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Does it take international integration of natural resources to ascend the ladder of environmental quality in the newly industrialized countries?

Tomiwa Sunday Adebayo[a,b], Stephen Taiwo Onifade[c,d], Andrew Adewale Alola[e,f,g,h,*], Obumneke Bob Muoneke[i]

[a] Department of Business Administration, Faculty of Economics and Administrative Science, Cyprus International University, Northern Cyprus, Mersin 10, Turkey
[b] Department of Finance & Accounting, AKFA University, 1st Deadlock, 10th Kukcha Darvoza Street, Tashkent, Uzbekistan
[c] Department of Economics, Faculty of Economics and Administrative Sciences, Selcuk University, Konya, Turkey
[d] Department of International Trade and Logistics, Faculty of Economics and Administrative Sciences, KTO Karatay University, Konya, Turkey
[e] Department of Economics, School of Accounting and Finance, University of Vaasa, Vaasa, FI, 65200, Finland
[f] Vaasa Energy Business Innovation Centre, University of Vaasa, 65101, Vaasa, Finland
[g] Department of Economics and Finance, Istanbul Gelisim University, Istanbul, Turkey
[h] Department of Economics and Finance, South Ural State University, Chelyabinsk, Russia
[i] Department of Finance, University of Lagos, Akoka-Yaba, Nigeria

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ABSTRACT

Among the new revelation in the natural resources-environment and climate change nexus literature is the criticality of ascending the environmental sustainability ladders of the industrialized economies such as the newly industrialized countries (NICs). This study considers the panel of top ten NICs (Brazil, China, India, Mexico, Malaysia, Philippines, South Africa, Turkey, Indonesia, and Thailand) by utilizing the novel Method of Moments Quantile Regression (MMQR) and other approaches including the Fully Modified Ordinary Least Square (FM-OLS), Dynamic Ordinary Least Square (D-OLS), and the Fixed-effects Ordinary Least Square (FE-OLS) to analyze the related dataset between 1990 and 2018. The combined empirical approaches help to measure the countries' drive for carbon neutrality. With a startling and unanimous evidence from the employed empirical techniques, natural resource rent is detrimental to the global goal carbon neutrality in the examined panel countries. However, there is a significant relieve that is brought about when globalization moderate the effect of natural resource rent on carbon emission. Another favorable outlook from the study is that economic growth and environmental nexus yields the affirmative validity of environmental Kuznets curve while renewable energy utilization and globalization independently promotes environmental quality in the examined panel countries. Therefore, the result from the study favours a more relaxed border to allow international integration of economic and financial aspects especially for the natural resources-related and environmental-friendly goods and services.

1. Introduction

The clamour for carbon neutrality has been a global matter of concern to all and sundry in recent times. This clamour is intensifying by the day as the global community is increasingly confronted with the dangers and hazards that accompany the environmental pollution and unabating greenhouse gases (GHGs) emissions ranging from the risk of environmental disasters like global warming and its attendant effects (UNEP, 2021; IPCC et al., 2021), to various health risks like heart diseases, the shortening of life expectancy, and cancer (Skinner et al., 2006; Pope and Dockery, 2006; Amann et al., 2011; Wang and Yang, 2016), to other ecological degradations matters that are associated with human activities such as the loss of natural habitat and the destruction of biodiversity among other issues (Panayotou, 1993; Whiteman et al., 2013; Destek and Sinha, 2020; Alola et al., 2021). Economic growth-inducing human activities that create undesirable environmental impacts cut across various sectors of the economy ranging from the extraction of fossil energy resources in the energy sector to its consumption and usage in various sectors and most especially in the industrial sector (Balat et al., 2007; Rothausen and Conway, 2011; Rosa

* Corresponding author. School of Accounting and Finance, University of Vaasa, Vaasa, FI, 65200, Finland.
E-mail addresses: twaikline@gmail.com (T.S. Adebayo), stephentaiwo.onifade@lisansustu.selcuk.edu.tr (S.T. Onifade), aadewale@gelisim.edu.tr (A.A. Alola), nnannamuoneke70@gmail.com (O.B. Muoneke).

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and Dietz, 2012). Industrialization plays a significant role in the pollution discussion. This does not only relate to the industrial production activities alone, as pollution in many other sectors often revolves around using environmentally unsafe industrial materials or end products. For instance, the use of fertilizers and chemicals in the agricultural sector (Verge et al., 2007; Wang et al., 2017), the case of cement production for the housing sector (OECD, 2012; Kajaste and Hurme, 2016), and the burning of fossil energy products to meet rising commuting demands in the transportation sector in typical urbanized settlements (Rosa and Dietz, 2012; Liao et al., 2013; Onifade et al., 2021a).

While the historical antecedents of industrialization date back to the early industrial revolution of the 18th century in England (De Vries, 1994), several other countries have also toed the path of industrialization to harness the benefits thereof, which include boosting of per capita income levels, general welfare enhancements through mass production and consumption, and maintaining favorable trade balance among other issues (Lucas, 2002). However, increasing energy demand and resources requirements are crucial for the advancement of the industrialization process, and this constitutes a fundamental issue of pollution, and ecological degradation in environmental discussions vis-à-vis the rise in the global GHG emissions levels as globalization deepens and more nations prioritize economic enrichment to environmental sustainability (Destek, 2021). Environmental concerns in the earliest and most industrialized European nations have received more attention in the literature, being the pioneers of industrialization; however, the wave of industrialization in new climes have further aggravated global environmental challenges in recent years. Rapid industrialization among the 10 NICs, which is comparatively higher than other developing countries, has made the NICs the world's production hub, and their involvement in the global supply value chains cannot be overemphasized (Boddin, 2016; Zhang et al., 2017). However, meeting the global environmental goal of keeping global warming to 2 °C by targeting 1.5 °C above pre-industrial levels as envisioned in the Paris Agreement of UNFCCC (2015) is becoming a bigger task considering the environmental implications of the rapid industrialization among these countries. For instance, the ten NICs alone accounted for around 42.4% of global carbon emissions in 2013, with around 15.2 billion metric tons of CO_2 (World Bank, 2016). Therefore, addressing global carbon emissions, which includes emissions from rapidly industrializing countries, is the main part of the tasks involved in achieving the global environmental goal.

