions will remains positive and statistically significant. Also, evidence of bidirectional causality was discovered between carbon emissions and the four independent variables in all three panels. Finally, the EKC hypothesis was confirmed for all three panels but with different turning points.

From a policy perspective, the possible occurrence of cross-sectional dependence across economies, demand the global or regional collaboration of countries in the quest to promote a low-carbon economy. Similarly, the increasing volumes of global value chain combined with increasing levels of economic integration have made economic growth highly pollution-intensive, particularly carbon emissions; therefore, investing in renewable energy technology will help to minimize the adverse environmental consequences of economic growth. Furthermore, the positive urbanization elasticity means that migration to urban regions is associated with growing emission levels and demands instant policy solutions. The effect of energy consumption on environmental pollution can be affected by the country-specific composition of energy consumption. For example, the percentage of clean energy in total energy use. Therefore, attempts should be made to boost the percentage of renewable energy consumption by applying strategic measures to deter heavy reliance on non-renewable energy. For instance, the need to incorporate the usage of low-carbon technology intended to reduce emissions and maintain sustainable economic growth.

Likewise, policymakers should consider the reduction of energy use by enforcing strategic environmental policies that are advantageous towards achieving a green environment. Such as new technologies with the capacity of purifying non-renewable energy to make them more eco-friendly (Soytas et al., 2007). It is important to note that efforts have been made by the European Union to implement some of the above-mentioned measures by outlining three main objectives for 2020; to decrease emissions by 20 percent, to increase the share of renewable energy in the total energy mix and increasing energy efficiency by 20 percent within this region. While energy-saving measures can be instituted without adversely influencing economic growth, in reality, cutting energy usage may not be feasible owing to the increasing level of household and industrial energy consumption. Energy efficiency is perhaps one of the approaches to decrease the quantity of energy consumed. However, it is significant to inquire into other environmental variables before enforcing these measures.

The evidence that urbanization causes carbon emissions is translated to mean that controlling urbanization would help decrease carbon emissions without considering the possible function of urbanization growth patterns and technological innovations. However, in recent urbanization development, emissions are heavily determined by household and industrial operations instead of urban development operations. In this regard, increasing energy efficiency at homes and industries is regarded to be the primary way to detach urban development from carbon emissions (Wang et al., 2016). Likewise, as urbanization grows, to reduce carbon emissions, economically viable planning of extensive land use and adequate levels of public transport should be introduced. With regard to the environment, city planners and decision-makers should show efficient planning of urban development and energy efficiency. Governments should make excellent attempts to properly build and manage towns, mobilize a range of stakeholders, provide extra funding, and improve alliances towards the double-win objective of green and integrated urban development and reducing carbon emissions. Future studies may consider the fluctuations in oil prices across the region as well as the impact of corruption on carbon emission within this region. In addition, several indicators for measuring emissions are available in the literature, such as SO_2, NO, etc.: Future research should also endeavor to consider other emission indicators. Other economic indicators such as sustainable energy allocation, sustainable development problems, innovation, human capital growth, environmental regulation policy must also be considered when grouping nations.

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REFERENCES

Adu, D. T., & Denkyirah, E. K. (2019). Economic growth and environmental pollution in West Africa: Testing the Environmental Kuznets Curve hypothesis. *Kasetsart Journal of Social Sciences*, *40*(2), 281-288.

Afzal, M., Farooq, M. S., Ahmad, H. K., Begum, I., & Quddus, M. A. (2010). Relationship between school education and economic growth in Pakistan: ARDL bounds testing approach to cointegration. *Pakistan Economic and Social Review*, *48*(1), 39-60.

Al-Mulali, U. (2014). Investigating the impact of nuclear energy consumption on GDP growth and CO2 emission: A panel data analysis. *Progress in Nuclear Energy*, *73*, 172-178.Available at: https://doi.org/10.1016/j.pnucene.2014.02.002.

