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Environmental sustainability and tourism growth: convergence or compensation?

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Abstract

In addition to the socio-economic advantages, tourism has been proven to be one of the most important sectors with adverse environmental effects. Therefore, this study examines the relationship between tourism and environmental sustainability by using a panel data from 32 countries in Latin America and the European Union for the period 2000–2019. Several techniques of cointegration and convergence of clusters are used to meet this objective. The empirical results show that on average, tourism growth has a negative impact on the environment in the two groups of countries, which could be attributed to the heterogeneity of the level of regional tourism development. On the other hand, the convergence of tourism growth and environmental sustainability is evident at different adjustment speeds in the different sample panels. It generates empirical evidence on whether the current expansion of the tourism sector in Latin American and European countries entails significant environmental externalities by using the ecological footprint variable as an indicator of environmental sustainability and foreign tourist arrivals as an economic indicator.

Keywords Environmental sustainability · Tourism · Cointegration panel · Convergence

1 Introduction

Over the past decades, countries have experienced rapid economic growth around the world (Koengkan et al. 2019). In line with the World Tourism Organization (UNWTO), more than 900 million tourists made international trips during the year 2022, twice as many as in 2021. This figure is 63% of the pre-pandemic level. In general, the number of international tourists has increased in all regions of the world. Europe, with 585 million arrivals in 2022, has reached almost 80% of pre-pandemic levels. Africa and North, Central and South America reached about 65% of pre-pandemic visitor levels (UNWTO 2023).

Tourism is one of the important factors that can affect the environmental and economic situation of any economy (Ozturk et al. 2023). Thus, tourism and economic growth have been found to go hand in hand, especially in tourist destinations (Adedoyin et al. 2021). In addition, tourism transfers economic income from developed to developing countries

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(Danish and Wang 2018). However, despite the benefits that tourism provides, it also affects environmental quality, as increased international tourism not only stimulates economic growth, but also increases energy consumption (Bojanic and Warnick 2020; Danish and Wang 2018) and the use of products derived from the extraction of natural resources (Robaina-Alves et al. 2016).

Therefore, most of the empirical and theoretical studies have argued that tourism contributes significantly to environmental degradation (Shahbaz et al. 2021; Danish and Wang 2018), so this relationship has been studied from two perspectives. The first perspective focuses on testing the Environmental Kuznets Curve (EKC) hypothesis, which is an inverted U-shaped relationship between pollutants and economic growth. Based on Kuznets (1955), this theory was put forth by scholars Grossman and Krueger (1991). According to this idea, economic expansion affects environmental degradation as measured by CO_2 emissions to a point when it becomes sustainable and has a negative influence (Arbulú et al. 2015; Ozturk et al. 2016; Mikayilov et al. 2019; Anser et al. 2020; Fethi and Senyucel 2021; Porto and Ciaschi 2021; Gao et al. 2021). The second perspective includes research that examines the relationship between tourism growth and environmental degradation (De Vita et al. 2015; Zaman et al. 2016; Pablo-Romero et al. 2019; Alizadeh 2020; Anser et al. 2020).

Most of these studies (Kusumawardani and Dewi 2020; Rahman 2020; Mohammed et al. 2015; Ozturk and Al-Mulali 2015; Galeotti et al. 2006) have analyzed the relationship between tourism growth and environmental degradation based on the variables of energy consumption and carbon dioxide emissions. According to Ozturk et al. (2023), the empirical findings point to a mix of favorable and unfavorable effects of visitor arrivals and CO_2 emissions in the majority of tourist locations. Environmental degradation has been shown to be a multifaceted phenomenon with a variety of indicators, which requires a comprehensive assessment of the state of the environment (Wackernagel and Rees 1998; Saqib and Benhmad 2021a, b; Pulido-Fernández et al. 2019).

In this regard, some studies (Saqib and Benhmad 2021a, b; Satrovic and Adedoyin 2022) have found that the ecological footprint is a more accurate tool for measuring and visualizing the resources that sustain the planet because it considers how dependent humans are on the environment in order support a lifestyle (Kyara et al. 2022; Saqib and Benhmad 2021a, b; Elshimy and El-Aasar 2020; Figge et al. 2017; Ozturk et al. 2016; Rojas-Downing et al. 2018). In line with this, Gössling (2000) points out that the relationship between tourism expansion and carbon emissions, as well as evidence of the detrimental effects of fossil fuels used in the industry on the environment are some aspects of the impact of tourism growth on the ecological footprint.

As a result, the main objective of this study is to assess how tourism growth and environmental sustainability in Latin America and the European Union are related. Due to the lack of comprehensive statistical data for all the countries in the region and for all the years, the statistical data from 14 Latin American countries and 18 European countries were used between 2000 and 2019. In order to do this, the present research used convergence cluster analysis, generalized least squares (DOSL), cointegration analysis using unit root and causality tests to examine the relationship between the ecological footprint (global hectares per capita) and the number of international tourist arrivals.

In addition, this study also contributes two important elements to the literature on tourism. First, it generates empirical evidence on whether the current expansion of the tourism sector in Latin American and European countries entails significant environmental externalities by using the ecological footprint variable as an indicator of environmental sustainability and foreign tourist arrivals as an economic indicator. Second, the research

ranks nations based on the likelihood that their environmental performance will be covered, considering the fact that environmental sustainability can be influenced by tourism growth. To do this, the convergence club method presented by Phillips and Su (2007) is used, which finds three convergence groups with the potential for the final two groups to merge into a single club.

Following this introduction, the study will be divided into the following sections: Sect. 2 presents the bibliographical and empirical review on the topic. In Sect. 3, two sections are presented: in the first section, the description of the data and bibliographical sources; and, in the second section, the methodologies used are described. Section 4 shows the results obtained, while Sect. 5 provides a discussion of the findings. The last section presents the conclusions obtained.

