Highlights

- Analysis of the impacts of the tourism sector on the overall eco-efficiency.
- Use of two-stage Data Envelopment Analysis to calculate the overall eco-efficiency.
- Analyse the impacts of tourism arrivals, tourism capital investment, and direct tourism contribution to employment on the eco-efficiency.
- Policymakers should cope with tourism destinations carrying capacity.
- Policymakers should encourage investments in sustainable tourism projects.

The impacts of the tourism sector on the eco-efficiency of the Latin American and Caribbean countries

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Abstract: The impacts of the tourism sector on the overall eco-efficiency of 22 Latin America and Caribbean countries from 1995 to 2016 were examined. A Data Envelopment Analysis was used to calculate the overall eco-efficiency of each country (considering the CO_2 emissions as the input and the GDP as the output). Posteriorly, a Panel Autoregressive Distributed Lag model was applied to analyse the impacts of tourism arrivals, tourism capital investment, and direct tourism contribution to employment on eco-efficiency. The results indicated that tourism arrivals decrease these countries eco-efficiency, both in the short- and long-run. Contrariwise, tourism capital investment and direct tourism contribution to employment seem to promote eco-efficiency in the long-run. These findings recommend that policymakers should respect these destinations carrying capacity and, simultaneously, encourage investments in sustainable tourism projects and productive employment to all.

Keywords: Eco-efficiency; Tourism arrivals; Tourism capital investment; Direct tourism contribution to employment; PARDL; Latin America and Caribbean countries

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1. Introduction

Overall, countries have experienced rapid economic growth in the entire world during the last decades, and Latin America and the Caribbean region are not an exception (Koengkan et al., 2019). Although economic growth is usually considered a relevant factor for the countries'

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development, the increases in the production scale typically induce an increase in energy consumption – and, in the LAC case, countries present some singularities in their energy systems. For instance, Brazil (the world's sixth-largest emitter of greenhouse gas) is one of the major fossil fuels exporters as well as Colombia, Mexico and, Peru (Fuinhas et al., 2017). Contrariwise, Chile, El Salvador, Panama, Honduras, Guatemala, and Nicaragua are major importers of commodities (Fuinhas et al., 2017). Costa Rica and Paraguay are the prominent pioneers in renewable energies since Costa Rica uses nearly 100% renewable energy to generate its electricity, and Paraguay has most of its power generation based on natural hydro resources (Itaipu power plant).

The Latin American Energy Organization (OLADE) has already announced that the regional goal for Latin America and the Caribbean is reaching at least 70% of renewable energy in electricity by 2030 (IRENA, 2019). This fact shows that the region is working in order to increase the pace of their energy transition. This energy transition is necessary given that energy systems are directly linked with the CO2 emissions increase – one of the major contributors to global warming, especially in emerging economies as the ones from the LAC, considering their production structure and extreme vulnerability to natural disasters (Alvarado and Toledo, 2017; Saidi and Hammaming, 2015).

The previously stated facts led to evaluate the state of the countries in terms of environmental degradation. One crucial concept has emerged in the environmental and sustainable development fields: "eco-efficiency". This concept can be defined as: "The delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the Earth's estimated carrying capacity" (WBCSD, 1992), being used as an instrument for assessing sustainable development which allows exploring the trade-off between the economic and environmental performances (Carvalho et al., 2017), with applications on both the micro and macro-level.

The eco-efficiency techniques have been extended through model calculations and innovative indicators. The Data Envelopment Analysis (see Piña and Martínez, 2016) remains the most used methodology on eco-efficiency focused studies. It produces an understandable index that does not present restrictions on the data distribution and allows multiple inputs and outputs simultaneously (Lee and Ji, 2010). This non-parametric method, based on linear programming, was developed by Charnes et al. (1978) and allows to measure the productivity and the scale efficiency of individual decision-making units (DMU) through an eco-efficiency ratio shaped as an input-output model – with the environmental and economic effects corresponding to the inputs and outputs, respectively (Lee and Ji, 2010; Kuosmanen and Kortelainen, 2005).

In addition to the evolution in terms of techniques, eco-efficiency become the focus of many researchers, including in the tourism research field (Qiu et al., 2017). This increasing interest can be explained by the fact that tourism being a vital tool for the countries' economy, society and culture (León-Gómez et al., 2021), which is rapidly developing around the world and produce multiple benefits on job creation and income distribution (Niñerola et al., 2019). However, that have both advantages and disadvantages, considering that tourism is also directly linked to negative consequences on the environment (Niñerola et al., 2019). This environmental damage is mainly motivated by two sources: through the natural resources depletion, air pollution and climate changes or given this sector association to the intensive energy consumption, stimulated by the production, hotel, and transport activities (Mikayilov et al., 2019; Paramati et al., 2016).

The inclusion of the eco-efficiency concept of sustainable tourism was empirically first proposed by Gössling et al. (2005), which explored the impact of some economic variables associated with the tourism activity on indicators as carbon dioxide emissions and energy consumption (to represent the eco-efficiency). Many researchers have followed the same guideline, and several use the number of arrivals to represent the tourism sector (see Le and Nguyen, 2020). As an example, we have Katircioglu et al. (2014), who demonstrated that the number of arrivals seems to affect Cyprus CO2 emissions positively and, corroborating with this outcome, we can see the investigation of Koçak et al. (2020), who studied the same relationship for OECD countries. Contrariwise, using the tourism capital investment to represent this sector, the investments seem to contribute to mitigating CO_2 emissions – as mentioned by some authors in their investigations (Lee and Brahmasrene, 2013; Fayissa et al., 2011), and was empirically proved by Paramati et al. (2018). They conclude that tourism investments significantly decreased the CO_2 emissions in 28 countries of the European Union. It can be noted a lack of studies that directly address this theme for Latin America and Caribbean countries.

Nonetheless, some authors include countries of this region in their samples (Le and Nguyen, 2020; Alam and Paramati, 2017). Le and Nguyen (2020) investigated the tourism arrivals impact on CO_2 emissions (inserting 14 countries of this region in their analysis), and the outcomes showed that tourism arrivals positively affect CO_2 emissions. On the other hand, Alam and Paramati (2017) analysed and confirmed that tourism investments lead to a decrease in CO_2 emissions in 10 major tourism countries' (inclusive Bahamas, Barbados, Belize, and St. Lucia).

Regarding the relationship between tourism and economic growth, is a well-established issue in the literature (e.g. Fuinhas et al., 2018; Du et al., 2016) and have been developed four main hypotheses, in order to define and analyse it: the tourism-led growth hypothesis, which confirm that tourism promote economic growth and is confirmed by most investigators (see Fuinhas et al., 2018); the conservation hypothesis, which suggest that economic growth have positive impacts on tourism development (Lin et al., 2019); the feedback hypothesis, which defend that tourism induce economic growth as well as economic growth induce tourism (see Al-mulali et al., 2014); and the neutrality hypothesis, which states that no relationship exist between tourism and economic growth (Chiu and Yeh, 2017) In LAC region, this thematic is also quite studied and – even with the variables, the samples, the time span or the empirical methods being different – most investigators obtained the same outcomes, supporting the tourism-led growth hypothesis (Fuinhas et al., 2018; Belucio et al., 2018).

In order to reach the balance between economic benefits and environmental damage of tourism, it is necessary to evaluate both factors simultaneously. Indeed, this balance must include different components affecting this sector. None of the previous literature has done it, and it becomes evident that is a gap in this investigation field. This issue is particularly relevant for the LAC region since that tourism activity works as a crucial development mechanism for these countries (Khan et al., 2020) and, despite some differences between them, are "among the most dependent in the world on the tourism sector" (Mooney and Zegarra, 2020). Following the UNWTO (2018), South America received 36.7 million international tourist arrivals in 2017, and the Caribbean received 26 million. Central America received 11.2 million, reinforcing the idea that tourism can be a future solution to LAC region economic improvement. However, it must be conducted to increase ecological awareness and ensure sustainable destination development (otherwise, it will become destructive).

