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Dynamic linkages between tourism, economic growth, trade, energy demand and carbon emission: evidence from EU

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Abstract

At the heart of the post-COP26 era and the European Green deal lies the underlying goals in Europe targeting climate neutrality and zero pollution through tourism developments and promotion of economic well-being of regions. This study empirically investigates the dynamic linkages among tourism developments and emission while controlling for the influence of economic growth, trade, energy demand under the framework of Panel Autoregressive Distributed Lag (PARDL) using the top 12 tourist countries in the EU from 1995 to 2018. The findings are as follows: First, the study found that trade openness negatively influences emissions. Second, economic growth, tourism, and energy use positively and significantly influence emissions. Third, energy demand positively and significantly influences economic growth and tourism development in the short and long run. The study recommends additional tourism and energy development policies along with structures that rapidly drive economic activities to turn carbon-intensive economies into green economies.

Keywords Tourism, Economic growth, Panel autoregressive distributed lag, Energy demand, Carbon emission, European Union

Introduction

Tourism is a phenomenon that drives social-economic activities and common norms worldwide [57]. Tourism is important for many countries and regions because it contributes to developing relationships among nations. In European Union, tourism generates 10% of foreign exchange revenues and creates jobs through direct, indirect and induced economic effects [39, 57]. It motivates investors and the government to invest in new capital projects and repositions infant industries to compete with companies in other tourism countries [23, 59]. A broad picture of the current trend has placed the tourism industry in the European economy as the fastest-growing sector, showing remarkable resilience and flexibility in the region [7, 58]. According to statistics published by World Travel & Tourism Council (2020), Fig. 1 shows that the Caribbean contributes to the growth by 13.9%, followed by Southeast Asia at 12.1%, and Europe at 9.1%. The total GDP contribution of Europe was US$ 2.0tn. However, while the tourism industry can bring major environmental, social and economic advantages, it has a negative effect [48]. The tourism sector in the Middle East and North Africa (MENA) is characterized by a fragmented structure, consisting mainly of small and

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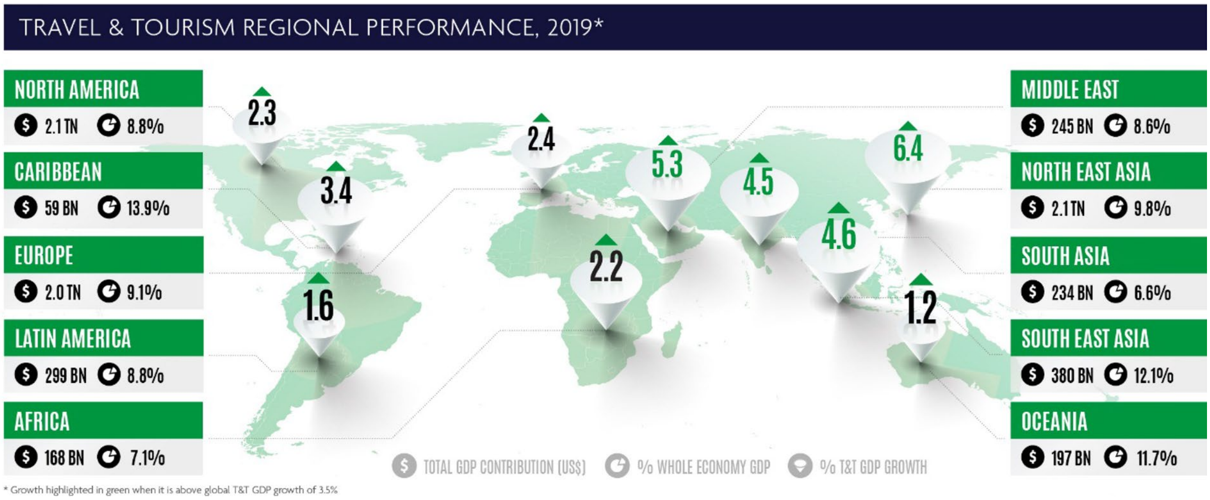

Fig. 1 Travel & Tourism Regional growth in 2019. Source: WTTC (2019)

micro-enterprises, and negative effects on environmental quality [51].

While tourism in Europe has continued to grow over the years amidst increasing trade among nations, trade openness has played a pivotal role in this trend through its impact on tourism development; and the environment through increased emissions due to the current trend in globalization [17]. The environmental consequences of trade openness are divided into three, i.e., the effect of size, technique, and composition. Environmental quality is declining due to the expansion of economic activity, tourism demand and demands for exported products whose production is detrimental to the environment. The position of the tourism sector has shown that the tourism sector is an energy-intensive industry that contributes significantly to the emission of carbon dioxide or methane, especially on account of economic, social and environmental costs [17]. In this regard, many studies evaluate tourism's environmental cost–benefit effects [11, 21]. It is generally accepted that tourism development may grow due to damaging environmental resources see [28, 51, 52]. If high inputs from socio-cultural and environmental factors could be converted into higher energy consumption rates, it could be responsible for rising emissions [4]. Thus, tourism activities, energy demand and environmental pollution can reduce a country's production capacity given the negative externalities emanating from the tourism sectors, which likely overwhelm its benefits and consequently deter economic growth in the long run. Tourism may only have an economic impact with contributions from socio-cultural and environmental conditions such as fossil transport, lodging and destination activities [42]. The demand for tourism products will offer opportunities for linkages with other economic components and could contribute to low productivity and rising emission level due to the high demand for energy [9].