2 Theoretical framework

There is a significant and growing interest in the connection between tourism and the environment within the analysis of the literature and empirical evidence, which suggests that this relationship can be studied from two relevant aspects. The first aspect explores the causal relationship of tourism on environmental degradation. For example, Usman et al. (2021) investigate the causal link in Asian countries and find that tourism is what is influencing the region's environmental degradation. On the other hand, Shi et al. (2020) find a two-way causal relationship in high-income economies around the world. Other research, such as that by Lee and Brahmasrene (2013) and de Vita et al. (2015) explores this connection along with electrical energy use, demonstrating the beneficial impact of tourism on environmental degradation; while Zaman et al. (2016) determine an inverse relationship between the variables considered for an analysis in three regions of the world. According to Lv and Xu (2023), tourism always has a major detrimental impact on environmental performance, meaning that environmental deterioration will inevitably come from tourism, regardless of how developed the industry is. On the other hand, tourism will comparatively have less of an impact on environmental performance after it reaches a certain level of development.

The second aspect examines whether the EKC hypothesis caused by tourism actually exists. Kuznets (1955) investigated "the inverted U-shaped relationship between income inequality and per capita income". Subsequently, the pioneering study by Grossman and Krueger (1991) analyzed the connection between air quality and income growth. This study provided evidence supporting the Kuznets curve. Numerous empirical studies that explored and validated the EKC hypothesis in global tourism have been conducted in recent years (Ozturk et al. 2016; Fethi and Senyucel 2021) by groups of countries (Anser et al. 2020; Adedoyin et al. 2021), in Latin America (Pablo-Romero et al. 2019; Ochoa-Moreno et al. 2022) and Europe (Arbulú et al. 2015; Saqib and Benhmad 2021a, b). In this same line, Ekonomou and Halkos (2023) processes regression tests of contemporary panels that consider possible structural ruptures and phenomena of cross-dependence in panel data. Empirical findings confirm the EKC hypothesis, while business tourism expenses, capital investment expenses and domestic travel and tourism consumption have a negative impact on greenhouse gas emissions.

In order to demonstrate the link between environmental degradation and tourism growth in many industrialized and emerging economies, Table 1 aggregates empirical studies. However, the results differ in terms of policy implications, methods and

Table 1 Summary of literature review

Authors	Period	Study area	Variables	Method	Result
Ghosh et al. (2022)	1990–2018	G7 countries	CO_2, EF, CF, TA, GDP, ECI, UR, GLB, RE, NR	Panel Fully Modified Ordinary Least Squares (FMOLS)	EKC validated hypothesis
Adedoyin et al. (2021)	2016	Top 10 tourist destinations	EF, BC, TA, GDP, GLB	Pooled Mean Group (PMG)–Autoregressive Distributed Lag (ARDL)	EKC validated hypothesis
Ochoa-Moreno et al. (2022)	1995–2018	15 Latin American countries	CO_2, TA	Panel Dynamics DOLS (PDOLS)	EKC validated hypothesis in high-income countries
Danish and Wang (2018)	1995–2014	BRICS	CO_2, GLB, GDP, TA, INV	Dynamic Ordinary Least Squares (DOLS)	EKC validated hypothesis
Saqib and Benhmad (2021a, b)	1995–2015	22 European countries	EF, EG, EC, PO	Panel Fully Modified Ordinary Least Squares (FMOLS)	EKC validated hypothesis
Satrovic and Adedoyin (2023)	1997–2018	Southeastern European countries (SEE)	EF, CO_2, GDP, PO, EC, TA	**Ordinary Least Squares** (OLS), Driscoll–Kraay (DK), panel Method of Moment Quantile Regression (MMQR)	EKC validated hypothesis
Kyara et al. (2022)	1995–2017	Tanzania	EF, TA, EC, TO, URB	VECM Granger causality	EKC hypothesis rejected in Tanzania
Gao et al. (2021)	1995–2010	18 Mediterranean countries	CO_2, EC, EG, TA	Panel Fully Modified Ordinary Least Squares (FMOLS)	EKC validated hypothesis
Porto and Ciaschi (2021)	1995–2013	18 Latin American countries	ELI, TI	Generalized Least Squares (GLS)	EKC validated hypothesis
Fethi and Senyucel (2021)	1996–2016	Top 50 tourist countries	CO_2, EC, GDP, TA	Dynamic Seemingly Unrelated Cointegrating Regressions (DSUR)	EKC validated hypothesis
Ozturk et al. (2016)	1988–2008	144 Countries	EF, GDP, EC, TO,UR	Generalized Method of Moments (GMM)	EKC hypothesis validated in high- and low-income countries

Table 1 (continued)

Authors	Period	Study area	Variables	Method	Result
Arbulú et al. (2015)	1997–2010	32 European countries	MSW, GDPPC	Generalized Least Squares (GLS)	EKC validated hypothesis
Pablo-Romero et al. (2019)	1999–2017	12 Mediterranean provinces	CO_2, EC, TA	Feasible Generalized Least Squares (FGLS)	TUR to CO_2 emissions (+)
Alizadeh (2020)	1995–2014	50 Countries	CO_2, TA	Continuously Updated and Fully Modified (CUP-FM)	TUR to CO_2 emissions (+)
Zhang and Liu (2019)	1995–2014	NSEA-10	CO_2, GDP, RE, TA	Panel Fully Modified Ordinary Least Squares (FMOLS)	TUR to CO_2 emissions (+)
Anser et al. (2020)	1995–2015	G7 Countries	CO_2, TA	Dynamic Ordinary Least Squares (DOLS)	TUR to CO_2 emissions (+)
Zaman et al. (2016)	2005–2013	Three regions of the world	CO_2, TA, GDP	(2SLS) two stages least squares	TUR to CO_2 emissions (−)
De Vita et al. (2015)	1960–2009	Turkey	TA, EC, GDP	Dynamic Ordinary Least Squares (DOLS)	TUR to CO_2 emissions (−)

Abbreviations for variables: *CO₂* carbon dioxide emissions; *EF* ecological footprint; *CF* carbon footprint; *TA* tourist arrivals; *GDP* GDP per capita; *UR* urbanization; *GLB* globalization; *RE* renewable energy; *NR* natural resources; *BC* biocapacity; *INV* investment in tourism; *EC* energy consumption; *PO* population; *TO* trade openness; *ELI* Environmental Legal Index; *TI* tourism industry; *MSW* municipal solid waste; *GDPPC* gross domestic product per capita

geographical location. In addition, there are limited studies in both the Latin American region (Alizadeh 2020; Porto and Ciaschi 2021; Ochoa-Moreno et al. 2022), as well as in the application of the ecological footprint variable as a more comprehensive indicator of environmental degradation (Kyara et al. 2022; Saqib and Benhmad 2021a, b; Elshimy and El-Aasar 2020; Figge et al. 2017; Ozturk et al. 2016; Rojas-Downing et al. 2018).