Thus, the primary purpose of this study is to evaluate the impacts that tourism has on the LAC's overall eco-efficiency and contribute to expanding the knowledge concerning the economic and environmental impacts of the tourism activity in this region. It can be a precious help in creating measures that will contribute to the sustainable development of the LAC countries. The main (central) question will be the following: "What are the impacts of the tourism sector on the Latin America and Caribbean countries eco-efficiency?"

In order to answer the previous question, the impacts of the tourism sector on the LAC countries eco-efficiency were investigated using the two-stage DEA methodology for a panel of 22 LAC countries, with annual data ranging from 1995 to 2016. During the first stage, a DEA was applied to assess the countries' overall eco-efficiency, using the CO_2 emissions (as undesirable output) to represent the environmental degradation and the GDP to measure the economic growth (as desirable output). This method allows us to analyse the eco-efficiency over time and estimate the dependent variable, which will be used in the second stage (the overall eco-efficiency). In the second stage, the Panel Autoregressive Distributed Lag (PARDL) model was chosen to regress the selected influential factors on the overall eco-efficiency. This approach was pursued because it is capable of producing robust results with small/moderate samples and supports both orders of integration (i.e. I(0) and I(1)) in the estimation. This method also evaluates the impacts of the tourism sector on the computed eco-efficiency, both in the short- and the long-run. Three variables that reflect different strands of the sector were chosen to reach this specific goal, namely tourism capital investment, tourism arrivals, and tourism direct contribution to employment.

After this introductory section, which included a comprehensive review of the literature, the study will be organised as follows: Section 2 presents the data, Section 3 describes the methodologies used, Section 4 displays the results, Section 5 provides their discussion, and Section 6 concludes.

2. Data

In order to achieve the goals of this analysis, we collected annual data, ranging from 1995 to 2016, for 22 LAC countries, namely: Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru and, Uruguay. The availability of the data was the main criteria to choose both the period and countries included in the analysis. Moreover, it should be referred that the statistical software package STATA 15 was used to perform econometric analysis. The name, definition, and source of the variables are presented in Table 1.

TABLE 1. Variable's description

Variable	Definition	Source
E	Overall eco-efficiency	Authors own calculation
Y	Gross Domestic Product in the constant local currency unit	World Development Indicators
C	Annual carbon dioxide emissions in tonnes	Our World in Data
IPC	Capital Investment in the constant local currency unit	World Travel & Tourism Council
A	Tourism arrivals in the number of persons	World Development Indicators
EMP	Direct contribution to employment in % share of total employment	World Travel & Tourism Council
EPC	Electric energy consumption in GWh	CEPALSTAT
T	Trade, in % of Gross Domestic Product	World Development Indicators
H	Human Development Index	Human Development Report
P	The total population in the total number of persons	World Development Indicators

The Gross Domestic Product in constant local currency unit (Y) and the annual carbon dioxide emissions in tonnes (C) were both used to calculate the dependent variable: Overall eco-efficiency (E). The dependent variable was obtained through a Data Envelopment Analysis –

using the annual carbon dioxide emissions (C) as the input and the Gross Domestic Product (Y) as the output. Following Kuosmanen and Kortelainen (2005), the present investigation uses the pollutants (or undesired outputs) as the input, and the economic value-added (Gross Domestic Product), as the desired output. The Gross Domestic Product (Y) was retrieved from the "World Development Indicators" database, while the annual carbon dioxide emissions (C) were obtained from the "Our World in Data" database.

Regarding the interest variables, the tourism capital investment in constant local currency unit (IPC) was used to represent the sector gross fixed capital formation (Barišić and Cvetkoska, 2019); the tourism arrivals in the number of persons (A) was used to measure the tourism market scale (Liu et al., 2017); and, the direct tourism contribution to employment in % share of total employment (EMP) was used in order to represent the direct economic impacts of this sector (Barišić and Cvetkoska, 2019). The tourism capital investment and tourism direct contribution to employment were obtained from the "World Travel and Tourism Council" database. The tourism arrivals were collected from the "World Development Indicators".

Given the characteristics of our dependent variable, the control variables were chosen considering the past empirical investigations on economic growth and CO_2 emissions. Were chosen the ones which are proven to influence both of these variables. Thus, our control variables will be the Electric Energy Consumption in GWh (EPC), collected from "CEPALSTAT", which will be used to represent the sophistication level of the economies (Santiago et al., 2018); Trade in % of Gross Domestic Product (T), retrieved from the "World Development Indicators", to proxy for trade volume (Alfaro et al., 2004); and Human Development Index (H), obtained from the "Human Development Report", to represent the countries social and economic well-being (see Ouedraogo, 2013).

The population measured in the number of persons (P) was retrieved from the "World Development indicators". It was used to transform both the tourism capital investment in constant local currency unit (IPC) and the electric energy consumption in GWh (EPC) in their respective *per capita* values, eliminating the distortions caused by population variations.

3. Methodology

A PARDL approach was applied to conduct this investigation. Although the present section was divided into two subsections: 1) to describe the DEA method, used to calculate the dependent variable; 2) to describe the estimation of the regression model to measure the impacts of the tourism sector on the overall eco-efficiency scores.

3.1. Data Envelopment Analysis

The DEA methodology was first proposed by Charnes et al. (1978), is a non-parametric, mathematical programming technique used to evaluate the relative efficiency of each DMU. The

DEA measures efficiency as a ratio between weighted outputs and weighted inputs. The model can be converted into a Linear Programming Problem (Charnes and Cooper, 1962) to determine the weights that maximise that ratio. In other words, this model estimates the optimal combination of inputs and outputs, which maximise the DMU's efficiency.

The results are expressed through an efficiency score with values ranging from 0 to 1. This evaluation consists of comparing a unit performance with the best score unit in a given sample. The best score DMU represents the DEA frontier, and the units that are not included in the frontier are considered inefficient. In order to ensure the validity of this analysis, the sum of inputs and outputs should be at least three times smaller than the total number of DMU's (Peng et al., 2017).

The DEA can follow an input orientation or an output orientation. The input orientation DEA minimises the inputs for a fixed level of outputs, while the output orientation DEA maximise the outputs for a fixed level of inputs. This work followed an input-orientation to evaluate the eco-efficiency of LAC countries, minimising the CO_2 emissions (input) for a given level of economic growth (output).

DEA methodology can also be different in terms of returns to scale: The Constant Returns to Scale (CRS) model (or the CCR model) considers that an increase in the inputs produces a proportional increase in the outputs (Charnes et al. 1978). The Variable Returns to Scale (VRS) model (or the BBC model) assumes that an increase in the inputs leads to a disproportionate increase in the outputs (Banker et al., 1984). The CRS and VRS efficiency scores are known as Technical Efficiency and Pure Technical Efficiency, respectively. Following the previous literature, the CRS was applied in this investigation. It is the most used in this type of studies. It enables us to measure the overall technical efficiency, including technical efficiency and scale efficiency. The VRS model is limited to estimating technical efficiency (Figueroa et al., 2017).