Based on these discussions, scholars are increasingly attracted by the growing debate between tourism development, emissions, economic growth, energy demand and trade openness in the EU. Europe-based studies conducted by Dogan and Aslan [10], Ekonomou and Halkos [13], Leitão and Balsalobre-Lorente [24] are broad in their focus on the entire bloc, whereas tourism is not at the same threshold in all member states, thereby reducing the meaningfulness and relatability attached to their empirical efforts as it concerns the tourism, energy use, trade and environmental quality nexus. The idea to focus on the top ten tourist countries in the EU is corroborated by the approach taken by Shaheen et al. [52] in studying the linkage between tourism, economic growth, energy use and environment using top ten tourism-induced countries globally. Meanwhile, previous studies conducted outside the confines of Europe such as Nepal et al. [34], Raza et al. [47], Isik et al. [19] and Naradda et al. [33] have concentrated on the same country-specific approach, very few have explored these linkages using the PMG panel data analysis. This technique is employed due to its scholarly features: It constrains the long-run coefficients to be the same across the group but allows the short-run coefficient and its error variance to vary across groups. Therefore, understanding the dynamic linkages between these factors is essential for policymaking. By exploring the European countries, this research contributes to the ongoing debate by exploring various channels and interactions between tourism and economic growth and its effect on the environment. This study applies a particular statistical method that fills the gap, provides novel results and provides policy implications within the framework of the Panel ARDL analyses. Also, this study could shed some light on the interesting issue of tourism activities, energy demand, trade openness, economic growth and emission level.

Other sections of this study are as follows: The latest scientific literature is discussed in Sect. "Review of literature review," Sect. "Method" presents scientific study data and methods, Sect. "Results and discussion" shows the empirical findings, and Sect. "Discussion of findings" highlights the empirical outcomes outlining policy implications.

Review of literature review

The seminal work of Ghali [15] was the first to explore the tourism growth nexus from a simple OLS system. Building on the initial effort, much research has been conducted concerning the relationship between economic development and tourism. These discussions are based on four hypotheses [19, 41, 56]. First, the growth-led tourism hypothesis indicates that tourism is the cause of economic growth. Some studies in Asia and Europe have verified the growth-led hypothesis see [3, 54, 60]. Second is the tourism-led growth hypothesis. Several reports, for example, support the tourism-led growth hypothesis [39, 41, 55, 56, 60]. The fact that tourism enriches the EU countries' economic growth has been confirmed recently [42, 43]. Third, tourism and economic development have a bidirectional causality. This implies a feedback hypothesis. Research in this area (see [50]) investigated the countries that support the feedback theory [2]. Last, some studies, especially in developing nations, showed noncausality between tourism and growth. Ekanayake and Long [12], Arslanturk, Balcilar, and Ozdemir [5], and [1] and Chou [8] found no causality in their numerous studies showed hypothesis of neutrality in transition economies and no linkages between the tourism sector and economic growth.

The existing literature on tourism-led growth has highlighted that tourism development could cause adverse environmental effects during tourism-related services from high economic activities [39]. Usually, this is done by overriding the negative externalities of tourism, and thus, the growth of tourism can result in economic growth being discarded. Within this line of debate, Kadir et al. (2019) claimed that tourism and emissions had a positive impact on economic growth and that the business growth and tourism industry are major contributors to emissions. Similarly, Dogan et al. [10] investigated the association between emissions, real GDP, GDP squared, energy consumption, trade openness, and tourism for countries (OECD). The study showed that energy and tourism have a positive relationship leading to a rise in emissions while growing trade openness leads to environmental improvements. Similarly, Dogru et al. [11] examined the association between tourism development, economic growth, and carbon emission for selected countries in Europe, New Zealand, Canada and Turkey using an Augmented Mean Group (AMG) for panel data. The research output revealed mixed results ranging from the negative effect of tourism development on carbon emission in Canada, Czechia, and Turkey to the positive influence on Italy, Luxembourg, and the Slovak Republic.

Analyzing causalities between trades, financial growth, tourism, and emission expenditures in Greece from 1974 to 2014 in the context of the ARDL framework, Işik et al. [19] found that the tourism industry drives emissions in both the short and long run. In a similar study, Nepal et al. [34] explored the effect of tourist arrivals on carbon emissions from 1975 to 2014 in Nepal. The findings indicate that tourism contributes substantially toward emissions. Raza et al. [47] investigated the impact of tourist arrivals on emissions in the USA using a wavelet transformation approach with monthly data for 1996–2015. The results showed that tourist arrivals rapidly impact emissions. Naradda et al. [33] investigated the relationship between tourism receipts, energy use, and environmental degradation in Sri Lanka during 1974–2013 under the cointegration and DOLS approach. The study found that tourism receipt reduces emissions. The study argues that increasing energy consumption and tourism in both the short- and long-term could lead to high carbon emissions. The study further validates the EKC hypothesis.

