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RESEARCH ARTICLE

Natural resource, globalization, urbanization, human capital, and environmental degradation in Latin American and Caribbean countries

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Abstract

The world is increasingly getting urbanized and globalized, and the increase in natural resource exploration could have a far-reaching impact on environmental quality. Since most Latin American and Caribbean countries (LACCs) have proximity to the Amazon, they, therefore, rely heavily on agriculture and mining which develop via deforestation which could exacerbate the already increasing carbon dioxide emissions (CO_2 emissions). Therefore, to the best of our knowledge, this study becomes the first to investigate the link between natural resources, globalization, urbanization, and environmental degradation in LACCs countries from 1990 to 2017 with advanced panel data econometric techniques. The unit root tests affirm all the variables to be stationary at first difference, and the Westerlund (Oxf Bull Econ Stat 69(6):709–748, 2007) cointegration test confirms the long-run relationship among the variables. The augmented mean group (AMG) and the common correlated effects mean group (CCEMG) results affirm that the aforementioned variables add to CO_2 emissions, while human capital mitigates it. Further findings reveal that human capital performs a moderating role in promoting urbanization sustainability. The country-specific results confirm that economic growth adds to emissions in all the countries, except in the Dominican Republic. A feedback causality exists between economic growth, globalization, urbanization, and CO_2 emissions. This study argues for the development of human capital, a gradual transition to sustainable growth-driven and knowledge-based industries, and the introduction of sustainability practices in the natural resource sector to mitigate CO_2 emissions in LACCs.

Keywords Natural resource · Globalization · Human capital · Urbanization · AMG · Latin American and Caribbean countries

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Introduction

Many things have changed right from the inception of the world. One, and the most important of them, is the climate. As each day passes by, issues relating to environmental preservation and sustainability are gaining more popularity. This is true, as various economies in the world today seek to abate environmental degradation and uphold growth that is sustainable (Ali et al. 2019; Nathaniel 2020). In the core of this dilemma is the issue of climate change which is caused by global warming. The world is indeed not relaxing in its effort to curb the menace unleashed on the environment by climate change. As a result, the Earth Summit of 1992 in Rio de Janeiro, the Kyoto Protocol of 1997 in Japan, the Durban Platform for Enhanced Action of 2011 in South Africa, the Cancun Agreement of 2010 in Mexico, and the more recent Paris Agreement of 2015 in France are frameworks adopted to abate the horrendous effects of climate change.

However, all these efforts appear to be a tiny speck of good as 2016 was recorded as the Earth warmest year (National Geographic 2017; NASA 2018; IREA 2018). The gases that add to global warming include nitrous oxide (N_2O), chlorofluorocarbons (CFCs), carbon dioxide (CO_2), methane (CH_4), and water vapour (H_2O) (NASA 2018). Of all these gases, CO_2 emissions contribute about 81% to GHGs. As of 2017, global CO_2 emissions stood at 33,444.0 (Mtoe) (British Petroleum 2018). Economic growth, urbanization, natural resource exploration, and globalization have been identified as the culprit for the upward surge in CO_2 emissions (Danish et al. 2020; Nathaniel et al. 2020b, c; Dong et al. 2019).

There is an increase in polluting gas emissions globally, and even in LACCs, the trend is similar to Argentina, Chile, and Venezuela being the highest emitters in the region. Bolivia and Paraguay are the lowest emitters in LACCs. Uruguay on its own has made a drastic effort in declining CO_2 emissions to 67.47 kt in 2014 from 77.63 kt in 2011 (World Bank 2019). While some of the countries are involved in mining, refining, and oil export, some specialized in agricultural activities. There is a consensus in the literature that production activities can stimulate environmental degradation. In LACCs, where agricultural activities are dominants, the desire to expand the agricultural frontier leads to damaged vegetation, desertification, and deforestation which expose the land to degradation (Deng et al. 2020). This is a peculiar case in Amazonian countries (Gollnow et al. 2018; Jung and Polasky 2018). Hence, the undeniable link between production activities/specialization and environmental deterioration has caught the attention of policymakers. Studies have supported that urbanization, economic growth/development, and globalization are directly connected with pollutant emissions (Liu et al. 2020a, b).

Urbanization has increased drastically in Latin America. It is now about 80% higher than in other regions of the world. It was about 13% of the world's urban population in 1950, increased to 80% in 2015 portraying 93% growth since 1950. It is expected to be 83% by 2015 (BBVA Research 2017; Tanco et al. 2018). Urbanization has a close association with income. LACCs are rich in natural resource, but countries in the region need to rethink their forestry, agriculture, and other sectors to mitigate emissions (Sinnott et al. 2010). However, change does not imply truncating the growth trajectory, but sustainable practices to halt emissions, sustain the economy, and ensure food security. Natural resource could deteriorate the environment. However, resources like forest, croplands, fishing grounds, built-up land, and grazing land mitigate human-caused emissions (Global Footprint Network 2018), unlike petroleum and coal that perform the opposite (Ahmadov and van der Borg 2019; Nathaniel et al. 2019). While LACCs has also been going through rapid globalization and urbanization for quite a while, the research question that this study address is, "Do these two factors add to the environmental challenges the LACCs already has?"

Natural resource is also linked with income. At the early stage of development, countries tend to consume more energy (that is, more natural resource) with little attention to environmental wellness, but as growth persist, attention shifts to renewables with an increase for natural resource preservation, clean energy, etc. (Nathaniel and Khan 2020). Thus, the quality of the environment starts to improve. Economic growth promotes industrialization which increases natural resource extraction. The consumption of natural resource through mining, agriculture, and deforestation could reduce environmental quality through an increase in emissions (Danish et al. 2019). The extraction of natural resource reduces the biocapacity which causes environmental degradation (Panayotou 1993). However, for natural resource use to be sustainable, human capital must be skilled and educated. Human capital will stimulate societies' readiness to adopt environmental-friendly and energy-efficient technologies (Zafar et al. 2019). This justifies the reason for including human capital in the model. The high urbanization rate in LACCs, the difficulties in gaining environmental quality, unsustainable natural use, the need to improve human capital development, and the regions' desire to attain environmental preservation and sustainability are among the motivations for this study.