It is significant to highlight that the above examines the EKC hypothesis using only one indicator of environmental pollution, namely carbon dioxide emissions, and is restricted to a one-dimensional consumption-based study. In this regard, Wackernagel and Rees (1998) state that environmental degradation is a multidimensional phenomenon and is represented by several indicators, not only as a result of ongoing carbon emissions, but also of the loss of fish species, reduction of grazing land and reduction of crops (Global Footprint Network 2021). For example, according to Ehigiamusoe et al. (2023), the ecological footprint and carbon emissions reflect various aspects of environmental degradation highlighting the imperative for nations to take into account the interaction between globalization and tourism in their effort to ensure environmental sustainability.

In addition, because the biocapacity available is ignored, it restricts our knowledge of the dynamics of environmental stresses. According to Destek and Sarkodie (2019), the biocapacity of a nation has a substantial impact on the outcome of the EKC hypothesis. In line with this, Khan et al. (2019) found decreasing forest cover has a variety of negative effects, such as droughts, unpredictable rainfall and flash floods. In order to reduce climate change and its effects, it is crucial to analyze the ecological footprint of growing economies (Destek and Sarkodie 2019).

On the other hand, regarding the methodology implemented in several of the studies presented in this section, the relationship between tourism and the environment is analyzed mainly based on some common econometric techniques. However, this research seeks to broaden the analysis of the relationship from convergence, alluding to the idea that over time, the per capita production of all economies will converge (Du 2017), adapting and expanding it to tourism and sustainability, based on the study by Simo-Kengne (2022), who builds a tourism sustainability index and analyzes the convergence of tourism growth and environmental sustainability in 148 countries for the period from 2006 to 2016.

A number of studies (Baumol 1986; Bernard and Durlauf 1995; Barro and Sala-I-Martin 1997; Lee et al. 1997; Luginbuhl and Koopman 2004) have helped to establish techniques for convergence testing and to empirically investigate the convergence hypothesis in various countries and areas. Convergence analysis has recently been used to examine a variety of different topics, including the cost of living (Phillips and Sul 2007), carbon dioxide emissions (Panopoulou and Pantelidis 2009), eco-efficiency (Camarero et al. 2013), housing prices (Montanés and Olmos 2013), corporate taxation (Regis et al. 2015), etc.

Using a non-linear time-varying component model, Phillips and Sul (2007) suggested a unique method (called the "log t" regression test) to evaluate the convergence hypothesis. The following are the benefits of the suggested strategy: First, it considers the diverse behavior of agents and their evolution. Second, the proposed test is robust to the stationarity property of the series, since it does not make any specific assumptions regarding trend stationarity or stochastic non-stationarity. Subsequently, Phillips and Sul (2007) demonstrated certain flaws in conventional convergence tests for economic development. Due to missing variables and endogeneity problems, the Solow regression estimate enhanced under transient heterogeneity, for instance, is biased and inconsistent. Due to the fact that the presence of a unit root in the series differential does not always

imply divergence, conventional cointegration tests frequently lack the sensitivity required to detect asymptotic motion.

The potential existence of convergence clubs is another recurring concern in convergence analysis. Traditional studies generally divide all participants into subgroups based on some previous knowledge (e.g., geographical region, institution), and then test the convergence hypothesis for each subgroup separately. A new algorithm was created by Phillips and Sul (2007) to locate subgroups of convergence in clusters. The algorithm developed is a data-based approach that does not separate samples ex ante. Some typical models are compatible with the relative transition parameter method presented by Phillips and Sul (2007) to characterize individual variations. To put people into groups with comparable transition paths, it can be used as a universal panel approach.

In this regard, the present research aims to fill the gaps identified in the aforementioned bibliography. Firstly, by expanding the analysis of the convergence of the relationship between tourism growth and environmental sustainability. Secondly, a proxy for environmental degradation for the Latin American and European regions using new indicators and with more comprehensive dimensions.

3 Methodology

3.1 Data

The data used in this study were taken from the World Bank (2022) and Global Footprint Network (2021). The variables extracted are the ecological footprint (ECO), which serves as the dependent variable in this study, and the number of international arrivals (TUR), which serves as the independent variable. This study covers 32 countries (Latin America, 14 and the European Union, 18) during the period 2000–2019. With 640 observations over the 20-year period and 32 countries, the variables provide a fully balanced panel over the 20-year period (t = 1, 2, …, 20), and 32 countries (i = 1, 2, …, 32).

Within countries, measured in global hectares per person, the ecological footprint is more stable than between them. Within countries, the standard deviation (SD) is 0.33, and between countries, it is 1.47. Similarly, the within-country variation in tourist revenues (log) (TUR) is lower than between countries. In comparison to the standard deviation across countries, which is 0.58, the standard deviation within countries is 0.32 (Table 2).

