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Expanding the tourism energy growth nexus: an empirical analysis within the Eurozone

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Abstract
This study extends the energy tourism growth discussion by adopting the concept of market segments when investigating tourism proxies. We adopt econometric procedures to identify potential structural breaks and cross-sectional dependence together with appropriate panel data model specifications. Causality tests are also processed to search for the direction of potential linkages. The rationale behind such an approach is to integrate the energy growth nexus discussion with the tourism growth nexus into one specification and investigate holistically potential impacts and causalities under a new, unobserved in relative literature set of variables. Interestingly, we offer to the relevant literature in the following ways: first, the concept of market segments regarding business and leisure tourism spending as a proxy for tourism expansion is used. Second, we also encompass internal consumption, by international and domestic visitors, instead of international receipts when searching for causalities. Third, we consider capital investment spending within the travel and tourism sector. This issue is less visible, if not unnoticed, in relevant studies since the vast majority adopt the concept of foreign investment spending. Our empirical findings confirm the conservation hypothesis, while the feedback hypothesis is also present in our specifications. Practical implications demand effective management within the tourism system to foster pro-environmental behavior and achieve efficient energy use within the economic system.

Keywords Tourism · Energy consumption · Economic growth · Sustainability

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1 Introduction

Nowadays, many environmental problems require serious consideration of how society, the economy, and nature interrelate simultaneously. Also, there is a debate on issues to address environmental concerns, mitigate environmental risks, and decode environmental limits that potentially restrict growth. Energy resource availability and (over)exploitation of natural resources in favor of developing economic activities are among the most critical research issues (Adedoyin et al., 2021). In this perspective, tourism is considered energy-intense economic activity (Katircioglu et al., 2019), whereas it is a fast-growing industry that interrelates sustainability (e.g., environmental and energy issues) and economic growth to a great extent (Aslan et al., 2021; Hall & Page, 2014; Nepal et al., 2019). Moreover, it stresses the importance of growth that creates in destinations (Saarinen, 2006).

In the literature, there are two main strands to search for causalities among energy, economy, and tourism, namely the energy growth nexus discussion as well as the tourism growth nexus discussion, which elaborate on four hypotheses (Menegaki & Tugcu, 2018; Tugcu, 2014): the growth hypothesis, which discloses a unidirectional causality running from energy consumption to economic growth; the conservation hypothesis, which reveals a unidirectional causality running from economic growth to energy consumption; the feedback hypothesis which evidence that a reciprocal causality running from energy consumption to economic growth and vice versa is present; and the neutrality hypothesis which indicates that no causality is present concerning energy proxies and growth variables.

The present study aims to investigate the tourism energy growth nexus discussion across the Eurozone countries. We then for potential causalities among a country's growth (e.g., Gross Domestic Product (GDP)), energy consumption, ecological footprint, and tourism expansion. In this perspective, we aim to offer insights into the relevant scientific discussion: (1) we consider a new set of explanatory determinants when testing the energy tourism growth nexus hypotheses, and (2) we investigate the predictive power of high-impact tourism sub-sectors, namely business tourism and leisure tourism spending, highlighting the heterogeneous nature of tourism when testing causalities between tourism and the environment. We claim this is a contemporary issue within academia that constantly investigates ways to improve human and technical aspects and issues, sectoral and organizational, to integrate sustainability into the economy (Ekonomou & Halkos, 2023a, 2023b). In this perspective, perceiving the links between environmental issues and the economy is vital for establishing effective policy mitigation initiatives (Borozan, 2022).

Furthermore, this research effort's root cause derives from exploring untested potential factors that might impact growth and environmental quality levels within the economic system. Consequently, a chance to depict sustainable patterns concerning growth rates, energy consumption, and tourism is present. Notably, at a time of increasing interest in developing 'green' consumption behavior, the relationship between economic growth, energy consumption, and high-leverage market sectors seems to be a motivating topic for research. In this context, the energy consumption concept should be incorporated into adequate empirical analyses in favor of effective decision-making processes and practical or theoretical explanations (Halkos & Petrou, 2019).

The present study combines two 'nexus' in the energy growth and tourism growth discussion into one strand to test relevant linkages and impacts on economic growth under an untested set of variables. We disaggregate the tourism sector into profitable and popular market segments and evidence relevant relationships based on panel data analysis. We stress the importance of the heterogenous dynamic of the tourism phenomenon on

environmental degradation (e.g., carbon dioxide emissions), which has been untested so far in the literature. To complement our work in the tourism energy growth nexus discussion, we investigate less visible tourism proxies in relevant research efforts such as internal travel and tourism consumption and investments directly related to the tourism phenomenon. The predictive power for both variables has been overlooked so far in the literature. Also, our holistic approach includes energy consumption and carbon dioxide emissions, offering a complete set of explanatory variables to test the effects on a nation's GDP.