Further studies have reported casual relationships between tourism and growth (for example, [3, 54–56]). Ohlan [35] studied the link between tourism and economic growth in India from 1960 to 2014. Using Bayer and Hanck model, the study showed that inbound tourism drives long-term and short-term economic growth. A further study by Aras et al. [3] in Cambodia revealed that tourism receipts drive GDP in the short and long run, indicating a tourism-led hypothesis. Kadir et al. (2019) found that tourism has a significant positive impact on economic growth. Further, their result affirmed that economic growth and tourism contribute to emissions under the emission model. However, [10] explored the relations between emissions, energy use, and economic and tourism development of OECD Member States. The results showed a long-term relationship between these variables, while energy use and tourism led to rising carbon emissions. Another strand of literature in the EU zone highlights the link between tourism, real GDP and energy use (see [6, 10, 28]). Dogan et al. [10] investigated the long-term dynamic framework between carbon emissions, real GDP, square GDP, energy consumption, trade openness and country tourism (OECD). The study documented an increase in energy consumption and tourism concurrently leading to higher emissions, while higher trade openness led to environmental sustainability. Naseem et al. [32] investigated the tripod relationship between energy consumption, economic growth and environmental degradation in BRICS countries. Findings show that economic expansion and environmental degradation are interrelated in the long run. However, environmental degradation can be eradicated through continuous economic growth, management of energy demands, implementation of environmental-friendly policies and application of green technologies.

Gulistan et al. [17] examined the environmental degradation effects of growth, energy use, trade openness, and tourism. The overall sample results show that economic growth and energy use, and tourism are environmentally harmful, although the trade openness was not statistically significant in line with the findings of Mohsin et al. [29]. In a similar argument, Shahbaz, Nasreen, Ahmed, & Hammoudeh [53] observed that trade openness dampens environmental quality by implementing the FMOLS (fully modified OLS). The research output further identified a feedback mechanism between trade openness and carbon emissions. Applying the Pooled Mean Group (PMG), Yazdi and Beygi [61] examined the effect of economic growth, energy, financial innovation, trade openness and urbanization development on emissions in the selected African nations within the period 1985–2015 and found an increase in the use of renewable energy and access to trade lower emissions. Dogan et al. [10] investigated the OECD countries to ascertain the long-term dynamic relationship between emissions, real gross national product (RGNP), real gross domestic squared, energy use, trade and tourism. The study found that trade increases lead to environmental change, while energy demand and tourism contribute to gas emissions. Omri et al. [38] concentrated on the links between emissions, TR, economic growth and MENA financial development from 1990 to 2011. They found that estimates of the economic growth coefficient of nuclear energy consumption are positive and significant. At the same time, further results revealed that trade openness exerts positive and significant effects on nine countries, while it has a small negative impact on Egypt and Oman.

Other influential studies addressing the influence of industrial development, agricultural output and economic growth on environmental quality are seen in the empirical efforts of Liu et al. [26], Okere et al. [36], Okere et al. [37], Muoneke et al. [30] and Naseem et al. [31]. Interfacing with the industrial development and environmental quality nexus, Okere et al. [36] posited that improved finance and industrial restructuring are needed economic acumen that can accelerate a quick transition to low-carbon development in Argentina, while fossil fuel, population, economic growth, and government consumption expenditure generate environmental challenges. Okere et al. [37] introduced a panacea in the case of Peru, stating that economic integration reduces environmental challenges in the Peruvian Amazon. Liu et al. [26] posit that industrial development, gross domestic product and gross capital formation increase environmental degradation in BRICS countries. Naseem et al. [31] and Muoneke et al. [30] investigated the agriculture-environmental quality nexus in Latin America and Asia, respectively. Muoneke et al. [30] established the presence of an inverted U-shaped EKC pattern involving agricultural development and ecological footprint in the case of the Philippines. It is also found that the agricultural level operates below the threshold level required to maximize the growth benefits of the agricultural system toward mitigating environmental sustainability. Likewise, Naseem et al. [31], using the ARDL econometric technique, posited that agricultural activities increase carbon emissions in the case of Latin America and the Caribbean.

Method

Research design

Expost-facto research design was employed for this study. An expost-facto research design is very appropriate for this study because it describes the statistical association between two or more variables. The use of this design allows for the testing of expected dynamic relationships between tourism, economic growth, trade, energy demand and carbon emission in the EU and proffering consolidated policy recommendations.

Data description

The study uses panel data for the period 1995–2018 to explore the links between tourism expenditure, emission, economic growth and trade openness among the countries: Denmark, Iceland, Norway, France, Greece, Poland, Finland, Germany, Sweden, Italy, Portugal and Spain. The reasons for selecting these countries are (i) their exposure to carbon dioxide emissions, economic effects, and willingness to invest in tourism. (ii) a group of countries characterized by many arrivals and a large volume of international trade, manufacturing, gas and energy consumption. Emissions are expressed in metric tons per capita. The real GDP reflects economic growth per capita. In the sense of tourism-led growth [39], it is asserted that tourism has a positive effect on economic development and may have a negative environmental impact during the service provision. The growth-led hypothesis indicates that growth drives tourism and has been confirmed in numerous studies in Asia and Europe

[3, 54, 60]. International tourism expenditure (current US$) covers foreign outbound tourists in other countries, including international transportation payments. Tourism-led growth hypothesis suggests that tourism granger causes economic growth. For example, several studies support the tourism-led growth hypothesis (e.g., [39, 41, 55, 56, 60]). Energy consumption is measured as energy usage (kg oil equivalent per capita). This covers primary energy before the transition to other end-use fuels, equal to indigenous production plus imports and adjustments in stocks, minus exports and fuels supplied to ships and aircraft engaged in foreign transport. Trade openness is the number of exports and imports expressed as a share of the gross domestic product. Detailed explanations of data and definitions of variables are presented in Table 1.