Hence, in the present study, we focused on examining the newly industrialized countries, including Brazil, China, Mexico, India, Malaysia, Philippines, Turkey, South Africa, Thailand, and Indonesia. The push for industrial development amongst these nations necessitates resources exploitation alongside increasing energy demand even as they strive to maintain economic growth and full production capacity. It is highly imperative to holistically address emission issues while also addressing economic concerns in industrialized countries around the globe and especially among the rapidly emerging economies. An analysis of the case of the newly industrialized countries (NICs) has been done in the current study, thus further extending the frontiers of knowledge on the environmental literature. Besides, some of these countries are signatory to the Paris Agreement in 2015 that culminated the global decarbonization campaign in subsequent years; however, emissions from the countries in the bloc are still amongst the highest in the world given their rapidly emerging status, as seen in Figure A in the Appendix. Given the rising trend of global GHGs emissions, attaining the Paris Agreement appears to be a herculean task that must be decisively addressed, especially among rapidly emerging economies.

The significance of studies addressing the matter of rising emissions levels amidst economic growth drives in the industrial era of NICs cannot be overemphasized as unabated GHG emissions stand to trigger catastrophic losses and damages in the world. Even though the issue of climate change and the dangers of emissions are global matters, it will definitively require individual countries' collective actions to reach a carbon neutrality state. Therefore, in the wake of industrialization as an engine room of the observed economic growth trajectory that has triggered more pressure on energy resource use among the newly industrialized economies in our globalized world, this study examines the long-run effects of natural resources and globalization on environmental degradation in the NICs. While doing so, the study also carefully addressed the flaw in the empirical literature by controlling for distributional heterogeneity using the novel Method of Moments Quantile Regression. The observed outcomes from the simulations were very important and highly suggestive for guidance to policymakers and the NICs' authority. Firstly, we observed that natural resource increases pollution while renewable energy decreases CO2 emissions in the NICs. Secondly, the joint effect of globalization and natural resource negatively impacts environmental degradation in the newly industrialized countries. Thirdly, complementary estimates from the fully modified ordinary least square (FMOLS), dynamic ordinary least square (DOLS), the fixed effect ordinary least square (FE-OLS), and the method of moment quantile regression validated the environmental Kuznets curve (EKC) and Pollution Hallo hypotheses among the countries.

We have provided a comprehensive review of a list of extant studies relating to the effects of energy use, globalization, and natural resource on environmental degradation in Table 1 (see the appendix) to include the summary of their methodological approaches, the sample focus, the findings, and the various conclusions thereof. In a nutshell, the findings vary from one economy to the other in the empirical literature, as shown in Table 1. Hereafter, the other aspects of the study are structured into three sections in the following order: the information on data and methodology are organized in Section 2, while Section 3 contains the analysis and interpretations of outcomes of the simulations. Section 4 concludes the research with the study's implications and policy framework.

2. Data and method

2.1. Data

The variables CO_2, GDP, GDPSQ represent carbon dioxide emission, gross domestic product and squared gross domestic product. Carbon dioxide emission is measured in metric tons per capita, while gross domestic product is measured by per capita GDP (constant 2010 US$). The data for the aforementioned variables is sourced from British Petroleum and the World Development Indicators dataset of the World Bank. Sliding away from CO_2 and GDP, the proxy adopted to capture natural resource (NR) is total natural resources rent (as a percentage of GDP), whereas the proxy used to capture renewable energy consumption (REC) is the percentage of total final energy consumption. The author also used another proxy to capture globalization (GLO), the KOF index of globalization (economic, political and social). The data source for the three variables (NR and REC) emanates from the World Development Indicator dataset, while GLO emanates from Konjunkturforschungsstelle (KOF) (overall) Index of Globalization. This current study uses data from newly industrialized countries (NICs) spanning from 1990 to 2018.

2.2. Methods

Motivated by recent studies that have looked at the environmental sustainability drive from the perspective of the NICs (Hossain, 2011; Destek and Okumus, 2019; Anwar et al., 2021; Karaduman, 2021; Rahman et al., 2021), the current study modified the employed carbon-model in the aforementioned investigation by incorporating the natural resource rent such that.

$CO_{2it} = f\,(GLO_{it}, REC_{it}, GDP_{it}, GDP^2{}_{it}, NR_{it})$.

The logarithmic transformation of the econometric model is expressed thus;

Table 1
Summary of related extant studies.