Specifically, we conceptualize energy in terms of final energy consumption and ecological footprint as a means of carbon dioxide emissions. In addition, we extend our research and test cause and effect relationships at the interface of environmental footprint and tourism expansion in the Eurozone economic space. As a result, we keep the carbon dioxide emissions as a variable of ecological footprint. Then, we search the exploratory power of tourism expansion on the environmental footprint regarding two discrete market segments: business and leisure. Furthermore, we consider the impact of tourism's contribution to a country's GDP on carbon dioxide emissions.

Sustainable energy use is not an issue of customization but an integrated concept profoundly related to energy efficiency. For instance, this becomes evident in high energy demand sectors such as tourism and relevant consumption patterns such as visitors' spending. Khan et al. (2019) argue that 61.4% of GHGs revealed in the environment come from the energy sector. Additionally, intense energy consumption in the tourism industry has caused adverse effects on environmental quality (Gokmenoglu & Baris, 2020; Sun et al., 2020). Within this framework, energy consumption has a broader impact on energy efficiency, GHGs, and related demand for economic activities (Khan et al., 2019). Nowadays, competing by using natural resources and the environment stresses the importance of formulating an effective process of getting things done in the context of sustainability without restricting business potential and relevant economic benefits. ϒet, these concerns do not seem to reflect significant progress of sustainable growth to achieve the desired equilibrium within the socioeconomic system and nature's dynamics (Halkos & Gkampoura, 2021).

The structure of the present study is as follows. The next section concerns the relevant literature. The third section presents the methodology and the econometric approaches adopted to process panel data analysis. The fourth section presents the empirical findings, whereas the fifth section discusses the results. Finally, the last section offers the conclusions.

2 Literature

The links between energy supply, energy demand, and economic growth (Khanal et al., 2021) widely interrelate to the questionable achievement of a nation's economic goals toward a sustainable future (Zhang & Gao, 2016). An issue highlighted in the energy growth nexus discussion (Menegaki & Tugcu, 2017, 2018). So far, empirical research efforts of testing causalities do not provide a clear justification if energy consumption patterns drive economic expansion or vice versa. All four hypotheses (e.g., growth, conservation, feedback, neutrality hypotheses) that have been justified so far profoundly depend on proxies used, research time, set of countries examined, and econometric approaches applied (Hajko et al., 2018; Le, 2020; Menegaki & Tugcu, 2018).

Nowadays, energy issues and tourism expansion are widely involved in achieving sustainability within the economic sphere (Hall & Page, 2014). However, researchers have

primarily focused on the energy growth nexus discussion and tourism growth nexus discussion as two distinct approaches (Anagnostou et al., 2021; Halkos & Paizanos, 2016). The former examines the causalities between energy growth and consumption (Menegaki & Tugcu, 2018). The latter is based on the export-led growth hypothesis (hereafter ELGH) and tests whether tourism expansion or development drives economic growth mainly reflected in terms of a nation's GDP (Cárdenas-García et al., 2015; Cerdeira Bento, 2016; Demirhan, 2016; Skrinjaric, 2019; Tang & Abosedra, 2014).

Specifically, in the energy growth nexus discussion, scientists concentrate on how energy consumption patterns (e.g., conservation measures) impact a nation's economic growth (e.g., GDP) (Menegaki & Tugcu, 2016). For instance, a research question that justifies the theoretical background of the energy growth nexus is as follows: Will energy-saving measures limit the process of economic growth? If this is the fact, how will relevant growth be affected? The four hypotheses (e.g., growth, conservation, feedback, neutrality) should be evidenced based on the models developed in the following paragraphs to further elaborate on these research questions. Interestingly, the tourism-led growth hypothesis is evidenced by the export-led growth hypothesis. This hypothesis considers exports of services and goods as core factors in the process of economic growth or expansion (Shan & Wilson, 2001). The argument that underlies such a methodological approach is focused on the foreign exchange earned by tourism (e.g., generated by foreign markets). This foreign exchange is needed to import capital goods to produce services and goods, enhancing growth in economic terms. Essentially, the tourism-led growth nexus reflects ELGH, which argues that economic growth results from the generation of jobs (labor) and income (capital) and the growth of exports in services and goods (Brida et al., 2016). In this empirical research, we integrate the energy growth nexus and tourism growth into one bundle of tourism energy growth nexus and investigate relevant effects on a nation's growth process. Based on panel data analysis, we classify research findings under the four hypotheses outlined above.