Al-Mulali, U., Sab, C. N. B. C., & Fereidouni, H. G. (2012). Exploring the bi-directional long-run relationship between urbanization, energy consumption, and carbon dioxide emission. *Energy*, *46*(1), 156-167.Available at: https://doi.org/10.1016/j.energy.2012.08.043.

Apergis, N., & Payne, J. E. (2009). CO2 emissions, energy usage, and output in Central America. *Energy Policy*, *37*(8), 3282-3286.Available at: https://doi.org/10.1016/j.enpol.2009.03.048.

Atasoy, B. S. (2017). Testing the environmental Kuznets curve hypothesis across the US: Evidence from panel mean group estimators. *Renewable and Sustainable Energy Reviews, 77*, 731-747.Available at: https://doi.org/10.1016/j.rser.2017.04.050.

Boamah, K. B., Du, J., Bediako, I. A., Boamah, A. J., Abdul-Rasheed, A. A., & Owusu, S. M. (2017). Carbon dioxide emission and economic growth of China—the role of international trade. *Environmental Science and Pollution Research, 24*(14), 13049-13067.Available at: https://doi.org/10.1007/s11356-017-8955-z.

Bölük, G., & Mert, M. (2014). Fossil & renewable energy consumption, GHGs (greenhouse gases) and economic growth: Evidence from a panel of EU (European Union) countries. *Energy, 74*, 439-446.Available at: https://doi.org/10.1016/j.energy.2014.07.008.

Breitung, J. (2005). A parametric approach to the estimation of cointegration vectors in panel data. *Econometric Reviews, 24*(2), 151-173.Available at: https://doi.org/10.1081/etc-200067895.

Breusch, T. S., & Pagan, A. R. (1980). The Lagrange multiplier test and its applications to model specification in econometrics. *The Review of Economic Studies, 47*(1), 239-253.Available at: https://doi.org/10.2307/2297111.

Chou, M. C. (2013). Does tourism development promote economic growth in transition countries? *A Panel Data Analysis. Economic Modeling, 33*, 226-232.Available at: https://doi.org/10.1016/j.econmod.2013.04.024.

Dao, M. Q. (2012). Population and economic growth in developing countries. *International Journal of Academic Research in Business and Social Sciences, 2*(1), 6-17.

Das Neves Almeida, T. A., Cruz, L., Barata, E., & García-Sánchez, I.-M. (2017). Economic growth and environmental impacts: An analysis based on a composite index of environmental damage. *Ecological Indicators, 76*, 119-130.Available at: https://doi.org/10.1016/j.ecolind.2016.12.028.

Dogan, E., & Aslan, A. (2017). Exploring the relationship among CO2 emissions, real GDP, energy consumption and tourism in the EU and candidate countries: Evidence from panel models robust to heterogeneity and cross-sectional dependence. *Renewable and Sustainable Energy Reviews, 77*(C), 239-245.

Dogan, E., Seker, F., & Bulbul, S. (2017). Investigating the impacts of energy consumption, real GDP, tourism and trade on CO2 emissions by accounting for cross-sectional dependence: A panel study of OECD countries. *Current Issues in Tourism, 20*(16), 1701-1719.Available at: 10.1080/13683500.2015.1119103.

Dong, K., Hochman, G., Zhang, Y., Sun, R., Li, H., & Liao, H. (2018). CO2 emissions, economic and population growth, and renewable energy: Empirical evidence across regions. *Energy Economics, 75*, 180-192.Available at: https://doi.org/10.1016/j.eneco.2018.08.017.

Dumitrescu, E.-I., & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels. *Economic Modeling, 29*(4), 1450-1460.Available at: https://doi.org/10.1016/j.econmod.2012.02.014.

Granger, C. W. J. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica, 37*(3), 424-438.Available at: 2307/1912791.

Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American free-trade agreement (No.W3914). National Bureau of Economic Research.

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The Quarterly Journal of Economics, 110*(2), 353-377.

Gunby, P., Jin, Y., & Reed, W. R. (2017). Did FDI really cause Chinese economic growth? A meta-analysis. *World Development, 90*, 242-255.Available at: https://doi.org/10.1016/j.worlddev.2016.10.001.