The annual evolution on average of the ecological footprint and the arrival of international tourists for Latin American countries can be observed in Fig. 1. The trend of

Table 2 List of variables and information sources

Variable	Unit		Symbol	Data sources
Dependent variable	Ecological footprint	Global hectares	ECO	Global Footprint Network (GFN 2023)
Independent variables	International tourist arrivals	Number	TUR	World Development Indicators (World Bank 2023)
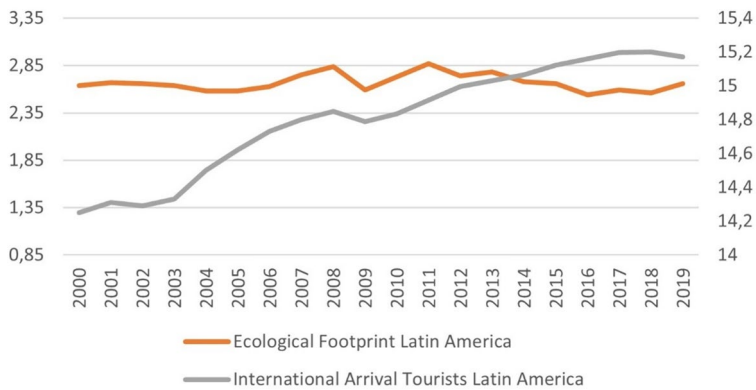
Fig. 1 Average ecological footprint and tourist arrivals in 14 Latin American countries

the dependent variable is constant, i.e., the ecological footprint is constant over the length of the study period in the sample of Latin American countries; while the independent variable is positive, i.e., it shows a constant increase in the study period (Table 3).

Figure 2 shows the average annual changes in the ecological footprint and the number of foreign visitors for the European Union member states. As can be seen, the independent variable has a positive trend throughout the study period and the dependent variable has a negative trend, which means that the ecological footprint in the sample of European countries has maintained an average decrease.

Over time you can see how Latin American countries converge in terms of sustainability and tourism growth; Meanwhile, the countries of the European Union diverge in terms of tourism and environmental sustainability, especially in the last years of the study; However, this differs depending on the macroeconomic conditions of each country; this is expanded

Table 3 Descriptive statistics

Group	Variable		Mean	Standard deviation	Min	Max	Observations
LATAM	ECO	Overall	2.67	0.65	1.26	4.29	N = 280
		Between		0.58	1.76	3.78	n = 14
		Within		0.32	0.97	3.75	T = 20
	TUR (log)	Overall	14.85	1.22	12.6	1.84	N = 266
		Between		1.20	13.37	1.83	n = 14
		Within		0.35	13.78	1.57	T = 20
EU	ECO	Overall	6.04	2.39	2.7	17.73	N = 360
		Between		2.34	3.93	14.38	n = 18
		Within		0.73	2.60	9.39	T = 20
	TUR (log)	Overall	16.54	1.37	13.60	19.19	N = 360
		Between		1.39	13.74	19.09	n = 18
		Within		0.22	15.63	17.24	T = 20

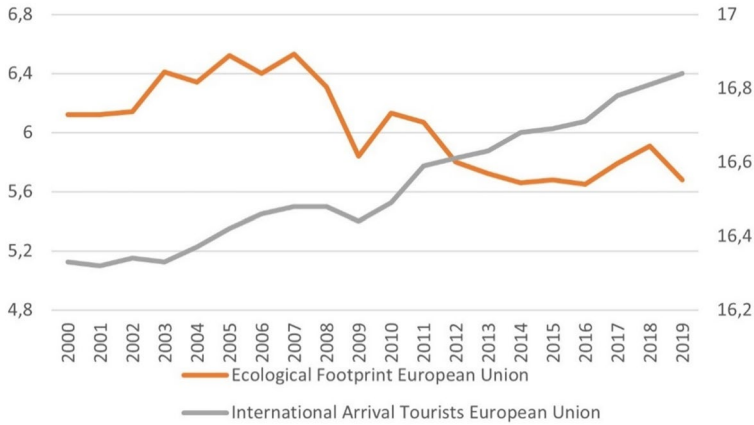Abbreviations for groups: *LATAM* Latin-American countries; *EU* European Union

Fig. 2 Average ecological footprint and tourist arrivals in 18 European Union countries

upon in the results and discussion section once the cluster convergence method has been applied.

3.2 Methodology

The empirical research follows a four-step process in line with the research objective of examining the convergence and interaction between the ecological footprint and international tourism growth in a panel of 32 countries from 2000 to 2019. The stationarity of the variables under study is first verified as a prerequisite in the first phase. The cointegration test is used in the second phase to assess whether there is stationarity between the variables under study in the long run. The third phase consists of estimating the fictitious cointegration connection in order to describe its dynamics, including how quickly it adjusts to long-term equilibrium and the short- and long-term effects. The causality analysis that comes at the end of this process, which considers the direction of the effects and any potential externalities to the research variables, is important for the creation of policy implications. The connection between tourism and environmental impact can be expressed as follows:

$$ECO_{i,t} = f\left(TUR_{i,t}\right) \tag{1}$$

If the logarithm of tourism is considered in Eq. 1, it is formulated as follows:

$$ECO_{i,t} = \varphi_0 + \varphi_1 \log(TUR)_{i,t} + \varepsilon_{i,t} \tag{2}$$

The ecological footprint of country i as a whole during period t is represented by $\log(ECO)_{i,t}$, the logarithm of tourism during period t is represented by $\log(TUR)_{i,t}$, and the error term is represented by $\varepsilon_{i,t}$. The results at this stage are interesting because they show the direction and strength of the effect of the relationship between independent and dependent variables.

The unit root test is used to check if the series are stationary—i.e., if there is no trend effect—prior to the cointegration analysis. Levin, Lin, and Chu-LLC and Im, Pesaran, and Shin-IPS, both suggested by Levin et al. (2002) and Im et al. (2003), were the tests

used. The Fisher-type test based on the ADF test (Dickey and Fuller 1981) and the Fisher-type test based on the PP test were also used in response to Maddala and Wu (1999), who suggested using a simpler non-parametric unit root test. This equation was used to estimate these tests:

$$\Delta X_{i,t} = \alpha_i + \gamma X_{i,t-1} + \sum_{j=1}^{p_i} \alpha_j \Delta X_{i,t-j} + \varepsilon_{i,t} \tag{3}$$

where Δ is the first difference operator, $X_{i,t}$ is the series for a member of panel (country) i during the period (i = 1, 2, … N); (t = 1, 2, … T), p_i indicates the number of lags in the ADF regression, and the error term $\varepsilon_{i,t}$ is assumed to be independently distributed random variables and normal for all i and t mean zero and finite heterogeneous variance.