Model specification

This empirical research uses the sample of European economies to examine the dynamic relationship between tourism, economic development, trade and emissions. The empirical analysis is divided into five model specifications; all the key variables are considered the dependent variables in the various model specifications [1–5] to capture the causality direction and significance level. Building on past empirical analysis and current theoretical approach (see [19, 28, 39, 60], Kadir et al. 2019; [27]), the natural logarithmic transformation of the models is developed as thus.

Model 1, the CO_2 emissions

$$\ln Co_{2_{it}} = \beta_0 + \beta_1 \ln rgdp_{it} + \beta_2 \ln Energy_{it} + \beta_3 \ln T\exp_{it} + \beta_4 \ln Trade_{it} + \varepsilon_{it} \quad (1)$$

Model 2, the tourism growth

$$\ln T\exp_{it} = \beta_0 + \beta_1 \ln Co_{2_{it}} + \beta_2 \ln Energy_{it} + \beta_3 \ln rgdp_{it} + \beta_4 \ln Trade_{it} + \varepsilon_{it} \quad (2)$$

Model 2, the economic growth

$$\ln rgdp_{it} = \beta_0 + \beta_1 \ln Co_{2_{it}} + \beta_2 \ln Energy_{it} + \beta_3 \ln T\exp_{it} + \beta_4 \ln Trade_{it} + \varepsilon_{it} \quad (3)$$

Table 2 Estimates of LM test of cross-sectional independence

Variables	BP LM	PS LM	BCS LM	PS CD
ln CO_2	576.78***	44.458***	44.142***	17.1242***
ln Energy	410.40***	29.976***	29.660***	8.2175***
ln Rgdp	954.78***	77.358***	77.042***	30.270***
ln Texp	947.39***	76.715***	76.399***	30.173***
ln Trade	757.35***	60.174***	59.858***	24.906***

BPM Breusch-Pagan LM, *PS* Pesaran scaled LM, *BCS* Bias-corrected scaled, *PS* Pesaran CD

*, ** and ***Indicate the probability level at 90%, 95%, and 99% level, respectively

Model 2, the energy growth

$$\ln Energy_{it} = \beta_0 + \beta_1 \ln Co_{2_{it}} + \beta_2 \ln rgdp_{it} + \beta_3 \ln T\exp_{it} + \beta_4 \ln Trade_{it} + \varepsilon_{it} \quad (4)$$

Model 2, the international trade

$$\ln Trade_{it} = \beta_0 + \beta_1 \ln Co_{2_{it}} + \beta_2 \ln Energy_{it} + \beta_3 \ln T\exp_{it} + \beta_4 \ln rgdp_{it} + \varepsilon_{it} \quad (5)$$

This study defines $i = 1, \ldots$ to N for each selected country in the panel analysis where $t = 1, \ldots, T$. This specifies the time period, and ε_{it} denotes the error term. The parameter β_0 allows for country-specific fixed effects. Table 1 describes other variables. Data normalization is needed in econometric to remove possible spurious result considering that the value of CO_2 emissions was recorded in metric tons, while others were recorded in US$.

Method of analysis

The first step in this study is to perform the cross-sectional dependency test(s) and pick the right panel unit root test(s). Table 2 records the cross-sectional findings of the dependence check. The test findings show that unobserved shocks in the error term are statistically significant, so it is best to check the stationary characteristics from the unit root testing via the second-generation unit panels. Cross-sectional data dependency

Table 1 Variable, data sources and descriptive statistics

Variable	Definition of Variables	Mean	Maximum	Minimum	SD	Source
ln CO_2	CO_2 emissions (metric tons per capita)	2.022717	2.618465	1.465926	0.255582	WDI, World Bank
ln Energy	Energy use (kg of oil equivalent per capita)	8.297751	9.807975	7.594299	0.49325	WDI, World Bank
ln Rgdp	GDP per capita (constant 2010 US$)	10.45834	11.42481	8.785685	0.527262	WDI, World Bank
ln Texp	International tourism, expenditures (current US$)	22.79954	25.38379	19.45742	1.277868	WDI, World Bank
ln trade	Trade openness (sum of imports and exports % of GDP)	4.183221	4.652323	3.613829	0.224758	WDI, World Bank

allows second-generation stationary panel research. Therefore, this study includes the first and second iterations of the experiments. In order to ensure the validity of the tests, we take the cross-sectional independence (CD) test by Pesaran, [44] better than the Breusch test and the LM Test by Pagan [40] when N is large enough. The current STATA16 xtscc program is adopted in this paper. The specific CD test formula is as follows:

$$\text{CD} = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \Rightarrow N(0,1)$$

$H_0 : U_{it} = \sigma_i \varepsilon_{it,} \sim IID(0.1)$ for all i and t.