He, J., & Richard, P. (2010). Environmental Kuznets curve for CO2 in Canada. *Ecological Economics, 69*(5), 1083-1093.Available at: https://doi.org/10.1016/j.ecolecon.2009.11.030.

Hu, H., Xie, N., Fang, D., & Zhang, X. (2018). The role of renewable energy consumption and commercial services trade in carbon dioxide reduction: Evidence from 25 developing countries. *Applied Energy, 211*, 1229-1244.Available at: https://doi.org/10.1016/j.apenergy.2017.12.019.

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, *115*(1), 53-74.Available at: https://doi.org/10.1016/s0304-4076(03)00092-7.

IPCC. (2007). Climate change: Synthesis Report (pp. 104). Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.

Jaffe, A. B., Newell, R. G., & Stavins, R. N. (2005). A tale of two market failures: Technology and environmental policy. *Ecological Economics*, *54*(2-3), 164-174.Available at: https://doi.org/10.1016/j.ecolecon.2004.12.027.

Jin, L., Duan, K., Shi, C., & Ju, X. (2017). The impact of technological progress in the energy sector on carbon emissions: An empirical analysis from China. *International Journal of Environmental Research and Public Health*, *14*(12), 1-14.Available at: https://doi.org/10.3390/ijerph14121505.

Kahouli, B. (2017). The short and long run causality relationship among economic growth, energy consumption and financial development: Evidence from South Mediterranean Countries (SMCs). *Energy Economics*, *68*, 19-30.Available at: https://doi.org/10.1016/j.eneco.2017.09.013.

Kaika, D., & Zervas, E. (2011). Searching for an environmental Kuznets Curve (EKC)-pattern for CO2 emissions. In Recent Researches in Energy, Environment, and Landscape Architecture;(LA'II) (pp. 19-24). WSEAS Press: Athens, Greece.

Kapetanios, G., Pesaran, M. H., & Yamagata, T. (2011). Panels with non-stationary multifactor error structures. *Journal of Econometrics*, *160*(2), 326-348.Available at: https://doi.org/10.1016/j.jeconom.2010.10.001.

Koçak, E., & Sarkgüneşi, A. (2018). The impact of foreign direct investment on CO 2 emissions in Turkey: New evidence from cointegration and bootstrap causality analysis. *Environmental Science and Pollution Research*, *25*(1), 790-804.Available at: https://doi.org/10.1007/s11356-017-0468-2.

Kuznets, S. (1955). Economic growth and income inequality. *The American Economic Review*, *45*(1), 1-28.

Madlener, R., & Sunak, Y. (2011). Impacts of urbanization on urban structures and energy demand: What can we learn for urban energy planning and urbanization management? *Sustainable Cities and Society*, *1*(1), 45-53.Available at: https://doi.org/10.1016/j.scs.2010.08.006.

Martínez-Zarzoso, I., & Maruotti, A. (2011). The impact of urbanization on CO2 emissions: Evidence from developing countries. *Ecological Economics*, *70*(7), 1344-1353.Available at: https://doi.org/10.1016/j.ecolecon.2011.02.009.

Mensah, C. N., Long, X., Boamah, K. B., Bediako, I. A., Dauda, L., & Salman, M. (2018). The effect of innovation on CO 2 emissions of OCED countries from 1990 to 2014. *Environmental Science and Pollution Research*, *25*(29), 29678-29698.Available at: https://doi.org/10.1007/s11356-018-2968-0.

Mensah, I. A., Sun, M., Gao, C., Omari-Sasu, A. Y., Zhu, D., Ampimah, B. C., & Quarcoo, A. (2019). Analysis of the nexus of economic growth, fossil fuel energy consumption, CO2 emissions, and oil price in Africa based on a PMG panel ARDL approach. *Journal of Cleaner Production*, *228*, 161-174.Available at: https://doi.org/10.1016/j.jclepro.2019.04.281.