The contributions of this study are as follows: (i) to our knowledge, it is the first attempt to link natural resource, urbanization, human capital, and environmental degradation in LACCs. (ii) We introduce the interaction term between urbanization and human capital in the model. This will help policymakers identify some new dimensions of urban sustainability, and if human capital moderates the relationship between CO_2 emissions and urbanization. (iii) We used a more comprehensive measure of human capital with advanced panel data econometric techniques that address core panel data issues like cross-sectional dependence (CD) and heterogeneity. The diverse orientation, beliefs, and cultures in the LACCs countries make it difficult if not impossible to implement a "blanket policy" that will be in consonance with each countries peculiarity. To avoid being trapped in the guise of overgeneralization of policies that marred most previous studies, we estimated the country-wise results for all the countries. This will help with the alignment of policies to suit each countries idiosyncrasy.

The sequence of the study is as follows: The "Literature review" section shows the literature review, the "Method, model, and data" section addresses the method and data source, results are presented and discussed in the "Results and discussion of findings", and the "Conclusion" section concludes.

Literature review

Previous studies have linked globalization and urbanization to CO_2 emissions, while others have examined the linkage between natural resource, urbanization, and environmental degradation all with mixed results. For this purpose, the literature is reviewed under two subheadings.

Urbanization, economic growth, globalization, and CO_2 emissions

The link between globalization and environmental degradation has gained lots of attention in the literature with mixed results. For instance, Liu et al. (2020a, b) investigated the anticipated damage that might have emanated from globalization on the environment in G7 countries from 1970 to 2015. They reported that growth and globalization add to CO_2 emissions, while renewable energy mitigates it. Similarly, for G7 countries, Shahbaz et al. (2019a) had earlier used the generalized method of moments (GMM) technique on data spanning 1980–2014 and reported that globalization exacerbates CO_2 emissions, while foreign direct investment (FDI), institutional quality, and trade reduce pollution. Acheampong et al. (2019) arrived at a similar result with those of Liu et al. (2020a, b) and Shahbaz et al. (2019a) even though the study was conducted for sub-Saharan Africa (SSA) countries. Twerefou et al. (2017) applied the GMM technique to examine the effects of globalization and economic growth on CO_2 emissions in 36 SSA countries from 1990 to 2013. They discovered that economic growth increases CO_2 emissions, similar to the finding of Qiao et al. (2019), Dong et al. (2020), and Zhao et al. (2020), while globalization exacted a more worsen impact on the environment. Shahbaz et al. (2018a) examined if the globalization-induced CO_2 emissions hypothesis exists in 25 developed countries for the period 1970–2014. The AMG and CCEMG estimate actually supports the hypothesis. Shahbaz et al. (2018b) and Khan et al. (2019) affirmed that globalization and economic growth worsen environmental quality in Japan and Pakistan, respectively.

There are also a group of studies that discovered that globalization does not encourage environmental degradation. For instance, Salahuddin et al. (2019b) investigated the influence of globalization on CO_2 emissions in SSA. They considered 44 SSA countries and also controlled for energy poverty and urbanization with a more advanced technique. Urbanization adds to emissions and globalization insignificantly reduces it, with energy poverty showing no meaningful result. Saint Akadiri et al. (2020) explored the effects of economic growth and globalization on CO_2 emissions in Turkey from 1970 to 2014. The consumption of electricity and economic growth degrades the environment, while globalization has no harmful impact on the environment. Analogously, Zaidi et al. (2019) examined the linkage between financial developments, globalization, and CO_2 emissions in Asia Pacific Economic Cooperation (APEC) countries from 1990 to 2016. Their findings suggest that both variables improve environmental quality in APEC countries. Similar findings have been supported by Rafindadi and Usman (2019) for South Africa.

Natural resource, human capital, and CO_2 emissions

As argued earlier, human capital could actually be a panacea for environmental sustainability. It links with natural resource, and environmental degradation has also been documented in the literature. Danish et al. (2020) considered the link between natural resource and the environment in Brazil, Russia, India, China, and South Africa (BRICS) using the fully modified OLS (FMOLS) and dynamic OLS (DOLS) technique. The study did not, however, considered human capital as a potential variable in the nexus. They discovered that natural resource is actually responsible for environmental wellness in BRICS countries. Economic growth was, however, the main culprit in relation to environmental degradation. Ahmed et al. (2020a) examined the impact of human capital on environmental quality in G7 countries from 1971 to 2014. They discovered that human capital ensures environmental sustainability, same with FDI and export, but not import and urbanization. Ahmed et al. (2020b) applied the autoregressive distributed lag (ARDL) technique to explore the link between natural resource, human capital, and environmental quality in China. Their findings showed that natural resource degrades the environment, while human capital improves it.

Zafar et al. (2019) investigated the effects of human capital and natural resource on the environment from 1970 to 2015 in the USA while controlling for FDI. They discovered that human capital and natural resource add to environmental quality in the USA. Hassan et al. (2019a) examined the impact of biocapacity and human capital on environmental degradation in Pakistan from 1971 to 2014 using the ARDL technique. They surprisingly discovered that human capital and biocapacity contribute to environmental degradation. This contradicts earlier findings in the literature. Still in Pakistan, Hassan et al. (2019b) discovered that natural resource degrades the environment, and a feedback causality exists between natural resource and environmental degradation. Danish et al. (2019) applied the AMG technique on data spanning 1990–2015 to examine the natural resource-CO_2 emissions nexus for BRICS and discovered that natural resource exacerbates emissions in South Africa, China, Russia, and Brazil but not in India. A bidirectional causality also was discovered between both variables.

In conclusion, most of the studies confirmed that economic growth and natural resource degrade the environment, while the influence of urbanization on the environment is still murky. The difference in results could be as a result of the estimation technique(s), region or country(s) considered, the nature of the dataset, etc. Also, only a few studies considered human capital in the natural resource-environmental degradation nexus. However, we still did not see any study that considered the linkage between urbanization, human capital, natural resource, and environmental quality in the LACCs.

Method, model, and data

Method

This section proceeds with the CD tests because they give information about cross-section independence/dependence and provide a guide on the econometric procedures to adopt.

Cross-sectional dependence and slope homogeneity test

The test for CD has gained popularity in recent panel studies, as residuals, in reality, are not exhibited to be cross-sectional independent. Urbain and Westerlund (2006) argued that the hypothesis of "cross-sectional independence" is invalid in macroeconomic analysis that has strong inter-economy relation. The main problem of panel approach is CD (Pala 2020). The CD tests help to overcome panel data issues and ensure the robustness and consistency of the estimators (Nathaniel et al. 2020a; Dogan et al. 2020). We applied three CD tests for this purpose. The test equation is given as:

$$CD = \left[\frac{TN(N-1)}{2}\right]^{1/2-}\widehat{\rho} \quad (1)$$

$\overline{\widehat{\rho}} = \left[\frac{2}{N(N-1)}\right]\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\widehat{\rho}_{ij}$, and $\widehat{\rho}_{ij}$ is the pair-wise cross-sectional correlation coefficients. T and N are the sample and panel size, respectively. If our findings confirm CD, econometric techniques that address CD issues would be adopted. Our concern would be on the output of the Pesaran Scaled and Breusch-Pagan LM tests since we want to analyse a dataset where $T > N$.