The authors	Sample period	Country(s)	Empirical Approach	Major Findings
Energy use, Economic Growth and Carbon Emissions				
Shahbaz et al. (2020)	1870–2017	UK	Bootstrapping bounds test method	Energy consumption increases CO_2 emissions levels
Ozturk and Acaravci (2010)	1968–2005	Turkey	ARDL, Granger causality method	There is no causality among energy use, carbon emission and GDP
Shahbaz et al. (2017)	1992–2016	BRICS and Next-11 countries	CCE-MG and AMG	Economic growth increases clean energy consumption in both BRICS and Next-11 countries.
Bekun et al. (2021)	1995–2016	E7 economies	AMG, and CCEMG methods	Rise in energy use induces CO_2 emission levels
Alola et al. (2019)	1997–2014	EU countries	PMG-ARDL	Increase in GDP and renewable energy use reduces CO2 emissions
Zhang and Cheng (2009)	1960–2007	China	Granger causality test	GDP granger causes energy use while energy use granger causes CO_2 emission levels
Ozturk and Acaravci (2016)	1980–2006	Cyprus and Malta	ARDL, Granger causality method	CO_2 emissions and energy use granger cause GDP but not vice versa
Onifade et al. (2021b)	1980–2018	Turkey & Caspian Countries	DOLS and FMOLS	Renewable energy use reduces CO_2 emissions but GDP growth does not
Sarkodie and Owusu (2017)	1971–2013	Ghana	Linear regression	Energy consumption and GDP growth increases CO_2 emissions
Leitão and Balsalobre-Lorente (2021)	1990–2018	EU-28-member countries	DOLS, Granger causality	Renewable energy use reduces CO_2 emissions
Alola (2019)	1990: Q1–2018: Q2	United States	Dynamic ARDL	Both energy use and GDP have significant impact on carbon emission
Globalization and Carbon Emissions				
Shahbaz et al. (2019)	1970–2012	87 countries based on income levels	Cross-correlation technique	Globalization reduces pollution only in high- and middle-income nations
Saint Akadiri et al. (2020)	1970–2014	Turkey	ARDL, Bayer and Hanck cointegration	Globalization does not impact CO_2 emissions.
Onifade et al. (2021c)	1990–2016	E7 Economies	AMG, FMOLS, DOLS	Globalization decreases pollution levels from CO_2 emission
Yuping et al. (2021)	1970–2018	Argentina	ARDL, Maki cointegration	Globalization reduces CO_2 emissions
Usman et al. (2020)	1971–2014	South Africa	FMOLS	Globalization reduces CO_2 emissions
Wang et al. (2020)	1996–2017	G7 economies	CS-ARDL	Globalization increases CO_2 emissions levels
Destek (2020)	1995–2015	Central and Eastern European Countries	AMG, Causality test	Globalization increases CO_2 emissions levels in the CEECs.
Shahbaz et al. (2017)	1970–2012	China	ARDL, VECM	Globalization help to decrease CO_2 emissions in China.
Erdoğan et al. (2022)	1990–2015	15 African countries	QR, FMOLS, DOLS	Globalization increases CO_2 emissions levels
Adebayo et al. (2021)	1980–2018	South Korea	ARDL	Positive link between globalization and CO_2 emissions levels
Lee and Min (2014)	1980–2011	255 countries	Panel and correlation analysis	Globalization reduces CO_2 emissions.
Natural Resources and Carbon Emissions				
Wang et al. (2020)	1996–2017	G7 economies	CS-ARDL	Natural resources induce CO_2 emissions levels
Tufail et al. (2021)	1990–2018	OECD countries	CS-ARDL, Panel causality test	Natural resources reduce CO_2 emissions levels
Gyamfi et al. (2021)	1990–2016	G7 Economies	AMG, FMOLS, DOLS	Natural resources increase CO_2 pollution level.
Shen et al. (2021)	1995–2017	China	CS-ARDL	Resources rent increases pollution levels.
Bekun et al. (2019)	1996–2014	16 EU countries	PMG-ARDL	Resources rent increases pollution levels.
Nwani and Adams (2021)	1995–2017	93 countries	AMG method	Natural resources induce both consumption and production-based CO_2 emissions levels
Adedoyin et al. (2020)	1980–2014	Sub-Saharan Africa (SSA) countries	PMG-ARDL	Natural resources induce CO_2 emissions levels.
Awosusi et al. (2022)	1970–2017	Colombia	FMOLS, ARDL, DOLS	Natural resources induce CO_2 emissions levels.

Note: AMG: Augmented Mean Group, CCEMG: Common Correlated Effects Mean Group, VECM: Vector Error Correction Model, PMG-ARDL: Pooled Mean Group, ARDL: Autoregressive distribution lag, CS-ARDL: Cross-sectional augmented autoregressive distributed lag, FMOLS: Fully modified OLS, DOLS: Dynamic OLS.

$$lnCO2 = \alpha_{0it} + \alpha_1 lnGDP_{it} + \alpha_2 lnGDP_{it}^{\ 2} + \alpha_3 lnGLO_{it} + \alpha_4 ln\mathrm{REC}_{it} + \alpha_5 lnNR_{it} + e_{it} \quad (1)$$

where the respective terms i, t, and e_{it} are the cross-section term, period, and the error term.

2.2.1. *Priori estimations*

In cross-country studies of this nature, ignorance of cross-sectional dependence or arbitrary assumption renders results unreliable and misleading. Econometricians in panel data studies rely on the result of the cross-sectional dependence test to decipher the right choice between first-generation and more recent econometric techniques going forward. Pesaran (2004) posited strongly that the set of first-generation econometric techniques is inefficient in accounting for cross-sectional dependence in panel data compared to the second-generation econometric techniques. This study seeing the econometric merits adopts the Pesaran CD test to test for cross-sectional dependence. The authors also checked for slope homogeneity as part of its pre-estimation diagnosis. Breitung (2005) highlighted the shortfalls of arbitrary assumption of slope homogeneity when the otherwise holds forth with a hanging consequence of biased and misleading estimates. In a bid to respect all adequacies in line with econometric protocol, the authors adopt the Pesaran and Yamagata (2008) slope homogeneity test.

Suppose cross-sectional dependence is established through the output of the Pesaran CSD test. In that case, the logical econometric decision is to adopt the more recent unit root tests such as the CIPS and CADF tests developed by Pesaran (2007). The order of integration of CO_2, GDP, GDPSQ, REC, NR and GLO is determined through the output of the CIPS and CADF tests which shores off dependence on the output of a single unit root test and increases reliability.

The aim of checking if there is a long-run association amongst selected variables in a model is deemed necessary. However, the battery of first-generation cointegration tests produces biased estimates owing to over-dependence on the arbitrary assumption on cross-sectional independence (Westerlund, 2007). The second-generation cointegration test Westerlund (2007) proposed is best suited as it accounts for cross-sectional dependence.

2.2.2. Cointegration regression

Fully Modified Ordinary Least Square (FM-OLS) was originally designed by Phillips and Hansen (1990) with an inbuilt historical aim to provide optimal estimates of co-integrating regressions. This method modifies the OLS to account for serial correlation effects and endogeneity in the regressors resulting from a co-integrating relationship (Phillips and Hansen, 1990). FMOLS method employs a non-parametric approach in controlling the endogeneity problem and autocorrelation issue. On the other hand, Dynamic Ordinary Least Square was proposed by Stock and Watson (1993); however, Kao & Chiang (2001) posited that the DOLS was developed to provide an unbiased comparison between FMOLS and OLS estimates in restricted samples. In sharp contrast to FMOLS, DOLS employs a parametric approach to address endogeneity through augmentation with the explanatory variable's leads and lags (Ibrahiem and Hanafy, 2020). Due to the huge distortion caused by cross-sectional dependence and autocorrelation, the authors employ the FE-OLS estimator expanded with Driscoll and Kraay (1998) standard errors, certified robust to general forms of cross-sectional dependence and auto-correlation up to a certain lag (Usman et al., 2020; An et al., 2020). The following equations of the FMOLS and DOLS are specified thus;

$$\widehat{\beta}_{FMOLS} = \left[N^{-1}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}(\rho_{it}-\overline{\rho}_i)^2\right)\right]^{-1} * \left[\left(\sum_{t=1}^{T}(\rho_{it}-\overline{\rho}_i)\right)\widehat{S}_{it} - T\widehat{\Delta}_{eu}\right]$$