Assuming that there are "n" DMU's to be evaluated, the relative efficiency (θ) of DMU_j (with j = 1, …, n) is the ratio of the weighted combination of outputs y_{rj} (with r = 1, …, s) and inputs x_{ij} (with i = 1, …, m). Then, the relative efficiency of a DMU_j can be evaluated by solving a fractional programming problem, as follows:

$$\theta_j = max_{u_r,v_i} \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}$$

subject to: (1)

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \text{ j = 1, …, n; } v_i \geq \delta, \text{ i = 1, …, m; } u_r \geq \delta, \text{ r = 1, …, s.}$$

In Eq. (1), u_r and v_i are the outputs and inputs weights, respectively, constrained to be greater than or equal to some small positive quantity, represented by δ. This last feature avoids that some input or output be entirely ignored when determining the relative efficiency (θ_j). With this in mind, Eq. (1) can be transformed into a linear programming model (Eq. (2)) and formulated as an envelopment model:

$$\theta_j = min_{\Lambda_j, s_i, s_j} \theta_j - \varepsilon \left(\sum_{i=1}^{m} s_i - \sum_{r=1}^{s} s_r \right)$$

subject to: (2)

$\theta_j x_{ij} - \sum_{j=1}^{n} \Lambda_j x_{ij} - s_i = 0$; j = 1, ..., n; i = 1, ..., m; $y_{rj} = \sum_{j=1}^{n} \Lambda_j x_{rj} - s_r = 0$; r = 1, ..., s.; $\Lambda_j, s_i, s_r \geq \forall_{j,i,r}$.

If θ_j = 1, this means that DMU_j is efficient relative to other units. If $\theta_j \leq 1$, then the DMU can be considered inefficient.

The previous equations (Eq. (1) and Eq. (2)) denote the CRS model with an input orientation, which is the one used in this study. For more information regarding the DEA methodology, see, e.g., Lee and Ji (2010).

3.2. Panel Autoregressive Distributed Lag Model

The PARDL model in the form of an Unrestricted Error Correction Mechanism (UECM) was used to evaluate the impacts of tourism capital investment, tourism arrivals, and direct tourism contribution to employment on the overall eco-efficiency of the selected LAC countries.

This study uses the PARDL method mainly due to fixed effects on our model and its flexible characteristics. It is robust in the presence of endogeneity, can deal with cointegration, and supports both I(0) and I(1) orders of integration, in the same estimation. Moreover, this methodology gives us the dynamic effects of the variables, allowing the division between the short-and long-run impacts. This decomposition can be understood as being similar to testing the Granger causality if a given coefficient present a statistically significant effect (Fuinhas et al., 2017).

The PARDL model follows the specification of Eq. (4), with the prefix "L" denoting the transformation of the variables into natural logarithms.

$$E_{it} = \alpha_{4i} + \beta_{4i1} E_{it-1} + \beta_{4i2} LIPC_{it} + \beta_{4i3} LIPC_{it-1} + \beta_{4i4} LN_{it} + \beta_{4i5} LN_{it-1} + \beta_{4i6} LEMP_{it} + \beta_{4i7} LEMP_{it-1} + \beta_{4i8} LEPC_{it} + \beta_{4i9} LEPC_{it-1} + \beta_{4i10} LT_{it} + \beta_{4i11} LT_{it-1} + \beta_{4i12} H_{it} + \beta_{4i13} H_{it-1} + \varepsilon_{4it} \quad (4)$$

The dynamic general UECM form of the PARDL model (Eq. (4)) can be reparametrised into Eq. (5) in order to obtain the dynamic relations between the variables.

$$DE_{it} = \alpha_{5i} + \beta_{5i1}DLIPC_{it} + \beta_{5i2}DLN_{it} + \beta_{5i3}DLEMP_{it} + \beta_{5i4}DLEPC_{it} + \beta_{5i5}DLT_{it} + \beta_{5i6}DH_{it} + \gamma_{5i1}E_{it-1} + \gamma_{5i2}LIPC_{it-1} + \gamma_{5i3}LN_{it-1} + \gamma_{5i4}LEMP_{it-1} + \gamma_{5i5}LEPC_{it-1} + \gamma_{5i6}LT_{it-1} + \gamma_{5i7}H_{it-1} + \varepsilon_{5it} \quad (5)$$

In the Eq. (5), the α_i represents the intercept, while β_{ik} and γ_{ik} represent the estimated parameters, with k = 1, …, 7 while the ε_{it} denotes the error term.

4. Results

This section is also divided into two sub-sections: 1) displays the DEA results; 2) presents the preliminary and specification tests of the PARDL model, as well as its outcomes.

4.1. Data Envelopment Analysis Results

The results of DEA are reported in Table 1, in the "Appendix" section. It reflects the changes in the overall eco-efficiency of each DMU, with CRS, during the period of analysis.

Looking at the individual outcomes, we conclude that Paraguay is the most efficient country (i.e. DMU) in our sample. It presents the highest eco-efficiency scores between 1995 and 2016, reaching a maximum value (E=1) in 2005. This value represents the DEA frontier, meaning that all other scores are considered inefficient against the 2005 score of Paraguay. This country is followed by Costa Rica, which is the second most efficient DMU in the entire period. On the contrary, Cuba seems to be the least efficient DMU during all period.

TABLE 2. Overall Eco-efficiency (E) scores averages with Constant Returns to Scale (%)

	1995-2005	2006-2016	1995-2016
Argentina	0.6700	0.6680	0.6690
Barbados	0.6952	0.6879	0.6916
Bolivia	0.6892	0.6834	0.6863
Brazil	0.6846	0.6820	0.6833
Chile	0.8400	0.8370	0.8385
Colombia	0.8823	0.8804	0.8813
Costa Rica	0.9105	0.9064	0.9084
Cuba	0.6599	0.6647	0.6623
Dominican R.	0.7720	0.7818	0.7769
Ecuador	0.6723	0.6665	0.6694
El Salvador	0.7087	0.7090	0.7089
Guatemala	0.7484	0.7421	0.7452
Guyana	0.8627	0.8657	0.8642
Haiti	0.7665	0.7433	0.7549
Honduras	0.7680	0.7567	0.7623
Jamaica	0.7945	0.8064	0.8004
Mexico	0.7117	0.7104	0.7110
Nicaragua	0.7826	0.7823	0.7824
Panama	0.7039	0.7033	0.7036
Paraguay	0.9945	0.9914	0.9930
Peru	0.7130	0.7037	0.7083
Uruguay	0.8072	0.8026	0.8049
Total average	0.7653	0.7625	0.7639

Table 2 shows the computed average for the Overall Efficiency scores of the countries between 1995 and 2016. According to the results, the regional average during the entire period was 76.39%, meaning that these countries could decrease the application of inputs (i.e. CO_2 emissions) by at least 23.61% to be more efficient. Following that guideline and considering the first- and second-decades averages, the CO_2 emissions from these LAC countries could be reduced by at least 23.47% and 23.75%, respectively. From the results displayed in Table 2, we can also note that almost all of the DMU's suffered a slight decrease in their efficiency scores between the first and second decades, except for Cuba, Dominican Republic, El Salvador, Guyana, and Jamaica, which were able to improve their scores between the 1995-2005 and 2006-2016 decades.

4.2. Panel Autoregressive Distributed Lag Results

Before we proceed with the PARDL estimation, it is crucial to understand the features of both the series and cross-sections. In this sense, a set of preliminary and specification tests were performed before the model estimation to uncover the variables' features and countries' analysis. First, in Table 3, we exhibit the descriptive statistics and the results from the Pesaran CD test (Pesaran, 2004). By the results of the CD test, we see that the presence of cross-sectional dependence is confirmed for all variables, both in natural logarithms and in first differences, with an exception for the overall eco-efficiency (E) in first differences. This outcome seems to point out that these countries share common shocks (see Fuinhas et al., 2015).