The slope homogeneity test was applied to investigate whether slope coefficients of the cointegration equation are homogeneous. The test was initially introduced by Swamy (1970), but Pesaran and Yamagata (2008) popularized Swamy's test and developed two statistics from it: $\widetilde{\Delta} = \sqrt{N}\left(\frac{N^{-1}\overline{S}-k}{\sqrt{Nk}}\right) \sim X_k^2$ for large sample, and $\widetilde{\Delta}_{\text{adj}} = \sqrt{N}\left(\frac{N^{-1}\overline{s}-k}{V(T,k)}\right) \sim N\ (0, 1)$ for small sample. S represents the Swamy test statistic; N stands for number of cross-section unit; k denotes independent variables. To accept the null hypothesis, the p value of the test must be larger than 5%. The null hypothesis is accepted at a 5% significance level and the cointegrating coefficients are considered homogenous. The result of Pesaran and Yamagata (2008) homogeneity test are presented in Table 3.

Panel unit root test

The presence of CD may render the first-generation tests inefficient, hence, the need for second-generation tests like the cross-sectionally augmented IPS (CIPS) and cross-sectionally augmented DF (CADF) to discover the integration of characteristics of urbanization, natural resources, globalization, economic growth, human capital, and CO_2 emissions. Unit root analysis is imperative to avoid spurious regressions. The CIPS test is formulated from the outputs of the panel-member-specific ADF regressions, which includes cross-sectional averages of the independent and dependent variables in the model. Hence, the test is super useful for identifying the existence of unit roots in heterogeneous panels. The test statistic has a non-standard distribution with the null hypothesis of nonstationarity. According to Pesaran (2007), the equation for the aforementioned tests is given as:

$$\Delta y_{it} = \mathfrak{C}_{it} + \beta_i x_{it-1} + \rho_i T + \sum_{j=1}^{n}\theta_{ij}\Delta x_{i,t-j} + \varepsilon_{it} \quad (2)$$

where the error term, time span, difference operator, study variables, and intercept are represented by ε_{it}, T, Δ, x_{it},and $\mathfrak{C}_{it}$, respectively. According to these tests, if a variable(s) is/are not stationary, the first difference of the variable ($x_t - x_{t-1}$) is taken, and the unit root test is applied again. If the variables become significant at $I(1)$, there will be a need for cointegration test before parameter estimation. The CIPS and CADF tests give some unique advantages; for instance, these tests generate accurate evidence of both CD and heterogeneity.

Panel cointegration test

The Westerlund (2007) cointegration test is applied to investigate the dynamic cointegration relationship among the model variables (urbanization, natural resources, globalization, economic growth, human capital, and CO_2 emissions). This test addresses the common factor restriction issue that bedevilled the first-generation cointegration tests. It is an error-correction model cointegration test that investigates the null hypothesis of no cointegration. The Westerlund (2007) test is based on whether the error-correction term is equal to zero, in a conditional panel error-correction model. The test equation is shown in Eq. 3.

$$\Delta y_{it} = \Psi_i' d_t + \phi_i y_{it-1} + \lambda_i' x_{it-1} + \sum_{j=1}^{pi}\omega_{ij}\Delta y_{it-j} + \sum_{j=0}^{pi}\gamma_{ij}\Delta x_{it-j} + e_{it} \quad (3)$$

where ω, $\Psi_t = (\Psi_{i1}, \Psi_{i2})'$,and $d_t = (1, t)'$ are the error-correction parameter, vector of parameters, and the deterministic components, respectively. The estimation of Eq. 3 will produce four different tests: the panel mean tests, $P_\tau = \frac{\widehat{\alpha}_i}{SE(\widehat{\alpha}_i)}$ and $P_\alpha = T\widehat{\alpha}$ and the group mean statistics, $G_\tau = \frac{1}{N}\sum_{i=1}^{N}\frac{\widehat{\alpha}_i}{SE(\widehat{\alpha}_i)}$ and $G_\alpha = \frac{1}{N}\sum_{i=1}^{N}\frac{T\,\widehat{\alpha}_i}{\widehat{\alpha}_i(1)}$. $SE(\widehat{\alpha}_i)$ and $\widehat{\alpha}_i(1)$ are the standard error and the semiparametric kernel estimator of $\widehat{\alpha}_i$, respectively.

Parameter estimation

Three techniques (AMG, CCEMG, and the Driscoll-Kraay (DK)) were used to estimate the parameters of the variables. The DK (Driscoll and Kraay 1998) panel-corrected standard errors approach accounts for CD, serial correlation, and heteroskedasticity. Apart from being a non-parametric approach, it involves collecting the average of the products between the explanatory variables and the residuals. Both are then used in a weighted heteroskedasticity-and-autocorrelation-consistent (HAC) estimator to obtain standard errors which are robust amidst CD (Jalil 2014). The DK is a flexible technique that accommodates missing values, large time dimension, and balanced/unbalanced panel (Özokcu and Özdemir 2017; Sarkodie and Strezov 2019). It requires the estimation of Eq. 4.

$$y_{i,t} = x_{i,t}^{'}\beta + \varepsilon_{i,t}, i = 1, \ldots, N, t = 1, \ldots, T \tag{4}$$

$y_{i,t}$ and $x_{i,t}^{'}$ represent the explained and explanatory variables, respectively. We further applied the AMG suggested by Bond and Eberhardt (2013). The AMG accounts for CD and heterogeneity which are the two main panel data issues (Dogan et al. 2020). The AMG includes a common dynamic process in a regression approach encompassing two step as in Eqs. 5 and 6.

$$\text{AMG—stage 1}: \Delta y_{it} = \alpha_i + b_i\Delta x_{it} + c_i f_t + \sum_{t=2}^{T} d_i \Delta D_t + e_{it} \tag{5}$$

$$\text{AMG—stage 2}: \widehat{b}_{AMG} = N^{-1}\sum_{i=1}^{N}\widehat{b}_i \tag{6}$$

The coefficient of the time dummies, country-specific estimates of coefficients, and the unobserved common factor are respectively d_t, b_t, and f_t. x_{it} and y_{it} are the observables, while $\widehat{b}_{AMG}$ is the AMG estimator. The CCEMG suggested by Pesaran (2006) is based on the following equations:

$$\widehat{b}_i = \left(X_i^{'} M_w X_i\right)^{'} X_i^{'} M_w Y_i \tag{7}$$

$$\widehat{b}_{\text{CCEMG}} = \frac{1}{N}\sum_{j=1}^{pi}\widehat{b}_i \tag{8}$$

$\widehat{b}_i$ is the individual CCEMG estimation for each of the cross-section unit. $\widehat{b}_{\text{CCEMG}}$ is the panel CCEMG estimator. Analogous to the AMG, the CCEMG estimator is robust to CD as it considers the correlation across panel members. In addition to other benefits, the CCEMG allows for heterogeneous slope coefficients, which provide individual country results.