DOLS

$$\widehat{\beta}_{DOLS} = \left[N^{-1}\sum_{t=1}^{N}\left(\sum_{t=1}^{N} Z_{it}Z_{it}^{'}\right)^{-1}\left(\sum_{t=1}^{T} Z_{it}\widehat{S}_{it}\right)\right]$$

Where ρ denotes explanatory variables, S is the dependent variables, and Z shows vector of repressors ($Z = (p - \overline{p})$

2.2.3. Method of Moments Quantile Regression

The MMQR econometric technique is better than the linearized (FMOLS, DOLS) and the ordinary panel quantile regression. The following points constrain the latter; a) linear estimation techniques do not condition the distribution of data; rather, they address only averages. b) the ordinary quantile regression is deficient of non-crossing estimates when calculating estimators for multiple percentiles prompting an invalid distribution for the response. c) inability to account for unobserved heterogeneity across panel cross-sections. Method of Moments Quantile Regression (MMQR) with a fixed-effects was initially proposed by Machado and Silva (2019), while Koenker and Hallock (2001) proposed the panel quantile regression technique to estimate a range of diverse quantiles of the outcome variables dependent on given values of the exogenous variables. The authors, fully aware of the deficiencies of the simple panel quantile regression, take solace in the merits of MMQR to capture the distributional heterogeneity of environmental quality-natural resource, renewable energy, globalization and growth nexus at different conditional quantile distributions of carbon emission by incorporating fixed effect, erroneously missing in conventional mean regressions.

Popularized by Machado and Silva (2019), the conditional quantiles of the following location-scale model is provided as:

$$Y_{it} = \alpha_i + X_{it}^{'}\beta + (\delta_i + Z_{it}^{'}\gamma)U_{it} \quad (4)$$

In the above equation, $(\alpha, \beta^{'}, \delta, \gamma^{'})^{'}$ are estimated parameters, Z is known as k-vector of known components of X, and Pr $(\delta_i + Z_{it}^{'}\gamma) > 0) = 1$. U_{it} is stochastic error term, and U_{it} and $X_{it}^{'}$ explanatory variables. To account for the moment conditions, U_{it} is normalized: $E(U) = 0$ and $E(/U/) = 1$.

Model 4 show the following;

$$Q_Y(\tau / X_{it}) = (\alpha_i + \delta_i q(\tau)) + X_{it}^{'}\beta + Z_{it}^{'}\gamma q(\tau)$$

Where $\alpha_i(\tau) \equiv \alpha_i + \delta_i q(\tau)$ is the distributional effect at quantile. (τ)

2.2.4. Panel causality tests

FMOLS and DOLS provided long-run relationships amongst the selected study variables. Furthermore, econometric logic requires the authors to ascertain the causal direction for such identified long-run relationships. Hence, the heterogeneous Dumitrescu Hurlin Panel Causality Test is employed to understand the nature of the causal relationship among study variables. This more recent panel causality test is robust in the presence of cross-sectional dependence and heterogeneity issues (Dumitrescu and Hurlin, 2012).

3. Findings and discussion

3.1. Slope homogeneity and cross-sectional dependence outcomes

In this section, we present the research findings centered on the methodologies adopted in section 3. We commenced by assessing the slope heterogeneity (SH) with outcomes presented in Table 2. Based on the SH outcomes, the null hypothesis is rejected (see delta tilde $(\widehat{\Delta})$ and adjusted tilde $(\check{\Delta}_{adj})$ values). Therefore, we used heterogeneous panel estimators based on this result in our empirical investigation.

Before estimating unknown parameters, we used second-generation unit root tests to evaluate the variables' stationarity characteristics. As a result, both CIPS and CADF unit root tests were used to identify variable stationarity characteristics. The Cross-sectional dependence (CSD) test, according to Sarkodie et al. (2019), may be used to evaluate the dependence of cross-sections inside a panel. The CSD can distort the precise parametric values of estimations and lead to the discovery of variables that, if overlooked, can reduce the effectiveness of panel data. The outcomes of the CSD, CIPS, and CADF tests are depicted in Table 3. The null hypothesis is rejected by the CSD test outcome. The CIPS and CADF tests, on the other hand, reveal that all variables are I(1).

3.2. Cointegration outcomes

The co-integration method of Westerlund (2007) is used to identify the long-run interrelationship between CO_2 emissions and the regressors. Unlike the Pedroni (2004) test, which assumes common-factor limitations on tests, the approach simplifies the assumption of common-factor limits on tests. Westerlund suggests four more tests (describing H_0: no co-integration). Shahbaz et al. (2019) stated that it is vital to conserve power-based co-integration of residual in the structural dynamics. With this restriction removed, long and short-run modification processes are no longer required to be equivalent. We can reduce the distorting impacts of the CSD process by employing Westerlund (2007) co-integration. After rejecting the null hypothesis of "no co-integration", the result affirms that variables under consideration are cointegrated in the long run. Thus, we affirmed the long-run interconnection between CO2 emissions and globalization, natural resource, economic growth, and renewable energy use (see Table 4).

3.3. Long-run estimators (DOLS, FMOLS and FE-OLS) outcomes

We proceed to estimate the long-run association between CO_2 emissions and the regressors by utilizing long-run panel estimators

Table 2
Slope Homogeneity Outcomes.

Tests	Value	P-value
$\widehat{\Delta}$	7.612	0.000
$\widehat{\widehat{\Delta}}_{adjusted}$	8.739	0.000

Table 3
CSD and CIPS & CADF Unit root Test.

Variables	CSD Results		CIPS		CADF	
	Pesaran scaled LM	Pesaran CD	I(0)	I(I)	I(0)	I(I)
CO_2	65.593*	22.522*	−2.103	−4.470*	−1.835	−3.454*
GDP	117.88*	34.080*	−2.143	−3.227*	1.714	2.980***
GLO	68.131*	24.601*	−2.033	−4.745*	−2.074	−3.519*
NR	48.393*	20.005*	−2.213	−5.530*	−2.451	−3.596*
REC	64.161*	23.5242*	- −2.326	−4.848*	- −2.450	−3.927*

Note: *, ** and *** represents P<1%, P<5% and P<10%.

Table 4
Westerlund (2007) Cointegration results.