TABLE 3. Descriptive statistics and cross-sectional dependence

Variables	Descriptive statistics					Cross-sectional dependence (CD)		
	Obs	Mean	Std. Dev.	Min.	Max.	CD-test	Corr	Abs(corr)
E	484	0.7639226	0.0869688	0.653919	1	6.44***	0.090	0.390
LIPC	484	-13.58398	2.508002	-18.34472	-8.323441	23.11***	0.324	0.498
LA	484	13.99844	1.161789	11.09741	17.37311	57.46***	0.806	0.806
LEMP	484	1.233882	0.5829695	-0.1395276	2.81116	13.45***	0.189	0.369
LEPC	484	-6.939026	0.9524391	-10.67969	-5.598604	45.61***	0.640	0.769
LT	484	4.129005	0.4972411	2.74955	5.362827	15.85***	0.222	0.468
H	484	0.6796364	0.0845778	0.418	0.842	69.48***	0.975	0.975
DE	462	-0.0004092	0.0036985	-0.019732	0.014057	0.03	0.000	0.194
DLIPC	462	0.0425435	0.211792	-0.860465	1.168026	16.01***	0.230	0.328
DLA	462	0.055384	0.1313973	-0.7962065	1.273706	9.31***	0.134	0.217
DLEMP	462	0.0145773	0.1229764	-0.6297776	1.22041	4.11***	0.059	0.200
DLEPC	462	0.0293593	0.0816952	-0.5647078	0.6469841	5.05***	0.073	0.203
DLT	462	0.0006979	0.0974585	-0.4373145	0.6474607	23.23***	0.334	0.346
DH	462	0.0048052	0.0038672	-0.011	0.027	5.41***	0.078	0.203

Notes: To achieve the results of descriptive statistics and to test the presence of cross-sectional dependence; the Stata commands *sum* and *xtcd*, respectively, were used; the CD test has N(0,1) distribution under the H0: cross-sectional independence; *** denote statistical significance at 1% level.

In order to check the degree of correlation between the variables and test for the presence of multicollinearity, both the correlation matrix and Variance Inflation Factor (VIF) tests were computed. The results are presented in Table 4 (for the variables in natural logarithms) and Table 5 (for the variables in first differences).

The results from the correlation matrices do not seem to cause concerns, except for the correlation between the Human Development Index (H) and electric energy consumption (LEPC). Following Ouedraogo (2013), this high correlation can be explained because energy is directly linked with basic human needs (such as health, life expectancy or education). As the VIF statistics test presents lower VIF and the mean VIF values, this means that multicollinearity does not represent an econometric problem to our estimation. The high correlation between the Human Development Index (H) and electric energy consumption (LEPC) does not hamper the analysis.

TABLE 4. Correlation matrices and VIF statistics (natural logarithms)

	E	LIPC	LA	LEMP	LEPC	LT	H
E	1.0000						
LIPC	0.8030	1.0000					
LA	-0.2586	0.0845	1.0000				
LEMP	-0.1553	0.1326	0.3945	1.0000			
LEPC	-0.0052	0.3401	0.5739	0.4604	1.0000		
LT	0.3114	0.1256	-0.4456	0.2396	-0.0781	1.0000	
H	-0.1023	0.2884	0.6190	0.3966	0.9101	-0.1709	1.0000
VIF	n.a.	1.17	2.45	1.69	6.56	1.73	6.47
Mean VIF		3.34					

TABLE 5. Correlation matrices and VIF statistics (first differences)

	DE	DLIPC	DLA	DLEMP	DLEPC	DLT	DH
DE	1.0000						
DLIPC	-0.0994	1.0000					
DLA	-0.0540	0.2071	1.0000				
DLEMP	-0.0213	-0.0180	0.0635	1.0000			
DLEPC	-0.1281	0.1078	0.1380	0.0746	1.0000		
DLT	-0.1139	0.1455	0.1015	0.1140	-0.0670	1.0000	
DH	-0.0947	0.1598	0.0851	0.0189	0.1045	0.0926	1.0000
VIF	n.a.	1.09	1.07	1.02	1.05	1.06	1.04
Mean VIF		1.06					

Both the 1st generation and 2nd generation unit root tests were carried out (see Table 6) to assess the order of integration of the variables.

The Maddala and Wu (1999) panel unit root test of 1st generation was used because it considers cross-sectional independence. The absence of cross-sectional dependence on the overall eco-efficiency (E), in first differences, recommend this test as the most suitable to evaluate the stationarity of this variable. The results of this test support that DE is I(0).

In order to analyse the orders of integration of the remaining variables, the cross-sectionally augmented IPS (CIPS) test (Pesaran 2007) was computed. This test accounts for the presence of cross-sectional dependence in the variables. Its results indicate that most of the variables are on the borderline between I(0) and I(1) orders of integration. Derived from this conclusion, we can assume that the PARDL methodology is the most suitable for our estimation since it is capable of handling at the same time I(0) and I(1) variables (or fractionally integrated variables).

TABLE 6. Panel Unit Roots tests

	1st generation unit root test		2nd generation unit root test	
	MW (Zt-bar)		**CIPS (Zt-bar)**	
	Without trend	**With trend**	**Without trend**	**With trend**
E	67.678**	59.944*	-0.846	0.649
LIPC	76.533***	94.045***	-5.940***	-2.374***
LA	39.811	77.400**	-0.812	0.606
LEMP	56.425*	40.809	-1.645*	-1.979**
LEPC	62.478**	60.919**	-0.364	0.205
LT	39.239	33.752	-0.618	1.298
H	20.024	49.275	-1.127	2.632
DE	293.902***	230.432***	-6.432***	-4.793***
DLIPC	217.249***	159.264***	-6.002***	-4.316***
DLA	154.714***	113.964***	-3.380***	-2.411***
DLEMP	177.993***	132.244***	-7.308***	-5.058***
DLEPC	175.872***	147.872***	-4.565***	-3.273***
DLT	193.608***	152.763***	-4.880***	-2.913***
DH	233.909***	187.768***	-4.703***	-3.185***

Notes: *, **, *** denote statistical significance at 10%, 5%, and 1% level, respectively; Maddala and Wu (1999) Panel Unit Root Test (MW) assumes that cross-sectional independence and H_0: series is I(1); Pesaran (2007) Panel Unit Root Test (CIPS) assumes that cross-sectional dependence is in the form of a single unobserved common factor and H_0: series is I(1); the Stata command *multipurt* was used to compute these tests.

The Hausman test was also performed to confront random and fixed effects in the panel and choose the most suitable estimator. The Hausman test results (in Table 7) seem to indicate that the individual effects of the countries are significant and should be taken into account, being the fixed effects model the most appropriate to analyse the impacts of the variables over time. Additionally, as a form of robustness, both the *sigmaless* and *sigmamore* options of the Hausman test were used (see Fuinhas et al., 2019; Santiago et al., 2018).

TABLE 7. Hausman test

	FE vs RE
Hausman test	Chi2(13) = 104.37***
Sigmaless	Chi2(13) = 105.10***
Sigmamore	Chi2(13) = 87.18***

Notes: *** denotes significance at 1% level; in both models, the Hausman test were performed with both the *sigmaless* and *sigmamore* options; H_0: random effects are the most appropriate, or the difference in coefficients is not systematic.

As we previously stated, before the model estimation, a group of specification tests were also computed. These tests were: 1) the Modified Wald Test, to check the presence of heteroskedasticity; 2) the cross-sectional independence Pesaran test[1], to test the presence of contemporaneous correlation; 3) The Breusch-Pagan Lagrangian multiplier test, to verify if the variances across individuals are not correlated; and 4) the Wooldridge test, to check the existence of serial correlation. The results of these tests confirmed heteroskedasticity and first-order autocorrelation in the model. Although, the result from the cross-sectional independence Pesaran test indicated that contemporaneous correlation is not present in the model. We should also refer that the Breusch-Pagan Langragian could not be carried out probably since, in our sample, the number of countries is higher than the number of years, giving origin to the problem: "the correlation matrix of residuals was singular". Although the cross-sectional independence Pesaran's test tests a similar hypothesis, this is far from a concern. All the results are displayed in Table 8.