The literature recognizes the central role of tourism in the growth process and expands the energy growth nexus discussion toward the tourism energy growth nexus discussion (Bano et al., 2021; Ben Jebli et al., 2018; Dogru et al., 2020; Gokmenoglu & Baris, 2020; Liu et al., 2019; Nepal et al., 2019; Sghaier et al., 2019).

Supportively, a research prospect arises to investigate whether tourism, commonly known as the "smokeless industry", affects environmental degradation levels (Akif Destek & Aydın, 2022). Consequently, it is crucial to investigate energy efficiency concepts and sustainability in the economy to promote environmentally friendly activities without compromising growth (Marques et al., 2019). The vast majority of research studies conceptualized tourism expansion or development when investigating its impact on a nation's GDP in terms of tourism receipts (Balaguer & Cantavella-Jorda, 2002; Brida & Risso, 2009; Demirhan, 2016; Durbarry, 2004; Tugcu, 2014) or tourism arrivals (Antonakakis et al., 2015a, 2015b; Cerdeira Bento, 2016; Cortés-Jimenez & Pulina, 2010; Demirhan, 2016; Kasimati, 2011; Massidda & Mattana, 2013; Skrinjaric, 2019).

In this study, we consider the contribution of tourism to a country's GDP as a growth variable and test cause-and-effect relationships. Such an approach is not visible in the literature. In addition, we consider capital investment spending by all industries directly involved in the travel and tourism sector instead of foreign direct investment since it offers indications for capital flows into the tourism industry to support the growth process (Ekonomou, 2022).

Additionally, we launch the concept of internal travel and tourism consumption to test relevant causalities on economic growth and vice versa. Specifically, we take into

consideration both domestic tourism spending as well as international tourism spending in the context of business and leisure tourism. The vast majority of studies so far conceptualize the impact of tourism on economic growth by taking into account only the international tourism earnings or revenues for all forms of tourism (Balaguer & Cantavella-Jordá, 2002; Dritsakis, 2004). Consequently, a potential research area in the literature might be present.

Furthermore, this paper aims to search the role of energy consumption and tourism expansion on the environment, conceptualizing the ecological footprint as a function of carbon dioxide emissions. So far, it is unclear whether, and if this is the case, to what extent potential positive economic benefit compensates for the negative environmental impact in terms of tourism expansion and long-term sustainable growth (Akif Destek & Aydın, 2022). Many research efforts investigate the linkages between energy and tourism without considering the role of CO_2 releases (Amin et al., 2020; Gokmenoglu & Baris, 2020; Isik et al., 2018). Interestingly, most studies that fall into this discussion conceptualize tourism as a proxy for international arrivals or international receipts (Dogru & Bulut, 2017; Isik & Radulescu, 2017; Isik et al., 2018; Lee & Brahmasrene, 2013; Leon et al., 2014; Tiwari et al., 2013).

In the following sections, we analyze all these research efforts based on relevant econometric models. Such research needs practical answers based on data processing and scientific research considering time and potential cross-country dependencies at the interface of economy, energy, and tourism.

3 Methodology

Panel data analysis is applied, and tests for detecting potential cross-sectional dependence across panel units are implemented. Then, we use contemporary unit root tests that consider potential structural breaks and accommodate dependencies across panel units. For this reason and in the presence of cross-sectional dependence, we utilize the fixed effects specification with Driscoll and Kraay's (1998) standard errors, as indicated, among others, in Hoechle (2007). In this way, consistent with cross-sectional dependence, robust results are provided. The last step contains Granger causality tests to recognize the direction and significance of any causalities.

Additionally, we employed Granger non-causality tests developed by Dumitrescu and Hurlin (2012). Contrary to traditional causality approaches that assume homogeneity of cross-sectional units (like countries), we adopt this procedure to stress the significance of heterogeneity in both causalities among panel units (e.g., Eurozone member states) and regression model slope coefficients.

3.1 Data

This research uses annual balanced panel data from World Travel and Tourism Council (WTTC) (2019). We search for causal linkages concerning countries that form the Eurozone[1] economic space from 2000 to 2019. More specifically, the relationships presented

[1] The Eurozone economic space is composed of Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Netherlands, Portugal, Slovakia, Slovenia, Spain.