Causality test

The CCEMG and AMG techniques give no information about causality, hence, the need for the Dumitrescu and Hurlin (DH) (2012) test for causality. The DH test supersedes the vector error-correction model (VECM) causality as it is robust amidst heterogeneity and CD. This causality test is composed of two different statistics, i.e., Zbar-statistics and Wbar-statistics. The latter takes average test statistics, while the former displays a standard normal distribution. The standardized statistics provided thereby are easy to calculate. These statistics obtained from the DH test presents three possibilities, that is, no causality, unidirectional causality, and bidirectional causality among variables. This involves estimating Eq. (9) where:

$$y_{i,t} = \phi_i + \sum_{i=1}^{p}\xi_i^{(p)} y_{i,t-n} + \sum_{i=1}^{p}\pi_i^{(p)} x_{i,t-n} + \mu_{i,t} \tag{9}$$

The intercept and coefficient ϕ_i and $\pi_i = \left(\pi_i^{(1)}, \ldots\ldots\pi_i^{(p)}\right)$ are fixed. The autoregressive parameter and regression coefficient are respectively $\xi_i^{(p)}$ and $\pi_i^{(p)}$. The test hypotheses are:

$$H_0 : \beta_1 = 0$$

$$H_1 : \begin{cases}\beta_i = 0 \\ \beta_i \neq 0\end{cases} \quad \forall_i = 1, 2 \ldots N \text{ and } \forall_i = N+1, N+2 \ldots N$$

The results of the casual relationship among the studied variables are reported in Table 8.

Data and model

The study considers annual data spanning 1990 to 2017 for 18 LACCs. Data availability informed the time period and country selection. For instance, Cuba was excluded because we could not find human capital data for it from the Penn World Table, while the data for Venezuela and the other excluded countries have many missing figures. We choose LACC countries because they have proximity to the Amazon. Amazonian countries mostly depend on mining and agriculture which develop through deforestation and could exacerbate the already increasing carbon emissions. Again, the LACCs are facing the challenges of maintaining environmental quality due to its dwindling biocapacity, depleting natural resource deposit, increasing CO_2 emissions and urbanization rate, and inadequate human capital development. (See Table 1 for the measurements and sources of the dataset.) The current study focused on the impact of economic growth, natural resource, urbanization, human capital, and globalization on CO_2 emissions in LACCs. The Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) of York et al. (2003) is the foundation of our empirical model. According to the STIRPAT framework, environmental impact is associated with population affluence and technology. The model is specified as follows:

$$I_t = \phi_o P_t^{\varsigma 1} A_t^{\varsigma 2} T_t^{\varsigma 3} \mu_t \tag{10}$$

In Eq. (10), 1− 3 and μ are the parameter estimates and the error term, respectively. *I* captures environmental degradation, while *PAT* stands for population, affluence, and technology. In the current study, CO_2 emissions are our environmental degradation indicator. In line with the literature, urbanization, economic growth, and globalization are the proxies for population, affluence, and technology, respectively. This study expands the conventional STIRPAT framework to accommodate human capital and natural resources for reasons already discussed. The models for this study are specified as:

$$lnCO_{2it} = \vartheta_0 + \vartheta_1 lnGR_{it} + \vartheta_2 lnNR_{it} + +\vartheta_3 lnHC_{it} + \vartheta_4 lnUB_{it} + \varepsilon_{i1t} \quad (11)$$

$$ln\mathrm{CO}_{2it} = \mathfrak{C}_0 + \mathfrak{C}_1 ln\mathrm{GR}_{it} + \mathfrak{C}_2 ln\mathrm{NR}_{it} + \mathfrak{C}_3 ln\mathrm{GB}_{it} + +\mathfrak{C}_4 ln\mathrm{HC}_{it} + \mathfrak{C}_5 ln\mathrm{UB}_{it} + \varepsilon_{i2t} \quad (12)$$

$$ln\mathrm{CO}_{2it} = \xi_0 + \xi_1 ln\mathrm{GR}_{it} + \xi_2 ln\mathrm{NR}_{it} + \xi_3 ln\mathrm{HC}_{it} + \xi_4 ln\mathrm{UB}_{it} + \xi_5 ln(\mathrm{HC^*UB})_{it} + \varepsilon_{i3t} \quad (13)$$

where $ln\mathrm{CO}_2$, $ln\mathrm{GR}$, $ln\mathrm{NR}$, $ln\mathrm{HC}$, $ln\mathrm{UB}$, $ln\mathrm{GB}$, and $ln(\mathrm{HC} * \mathrm{UB})$ stand for the natural logarithm of carbon emissions, economic growth, natural resource, human capital, urbanization, and the interaction term (human capital × urbanization), respectively. ε_{i1t}, ε_{i2t}, and ε_{i3t} are the error terms. Urbanization increases the population of cities which already possess limited resources. Consequently, the demand for public utilities, electric appliances, commercial buildings, food, energy, transportation, housing, water, etc. increases which leads to pollution and climate change (Wang et al. 2019). Despite its contribution to knowledge, innovation, and economic development, urbanization spreads emissions, negatively impacts local food production (Winoto and Schultink 1996), decreases soil fertility (Ali et al. 2019), and generates environmental degradation. In addition, the urban population generates about 70% of total greenhouse gas (GHGs) emissions (UN-Habitat 2016), hence the inclusion of urbanization in the model. The relationship between urbanization and CO_2 emissions can be negative or positive. However, in this study, we expect positive relationship urbanization and CO_2 emissions because LACCs are developing economies, and the energy source consumed by the urban population in LACCs is non-renewable.