Gt	Ga	Pt	Pa
−7.197	−13.129	−20.661	−13.782
0.000	0.000	0.000	0.000

(DOLS, FMOLS, and FE-OLS) with outcomes presented in Table 5. The DOLS, FMOLS, and FE-OLS outcomes are similar regarding the sign and magnitude of the coefficients. We observed positive CO_2-GDP interconnection, which demonstrates that keeping other factors constant, a 1% upsurge in GDP caused CO_2 emission to increase by 1.631%, 1.941% and 1.867%, as disclosed by FMOLS, DOLS, and FE-OLS, respectively. Furthermore, the research outcomes uncovered a negative interrelationship between CO_2 and GDP squared. This shows that a 1% upsurge in GDP squared caused CO_2 emissions to decrease by 0.0795% ~ FMOLS, 0.0942% ~ FMOLS, and 0.1167% ~ FMOLS, respectively, keeping another factors constant. This outcome validates the EKC hypothesis for the newly industrialized countries (NICs). The study outcome aligns with the studies of (Su et al., 2021) for Brazil (Adebayo and Kirikkaleli, 2021), for Japan (Kihombo et al., 2021) for West Asian and the Middle East (WAME) economies (Shan et al., 2021) for selected OECD nations and Li et al. (2001) for Chinese province who reported that during the early phases of development, ecological deterioration rises in tandem with economic expansion, but after attaining a threshold, pollution begins to drop as economic progress accelerates (see Table 5).

In all of these techniques (FMOS, DOLS and FE-OLS), the use of renewable energy is negatively connected with CO_2 emissions. This demonstrates that a 1% upsurge in REC causes 0.0341% ~ FMOLS, 0.0248% ~ DOLS, and 0.0272% ~ FE-OLS decrease in CO_2 emissions. This implies that REC aid in curbing emissions of CO_2 in the NICs. This outcome is consistent with the studies of (Rjoub et al., 2021) for Sweden (Adebayo and Rjoub, 2021), for Argentina (Yuping et al., 2021), for Argentina (Kirikkaleli and Adebayo, 2020), for global economies who reported that REC aid in abating degradation of the environment.

Moreover, the globalization effect on CO_2 is negative and significant, as disclosed by the long-run estimators (FMOLS, DOLS and FE-OLS), which validate the pollution halo hypothesis. This unveils that 0.3572% ~ FMOLS, 0.3249% ~ DOLS and 0.3138%~ FE-OLS decrease in CO_2 emissions is caused by a 1% upsurge in globalization. This demonstrates that globalization abate emissions of CO_2 in the NICs. This outcome is affirmed by the studies of Yuping et al. (2021) for Argentina, Awosusi et al. (2022) for BRICS (He et al., 2021), for Mexico, and (Rjoub et al., 2021) for Sweden, who reported negative emission-globalization interconnection. Nonetheless, this outcome contradicts the works of Kirikkaleli and Adebayo (2020) for Turkey (Adebayo and Acheampong, 2021) for Australia and Coelho et al. (2021) for South Korea, who reported positive emission-globalization interrelationship.

Furthermore, we noticed a positive natural resource-emissions interconnection which suggests that natural resource dampen the quality of the environment. This demonstrates that ~ 1.2474% (for FMOLS), ~ 1.5159% (for DOLS), and ~ 1.3871% (for FE-OLS) increase in CO_2 emissions is caused by a 1% upsurge in natural resource if other factors are held constant. This demonstrates that natural resource depletion (undesirably) abates environmental quality in the NICs. This outcome complies with the works of (Hussain et al., 2020) for Belt & Road Initiative countries, Okere, et al. (2021) for Argentina, Okere et al. (2022) for Peru and (Bekun et al., 2019) for 16-EU nations.

Lastly, the joint effect of globalization and natural resource impact CO_2 emissions negatively in the NICs, suggesting that globalization potentially moderate natural resource rent to improve environmental quality. This implies that keeping another factors constant, 1% upsurge in GLO*NR mitigates CO_2 by ~ 0.2941% (for FMOLS), ~ 0.3528% (for DOLS), and ~ 0.3992% (for FE-OLS).

3.4. *Method of Moments Quantile Regression outcomes*

We proceed by assessing the influence of GDP, REC, NR, GLO and GLO.NR on CO_2 in each quantile (0.1–0.90). This is accomplished by applying the novel MMQR with outcomes illustrated in Table 6 and Fig. 1, respectively. Firstly, the EKC hypothesis is validated at all quantile ranges. This result suggests that economic expansion contributes favourably to ecological contamination in the initial phases but has a declining influence after a threshold is reached. This outcome is validated by the works of (Altinoz and Dogan, 2021) for 82 countries (Akadiri and Adebayo, 2021), for India, and (Lin et al., 2021) for Chinese provinces. As a result, GDP in nations with higher, medium, and lower pollution levels causes composite, technique, and scale effects, respectively (Grossman and Krueger, 1991). As a result, the sample nations are adopting ecologically beneficial changes in tandem with economic expansion.

We noticed a negative CO_2-renewable energy use interrelationship across all quantiles (0.1–0.90) with an increasing coefficient from 0.1 to 0.90 quantiles. This implies that across all quantiles (0.1–0.90), the REC effect on CO_2 is negative. However, when the quantile level rises, the proportion of renewable energy use to environmental quality rises. This finding shows that the trend toward renewable energy sources leads to lesser emissions mitigation in nations with lower levels of emissions, whereas it has a very large emission-reduction effect in nations with higher levels of emission. The major reason for this is that in nations with higher levels of emissions, renewable energy utilization is practically a need rather than a policy option. Even a little growth in the use of such resources is crucial to the sustainability of the environment. As a result, when nations increase the percentage of REC in their energy mix

Table 5
FMOLS, DOLS and FE-OLS outcomes.

	GDP	GDPSQ	REC	GLO	NR	GLO*NR
FM-OLS	1.6311***	−0.0795*	−0.0341**	−0.3572**	1.2474*	−0.2941**
D-OLS	1.9417*	−0.0942**	−0.0272*	−0.3249***	1.5159*	−0.3528*
FE-OLS	1.8679**	−0.1167*	−0.0284***	−0.3138**	1.3871**	−0.3992**

Note: *, ** and *** stands for P<1%, P<5% and P<10%.

Table 6
Outcomes of the MMQR.