The disturbances of $\varepsilon_{it,}$ are distributed symmetrically around 0.

The unit root test is used for a series stationary characteristic [16]. Many unit root panel tests are equipped with tools to monitor interdependencies (or cross-sectional dependence), i.e., second-generation unit root panel tests. Unless the results suggest cross-sectional dependency, second-generation tests must be used [22]. The second-generation root unit tests fit better because our panel data are based on cross-sectional dependency. This research uses both tests (first and second generation) to improve the result.

In particular, second-generation tests from Pesaran [45] developed by Levin, Lin, and Chu [25] and the CADF panel root unit tests are used in this study. Therefore, CADF panel unit root tests are used for each panel time series data. The unit root test is Augmented Dickey – Fuller (ADF) as follows.

$$\Delta x_{i,t} = \alpha_i + \beta_i x_{i,t-1} + \rho_i T + \sum_{j=1}^{n}\theta_{ij}\Delta x_{i,j} + \varepsilon_{i,t}$$

α and T are the different intercepts and time patterns, respectively, where $x_{i,t}$ means an evaluated variable $\varepsilon_{i,t}$ is the error term, Δ is the differentiating operator. According to the Schwarz Information Criteria (SIC), the correct lag lengths are selected. The tests lead to the null hypothesis that every individual in a panel is not stationary versus the alternative hypothesis that at least one individual series is stationary.

$$H_0 : \beta_i = 0,$$

$$H_a : \begin{cases} \beta_i < 0 \ \text{for}\ i = 1, 2\ldots, N_1 \\ \beta_i = 0 \ \text{for}\ i = N_1 + 1, N_1 + 2, \ldots, N \end{cases}$$

Table 2 displays the estimates of the cross-sectional dependency test for each variable. For all the variables we analyzed, there is strong evidence to reject the null hypothesis of CSD. In other words, there is cross-sectional dependence (CSD) on all the variables selected in this study. Therefore, this analysis refers to each of the individual panel time series data using unit root CADF panel unit tests. Pesaran's CADF panel root test result is recorded in Table 3. CO_2, Energy, rgdp, Texp, and Trade are of mixed order of integration at their level but evidence of stationarity at their first difference. Therefore, we have sufficient proof to reject 5% of the null hypothesis of unit root. Considering the order of integration position, our study will adopt the pool mean group and mean group technique under the framework of ARDL approach to cointegration.

Data analysis

Engle and Granger [14] and Johansen [20] concluded that if variables are combined into the same order, there are long-term relations. Building on this concept, Pesaran

Table 3 Panel unit root estimates

Variables	LLC		IPS		CIPS		Result
	Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend	
ln CO_2	3.95789	− 0.11978	3.69498	1.37362	− 2.492**	− 2.291	I(1)
ln Energy	0.54592	− 0.60393	0.80616	0.72006	− 1.588	− 2.037	I(1)
ln Rgdp	− 6.29115***	− 4.52312***	− 4.02119***	− 2.51377**	− 2.415**	− 3.15***	I(0)
ln Texp	− 2.16967**	− 2.90621***	0.88428	− 2.69095***	− 2.343**	− 2.598	I(0)
ln Trade	− 3.04983***	− 3.93587***	− 0.59663	− 1.91400*	− 1.329	− 1.399	I(1)
Δ ln CO_2	− 9.23739***	− 11.7617***	− 8.89934***	− 11.5886***	− 3.134***	− 3.449***	I(1)
Δ ln Energy	− 9.32433***	− 15.2386***	− 8.12435***	− 14.0263***	− 3.540***	− 3.540***	I(1)
Δ ln Rgdp	− 6.38245***	− 7.04108***	− 4.59054***	− 5.52226***	− 2.897***	− 2.731*	I(1)
Δ ln Texp	− 9.56052***	− 6.86980***	− 8.33124***	− 5.94916***	− 2.342**	− 2.887**	I(1)
Δ ln Trade	− 13.0986***	− 11.3133***	− 10.3332***	− 8.38967***	− 2.256**	− 3.444***	I(1)

*, ** and ***Indicate significance at 10%, 5%, and 1% level, respectively

et al. [46, 47] presented the Mean group (MG) and pooled Mean group (PMG) by using the maximum-likelihood estimates (MLE) against Engle and Granger [14], as well as Johansen [20]. Also, when variables are combined in mixed order, these estimators function better. Hence, cointegration tests are not needed for applications of MG or PMG estimates and analysis of the distributed autoregression lag for time periods $t = 1, 2, \ldots, T$ and the groups $i = 1, 2, \ldots, N$ can be performed with unrestricted specification. Since the mixed integrated order among the variables does not affect estimation performance, traditional stationary checks are no longer necessary. In addition, this model is ideal for large panels N and T.