It is now an open secret that human activities contribute more to climate change and environmental degradation. However, despite the increasing literature on measures to mitigate climate change and environmental degradation, the problems appear not to be declining as expected. Therefore, there is a need to explore beyond conventional thinking and consider other aspects, such as education and awareness, to control environmental deterioration. Human capital based on education and return to education is a potential factor that may influence environmental quality as earlier researches identified a link between environmental awareness, pro-environment behaviour, and education. Chankrajang and Muttarak (2017) reported that human capital influences individuals' behaviour to use renewables. UNESCO (2010) highlighted the great role education plays in mitigating pollution and controlling climate change. Education influences individual/firms recycling activities (Zen et al. 2014). Also, education modifies an individual's behaviour in terms of conforming to environmental regulations (Desha et al. 2015). Human capital plays a vital role in abating CO_2 emissions via promoting energy efficiency (Bano et al. 2018) and reduces deforestation (Godoy et al. 1998). Hence, this study considered the effects of human capital on CO_2 emissions in LACCs. Therefore, we expect human capital to have a negative relationship with CO_2 emissions in LACCs.

The exploration of natural resource involves activities like mining and deforestation which may lead to CO_2 emissions. Again, natural resource consumption in the form of coal, petroleum, and natural gas constitute environmental deterioration (Danish et al. 2019). We expect natural resource to exhibit a positive relationship with CO_2 emissions in LACCs as the region heavily depends on its high-polluting natural resource to meet local consumption and electricity demands. Globalization opens up the economy and allows for the importation of products, and technologies which could improve human well-being or add to the already existing emissions level (Sinha and Sengupta 2019). This necessitated the

Table 1 Sources and measurements of data

S/N	Indicator name	Measurement	Source
1	Urbanization	Urban population (% of total population)	WDI (2019)
2	Natural resource	Total natural resource rent (% of GDP)	✓
3	GDP per capita	in constant 2010 USD	✓
4	Interaction term	(Human capital × urbanization)	✓
5	Globalization	Overall KOF index	KOF index
6	Carbon emissions	Tonnes per capita	IEA (2019)
7	Human capital	Human capital index	Penn World Table

Sources: Author's compilation

inclusion of globalization in the model. Globalization can help reduce or increase environmental degradation. In the case of globalization, the relationship can be negative or positive with environmental degradation (Gómez and Rodríguez 2019). However, it is possible for globalization to exacerbate environmental degradation in LACCs because of weak environmental regulations in the region.

Economic growth can add to CO_2 emissions since growth is heralded by increase energy consumption (mostly non-renewable) and the consumption of nature's resources which could trigger environmental pressure. The LACCs countries have experienced fairly stable growth over the years, accompanied by increasing level of CO_2 emissions; therefore, it is necessary to explore the effects economic growth on CO_2 emissions in the LACCs. We expect economic growth to increase CO_2 emissions in LACCs as the region's economic progress is energy and natural resource dependent; and most of the energy comes from fossil fuels.

After showing the measurements and sources of all the variables, we went further to examine the properties of all the variables. From the results in Table 2, economic growth has the largest average (8.446), while CO_2 emissions have the lowest (0.363). Economic growth is also the most volatile of all the variables while human capital is the least volatile. All the variables are positively skewed and platykurtic. The Jarque-Bera statistic reveals that the variables are not normally distributed.

Concerning the correlation analysis, the studied variables are positively associated with CO_2 emissions and economic growth. This suggests that all the variables move in the same direction as CO_2 emissions. Since CO_2 emissions have been increasing in LACCs, there is a possibility that the other variables have also been increasing. Human capital, urbanization, and globalization are positively correlated with natural resource. The same direction of association exists between urbanization, globalization, and human capital. The partial correlation results are shown in the Annex section. The results confirmed no issue of spurious correlation.

Table 2 Descriptive statistics

Statistics	*ln*CO	*ln*GR	*ln*NR	*ln*HC	*ln*UB	*ln*GB
Mean	0.363	8.446	0.765	0.847	4.186	4.056
Std. D	0.579	0.649	1.116	0.157	0.213	0.160
Min.	− 1.061	6.957	− 2.865	0.408	3.700	3.538
Max.	1.539	9.600	3.063	1.133	4.556	4.361
Skewness	0.132	0.424	0.342	0.398	0.176	1.765
Kurtosis	2.216	1.635	2.659	1.965	2.765	2.699
J-B stat.	10.23	9.241	9.178	12.49	8.546	9.127
Prob.	0.014	0.019	0.025	0.000	0.046	0.032
Correlation						
*ln*CO	1					
*ln*GR	0.542	1				
*ln*NR	0.176	0.008	1			
*ln*HC	0.123	0.203	0.226	1		
*ln*UB	0.561	0.324	0.067	0.453	1	
*ln*GB	0.032	0.434	0.162	0.032	0.223	1

Source: Authors' computations

Results and discussion of findings

This section proceeds with the CD and slope homogeneity tests of Pesaran and Yamagata (2008). Table 3 shows the results of the CD tests. As earlier mentioned, this test (CD) is necessary because it provides a guide for further analysis.

The three results of the CD tests confirmed the existence of CD; therefore, further analysis in this study will be those that ameliorate the problems associated with CD and other panel data issues.

Unlike the first-generation unit root tests, the CIP and CADF still produce robust results amidst CD. The results in Table 4 suggest that all the variables are $I(1)$, hence the need for cointegration. Cointegration tests are used to confirm the existence of a long-run relationship. The results in Table 5 are in the affirmative. Thus, since the probability values of Gt and Pt are less than 5%, a long-run relationship exists.

In Table 6, three different estimation techniques were adopted. Interestingly, the results were similar. Economic growth adds to CO_2 emissions across the models, hence contributing to environmental degradation. This result is in line with our thought. These countries are evolving, and at the initial stage of growth where less attention is accorded to environmental sustainability. Another plausible reason for this outcome is the economic structure of LACCs. Their economy is structured in a way that it is heavily dependent on the region's resource endowments of which most are high in emissions (e.g. coal and fossil fuels). Analogous results have been reported in the literature, such as those of Ulucak et al. (2020) and Liu et al. (2020a, b), Nathaniel et al. (2020a), Saint Akadiri et al. (2020), Cosmas et al. (2019), and Apergis et al. (2018) for BRICS, MENA, Turkey, Nigeria, and SSA, respectively.