			Lower Quantile			Middle Quantile			Higher Quantile		
Variables	Location	Scale	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
GDP	1.6502*	0.8487*	0.1461*	0.5434*	1.3128*	1.6113**	1.8600**	1.9904*	2.2593**	2.4930*	2.9301**
GDPSQ	−0.0804*	−0.0528*	0.0133*	−0.0114*	−0.0593*	−0.0779*	−0.0934*	−0.1015**	−0.1183**	−0.1328*	−0.1601*
REC	−0.0362	−0.0086	−0.0284*	−0.0304*	−0.0345*	−0.0360*	−0.0373*	−0.0380*	−0.0394*	−0.0406*	−0.0429*
GLO	−0.3472	−0.0044	−0.4750*	−0.4412***	−0.3759	−0.3505	−0.3294	−0.3183	−0.2955**	−0.2756**	−0.2385*
NR	1.04606*	0.7850*	−0.3450	0.0223*	0.7340*	1.0101*	1.3497*	1.3607*	1.6094**	1.8256**	2.2299***
GLO*NR	−0.2373**	−0.1809**	0.0833	−0.0013	−0.1654*	−0.2291**	−0.2821*	−0.3099*	−0.3672*	−0.4171**	−0.5103**

Note: *, ** and *** stands for 1%, 5% and 10% significance level.

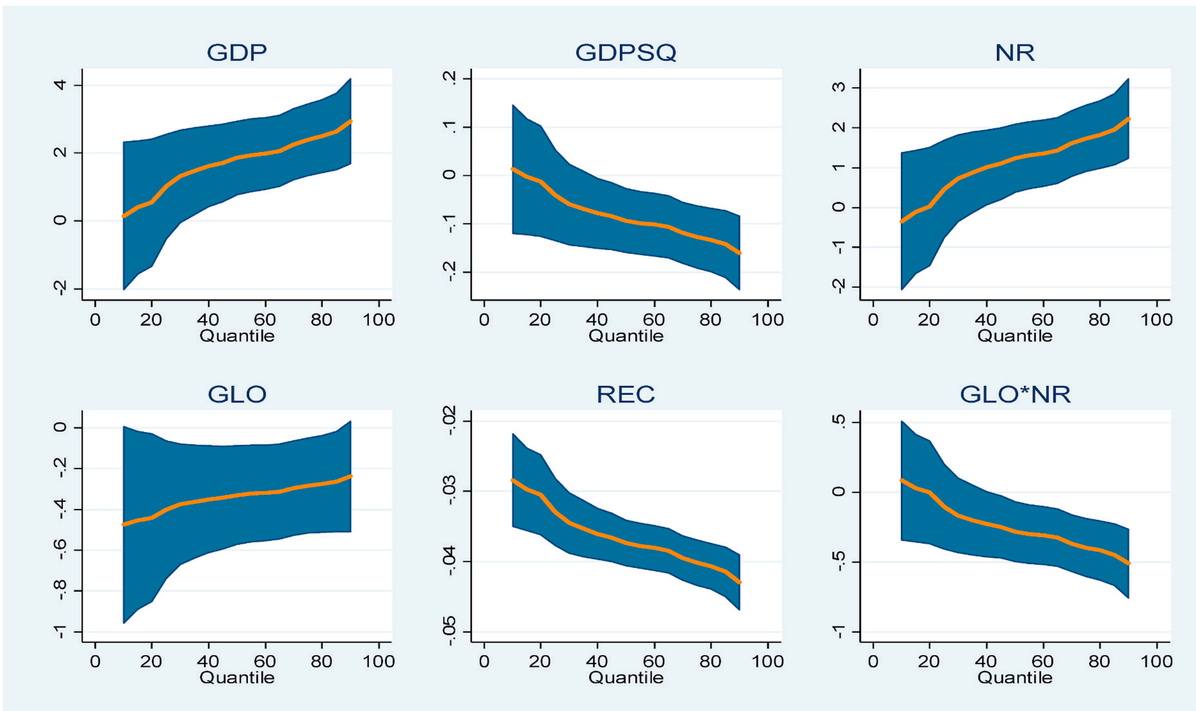

Fig. 1. Graphical outcomes of MMQR

rather than relying only on fossil fuels to meet rising energy demand, the quality of the environment improves significantly. As stated by (Alola et al., 2021), the most important benefit of such measures is that they reduce the scale effect, which opens countries to rising levels.

Moreover, we observed a negative emissions-globalization interrelationship across all quantiles (0.1–0.90). However, when the quantile level rises, the proportion of globalization to environmental quality decreases. This finding shows that the trend toward globalization leads to higher emissions mitigation in nations with lower emissions levels. In contrast, it has a very less emission-reduction effect in nations with higher emission levels. The outcome affirmed the pollution halo hypothesis (PHH) for the NICs. The studies of Miao et al. (2022) for newly industrialized nations (Yuping et al., 2021) for Argentina (He et al., 2021), for Mexico, and (Rjoub et al., 2021) for Sweden reported negative emission-globalization interconnection.

Lastly, we assessed globalization and natural resource's combined effect on CO_2 emissions. At all quantiles (0.1–0.90), the GLO*NR effect on CO_2 emissions is negative, implying that the GLO*NR aids in abating environmental degradation in NICs economies across all quantiles. Moreover, Fig. 2 depicts the comparison of panel estimations (FMOLS, DOLS, FE-OLS, and MMQR).

3.5. Comparison of DOLS, FMOLS, FE-OLS and MMQR outcomes

The computed coefficients for all techniques employed, namely MMQR, FE, DOLS, and FMOLS, are compared in Fig. 2. While the DOLS, FMOLS, and FE coefficients are fixed, the MMQR coefficients are heterogeneous and offer a vivacious image in all quantiles. Fig. 1 represents that the economic growth coefficient increased from the lower to the upper quantiles, which indicates that a surge in economic growth worsens the quality of the environment. In addition, the economic growth squared coefficients are moving downward in the MMQR method, illustrating that economic growth squared enhance the quality of the environment in the newly industrialized nations. This outcome validates the EKC hypothesis for the NICs, which implies that the NICs are on the right path towards a sustainable environment.