TABLE 8. Specification tests

	Statistics
Modified Wald test	1789.78***
Pesaran's test	-0.142
Wooldridge test	57.938***

Notes: H_0 of Modified Wald test: sigma(i)^2= sigma^2 for all I; H_0 of Pesaran's test: residual are not correlated and follow a normal distribution; H_0 of Wooldridge test: no first-order autocorrelation; *** denotes statistical significance at 1% level; both the Frees and Friedman tests (H_0: cross-sectional independence) were also performed, and the results corroborate with the Pesaran's test results.

Considering the presence of cross-sectional dependence in the variables and heteroskedasticity and first-order autocorrelation in the model, the Driscoll and Kraay (1998) estimator seems to be the most suitable estimator because it is capable of producing standard errors robust to the previously mentioned disturbances.

In the first estimation of the model, the tourism capital investment (DLIPC), the direct tourism contribution to employment (DLEMP) and, the Human Development Index (DH), were all not statistically significant in the short-run. Given this outcome, in accordance with the principle of parsimony, these variables were retrieved from the estimation (following a stepwise regression with a backward elimination approach). Eq. (5) was replaced by Eq. (6) to represent the most parsimonious model:

$$DE_{it} = \alpha_{5i} + \beta_{6i1}DLN_{it} + \beta_{6i2}DLEPC_{it} + \beta_{6i3}DLT_{it} + \gamma_{6i1}E_{it-1} + \gamma_{6i2}LIPC_{it-1} + \gamma_{6i3}LN_{it-1} + \gamma_{6i4}LEMP_{it-1} + \gamma_{6i5}LEPC_{it-1} + \gamma_{6i6}LT_{it-1} + \gamma_{6i7}H_{it-1} + \varepsilon_{6it} \quad (6)$$

When working upon macro panels, it is generally recommended to test the panel heterogeneity/homogeneity. In order to cope with this recommendation, both the Mean Group (MG) and Pooled Mean Group (PMG) estimators were computed. The MG runs a regression for each cross, computing posteriorly an average coefficient for all individuals, although it is inefficient in the presence of homogeneity (Pesaran et al., 1999). Contrariwise, PMG performs restrictions among cross-sections, i.e., the long-run parameters must be homogeneous while in the short-run parameters can be heterogeneous.

To evaluate if MG and PMG are adequate estimators, we tested them against the Dynamic Fixed Effects (DFE) estimator. The Hausman tests to the three specifications are presented in Table 9. The outcomes of these tests revealed that the DFE is the preferable estimator over the MG and PMG, indicating that the panel seems to be homogeneous. This result supports, once again, the idea that countries from our sample share identical behaviours and common shocks.

TABLE 9. Estimation Results of Heterogeneous estimators and Hausman test for selection

Dependent Variable: **DE**	**MG**	**PMG**	**DFE**
Constant	0.4509***	0.2913***	0.2470***
DLA	0.0016	-0.0009	-0.0017
DLEPC	-0.0004	-0.0072*	-0.0061***
DLT	-0.0042	-0.0007	-0.0040**
E (-1) (ECM)	-0.8581***	-0.4699***	-0.3161***
LIPC (-1)	-0.0015	0.0014***	0.0028**
LA (-1)	0.0047	0.0011	-0.0060**
LEMP (-1)	0.0029	0.0020**	0.0039
LEPC (-1)	-0.0264***	-0.0164***	-0.0119***
LT (-1)	-0.0014	-0.0020**	-0.0090***
H (-1)	0.0510	0.0544***	0.0809**
Diagnostic statistics			
N	462	462	462
Hausman test for selection			
	MG vs PMG	**MG vs DFE**	**PMG vs DFE**
	Chi2(11) =1.13	Chi2(11) =0.00	Chi2(11) =0.00

Notes: ***, **,* denote statistical significance at 1%, 5% and, 10% level, respectively; the Stata command *xtpmg* was used to estimate the models; the Hausman test was performed with the *sigmamore* and *constant* options; H_0: difference in coefficients not systematic.

Table 10 shows the estimation results from the parsimonious model with the fixed-effects Driscoll-Kraay (FE-DK) estimator. We should stress that the previously mentioned specification tests were remade to the parsimonious model to grant that the results also hold for this model, i.e., grant that the model specification remained valid. In Table 10, the fixed effects (FE) and the fixed effects robust (FER) estimators were also presented, but only to reveal the differences when we correct/not correct the phenomena found. For that reason, our analysis is based on the fixed-effects Driscoll-Kraay (FE-DK) results.

TABLE 10. PARDL Estimation Results of Fixed Effects and Driscoll-Kraay estimators

Dependent Variable: **DE**	**FE**	**FER**	**FE-DK**
Constant	0.2470***	0.2470***	0.2470***
DLA	-0.0017	-0.0017	-0.0017*
DLEPC	-0.0061***	-0.0061***	-0.0061***
DLT	-0.0040**	-0.0040*	-0.0040**
E (-1) (ECM)	-0.3161***	-0.3161***	-0.3161***
LIPC (-1)	0.0009**	0.0009**	0.0009***
LA (-1)	-0.0019**	-0.0019*	-0.0019***
LEMP (-1)	0.0012	0.0012	0.0012**
LEPC (-1)	-0.0037***	-0.0037*	-0.0037***
LT (-1)	-0.0029***	-0.0029	-0.0029***
H (-1)	0.0256**	0.0256	0.0256**
Diagnostic statistics			
N	462	462	462
R^2	0.2236	0.2236	0.2236
F	F(10,430)=12.39***	F(10,21)=18.97***	F(10,20)=50.45***

Notes: ***, **, * denote statistical significance at 1%, 5%, and 10% level, respectively; the Stata command *xtreg* and *xtscc* were used to estimate the models.

The results of our estimation demonstrate that, in the short-run, the tourism arrivals (DLA), the electric energy consumption (DLEPC), and the trade openness (DLT) are all statistically significant at 10%, 1%, and 5% level, respectively, and all have a negative effect on the eco-efficiency (i.e. contribute to its decrease). Table 10 also shows that all variables included in the model are statistically significant in the long-run, with the tourism capital investment (LIPC), the tourism direct contribution to employment (LEMP), and the Human Development Index (H), all having a positive impact on eco-efficiency (i.e. contribute to its increase). Conversely, tourism arrivals (LA), electric energy consumption (LEPC), and trade openness (LT) all seem to have a negative effect on these countries eco-efficiency in the long-run.

The long-run elasticities are not displayed in Table 10. The elasticities are calculated doing the ratio between the variables coefficient and the E(-1) coefficient, both lagged once, being posteriorly this ratio multiplied by - 1. The short-run impacts, the long-run elasticities, and the adjustment speed of the model (ECM) are presented in Table 11.

TABLE 11. Short-run impacts, elasticities and speed of adjustment

Dependent Variable: **DE**	**FE**	**FER**	**FE-DK**
Short-run impacts			
DLA	-0.0017	-0.0017	-0.0017*
DLEPC	-0.0061***	-0.0061***	-0.0061***
DLT	-0.0040**	-0.0040*	-0.0040**
Long-run (computed) elasticities			
LIPC	0.0028269**	0.0028269***	0.0028269***
LA	-0.0060279**	-0.0060279**	-0.0060279**
LEMP	0.0038883	0.0038883	0.0038883**
LEPC	-0.0118508***	-0.0118508**	-0.0118508***
LT	-0.0090347***	-0.0090347	-0.0090347***
H	0.0809307**	0.0809307**	0.0809307***
Speed of adjustment			
ECM	-0.3161***	-0.3161***	-0.3161***
Diagnostic statistics			
N	462	462	462
R^2	0.2236	0.2236	0.2236
F	F(10,430)=12.39***	F(10,21)=18.97***	F(10,20)=50.45***

Notes: ***, **, * denote statistical significance at 1%, 5%, and 10% level, respectively; the ECM denotes the coefficient of the variable E lagged once.