The PMG estimator is deployed to account for a more moderate level of heterogeneity [46], this estimate imposes homogeneity in the long-run coefficients while allowing for heterogeneity in the short-run coefficients and error variances. So, the PMG estimator allows for varying intermediate effects of the independent variables on the dependent variable while preserving the same long-term effects. There is a long-run relationship between the dependent and independent variables; the long-run factors are the same across nations, and the error terms are serially uncorrelated and distributed independently of the regressors (the independent variables can be viewed as exogenous). In addition, this strategy offers long-run coefficient homogeneity within a single country or set of repressors [46]. The MG estimator assumes that both the slope and intercepts can change across the countries, while the PMG estimator assumes that the long-run slope is homogeneous. This means that the MG estimator is more flexible and allows for more variation in the data, while the PMG estimator is more rigid and assumes that the long-run slope is the same across all countries. Employing the Hausman [18] specification test, the null hypothesis of homogeneity was based on two distinct comparisons:

(i) M.G.-Means group
(ii) PMG. -pooled means group.

The general form of the empirical specification under the autoregressive distributed lag ARDL(p,q) technique can be written as shown below.

$$y_{i,t} = \sum_{j=1}^{p} \beta_{ij} y_{i,t-j} + \sum_{j=0}^{q} \delta_{ij} x_{i,t-j} + \mu_t + \varepsilon_{it}$$

where number of cross sections $i = 1, 2, \ldots N$ and time $t = 1, 2, 3 \ldots T \cdot x_{i,t}$ is a vector of $k \times 1$ regressors, β_{ij} is a scalar,μ_t is a group specific effect. The disturbance is an I(0) process if the variables are I(1) and co-integrated. The co-integrated variables are defined by their convergence toward long-term equilibrium. This function implies that the system variables are influenced by the deviance from equilibrium in their error correction dynamic. Therefore, it is common to re-parameterize the above equation in the error correction equation.

$$\Delta y_{i,t} = \emptyset_i y_{i,t-j} - \theta_i x_{i,t-j} \sum_{j=1}^{p-1} \beta_{ij} y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij} \Delta x_{i,t-j} + \mu_t + \varepsilon_{it}$$

where $\Delta =$ difference operator

The $\emptyset_i$ is the parameter of the speed of adjustment or correction to long-run disequilibrium.

If $\emptyset_i = 0$, then no evidence of a long-run association of variables is present.

The negative and statistical significance of the $\emptyset_i$ variable under the previous assumption, in case of a disturbance, should be assumed to imply a convergence to long-term equilibrium.

Results and discussion

ln is the natural logarithm. WDI = World Development Indicators. All data were sourced from, World Bank (Available online: https://databank.worldbank.org/home.aspx); a list of the variables used in the analysis is shown in Table 1. There are major differences in minimum and maximum values of different variables, emission minimum value is 1465 while maximum value is 2618, minimum energy usage value is 7594 and maximum value is 9.807, minimum GDP per capita is 8.785 and maximum value is 11.42. International tourism varies significantly, expenditure ranges from 19.45 to 25.383. Similarly, trade openness with a minimum of 3.613 and a maximum of 3.652 varies.

We start by estimating the level dynamics in the long-run and the short-run relationship between emissions, energy use, tourism expenditure, economic growth and trade openness and infer the causal effect from the estimates. The optimum lag selection was determined using the Schwarz information criterion (SIC), which suggests lag one as the most suitable lag for the linear ARDL (p,q) estimations. To achieve robustness in this study, MG and PMG are applied simultaneously. The findings of the Hausman [18] test confirm that the use of PMG and MG is more consistent, efficient and statistically significant estimators for all the specifications in Tables 4 and 5. Hence, all discussions are based on the PMG and MG results estimates.

The presence of long-run relationship requires negative and significant error correction coefficient. Tables 4 and 5 show the long- and short-term dynamics relationship between CO_2 emissions, energy use, tourism expenditure, economic growth and trade openness of panel data set investigated. Specifically, Table 4 illustrates the speed of adjustment coefficients, which ranges from − 0.154 to − 0.908 with an average of − 0.2124 for all the models. Thus, it takes approximately 2.214 years for a deviation from the short-run equilibrium to return to long-run equilibrium between the variables: ln CO_2, ln exp, ln gdp, ln energy, ln trade. However, the long-run stable state is much faster in specification 4, i.e., 0.908 that includes energy use as the dependent variable and ln CO_2, ln exp, ln gdp, ln trade as independent variables within the model. The coefficient of international tourism expenditure (ln Texp) in all the five models is positive and statistically significant at 1% level.

The results of the two-model specification 3 &4 show that a 1% increase in international tourism expenditure would cause at least 0.0353% and 0.02% increase in economic growth (ln rgdp) and energy use in the short-run, respectively. This scenario might be because the tourism industry uses primary energy sources, particularly in transport, accommodation and destination, thus increasing its contribution to global carbon emissions. Tourism destinations consume considerable energy to import food and other materials and transport them. The mundane finding is in support of vast empirical entries by Dogan et al. [10] for the case (OECD) countries, Işik et al. [19], who found that the tourism industry drives emissions in both the short and long run, Nepal et al. [34] for the case of Nepal. This result also concurs with the recent submission by Dogru et al. [11], who found that tourism development positively influences Italy, Luxembourg, and the Slovak Republic.