The following stage tested for long-term equilibrium between the variables under study using cointegration techniques (Pedroni 1999, 2004). The panel series are compared to see if there is a long-term link by using the Pedroni (1999, 2004) cointegration test. The panel v statistic, panel rho statistic, panel PP statistic, panel ADF statistic, and the panel statistic—group rho, group PP statistic, and group ADF statistic are all calculated using the regression of Eq. (3) in the Pedroni cointegration test (Pedroni 1999, 2004):

$$Y_{i,t} =_i + \delta_i t + \sum_{j=1}^{M} \beta_{i,j} X_{i,j} + \varepsilon_{i,t} \tag{4}$$

In addition, a short-term equilibrium based on error correction models (ECVM) is present (Westerlund 2007). The null hypothesis of no cointegration versus cointegration between the variables used is considered at the regional level. As opposed to residual dynamics, this demonstrates structural dynamics, hence there are no restrictions on any common element. On the other hand, the error correction model developed by Westerlund in 2007 is denoted by the following notation and it is assumed that all variables are integrated in order 1 or I (1):

$$\Delta X_{i,t} = \theta_i d_i + \pi_i \left(X_{i,t} - \beta_i Y_{i,t-1} \right) + \sum_{j=1}^{m} \pi_{i,j} \Delta X_{i,t-j} + \sum_{j=1}^{m} \varphi_{i,j} \Delta Y_{i,t-j} + \varepsilon_{i,t} \tag{5}$$

where $d_t = (1 - t)$ contains the deterministic components and $\theta_t = (1 - t)$ is the vector of unknown coefficients to be estimated.

As indicated by Dumitrescu and Hurlin (2012), the Granger non-causality approach was used after calculating the equilibrium connection to take into consideration panel data heterogeneity problems. In the situation of imbalanced and heterogeneous data, the Dumitrescu-Hurlin (DH) test is a modified version of the Granger causality test that is more lenient for T < N and T > N. Equation (6) is used in the DH test:

$$Y_{it} = \varphi_i + \sum_{k=1}^{k} \gamma_i^{(k)} Y_{i,t-k} + \sum_{k=1}^{k} \theta_i^{(k)} X_{i,t-k} + \varepsilon_{i,t} \tag{6}$$

where φ_i is the intercept of the slope, γ_i and θ_i are the slope coefficients, ε is the error term, and k is the number of lag lengths.

In order to investigate the presence of convergence clubs according to the Phillips and Sul (2007) clustering procedure, the following steps are implemented:

1. (Cross section last observation ordering): Sort units in descending order according to the last panel observation of the period;
2. (Core group formation): Run the log-t regression for the first k units $(2 < k < N)$ maximizing k under the condition that t-value is > -1.65. In other words, chose the core group size k^* as follows:

$$k^* = \arg \max_k \{t_k\} \tag{7}$$

Subject to

$$\min \{t_k\} > -1.65 \tag{8}$$

If the condition tk > -1.65 does not hold for k $= 2$ (the first two units), drop the first unit and repeat the same procedure. If tk > -1.65 does not hold for any units chosen, the whole panel diverges.

4 Results

The fixed-effects and random-effects models were compared using the Hausman test (1978). As a result, for each panel, the model that best fitted the test data was chosen. The modified Wald test and the Wooldridge (1991) test were also used to test for heteroscedasticity and to identify autocorrelation in the panel, highlighting the need to estimate the parameters of Eq. (2) using generalized least squares (GLS) for panel data (Wooldridge 2004). The results are shown for the two groups of countries (Table 4).

Next, the non-stationarity of the series is confirmed using unit root tests for panel data. Three tests, those of Levin et al. (2002) and Im et al. (2003), known respectively as LLC and IPS tests in the empirical literature on panel data, were applied to confirm the reliability of the findings. Comparisons were made between the results of these tests and those produced by Maddala and Wu (1999). Both with and without the effects of time were considered in the testing. According to the findings in Table 5, the series show an order of integration (1). The existence of long-term and short-term cointegration vectors between the variables is confirmed in the following step of this research.

Table 4 Relationship between the ecological footprint and the logarithm of international tourist arrivals

	LATAM	EU
TUR (log)	−0.099***	−0.580***
	(2.28)	(7.19)
Constant	1.012	15.414***
	(1.59)	(11.05)
Observations	280	360
Autocorrelation test p value	0.373	0.274
Fixed effects (time)	No	No
Fixed effects (country)	No	No
χ^2	20	18
N_g	20	18

Note t statistics in brackets. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$

Table 5 Unit root test in first difference

Region	Variable	Without time				With time			
		PP-statistic	ADF	LLC	IPS	PP-statistic	ADF	LLC	IPS
LATAM	$eco_{i,t}$	−15.427*	−11.262*	−7.517*	−8.658*	−12.386*	−6.882*	−5.120*	−5.438*
	$logtur_{i,t}$	−9.233*	−9.493*	−7.116*	−6.593*	−7.908*	−6.125*	−6.696*	−6.947*
UE	$eco_{i,t}$	−16.570***	−12.116***	−7.868***	−10.201***	−13.999***	−6.728***	−4.889***	−9.493***
	$logtur_{i,t}$	−11.995***	−11.051***	−8.360***	−7.793***	−9.940***	−6.492***	−7.724***	−8.381***

Abbreviations unit root test: *PP* Phillips-Perron test; *ADF* Augmented Dickey–Fuller test (ADF); *LLC* Levin, Lin and Chu test (LLC); *IPS* Im, Pesaran and Shin test