In the results presented above, we observe that the tourism arrivals (DLA and LA), the electric energy consumption (DLEPC and LEPC), and the trade openness (DLT and LT) all contribute to the LAC eco-efficiency decrease (both in short- and long-run). Regarding the tourism capital investment (LIPC), the direct tourism contribution to the employment (LEMP) and the Human Development Index (H) all proved to be statistically significant, but only in the long-run, with all seeming to contribute to increasing these countries eco-efficiency.

Regarding the ECM, we see that it has a negative and statistically significant coefficient in our estimation, pointing to the presence of long-memory between the variables. This value represents the speed of adjustment of the models, i.e., the speed at which the dependent variable returns to equilibrium after changes in the explanatory variables. In our case, the speed of adjustment is relatively moderated, indicating that after a change in the explanatory variables, our dependent variable will return to equilibrium after a relatively short/moderate period.

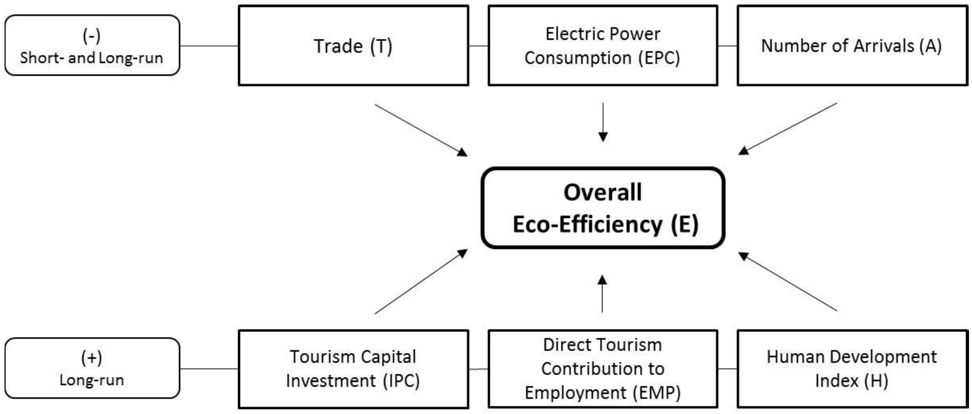

Fig. 1. *Summary of* the PARDL results*. The impact signals were based on the coefficients of the PARDL estimation* (TABLE 11)*.*

5. Discussion and policy implications

By the outcomes of the DEA estimation, it is possible to perceive that almost all LAC countries suffered a slight decrease in the overall eco-efficiency values between the first and second decade. The reason that can probably explain these results in this region is that the CO_2 emissions are caused mainly by fossil fuels (Vergara et al., 2015).

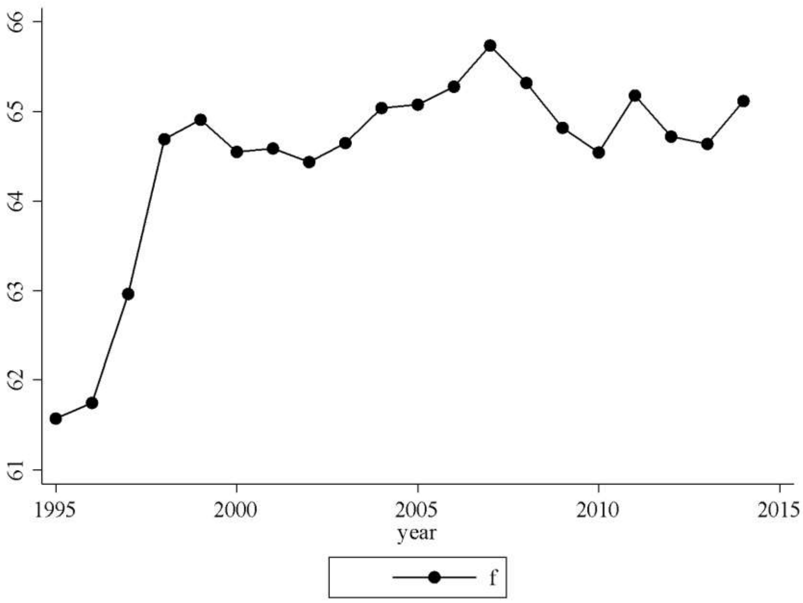

Fig. 2. Fossil fuel consumption (% of total) of Latin America and Caribbean countries. Notes: the Stata command *twoway scatter* was used to obtain this graph; the black dots represent the mean of the fossil fuels consumption for the region.

According to Fig. 2., we can see that the consumption of fossil fuels grew over time, with the most accentuated peaks being reached during the second period of our analysis. This fact could probably explain the observed reduction in the eco-efficiency scores ranging from 2005 to

2016. This point heightens a possible link with the pressure from transport demand, one of the major challenges this region faces (Viscidi and O'Connor, 2017). In LAC countries, both passenger and freight transport are rapidly increasing. Although public transport continues to be the most used by the population of this region, the inefficiency, unsafe conditions of urban mobility, the middle-class and urbanisation growth encourage the purchase of private cars and motorcycles (Yañez-Pagans et al., 2019). These factors result in severe urban congestion, traffic accidents, and air pollution in the LAC region (Viscidi and O'Connor, 2017).

Following the previous idea and the report from IRENA (2016), countries as Paraguay and Costa Rica account for a small percentage of total LAC CO_2 emissions. By contrast to the other countries in the region, they are a pioneer in hydroelectric (Itaipu power plant) and renewable (it uses nearly 100% renewable energy for generating its electricity) energy supply, respectively. This fact can explain why these two countries were noticed as being the most efficient countries of our analysis. However, in order to enhance their eco-efficiency even more, Paraguay and Costa Rica must continue to work on the decarbonisation of their transport sectors since that it is the main factor motivating the oil and derivatives consumption and the increase of the national CO_2 emissions in both countries (IRENA, 2019a; Timilsina and Shrestha, 2009).

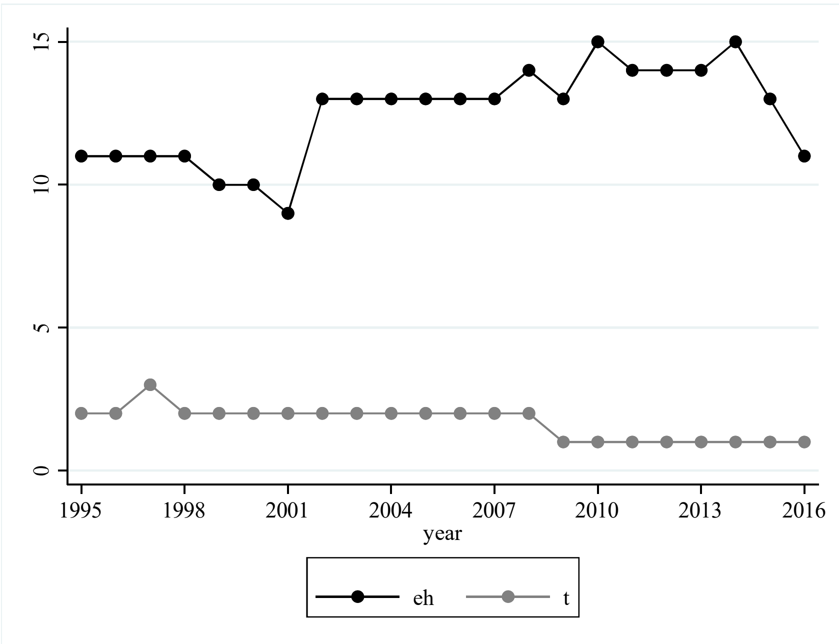

Fig. 3. CO_2 emissions by electricity and heat generation and transport sectors in Cuba. Notes: the Stata command *twoway scatter* was used to obtain this graph; the black dots represent CO_2 emissions from the electricity and heat generation sector (eh) while the grey dots represent CO_2 emissions from the transport sector (t), both from Cuba.