Carbon emission (ln CO_2) exerts significant influence on energy in the short and long run, and trade openness in the long run, respectively. Accordingly, there is a bidirectional causality between carbon emission (ln CO_2) and energy consumption. It means that a 1% increase in CO_2 emission increases energy use by 0.76%. The short-run causal effect of real GDP per capita (ln gdpc) on CO_2 emission and trade openness in models 1& 5, respectively, are found to be positive and statistically significant at 10% and 1% level. A 1% increase in economic growth causes 0.288% and 2.02% increase on carbon emission (ln CO_2) and trade openness ceteris paribus. The short-run causal effect of energy consumption (ln energy) on CO_2 emission and tourism expenditure (ln exp) in models 1& 2, respectively, are found to be positive and statistically significant at 1% and 10% level. A 1% increase in energy consumption (ln energy) causes a rise of 1.315% and 1.547% increase on carbon emission (ln CO_2) and

Table 4 Estimation of short elasticity

Variables	Spec 1 PMG ln CO_2	Spec 2 MG ln exp	Spec 3 PMG ln gdp	Spec 4 MG ln Energy	Spec 5 MG ln trade
ECT	− 0.199**	− 0.462***	− 0.154***	− 0.908***	− 0.688***
Δ ln CO_2		− 0.794	0.07	0.546***	− 0.372
Δ ln Texp	0.00377		0.0353***	0.0202***	0.00788
Δ ln gdp	0.288*	1.42		− 0.00324	2.027***
Δ ln Energy	1.315***	1.547*	0.0903		
Δ ln trade	− 0.171***	0.0786	0.168***	0.0927**	

The level of significance is indicated by 1%, 5%, 10& for *, **,***ARDL (PMG & MG) models selected on *SC* Schwarz information criterion, $k = 1$, Δ is the first difference term

Table 5 Long-run estimates

Variables	Spec 1 PMG ln CO_2	Spec 2 MG ln exp	Spec 3 PMG ln gdp	Spec 4 MG ln Energy	Spec 5 MG ln trade
ln CO_2		− 3.235	− 0.116	0.524***	− 1.565***
ln Tex				0.0293	
ln gdp	0.159**	− 2.209		0.232**	1.245***
ln Energy	1.388***	6.189	0.711***		1.957*
ln trade	− 0.410***	0.272	0.285***	0.0903	
C	− 2.140**	− 2.816	0.697***	4.577***	− 13.42*
observation	228	228	228	228	228
Hausman test	5.91 (0.2063)	1026** (0.0363)	2.45 (0.652)	11.99** (0.0174)	13.36*** (0.0096)

The level of significance is indicated by 1%, 5%, 10& for *, **,***ARDL (PMG & MG) models selected on *SC* Schwarz information criterion, $k = 1$

tourism expenditure (ln exp) ceteris paribus. Finally, causal effect of trade (ln trade) on CO_2 emission and trade openness in models 1, 3 & 4, respectively, are found to be statistically significant at 1% level. Meanwhile, the effect on CO_2 emission is negative, while energy demand (ln energy) and (ln gdp) is positive; the negative coefficient (–0.171) implies that a 1% increase in energy demand (ln energy) would decrease the CO_2 emission in by 0.171% in the short run. The results also suggest that a 1% increase in effect of trade (ln trade) causes 0.168% and 0.0927% increase in energy demand (ln energy) and (ln gdp) ceteris paribus.

Similarly, in the long-run, international tourism expenditure (ln exp) exerts a positive and significant impact on CO_2 emissions in model 1 and is positive and insignificant in the rest of the models. This implies that the environmental impact of investment in tourism mitigates CO_2 emissions. All things being equal, a 1 percent increase in tourism expenditure may lead to a 0.04% increase in the levels of ln CO_2 emissions. In sum, a unidirectional causality flows from tourism expenditure to carbon emission. These empirical findings suggest that investment in tourism improves environmental quality in the selected countries. While the tourism coefficient is comparatively lower relative to economic growth, trade, energy demand and carbon emission, it remains substantially different from zero both in the short and long-run. Therefore, the tourist sector contributes to gas emissions in European nations through various channels such as transport, the construction of tourism facilities, and local government services.

The effect of real GDP per capita (ln gdpc) on CO_2 emission, energy use and trade openness in models 1, 4 & 5, respectively, are found to be positive and statistically significant at 5% and 1% level. A 1% increase in real GDP per capita (ln gdpc) increases the carbon emission (ln CO_2), energy use and trade openness. The results also indicate a positive but insignificant relationship between ln gdp and ln CO_2, ln exp, ln gdp, ln trade. The effect of energy use (ln energy) on CO_2 emission, real GDP per capita (ln gdpc) and trade openness in models 1, 2 & 5, respectively, are found to be positive and statistically significant at 1% and 10% level. A 1% increase in energy use (ln energy) increases carbon emission (ln CO_2), real GDP per capita (ln gdpc) and trade openness by 1.38%, 0.711% and 1.95%, respectively. Finally, the effect of trade openness on CO_2 emission energy use in model 1 is found to be negative and statistically significant at 5% level. This implies that a 1% increase in trade openness keeping other factors constant would decrease the carbon emission (ln CO_2) by 0.41% in the long-run. In model 3, trade openness exerts a positive and statistically significant effect at 1% on real GDP per capita (ln gdpc). Hence, a 1% increase in trade openness would increase the real GDP per capita (ln gdpc) by 0.285% in the long-run.