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

Table 6 Pedroni cointegration test

	LATAM	EU
Within dimension test statistics		
Panel v-statistic	−0.170	0.641
Panel p-statistic	−5.015[*]	−1.328[*]
Panel PP-statistic	−6.839[*]	−2.714[***]
Panel ADF-statistic	−6.520[*]	−2.737[***]
Between dimension test statistics		
Panel p-statistic	−1.844[**]	−0.387
Group PP-statistic	−5.426[*]	−3.520[***]
Group ADF-statistic	−4.089[*]	−3.554[***]

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

Table 7 Results of the Westerlund ECM error correction model

Group	Stat	Value	Z value	*P* value
LATAM (14 countries)	Gt	−2.016	−3.740	0.000
	Ga	−7.139	−2.745	0.003
	Pt	−5.008	−2.654	0.004
	Pa	−3.664	−3.408	0.000
EU (18 countries)	Gt	−0.989	−0.053	0.479
	Ga	−2.685	1.042	0.851
	Pt	−4.219	−1.759	0.039
	Pa	−2.136	−1.626	0.052

Pedroni (1999, 2004) developed the cointegration test in heterogeneous panels, which allows to merge cross-sectional dependence with various individual effects, to determine the presence of a long-term equilibrium. This analytical framework, which incorporates seven repressors based on seven residual-based statistics, enables cointegration tests to be run in both heterogeneous and homogeneous panels.

The results of the seven statistics used by Pedroni (1999, 2004) are shown in Table 6. With varying degrees of significance, the majority of the statistics for each set of countries reject the null hypothesis of no cointegration. As a result, these findings suggest that throughout the years 2000–2019 in the groupings of countries, tourism and the ecological footprint have moved together and simultaneously.

In addition, the short-run equilibrium was calculated using an error correction model (ECVM) for panel data created by Westerlund (2007). If there is a short-run equilibrium, this implies that changes in tourism revenues will quickly result in changes in the ecological footprint. According to the data compiled in Table 7, each group of countries is in short-term equilibrium.

Granger-type causality of the variables was established using the formalization created by (Dumitrescu and Hurlin 2012). In both country groupings, it was found that there are causal connections that stem from TUR→ECO (gha). In other words, changes in the number of visitors will have an impact on the ecological footprint on average in both European and Latin American countries. When considering the direction of the effects and

their potential externalities to the research variables, these causal analyses are crucial for the creation of policy implications (see Table 8).

To do this, the Phillips and Sul (2007) proposed convergence club technique is used, which finds three convergence clusters with the possibility of the two final clusters combining to form a single club. The convergence club hypothesis, which holds that countries moving from a point of environmental imbalance to their club-specific steady state trajectory belong to the same cluster, is where the three mega clubs in Table 9 come from.

Table 9 shows that there are three clubs and three divergent units in club 4 for Latin America. It lists the number of units (countries) covered for each club, as well as the beta coefficient of the log-t test and the value of the t-statistic. Since the t-value for clubs 1 and 2 is less than −1.65, the null hypothesis of convergence is rejected at the 5% level; however, the hypothesis is not rejected for club 3.

On the other hand, two clubs representing 9 and 4 countries, respectively, are shown for the 18 countries that make up the European Union, along with 5 divergent units in club 3. Given that the t-value in the two established clubs is less than −1.65 in this case, the null hypothesis of convergence is rejected at the 5% level.

The results in Fig. 3a, b demonstrate graphically that the economies of Europe and Latin America are not close to reaching their stationary states. In addition, the last graph of each section (a) and b)) shows the comparison between the average transitory behavior of each club, where it can be more clearly identified that the path of the countries in both regions has a different pattern.

5 Discussion

In the previous section, the results of the estimated GLS are presented, which allowed to establish the relationship of the ecological footprint based on the logarithm of international tourist arrivals, showing a negative effect on the panel of Latin America and Europe. In other words, as tourism increases, it has a positive and significant effect on the deterioration of the ecological footprint in both regions. These results are similar to those found by authors such as Porto and Ciaschi (2021) and Arbulú et al. (2015), who by using generalized least squares verified that tourism activity causes an increase in environmental degradation, measured through carbon emissions for 18 Latin American and 32 European countries. This suggests that the non-linear impact of tourism on the environmental degradation of countries is not sustainable as tourism increases, so efforts to mitigate environmental degradation from tourism must be implemented (Simo-Kengne 2022).

Both the existence of short-term (Westerlund 2007) and long-term equilibrium (Pedroni 1999, 2004) have been tested using the approach. Similar methodological techniques
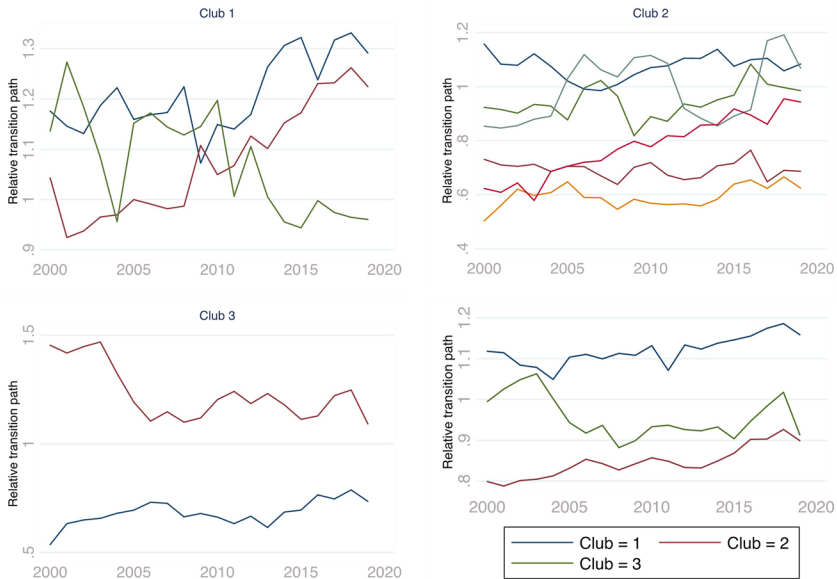
Table 8 Dumitrescu–Hurlin causality tests	Causal direction	Group	W bar	Z bar	P value
	ΔECO > ΔTUR	LATAM	3.038	1.943	0.051[*]
		EU	3.767	3.748	0.000[***]
	ΔTUR > ΔECO	LATAM	3.872	3.502	0.005[**]
		EU	4.705	5.738	0.000[***]