Furthermore, it is possible to observe that Cuba was one of the few countries that improved the eco-efficiency score between the first and second decades. This improvement can be linked with the CO_2 emissions decrease from the electricity and heat generation and the transport sector – see Fig. 3. Although, due to the high fossil fuel consumption in its energy mix (which reached about 80% of total energy production in 2014), and to the deceleration of its economic growth (apparently caused by the Venezuela political and economic crisis in 2015 to 2016, given that it is the major Cuban trade partner). Cuba remained the least efficient DMU during the 1995-2016 period (Pedraza, 2018; BTI, 2018).

Given the previously stated facts, renewable energy deployment becomes extremely necessary to decrease the region's fossil fuel dependence and attenuate its environmental issues. In this sense, a battery of new and variated policies must be adopted to support the penetration of renewable sources in the energy mix of a range of sectors. As an example, being the transport sector one major contributor to the escalation of the LAC environmental concerns, mainly due to its energy intensity, the increases in its energy efficiency and the renewable share can be a precious help to decarbonise the region's energy sector. The policymakers should be bearing this in mind when exploring the synergies between the power and transport sectors (for example, offering favourable conditions to electric vehicles acquisition), remove fossil fuel subsidies, and promote the investment in R&D and renewable fuels (more efficient biofuels).

Regarding the PARDL estimation outcomes, we can say that the depressing effect of the electric energy consumption and the trade openness on the LAC eco-efficiency (both in the short- and long-run) is probably linked with these countries' economic dependence on fossil fuels. Part of them is dependent on the imports of commodities, and others are substantial fossil fuels producers (Fuinhas et al., 2017; Keho, 2017). Moreover, the human development index (in the long-run) seems to improve the overall eco-efficiency of this region. This fact can be associated with the education dimension upsurge, which probably has led to the positive progress in the LAC HDI and is an essential tool for sustainable development (Prados de la Escosura, 2015; Rasekhi and Mohammadi, 2015).

Looking at the interest variables outcomes and answering the central question, we see that tourism arrivals have a negative impact (contribute to a decrease) on the LAC eco-efficiency. This negative impact is because countries probably adopt tourism as an economic development strategy but seem to forget that the tourism arrivals' growth can involve unsustainable practices, possibly resulting in over-tourism emergence.

Over-tourism embraces both tourism carrying capacity and tourism congestion management. It is commonly associated with irreversible environmental implications, such as the loss of destination authentic heritage, deterioration of natural ecosystems or air pollution, and overcrowding and congestion in transport infrastructure, public spaces, and local roads (Capocchi et al., 2019). Given that tourists are becoming sensitive to the environment quality and its features, this phenomenon can also be responsible for a demand decline in the tourism sector, with negative economic repercussions, especially in economies strongly dependent on tourism (Peeters et al., 2018). An example of these shortcomings is the lack of carrying capacity, uncivilised comportments and congestion, which tourists felt at Machu Picchu (Peru) (Peeters et al., 2018).

Contrariwise, tourism direct contribution to employment positively affects eco-efficiency (but only in the long-run). The explanation for that seems to be connected to the local population benefits generated by the tourism job creation (Barišić and Cvetkoska, 2019). Particularly in developing countries, the local community's access to employment is crucial to tourism sustainable development. That it is a form to involve these communities in the economic benefits of this sector (Dogra and Gupta, 2012) and to incentive education and training of the employees, which, in turn, can lead to a decrease in environmental degradation and improvement of the natural heritage conservation (Anup, 2016). These positive effects can also be associated with the integration of vulnerable groups – as women, young people and indigenous – which can lead to poverty reduction and social/economic development (International Labour Organization, 2011).

Regarding the positive impact of tourism capital investment on these countries eco-efficiency in the long-run, it can be related to the critical tourism role in spurring investments in human capital development and new infrastructures in the LAC countries (Fayissa et al., 2011). Thus, it can bring considerable benefits to the local community (OECD, 2018) – through employment, higher income, or social cohesion – and be a mechanism to the own sector development and, consequently, to economic growth (Du et al., 2016).

Moreover, some authors have identified tourism investment as a relevant factor to CO_2 emissions mitigation (Paramati et al., 2016). That is probably linked to the capacity of tourism investments to heighten the environmental quality – investing in renewables energy, clean technologies, and eco-friendly activities by tourism companies (Lu et al., 2019). Given the previously mentioned facts, the projects developed and financed by the Inter-American Development Bank (IDB) to help LAC countries achieve sustainable tourism can be stressed as some of the reasons for the obtained results. For example, in 2010, the IDB approved the financing to the construction of 8 Marriott hotels in the region, imposing its *Leadership in Energy and Environmental Design* (LEED) certification (IDB, 2010).

Overall, the results from the interest variables reveal a necessity for the policymakers to rethink and rebalance their strategies on how to achieve tourism sustainable growth. Instead of developing measures that are only focused on increasing tourism arrivals, they must pay more attention to tourists' distribution and respect the destination carrying capacity. To regulate demand without increasing supply should be applied "congestion pricing" in high seasons and/or in specific areas (such as museums, natural parks, or hotels). Additionally, it could be advantageous to promote less visited places or tourist attractions and develop experiences/projects during off-seasons. It could be beneficial to focus on the residents' inclusion to encourage their contribution in the new tourism products development and based on what they would like to offer to visitors. In addition, it would be essential to provide financial funds (promoted by NGOs or organizations directly linked to the tourism sector) to develop regional employment plans in tourism. It is also essential to support training programs for the local community to improve their skills or improve agreements between companies linked to the sector. Together with the expansion of attractions in low seasons, these plans will decrease seasonality and create more decent workplaces. Lastly, policymakers should also continue to increase the levels of green R&D investments in tourism, which will help take advantage of these countries' potential to the renewables' energy penetration and, simultaneously, enhance the profitability and economic output of this region. Moreover, the investments in public transport oriented for visitors' (mainly in high seasons) and cycling routes creation possible will lead to a traffic congestion decrease and improvement environmental preservation.

6. Conclusion

In this investigation, a PARDL method was applied to a panel of 22 LAC countries between 1995 and 2016 to investigate the impacts of the tourism sector on the region eco-efficiency. Firstly, we applied a CRS DEA model to measure the countries eco-efficiency scores. Posteriorly, the impacts of tourism arrivals, tourism capital investment, and tourism direct contribution to employment on the eco-efficiency scores were investigated in the short-and long-run, using a PARDL model. The specification tests confirmed that variables have cross-sectional dependence, and the estimated model revealed heteroscedasticity and first-order autocorrelation. For these reasons, the Driscoll-Kraay estimator with fixed effects was used to conduct the analysis. The EMC presents a negative coefficient with a 1% statistical significance level, pointing to cointegration/long-memory relationships between the variables.

The DEA outcomes revealed a reduction in the eco-efficiency scores between the first and second decades of our analysis (1995-2005; 2006-2016) in most LAC countries, with Paraguay and Costa Rica being the most efficient DMU's and with Cuba being the least efficient DMU during all periods. Given the decrease in eco-efficiency, we think the LAC governments must develop policies to promote renewable sources penetration. Thus, the decarbonisation of these economies should be encouraged, especially in the transport sector. This strategy can probably reduce this region's dependence on fossil fuels and be used as a tool to decarbonise its energy sector.