Omri, A. (2013). CO2 emissions, energy consumption and economic growth nexus in MENA countries: Evidence from simultaneous equations models. *Energy Economics*, *40*, 657-664.Available at: https://doi.org/10.1016/j.eneco.2013.09.003.

Ozturk, I., Aslan, A., & Kalyoncu, H. (2010). Energy consumption and economic growth relationship: Evidence from panel data for low and middle income countries. *Energy Policy*, *38*(8), 4422-4428.Available at: https://doi.org/10.1016/j.enpol.2010.03.071.

Panayotou, T. (1993). Empirical tests and policy analysis of environmental degradation at different stages of economic development. World Employment Programme Research Working Paper WEP 2-22/WP 238 (International Labour Office, Geneva).

Parikh, J., & Shukla, V. (1995). Urbanization, energy use and greenhouse effects in economic development: Results from a cross-national study of developing countries. *Global Environmental Change*, *5*(2), 87-103.Available at: https://doi.org/10.1016/0959-3780(95)00015-g.

Pesaran, M. H., & Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of Econometrics*, *142*(1), 50-93.Available at: https://doi.org/10.1016/j.jeconom.2007.05.010.

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics, 22*(2), 265-312.Available at: https://doi.org/10.1002/jae.951.

Pesaran, M. H., & Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics, 68*(1), 79-113.Available at: https://doi.org/10.1016/0304-4076(94)01644-F.

Pesaran...., M. H. (2006). Estimation and inference in large heterogeneous panels with a multifactor error structure. *Econometrica, 74*(4), 967-1012.Available at: https://doi.org/10.1111/j.1468-0262.2006.00692.x.

Pesaran, M. H. (2004). General diagnostic tests for cross section dependence in panels. CESifo Working Paper Series No. 1229, IZA Discussion Paper No. 1240. Retrieved from SSRN: http://ssrn.com/abstract=572504.

Phillips, P., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika, 75*(2), 335-346.Available at: https://doi.org/10.1093/biomet/75.2.335.

Policy, U. N. E. C. F. E. C. O. E. (2008). *ECE/CEP/142*: United Nations Publications.

Poumanyvong, P., & Kaneko, S. (2010). Does urbanization lead to less energy use and lower CO2 emissions? A cross-country analysis. *Ecological Economics, 70*(2), 434-444.Available at: https://doi.org/10.1016/j.ecolecon.2010.09.029.

Rafiq, S., Salim, R., & Nielsen, I. (2016). Urbanization, openness, emissions, and energy intensity: A study of increasingly urbanized emerging economies. *Energy Economics, 56*, 20-28.Available at: https://doi.org/10.1016/j.eneco.2016.02.007.

Sadorsky, P. (2014). The effect of urbanization on CO2 emissions in emerging economies. *Energy Economics, 41*, 147-153.Available at: https://doi.org/10.1016/j.eneco.2013.11.007.

Samargandi, N. (2017). Sector value addition, technology and CO2 emissions in Saudi Arabia. *Renewable and Sustainable Energy Reviews, 78*, 868-877.Available at: https://doi.org/10.1016/j.rser.2017.04.056.

Sanglimsuwan, K. (2011). Carbon dioxide emissions and economic growth: An econometric analysis. *International Research Journal of Finance and Economics, 67*(1), 97-102.

Shafik, N., & Bandyopadhyay, S. (1992). *Economic growth and environmental quality: Time-series and cross-country evidence.* Washington DC: World Bank Policy Research Working Paper WPS904.

Shahbaz, M., Loganathan, N., Muzaffar, A. T., Ahmed, K., & Jabran, M. A. (2016). How urbanization affects CO2 emissions in Malaysia? The application of STIRPAT model. *Renewable and Sustainable Energy Reviews, 57*, 83-93.Available at: https://doi.org/10.1016/j.rser.2015.12.096.