Akin to the role of economic growth, natural resource also encourages CO_2 emissions in these countries. This complements the findings of Ahmed et al. (2020b) and Hassan et al. (2019a), but not in consonance with those of Danish et al. (2019), Zafar et al. (2019), and Balsalobre-Lorente et al. (2018). These countries are endowed with lots of resources which are exploited for revenue and domestic consumption. However, this result points to the fact that the exploitation of natural resource has not been sustainable in these countries. Over-reliance on natural resource causes the biocapacity to deplete as resources are not allowed to regenerate. Also,

Table 3 Cross-sectional dependence and slope homogeneity tests

Variables	Breusch-Pagan LM	Pesaran scaled LM	Pesaran CD
CO (log)	2256.294***	120.2373***	39.08402***
GR (log)	3299.244***	179.8588***	55.49866***
NR (log)	1197.965***	59.73669***	18.23320***
HC (log)	3874.028***	212.7170***	62.10895***
UB (log)	4156.542***	228.8673***	64.46254***
GB (log)	3708.692***	203.2654***	60.76193***
Slope homogeneity results	Δ statistic		
Model 1			
$\tilde{\Delta}$test	7.869***	0.000	
$\tilde{\Delta}$	8.132***	0.000	
Model 2			
$\tilde{\Delta}$test	10.12***	0.000	
$\tilde{\Delta}$	10.58***	0.000	
Model 3			
$\tilde{\Delta}$test	12.34***	0.000	
$\tilde{\Delta}$	13.09***	0.000	

Note: *** implies statistical significance at the 1% level

Source: Author's computation

considering the strategic location of LACCs, the consumption and processing of agricultural resources encourages deforestation which enhances CO_2 emissions. Some of these countries also use their natural resource (coal, oil, and gas) to meet their energy needs. It has been argued that the abundance of resources can make a country to be self-reliant by reducing energy import and concentrating more on domestic energy sources with fewer emissions (Ahmed et al. 2020b). However, the opposite is the case for LACCs were fossil fuel is the chief energy source. On the flipside, fossil fuels contribute the largest share to GHGs, thereby increasing CO_2 emissions (Joshua and Bekun 2020; Joshua et al. 2020; Adedoyin et al. 2019; Udi et al. 2020).

In tandem with what is obtainable in the literature, human capital reduces emissions. This suggests that human capital has been playing a vital role in relation to environmental wellness in LACCs. In the past few years, the LACCs have been making efforts to improve human capital through quality education and environmental awareness. An educated human capital will have a higher appetite for clean energy which is vital for innovation, environmental preservation, efficient use of natural resource, and energy-saving. This complements the earlier studies of Zafar et al. (2019) and Bano et al. (2018). Another look at Table 6 reveals that the additive effect of natural resource and economic growth supersedes that of human capital. This suggests that LACCs should enhance human capital development to achieve a greater height of environmental preservation.

We further discovered that urbanization exacerbates CO_2 emissions in LACCs. This complements the findings of Salahuddin et al. (2019a) and Nathaniel et al. (2019) for South Africa, and Charfeddine (2017) for MENA. Urbanization stimulates economic activities and increases

Table 4 Panel unit root tests

Variables	Level		First difference	
	CIPS	CADF	CIPS	CADF
CO (log)	− 3.657	11.32	− 6.435***	25.44**
GR (log)	2.003	10.54	− 3.452**	35.11***
NR (log)	− 2.453	12.42	− 5.654***	41.17***
HC (log)	− 1.541	14.34	− 1.909**	43.56**
UB (log)	− 3.564	25.21	− 4.721***	31.31**
GB (log)	− 1.453	31.43	− 4.453***	40.21***

Source: Authors' computations. Note: *** and ** imply statistical significance at the 1% and 5% levels, respectively

Table 5 Cointegration results

Models	?		?	
Model 1	− 2.944***	− 5.899	− 10.902***	− 4.685
Model 2	− 2.712**	− 9.657**	− 4.325	− 9.435*
Model 3	− 4.982***	− 7.438	− 9.798***	− 8.143

Note: ***, **, and * imply statistical significance at the 1%, 5%, and 10% levels, respectively

Source: Author's computation

Table 6 AMG, Driscoll-Kraay, and CCEMG results

Variables	AMG	Driscoll-Kraay	CCEMG
Model 1			
GR (log)	1.074 (6.26)***	0.571 (35.25)***	1.469 (2.47)**
NR (log)	0.011 (2.49)***	0.053 (6.21)***	0.026 (0.65)
HC (log)	− 0.301 (− 3.21)***	− 0.487 (− 6.70)***	− 0.947 (− 2.15)***
UB (log)	0.032 (− 5.32)***	1.572 (21.46)***	21.97 (1.85)*
Number of regressors	4	4	4
Number of observations	504	504	504
Number of groups	18	18	18
R-squared	-	0.715	-
Model 2			
GR (log)	1.033 (6.65)***	1.034 (14.68)***	1.065 (3.87)***
NR (log)	0.028 (7.45)***	0.168 (11.10)***	0.121 (1.98)**
HC (log)	− 0.035 (4.46)***	− 2.064 (10.00)***	− 0.106 (− 5.37)***
UB (log)	− 0.212 (2.01)***	− 1.417 (− 4.12)***	− 0.906 (− 1.66)*
GB (log)	0.730 (2.31)***	0.455 (2.29)**	1.049 (5.93)****
Number of regressors	5	5	5
Number of observations	504	504	504
Number of groups	18	18	18
R-squared	-	0.717	-
Model 3			
GR (log)	0.848 (3.32)***	0.211 (2.10)***	2.461 (2.88)***
NR (log)	0.797 (3.01)***	0.568 (34.20)***	3.021 (0.14)***
HC (log)	− 2.746 (− 5.62)***	− 0.500 (− 6.86)***	− 2.746 (− 2.97)***
UB (log)	0.145 (6.25)***	0.560 (6.33)***	0.145 (3.02)***
(HC ∗ UB) (log)	− 1.035 (3.15)***	− 4.461 (− 12.48)***	− 0.108 (− 32.8)***
Number of regressors	5	5	5
Number of observations	504	504	504
Number of groups	18	18	18
R-squared	-	0.973	-

Source: Author's computation. Note: ***, **, and * imply statistical significance at the 1%, 5%, and 10% levels, respectively

the population of cities which already possess limited resources. Urbanization increases the demand for transportation, housing, domestic appliances, among others, which in turn promote energy demand (Lin and Du 2015). Since the energy consumed in LACCs is mostly non-renewable, CO_2 emissions are expected to rise. The increase in the urban population in LACCs could be as a result of improvement in growth trajectory accompanied by energy consumption, waste generation, and low energy efficiency.