Focusing on the PARDL model results, it is possible to observe that the tourism arrivals negatively influence the LAC eco-efficiency, both in the short- and long-run. Contrariwise, in the long-run, we saw that the tourism capital investment and the direct tourism contribution to employment contributed to increasing the region eco-efficiency, with the tourism capital investment being its primary driver. In this sense, the policymakers should apply measures with paramount awareness in destinations carrying capacity and congestion management and not only in promoting mass arrivals. They also should take advantage of the tourism economic benefits without neglecting their countries' environment. Furthermore, they should continue to plan and sustainably regulate investments and promote the tourism sector productive employment (mainly to ensure residents' inclusion and enhance their well-being).

For further research, considering that sustainable energy sources remarkably influence the eco-efficiency performance of the LAC countries, it could be suitable the inclusion of ratio variable that represents the renewable fuel percentage on power generation.

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Appendix

TABLE A1. Overall Eco-efficiency (E) scores with Constant Return to Scale (%)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	0.67068	0.670098	0.671278	0.671756	0.66911	0.670099	0.671162	0.670764	0.670045	0.666719	0.667845
Barbados	0.70555	0.70568	0.704489	0.693979	0.691084	0.693514	0.69132	0.691483	0.690681	0.69018	0.689342
Bolivia	0.687315	0.688662	0.685491	0.686749	0.689059	0.687274	0.698576	0.691168	0.68921	0.690361	0.687741
Brazil	0.688905	0.686048	0.684974	0.683697	0.682916	0.683076	0.682477	0.68378	0.685126	0.684727	0.684609
Chile	0.84728	0.841944	0.836643	0.836619	0.833258	0.836804	0.842372	0.841485	0.842197	0.840575	0.840546
Colombia	0.879724	0.879558	0.877008	0.876516	0.883287	0.882985	0.884278	0.885286	0.884626	0.887933	0.884208
Costa Rica	0.913739	0.915557	0.914355	0.912676	0.911598	0.913216	0.911364	0.906837	0.905341	0.904275	0.906351
Cuba	0.653919	0.654107	0.658401	0.658685	0.659044	0.659469	0.661252	0.660683	0.662626	0.664925	0.666325
Dominican R.	0.772145	0.769762	0.770412	0.77123	0.772502	0.770839	0.771515	0.769402	0.768627	0.776815	0.778543
Ecuador	0.670854	0.669082	0.681371	0.674062	0.674454	0.676289	0.67301	0.671105	0.668798	0.668088	0.667924
El Salvador	0.712075	0.716873	0.709377	0.707433	0.70897	0.708978	0.70771	0.707592	0.704377	0.705924	0.706037
Guatemala	0.755897	0.760358	0.755254	0.750003	0.750205	0.746418	0.74388	0.742989	0.744876	0.742578	0.739957
Guyana	0.862785	0.863063	0.862175	0.859176	0.859337	0.861435	0.862725	0.863653	0.864009	0.862158	0.869083
Haiti	0.789479	0.783063	0.768445	0.774889	0.771529	0.770331	0.763091	0.755115	0.758006	0.74969	0.748026
Honduras	0.778385	0.778102	0.777038	0.772249	0.771097	0.770452	0.764906	0.762787	0.75896	0.75672	0.757262
Jamaica	0.79898	0.796237	0.794003	0.795185	0.794161	0.792687	0.791842	0.794181	0.793037	0.793845	0.795154
Mexico	0.713277	0.713299	0.712552	0.711869	0.712314	0.712946	0.711544	0.711418	0.709593	0.710415	0.708977
Nicaragua	0.790238	0.790417	0.786908	0.783562	0.7826	0.782108	0.780297	0.779636	0.776174	0.777256	0.779818
Panama	0.726387	0.706655	0.6994	0.699208	0.702551	0.702506	0.694031	0.702633	0.701834	0.7068	0.701417
Paraguay	0.994029	0.998149	0.992102	0.987537	0.987121	0.999471	0.996924	0.995447	0.994006	0.994915	1
Peru	0.715975	0.715851	0.712581	0.711979	0.710082	0.709506	0.714262	0.71571	0.718133	0.711557	0.706987
Uruguay	0.812005	0.804726	0.806164	0.806313	0.79704	0.808697	0.809917	0.812677	0.813271	0.803953	0.804632

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Argentina	0.666988	0.66919	0.667488	0.667743	0.668611	0.669379	0.668979	0.670046	0.666872	0.6669	0.66627
Barbados	0.690547	0.691307	0.682892	0.681555	0.685962	0.684496	0.686361	0.687049	0.693485	0.691957	0.691726
Bolivia	0.680241	0.689993	0.68881	0.68754	0.685216	0.684204	0.679313	0.680961	0.679379	0.680754	0.680797
Brazil	0.685548	0.685456	0.684426	0.686297	0.683412	0.68278	0.680929	0.679227	0.677611	0.677257	0.679109
Chile	0.839875	0.836462	0.837287	0.840211	0.838015	0.835369	0.835758	0.835655	0.836499	0.836979	0.834682
Colombia	0.884351	0.886576	0.883086	0.880147	0.878969	0.880516	0.879249	0.874877	0.879169	0.878434	0.878767
Costa Rica	0.906081	0.901268	0.902471	0.903872	0.907201	0.907252	0.908465	0.910471	0.910298	0.907097	0.905643
Cuba	0.667412	0.670244	0.666337	0.667428	0.658472	0.661674	0.662308	0.664486	0.664718	0.664406	0.663844
Dominican R.	0.778435	0.777346	0.779322	0.780638	0.781116	0.78151	0.780353	0.783181	0.785148	0.785979	0.787081
Ecuador	0.671021	0.667759	0.667244	0.664966	0.665489	0.665361	0.667351	0.665901	0.664216	0.665419	0.667066
El Salvador	0.704749	0.70447	0.708064	0.708118	0.708837	0.70866	0.709451	0.713085	0.713028	0.711098	0.70983
Guatemala	0.741211	0.743128	0.748746	0.746804	0.748919	0.749451	0.749791	0.744769	0.732595	0.72938	0.727815
Guyana	0.877394	0.867879	0.868664	0.869522	0.865161	0.864667	0.859604	0.862953	0.861958	0.862666	0.862699
Haiti	0.747825	0.742517	0.742683	0.746498	0.748082	0.747627	0.746371	0.745688	0.737762	0.736096	0.735637
Honduras	0.763048	0.753934	0.755778	0.759796	0.760135	0.755648	0.756758	0.757113	0.755883	0.753196	0.751947
Jamaica	0.79115	0.800033	0.797179	0.809344	0.812286	0.809131	0.8115	0.807552	0.811871	0.810223	0.809878
Mexico	0.709037	0.709307	0.708632	0.708594	0.710688	0.710006	0.709966	0.710717	0.712095	0.713242	0.711906
Nicaragua	0.779366	0.779331	0.782482	0.780619	0.781577	0.779791	0.784462	0.786757	0.784805	0.783255	0.782346
Panama	0.700531	0.704988	0.707198	0.700509	0.699249	0.698216	0.70114	0.700515	0.710764	0.707235	0.706035
Paraguay	0.998915	0.998154	0.995558	0.993658	0.9897	0.988194	0.988697	0.989513	0.987836	0.98757	0.987841
Peru	0.711603	0.705319	0.709666	0.70069	0.698524	0.706138	0.703644	0.703666	0.70118	0.700643	0.699485
Uruguay	0.798577	0.805784	0.791552	0.794338	0.808395	0.799926	0.795145	0.803386	0.81037	0.810519	0.810146