Shao, Y. (2018). Does FDI affect carbon intensity? New evidence from dynamic panel analysis. *International Journal of Climate Change Strategies and Management, 10*(1), 27-42.Available at: https://doi.org/10.1108/ijccsm-03-2017-0062.

Sharma, R., & Joshi, P. (2013). Monitoring urban landscape dynamics over Delhi (India) using remote sensing (1998–2011) inputs. *Journal of the Indian Society of Remote Sensing, 41*(3), 641-650.Available at: https://doi.org/10.1007/s12524-012-0248-x.

Shi, A. (2003). The impact of population pressure on global carbon dioxide emissions, 1975–1996: evidence from pooled cross-country data. *Ecological Economics, 44*(1), 29-42.Available at: https://doi.org/10.1016/s0921-8009(02)00223-9.

Soytas, U., Sari, R., & Ewing, B. T. (2007). Energy consumption, income, and carbon emissions in the United States. *Ecological Economics, 62*(3-4), 482-489.Available at: https://doi.org/10.1016/j.ecolecon.2006.07.009.

Ssali, M. W., Du, J., Mensah, I. A., & Hongo, D. O. (2019). Investigating the nexus among environmental pollution, economic growth, energy use, and foreign direct investment in 6 selected sub-Saharan African countries. *Environmental Science and Pollution Research, 26*(11), 11245-11260.Available at: https://doi.org/10.1007/s11356-019-04455-0.

Sulemana, I., James, H. S., & Rikoon, J. S. (2017). Environmental Kuznets Curves for air pollution in African and developed countries: Exploring turning point incomes and the role of democracy. *Journal of Environmental Economics and Policy, 6*(2), 134-152.Available at: https://doi.org/10.1080/21606544.2016.1231635.

Sun, H., Attuquaye, C. S., Geng, Y., Fang, K., & Clifford, K. A. J. (2019). Trade openness and carbon emissions: Evidence from belt and road countries. *Sustainability, 11*(9), 1-20.Available at: https://doi.org/10.3390/su11092682.

Wang, C., Wang, F., Zhang, X., Yang, Y., Su, Y., Ye, Y., & Zhang, H. (2017). Examining the driving factors of energy related carbon emissions using the extended STIRPAT model based on IPAT identity in Xinjiang. *Renewable and Sustainable Energy Reviews*, *67*, 51-61.Available at: https://doi.org/10.1016/j.rser.2016.09.006.

Wang, S., Zhou, D., Zhou, P., & Wang, Q. (2011). CO2 emissions, energy consumption and economic growth in China: A panel data analysis. *Energy Policy*, *39*(9), 4870-4875.Available at: https://doi.org/10.1016/j.enpol.2011.06.032.

Wang, Y., Li, L., Kubota, J., Han, R., Zhu, X., & Lu, G. (2016). Does urbanization lead to more carbon emission? Evidence from a panel of BRICS countries. *Applied Energy*, *168*, 375-380.Available at: https://doi.org/10.1016/j.apenergy.2016.01.105.

Westerlund, J., & Edgerton, D. L. (2007). A panel bootstrap cointegration test. *Economics Letters*, *97*(3), 185-190.Available at: https://doi.org/10.1016/j.econlet.2007.03.003.

Zaman, K., Shahbaz, M., Loganathan, N., & Raza, S. A. (2016). Tourism development, energy consumption and Environmental Kuznets Curve: Trivariate analysis in the panel of developed and developing countries. *Tourism Management*, *54*, 275-283.Available at: https://doi.org/10.1016/j.tourman.2015.12.001.

Zeng, K., & Eastin, J. (2012). Do developing countries invest up? The environmental effects of foreign direct investment from less-developed countries. *World Development*, *40*(11), 2221-2233.Available at: https://doi.org/10.1016/j.worlddev.2012.03.008.

Zhang, Y.-J., Yi, W.-C., & Li, B.-W. (2015). The impact of urbanization on carbon emission: Empirical evidence in Beijing. *Energy Procedia*, *75*, 2963-2968.Available at: https://doi.org/10.1016/j.egypro.2015.07.601.