Regarding the MMQR outcomes for natural resources, we observed that in the extreme lower tail, natural resources enhance the quality of the environment; however, from the middle tail to the upper tail, there is evidence to support the damaging effect of natural resources on the environment. Furthermore, the MMQR approach outcomes disclosed that the negative coefficient of globalisation increased from the lower to the upper quantiles, which indicates that a surge in globalisation boosted the quality of the environment. Similarly, the renewable energy coefficient has meritoriously abated the negative effects of economic operations on the environment and society by offering realistic elucidations that aid policymakers render decisions that can result in sustainable growth. Lastly, the negative coefficient of the joint effect of globalisation and natural resource is a downward slope, as disclosed by the MMQR. As a result, when comparing all panel estimators to provide an inclusive explanation of the connection among variables, MMQR is a clear and efficient method.

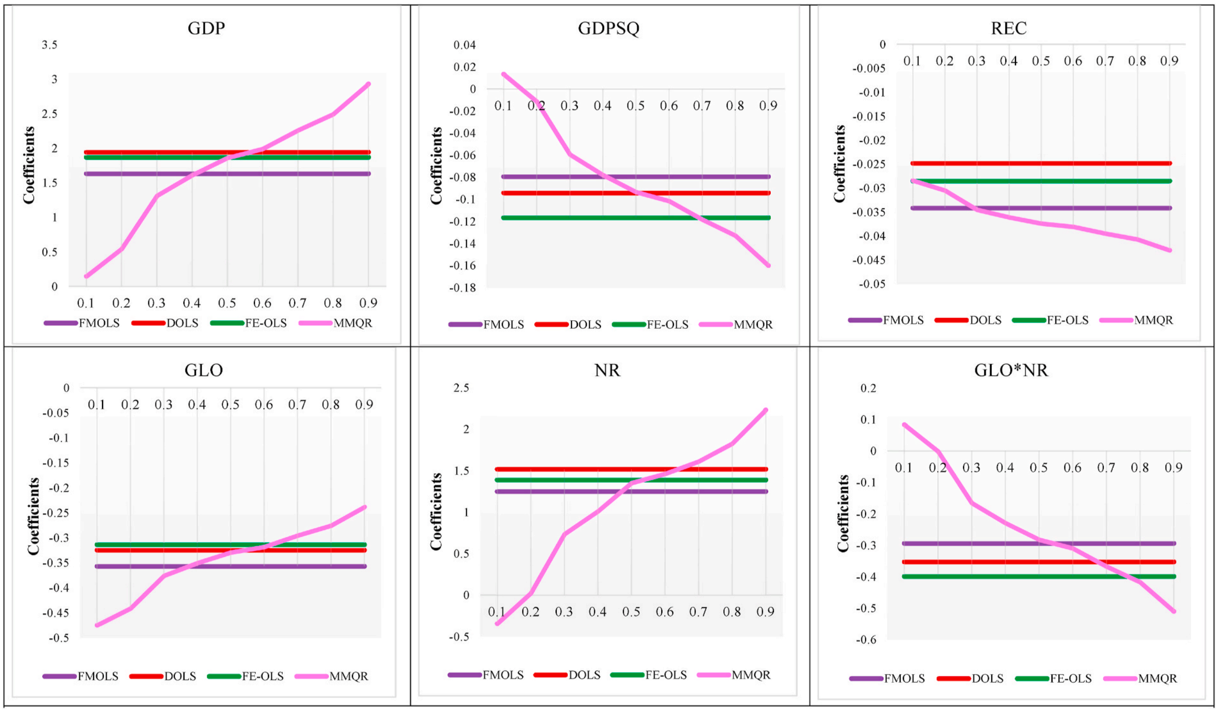

Fig. 2. Comparison of panel estimations (FMOLS, DOLS, FE-OLS, and MMQR).

3.6. Dumitrescu hurlin panel causality

The current paper also assesses the causal effect of NR, GLO, GDPSQ, and REC on CO_2 emissions in NICs nations. The outcomes of the causality are depicted in Table 7. The outcomes showed unidirectional causal interconnectedness from GLO*NR to CO2. This infers that GLO*NR can predict emissions in NICs. Furthermore, we observed one-way causal interconnection from NR to CO_2, suggesting that changes in NR will have a significant effect on CO_2. Moreover, we noticed a one-way causal connection between GDP to CO_2, unveiling that GDP can predict NICs CO_2 emissions. Lastly, unidirectional causality from GLO to CO_2 is validated. These outcomes significantly influence policy recommendations for policymakers in NICs economies.

4. Conclusion and policy recommendation

4.1. Conclusion

Combing the environmental literature revealed wide-ranging cases of countries, groups of countries with different nomenclature with little reference to the case of the newly industrialized countries. Given this reason, this study outlined the curiosity to reveal the critical situation of ascending the environmental quality ladder by the newly industrialized countries amidst the natural endowment and the drive for economic prosperity by the countries. Therefore, a selection of the top ten newly industrialized countries (Brazil, China, India, Mexico, Malaysia, Philippines, South Africa, Turkey, Indonesia, and Thailand) was employed in this study with a selection of relevant datasets over the period 1990 to 2018. By implementing a series of empirical tools that include cointegration techniques, quantile regression (which controls for distributional heterogeneity), and panel Granger causality, interesting results that prompt policy insight was revealed. First, the investigation revealed a long-run effect among natural resources, renewable energy utilization, globalization, and economic growth. Second, the results of the FMOLS, DOLS, FE-OLS, and across the quantiles (for quantile regression) unanimously affirmed that renewable energy and globalization promotes environmental quality in addition to validating the EKC hypothesis. Third, the contribution of natural resource rent is environmentally devastating according to the results of the aforementioned techniques. However, there is consolidation because the findings further revealed that globalization significantly moderates natural resource rent to achieve environmental sustainability.

Table 7
Dumitrescu Hurlin panel causality tests.

Path of Causality	W-Stat.	Zbar-Stat.	Prob.
GLO*NR → CO_2	6.9884**	1.9306	0.0535
CO_2 →GLO*NR	4.9847	0.3301	0.7413
NR → CO_2	7.2312**	2.1245	0.0336
CO_2 → NR	5.0351	0.3704	0.7111
GLO → CO_2	7.2866**	2.1688	0.0301
CO_2 →GLO	4.0483	−0.4178	0.6761
GDPSQ →CO_2	7.1469**	2.0572	0.0397
CO_2 → GDPSQ	5.5047	0.7455	0.4560
GDP →CO_2	7.0294**	1.9634	0.0496
CO_2 →GDP	5.4555	0.7061	0.4801
REC →CO_2	6.8730**	1.8384	0.0660
CO_2 →REC	5.3494	0.6214	0.5343

Note: *, ** and *** stands for 1%, 5% and 10% level of significance.