Discussion of findings

This paper makes some important contributions to the literature concerning the long-run and short-run relationship among tourism expenditure, emission, economic growth, energy consumption and trade openness. Tourism expenditure, real GDP per capita (ln gdpc) and energy consumption cause environmental degradation in the form of emissions. This means that rising emissions are negative, ranging from health problems to climate change and other problems that can impact the community and tourism. The study's finding supports the tourism-led growth hypothesis, and the results are in line with previous studies [39, 41, 55, 56, 60]. Kadir et al. (2019) observed that economic growth and the tourism industry contribute significantly to emissions in the long run in the emissions model. Trade openness shows a negative impact on emissions and a positive impact on economic growth since trade openness gives global prosperity to the world and contributes to environmentally sustainable economic growth. The plausible explanation is divided into two aspects on the impact of trade openness on CO_2 emissions. First, it accelerates capital and product flow, thereby increasing CO_2 emissions from commodity production and energy use [54], and second, it can lead to a technological breakthrough between different nations that promote economic growth by reducing carbon emissions [27]. In addition, the standard economic block, the Eurozone, has lowered trade barriers between the countries, saving unnecessary transaction costs and promoting technology communication and trade. It has broadened the trade scale and jointly helped achieve carbon emission reduction goals. Thus, removing trade barriers in the EU provides an opportunity to broaden trade openness and promote technology cooperation and communication between countries. International business requires countries to follow strict and structured environmental practices for export to high-income countries during the manufacturing process. Similar findings were observed by Omri et al. [38], Dogan et al. [10], and Khoshnevis et al. (2018) for different countries. In the case of Gulistan et al. [17], trade openness is not statistically significant.

In sum, a long-run equilibrium relationship among tourism, CO_2 emissions, economic growth, energy consumption and trade openness implies a long-run causal relationship between the variables. Economic growth and energy consumption may lead to an eventual adverse increase in emissions, except trade openness. However, increasing trade openness could reduce emissions to a great extent.

Conclusion and policy direction

This paper combines tourism, economic growth, pollution, energy use, and trade openness in a dynamic format for cointegration testing with panel data from 12 tourism-induced European countries covering 1995–2018. The study recognizes the issue of cross-sectional dependency, which can lead to unsustainable results and methodological problems. The study uses panel root tests in the first and second generation and has a particular interest in the second-generation root, which is responsible for cross-sectional dependency issues. The Pesaran CD test [44] indicates that disturbances are section by section in each panel time series. For the second generation of estimators, the dynamic ARDL method shows the coefficient estimates. Five models were developed, and the long-term relationship between variables received further attention. With particular attention to MG and PMG, each model under the ARDL system was chosen for further study using the Hausman technique.

Therefore, we provide a clear appreciation of long-run equilibrium relationship among the variables. Particularly, the study found that tourism, economic growth, and energy consumption exact significant impact on CO_2 emissions, while trade openness negatively influences CO_2 emissions in the twelve tourism-induced countries in Europe. The positive impact of economic growth, tourism, and energy use on CO_2 emissions offers evidence that these variables contribute to higher CO_2 emissions through rising energy demand and transport usage to support tourism facilities. Therefore, policymakers need to enforce environmental regulation policies and promote the use of tourist and economic activities for energy efficiency. Trade openness plays a key role in the region's continued economic growth and emission reductions through policy reform, while economic growth drives energy consumption. Lastly, it is recommended that policymakers should also control such policy measures that drive trade activities as trade openness detracts from the CO_2 emissions.

A final recommendation on the outlook for global emissions is that carbon-intensive economies will easily be turned into green economies. To incorporate such an approach, more analytical exercises are required to assess future related emissions, growth and economic activity with respect to the tourism sector. This offers initial guidelines to rate sustainable growth behavior. In choosing the correct policies to implement, policymakers may measure the reduction potential against other sustainability aspects.

Limitations of the study and suggestions for further research

This research focused solely on the impact of tourism, economic growth, trade, and energy demand on carbon emissions in the EU. Only twelve top tourist countries in the EU were considered. Considering the number of countries and variables involved, we were unable to use advanced econometric techniques that are more robust and efficient. Therefore, the study is limited to the six variables adopted (tourism, economic growth, trade, energy demand and carbon emission), and left-out policy variables like EKC and other relevant economic fundamentals and renewable energy variables constitute a path for future authors to examine further.

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Author contributions
NCN collected the data, wrote the empirical literature, funding: providing personnel, environmental and financial support and tools and instruments vital for the project. KIO conceived and designed the analysis, collected the data, performed analysis, organizing and supervising the course of the project or the article and taking the responsibility. IO collected the data, planning methodology to reach the conclusion, funding: providing personnel, environmental and financial support and tools and instruments that are vital for the project. OBM wrote the theoretical literature, constructing an idea or hypothesis for research and/or manuscript, planning methodology to reach the conclusion. INSN collected the data, performed analysis, organizing and supervising the course of the project or the article and taking the responsibility, planning methodology to reach the conclusion. SUA collected the data, wrote the empirical literature, funding: providing personnel, environmental and financial support and tools and instruments that are vital for the project. All authors have read and approved the final manuscript.

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