Note *, **, *** denotes statistical significance at the 10, 5 and 1% levels, respectively
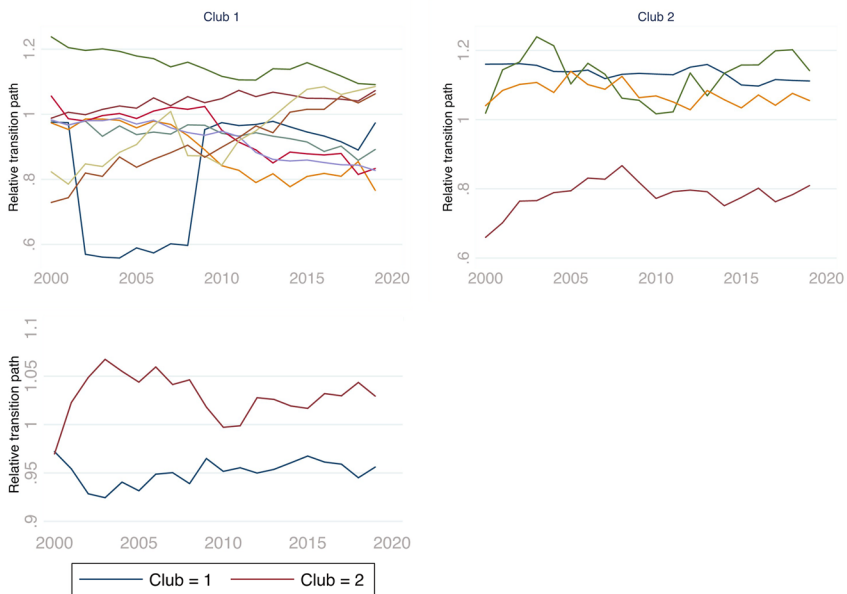
Table 9 Convergence clubs in environmental performance

Region	Club	Number of countries	Countries	Beta coefficient	t-Statistic
LATAM					
	Club 1	3	Argentina, Bolivia, Mexico	−3.018	−9.083
	Club 2	6	Brazil, Colombia, Costa Rica, Guatemala, Panama, Peru	−0.672	−52.168
	Club 3	2	El Salvador, Paraguay	−0.053	−1.248
	Club 4 (Divergent)	3	Chile, Uruguay, Venezuela	−5.789	−82.700
EU					
	Club 1	9	Germany, Austria, Denmark, Spain, France, Greece, Italy, Latvia, Lithuania	−1.089	−6.399
	Club 2	4	Belgium, Croatia, Estonia, Finland	−0.836	−35.630
	Club 3 (Divergent)	5	Luxembourg, Netherlands, Poland, Portugal, Sweden	−0.612	−20.614

Fig. 3 Transition paths within each convergence club in the 14 Latin American countries and transition paths within each convergence club in the 18 European Union countries

are used by studies such as Ochoa-Moreno et al. (2022), Ghosh et al. (2022), and Saqib and Benhmad (2020) to establish equilibrium correlations in various study samples. The findings show that during the period 2000–2019, tourism growth and the ecological

footprint in global hectares per capita have a combined and synchronous movement in both sets of countries. This is in line with Saqib and Benhmad's (2020) hypothesis that the dynamics in developing countries affects how these variables are balanced. This is because the tourism industry generates significant economic advantages, while also contributing to an increase in environmental degradation. Due to the fact that these countries have not yet transitioned from traditional energy sources to more cutting-edge and environmentally friendly technology in tourism, the host country will suffer.

On the one hand, Granger's causality (Dumitrescu and Hurlin 2012) showed that the ecological footprint and growth of tourism in both categories of countries had mutual causal links. In other words, the extraction and exploitation of natural resources is accelerated by the economic growth of industrialized economies, which reduces the biocapacity of the environment and increases the ecological footprint (Panayotou 1993). This finding is comparable to those of Destek and Asumadu (2018) and Saqib and Benhmad (2020), which found a two-way causal link. On the other hand, Ghosh et al. (2022) find a two-way causal relationship between carbon dioxide emissions, tourism and ecological footprint in the G-7 countries. Ozturk et al. (2023) who use a unique technique through quantum-in-quantum regression and Granger causality and suggest a combination of positive and negative effects of tourist arrivals and CO_2 emissions at most tourist destinations. Moreover, Ekonomou and Halkos (2023) by applying Granger's non-causality tests to a eurozone data panel suggest that all Granger variables cause greenhouse gas emissions.

In addition, the convergence analysis in both regions indicates that the sample of countries selected for this study do not have convergence in environmental terms, i.e., they do not converge towards the stationary point of each convergence club created from the Phillips cluster procedure (Philips and Sul 2007, 2009). These findings contrast with those made by Simo-Kengne (2022) for a sample of 148 countries, who found that the convergence of tourism growth and environmental well-being tends to adjust at varying rates depending on the sample panels. Similarly, research by Phillips and Sul (2007) found that the relative cost of living in the 19 major American metropolises does not appear to converge over time, in addition to providing a new mechanism to model and analyze the behavior of the economic transition in the presence of common growth characteristics.