Model 2 portrays the results where we controlled for globalization. The same results, as obtained in model 1, were derived, except that urbanization exhibited an opposite sign. This shows that globalization mitigates the horrendous effects of urbanization on the environment.

We can attribute this outcome to economies of scale, positive externalities, and the provision of public services such as proper waste management, environment-friendly infrastructure, and health facilities which ease the development, operation, and building of a sustainable urban environment. However, globalization adds to CO_2 emissions in LACCs. The devastating impact of globalization on the environment is in consonance with the studies of Liu et al. (2020a, b) and Shahbaz et al. (2019a, b) for G7; Acheampong et al. (2019), Salahuddin et al. (2019b), and Twerefou et al. (2017) for sub-Saharan Africa; Shahbaz et al. (2018a) for developed countries; Shahbaz et al. (2018b) for Japan; and Khan et al. (2019) for Pakistan, but contradicts those of Shahbaz et al. (2019a, b) for middle and high-income countries, and Saint Akadiri et al. (2020) for Turkey.

In model 3, the intention was to examine if human capital exhibits a moderating role. The negative and significant coefficient of the interaction term is intuitive and appealing. The implication is that human capital weakens the adverse effects of urbanization on the environment. It suggests that urbanization and human capital can combine to reduce CO_2 emissions, even though urbanization initially increases emissions. This further affirmed the fact that human capital is vital for urban sustainability. Ahmed et al. (2020b) had earlier confirmed a similar relationship for China.

The country-wise results in Table 7 further reaffirmed the horrendous impact of economic growth on the environment, except in the Dominican Republic. In this case, the regions' highest emitters, Venezuela, Argentina, and Chile, may need to diversify and focus on improving the less-polluting sectors of its economy. The same was true for the effect of natural resources except in El Salvador, Guatemala, Honduras, Dominican Republic, and Nicaragua. This outcome is commensurate with the countries' heavy dependence on nature's wealth which results in rising ecological footprint. Urbanization reduces CO_2 emissions in Argentina, Chile, Ecuador, Honduras, and the Dominican Republic. This suggests that urbanization may have been well managed in the aforementioned countries, or perhaps the urbanization rate is not too high. The impact of human capital is mixed. It reduces CO_2 emissions in 50% of the countries considered and increases it in the remaining 50%. Human capital could be harmful to the environment when they lack the required education and ignorant of environmental sustainability procedures. Another potential factor could be poor government policy and low household income.

In Table 8, a feedback causality exists between economic growth, globalization, and urbanization and CO_2 emissions, human capital, natural resource, and economic growth. A unidirectional causality flows from natural resource and human capital to CO_2 emissions, globalization to natural resource and human capital, and from growth to globalization. No form of causality was discovered between human capital and natural resource, and between natural resource and urbanization. This further reveals that economic growth, globalization, and urbanization are major drivers of CO_2 emissions in LACCs. Human capital development is needed for environmental sustainability, and urbanization should be properly managed.

Conclusion

We investigated the linkage between urbanization, natural resource, human capital, and CO_2 emissions in eighteen LACCs from 1990 to 2017 with mainly second-generation econometric techniques. We estimated three different models, controlled for globalization in the second, and the interaction between urbanization and human capital in the third. The results suggest that natural resource, urbanization, and economic growth increase emissions, while human capital mitigates it. These results were similar across the three estimations, except for the second model where the impact of globalization reduces the horrendous effects of urbanization on the environment. Further findings revealed different directions of causality among the variables. These results inform the necessary policy directions.

Table 7 Country-specific AMG results

Countries	*ln*GR	*ln*NR	*ln*UB	*ln*HC
Brazil	1.376 (7.21)***	0.018 (0.95)	6.050 (4.39)***	9.096 (6.19)***
Argentina	0.090 (1.49)	0.044 (4.58)***	− 0.37(− 9.04)***	0.646 (0.75)
Bolivia	0.939 (2.28)**	0.039 (1.70)*	0.0.867 (0.45)	− 11.28 (− 6.85)***
Chile	0.686 (1.75)*	0.011 (0.15)	− 7.878 (− 1.17)	− 7.131 (−0.24)
Colombia	1.029 (4.63)***	0.019 (0.458)	3.68 (− 5.76)***	15.59 (2.50)**
Costa Rica	2.411 (4.17)***	0.071 (1.44)	1.449 (1.16)	2.039 (1.48)
Dominican R.	− 0.205 (− 0.06)	− 0.000 (− 0.06)	− 3.50 (− 2.70)**	− 6.938 (− 5.11)***
Ecuador	1.596 (4.20)***	0.003 (− 0.11)	− 1.968 (− 0.77)	2.834 (1.36)
El Salvador	2.051 (2.16)**	− 0.227 (− 3.60)***	2.027 (1.31)	− 3.834 (− 1.83)*
Guatemala	1.390 (1.20)	− 0.232 (− 2.84)***	15.50 (1.90)*	− 0.741 (2.70)***
Honduras	1.278 (2.49)**	− 0.166 (− 2.46)**	− 0.861 (− 0.12)	− 3.307 (− 4.48)***
Jamaica	1.309 (3.13)***	0.261 (3.54)***	30.16 (1.20)	3.913 (1.03)
Mexico	0.534 (1.95)*	0.088 (4.98)***	3.555 (− 0.43)	− 0.563 (− 0.25)
Nicaragua	0.087 (0.39)	− 0.121 (− 8.77)***	17.17 (3.49)***	5.403 (1.47)
Panama	0.307 (0.91)	0.103 (1.74)*	7.368 (− 1.18)	25.49 (1.52)
Paraguay	2.170 (8.07)***	0.294 (2.17)**	4.872 (2.34)**	− 1.857 (− 1.74)*
Peru	0.675 (2.13)**	0.008 (0.48)	2.181 (− 0.56)	− 1.536 (− 1.52)
Uruguay	1.419 (4.24)***	0.189 (1.73)*	25.02 (2.69)***	1.870 (0.42)

Source: Author's computation. Note: ***, **, and * imply statistical significance at the 1%, 5%, and 10% levels, respectively