4.2. Policy and prospect for future study

Seeing that globalization plays a significant role in moderating the environmental sustainability aspect of natural resource rent, there is a significant lesson for the newly industrialized countries, especially from the perspective of globalization. Therefore, international borders of these countries should be opened, especially to countries that are already implementing the environmental standardization of tradeable products. The NICs should adopt a more drastic and determined drive towards developing a greener world through investment in low-carbon technologies and green industrialization, especially since individual economies are now striving toward returning to a growth path considering the aftermath and losses of the Covid-19 pandemic. Renewable products and a green economy are the way to go; thus, the transition toward this new phase should be without compromise and no ambiguity to the climate action commitment. At the moment, about fifty nations, including the European Union (EU), have taken commitments for a net-zero emissions target by the mid-century. However, the progress thus far has been marred by delays due to political unwillingness and failure to implement plans, among other issues, as noted by the UNEP (2021). Furthermore, a policy mix that prioritizes decarbonization through decoupling growth from emissions for environmental sustainability is very important. Moreover, future studies in this direction could implement environmental specific variables such as the environmental-related tax, environmental-related tax, e.t.c to further capture the case of the NICs. With the exemption of globalization, the magnitude of the impact of other variables is relatively higher at the upper quantile, thus suggesting more corresponding measures that are targeted at these specific environmental indicators.

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CRediT authorship contribution statement

Tomiwa Sunday Adebayo: Data, Methodology, Conceptualization, Formal analysis. **Stephen Taiwo Onifade:** Writing – original draft, and, Methodology. **Andrew Adewale Alola:** Writing – original draft, Investigation, Supervision, and, Corresponding. **Obumneke Bob Muoneke:** Writing – review & editing.

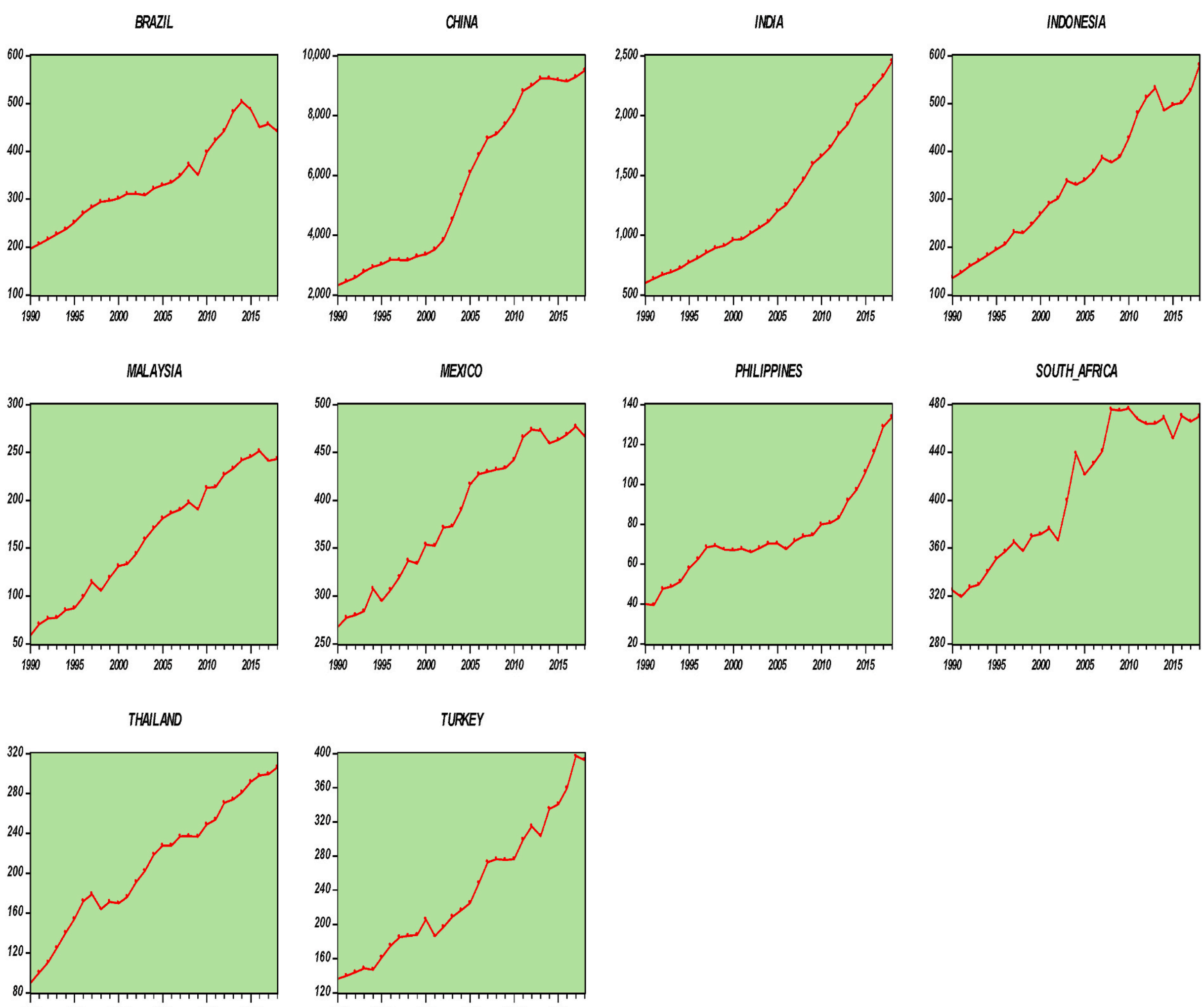
Declaration of competing interest

There is no conflict of interest.

Data availability

Data will be made available on request.

APPENDIX



Source: Authors computation using data from BP (2020). Emissions data is provided in million tons of CO_2

Figure A. Carbon emission growth among NICs (1990-2018).

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Further reading

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Figure A: Carbon Emission Growth Among NICs (1990-2018).
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Source, 2020. Authors computation using data from BP. Emissions Data Is provided in Million Tons of CO2.