6 Conclusions and political implications

The environment is a resource and an opportunity, as well as a constraint for tourism. As a result, while engaging in tourism activities might help the environment to remain sustainable, it can also worsen its condition. The overall impact depends on the nature of tourism, as well as on contextual factors like the development of technology, the level of environmental awareness, and society's lifestyle (Pigram 1980). Thus, the aim of the study is to investigate the connection between tourism growth and the ecological footprint in 14 Latin American and 18 European countries. To find the convergence of tourism growth and environmental sustainability, the annual period between 2000 and 2019 is examined using panel cointegration techniques and the clustering procedure.

The study findings support the notion that tourism development and environmental sustainability are mutually exclusive, since increasing biocapacity has a detrimental impact on environmental sustainability. Similarly, Danish et al. (2019), Adedoyin et al. (2021), and Chu et al. (2017), all reach the conclusion that decreasing biocapacity in Beijing, Tianjin, and Heibin is what leads to ecological improvement. These studies support the

finding of Danish et al. In addition, increased tourism-related activities, globalization and economic production can all have a negative impact on the environment, as demonstrated by the research of Nathaniel (2021c), who found that as tourism grows, so does energy consumption, which in turn causes the release of toxic chemicals that degrade the quality of the environment.

The current study adds important elements to the analysis of the literature on the growth of tourism and the impact on the environment, making important methodological contributions by using the ecological footprint variable as an indicator of sustainability, as well as the convergence club method presented by Phillips and Su (2007) to determine the convergence of tourist and environmental sustainability. However, some theoretical limitations have been presented, such as the lack of information for all countries in the Latin American region and the European Union; and empirical, there are limited studies examining the relationship or impact of tourism growth and ecological footprint as an indicator of environmental sustainability.

From the political point of view, it is imperative that nations take decisions and do things to achieve environmental sustainability. There are two ways to fulfill this commitment, which will ensure a smaller ecological footprint and a cleaner environment. First, it is suggested that governments and organizations adopt green tourism, which can reduce soil erosion and air pollution caused by various forms of tourism-related transportation. Second, in order to fulfill environmental preservation and economic development objectives, sustainable economic production is preferable in order to limit environmentally damaging emissions (Alola et al. 2019a, 2019b; Nathaniel et al. 2021). These findings suggest that policymakers should implement financial changes aimed at sustainable development, as well as assist tourism initiatives that use renewable energy sources. Furthermore, the findings suggest that these countries economic growth goals should be combined with carbon dioxide emission legislation (Koengkan et al. 2019).

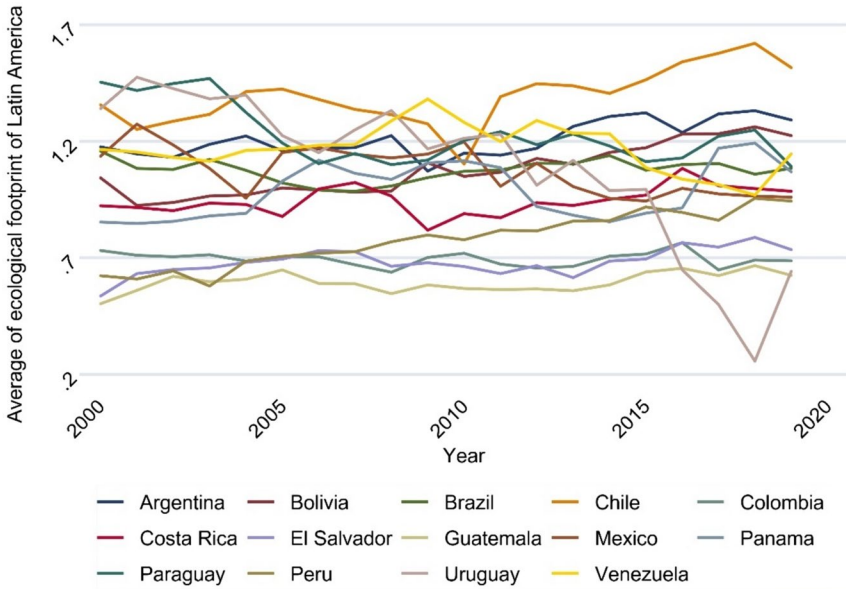## Annexes

See Figs. 4 and 5.

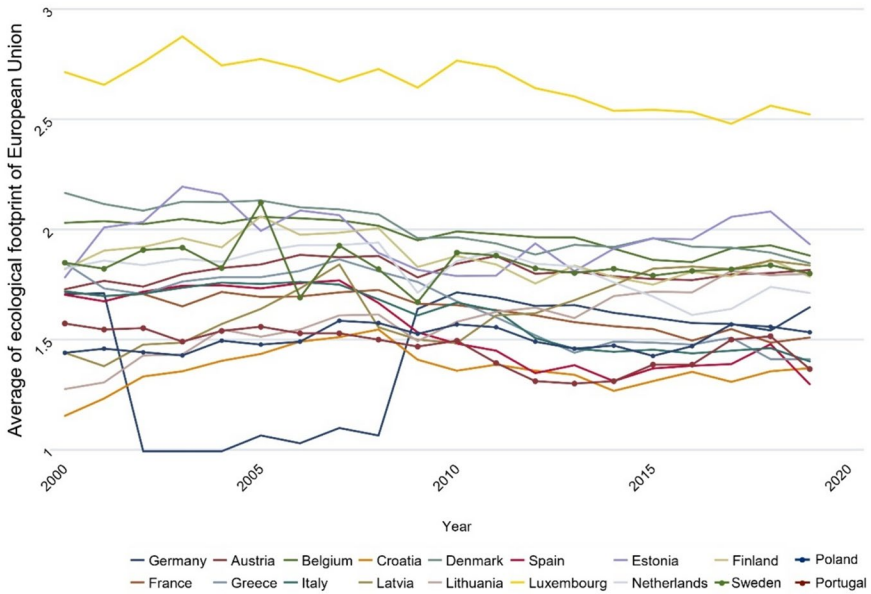**Fig. 4** Average transition path in the 14 Latin American countries

Fig. 5 Average transition path in the 18 European Union countries

Declarations

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