Table 8 D–H causality test

Null hypothesis	*W*-stat.	*Z*bar-stat.	Probability	Decision
*ln*CO → *ln*GR	5.284	6.967	0.000	Bidirectional causality
*ln*GR → *ln*CO	4.123	4.504	0.000	
*Ln*CO → *ln*NR	2.930	1.972	0.048	Unidirectional causality
*ln*NR→ *ln*CO	2.125	0.266	0.790	
*ln*CO → *ln*HC	4.846	6.038	0.000	Unidirectional causality
*ln*HC→*ln*CO	3.795	3.808	0.001	
*ln*CO → *ln*UB	4.312	4.904	0.000	Bidirectional causality
*ln*UB→ *ln*CO	4.651	4.215	0.000	
*ln*CO → *ln*GB	3.038	2.202	0.027	Bidirectional causality
*ln*GB→*ln*CO	2.999	2.121	0.033	
*ln*GB → *ln*NR	2.801	1.701	0.088	Unidirectional causality
*ln*NR→*ln*GB	4.353	4.992	0.000	
*ln*GR → *ln*GB	2.992	2.104	0.035	Unidirectional causality
*ln*GB→*ln*GR	1.878	− 0.258	0.796	
*ln*GB → *ln*HC	4.065	4.381	0.000	Unidirectional causality
*ln*HC→*ln*GB	2.182	0.387	0.691	
*ln*NR → *ln*GR	3.494	3.170	0.001	Bidirectional causality
*ln*GR→*ln*NR	5.340	7.086	0.000	
*ln*HC → *ln*GR	6.231	4.435	0.000	Bidirectional causality
*ln*GR→*ln*HC	4.584	3.544	0.003	
*ln*HC → *ln*NR	2.454	0.543	0.564	No causality
*ln*NR→ *ln*HC	2.783	1.412	0.238	
*ln*NR → *ln*UB	2.432	1.654	0.319	No causality
*ln*UB→ *ln*NR	1.091	0.543	0.431	
*ln*HC → *ln*UB	8.123	6.391	0.001	Bidirectional causality
*ln*UB→ *ln*HC	7.301	5.649	0.000	

Source: Author's computation. Note: → represents direction of causality. All the variables retained their earlier definition

First, sustainability practices must be imbibed in the exploration of natural resource in LACCs since the findings revealed that natural resource increases CO_2 emissions. The need for "green exploration" demands the enforcement and improvements in legislation that relates to water, soil, and mineral pollution in LACCs. This will not only reduce pollution but also uphold sustainability. The consumption of low polluting natural resource like hydropower and natural gas will allow for resource regeneration, increase the biocapacity, and reduce the ecological footprint with less natural resource depletion. Moreover, forests should be protected through penalties for violators.

Urbanization comes with lots of anomalies. The adverse effects of urbanization on the environment make us argue that the development of human capital will be a panacea for an urban anomaly and could also help identify some new dimensions of urban sustainability. An improvement in capitalization amenities and the establishment of smart cities are also keys for urban sustainability and suburban development. Smart cities promote efficiency, innovation, and sustainability in urban economic activities such as housing, energy, and transportation.

Since globalization adds to CO_2 emissions, we further recommend that governments in LACCs use effective and proper policy coordination to ameliorate the environmental cost emanating from globalization. The harmful impact of globalization calls for policymakers not to underestimate the role it (globalization) plays in the dynamics of CO_2 emissions in developing countries when they intend to draft a long-term and comprehensive environmental policy framework. Globalization must be considered a key economic tool so as to improve environmental wellness over the long run. Globalization encourages import and sometimes the importation of high-polluting technologies. Globalization is a product of policies from different domains including politics, migration, finance, trade (import and export), and transport. These dimensions of globalization should be considered when enacting environmental sustainability policies.

The feedback causality between economic growth and CO_2 emissions points to a possible defect in the region's economic structure. The introduction of diversification activities in LACCs economic structure will decline the heavy dependence on natural resource which tends to promote CO_2 emissions in the region. Incentives for sustainable growth-driven and knowledge-based industries should be a priority in LACCs. Tax-cut and low-interest rate should be adopted to incentivize these industries.

We discovered that urbanization is a major contributor to CO_2 emissions in LACCs except in Argentina, Chile, Ecuador, and Honduras. We recommend that policymakers in the remaining countries embark in launching various environmental awareness programs in urban areas. In addition, energy-efficient electric home appliances should be promoted in the residential sector. Since urbanization promotes increase demand for transportation, smart technology and energy-efficient hybrid vehicles are required in the urban centres. Policymakers can motivate the urban population to imbibe a sustainable lifestyle that is in consonance with energy-saving, recycling, and the usage of renewable energy instruments.

This study has some limitations. The sample period covers just 27 years. Some determinants of CO_2 emissions were not considered either due to data unavailability or the nature of the dataset. It would be interesting to see if institutional quality could mitigate the devastating impacts of natural resource exploration on the environment. This is a pointer for future researchers.

Authors' contributions SN conceived the idea, wrote the introduction, collected and analysed the data, and interpreted the results. NN reviewed the required literature and edited the manuscript. FB wrote the methodology section and provided the relevant policy recommendations/directions. All authors read and approved the final manuscript.

Data availability The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Compliance with ethical standards

Competing interests The authors declare that they have no competing interests.

Ethics approval and consent to participate Not applicable.

Consent to participate Not applicable.

Consent to publish Not applicable.

Annex 1

Table 9 Lists of abbreviations

Acronyms	Meanings
LACCs	Latin American and Caribbean Countries
CD	Cross-sectional dependence
VECM	Vector error-correction model
AMG	Augmented mean group
DOLS	Dynamic ordinary least squares
SDGs	Sustainable development goals
DH	Dumitrescu and Hurlin
FMOLS	Fully modified ordinary least squares
APEC	Asia Pacific Economic Cooperation
DK	Driscoll and Kraay
CCEMG	Common correlated effects mean group
SSA	sub-Saharan Africa
PMG	Pooled mean group
CIPS	Cross-sectionally augmented IPS
CADF	Cross-sectionally ADF

Source: Author's compilation

Annex 2. List of countries

Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, and Uruguay

Annex 3

Table 10 Partial correlation of CO

Variable	Partial	Semi P	Partial^2	Semi P^2	Sig.
NR (log)	0.1463	0.0895	0.0214	0.0080	0.001
GR (log)	0.5405	0.3890	0.2922	0.1513	0.000
HC (log)	0.1085	0.0661	0.0118	0.0044	0.015
UB (log)	0.3434	0.2811	0.1179	0.0079	0.000
GB (log)	0.2412	0.2156	0.0582	0.0465	0.000
HC*UB (log)	0.2722	0.2342	0.0741	0.0548	0.000

Source: Author's computation

Annex 4

Table 11 Partial correlation of HC * UB (log) with GB (log)

Variable	Partial	Semi P	$Partial^2$	$Semi\ P^2$	Sig.
GB (log)	0.5594	0.4811	0.3129	0.2314	0.000

Source: Author's computation

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