Table 1 Variables used in the models

Variable name	Abbreviation	Operationalization	Source
Gross domestic product	gdp	The value of all goods and services produced less the value of any goods or services used in their creation	Eurostat
Business tourism spending	bts	Spending on business travel within a country by residents and international visitors	World Travel & Tourism Council
Leisure tourism spending	lts	Spending on leisure travel within a country by residents and international visitors	World Travel & Tourism Council
Internal T&T consumption	ittc	Total revenue generated within a country by industries that deal directly with tourists, including visitor exports, domestic spending, and government individual spending	World Travel & Tourism Council
Direct contribution to GDP	dcgdp	GDP generated by industries that deal directly with tourists	World Travel & Tourism Council
Investment (capital investment)	invest	Includes capital investment spending by all industries directly involved in Travel & Tourism	World Travel & Tourism Council
Final energy consumption	energyf	Amount of energy end-use in a country. This variable does not concern the energy consumed by the energy sector itself	Eurostat
Carbon dioxide emissions	dioxide	Carbon dioxide emissions	World Bank

by expressions (1) and (2) are examined. Table 1 presents the regression variables, their sources, the names used in the models, and the operationalization of each variable.

$$\text{loggdp} = \text{f(logenergyf, logdioxide, logrittc, logrinvest)} \quad (1)$$

$$\text{logdioxide} = \text{f(logrinvest, logrbts, logrlts, logrdcgdp)} \quad (2)$$

We have included only real values for variables that are monetary. The time range of the analysis has been chosen based on data availability. We have log-transformed the panel variables. Consequently, we can interpret regression coefficients as elasticities.

Business tourism is a natural combination of business networking and alliances, given the open character of economies, free trade, and new market access to receive economic results (Ekonomou & Kallioras, 2020). Indicatively, in 2019 residents within the European Union made 125 million business trips, representing 11% of the total number of tourism trips (Eurostat, 2022). In addition, leisure tourism reflects the human need to experience recreation and enjoyment alternatives and receive satisfaction. The World Travel and Tourism Council (WTTC) argues that in 2018, the leisure market possessed a share of 78.5% of spending in the tourism sector (WTTC, 2019).

Consequently, emphasis should be placed on identifying patterns concerning the issue of 'spending,' not only as a pure proxy expressed in monetary values within the tourism industry but as a core determinant that creates multiplicative effects within a nation's growth process (Ekonomou, 2022). Global business travel spending dropped by nearly 54% for 2020 over the previous year because of the COVID-19 outbreak, amounting to roughly 661 billion US dollars (Statista, 2022). However, according to the Global Business Travel Association (GBTA), worldwide business tourism expenditure is projected to return to pre-pandemic levels by 2024, reaching around 1.48 trillion US dollars. Furthermore, according to WTTC's (2021) latest research on Travel and Tourism Global Economic Impact 2021, following a 61% decline in 2020, global business travel spending is expected to rise by 26% in 20,211 and by 34% in 2022, implying a recovery to 66% compared to 2019. Particularly in Europe, business spending is set to rise by 36% in 2021, more potent than leisure spending at 26%, followed by a 28% rise in 2022.

Although there have been signs of an upswing in business travel in 2021, leisure travel continues to drive the sector's recovery concerning the outbreak of COVID-19 (WTTC, 2021). Moreover, from a policy perspective, energy consumption has a significant effect on economic growth, as it is the basis for industry, whereas severe environmental impacts of energy have increased the GHG emissions, such as CO2 (Khan et al., 2019). Table 2 offers the descriptive statistics of panel variables under investigation.[2]

3.2 Testing for cross-sectional dependence

If not detected early in panel data analysis, cross-sectional dependence (CD) might cause serious problems when obtaining regression-estimated coefficients. In addition, results will not be efficient and consistent due to unobserved or ignored residual cross-sectional dependencies across panel variables (e.g., countries under investigation) (Pesaran, 2006).

[2] We used the Stata 16.1 and Gauss 22 software packages to process the analyses.

Table 2 Descriptive statistics of the variables under consideration

	GDP (€)	CO_2 (toe)	Final energy consumption (mtoe)	Internal travel and tourism consumption (€)	Capital investment spending (€)	Business tourism spending (€)	Leisure tourism spending (€)	Direct contribution of tourism to GDP (€)
Mean	4.97E+11	5.335159	42.45379	4.75E+10	5.58E+09	8.76E+09	3.87E+10	2.20E+10
Median	1.75E+11	5.111297	16.49000	1.54E+10	2.00E+09	2.34E+09	1.21E+10	5.11E+09
Maximum	3.44E+12	12.79457	225.3500	3.34E+11	3.90E+10	6.81E+10	2.66E+11	1.20E+11
Minimum	4.14E+09	1.604138	0.370000	7.82E+08	80,000,000	90,000,000	4.37E+08	1.45E+08
Std. Dev	7.53E+11	1.778912	59.29149	7.84E+10	8.19E+09	1.45E+10	6.41E+10	3.34E+10
Skewness	1.871958	1.028422	1.759528	2.218968	1.891014	2.192591	2.224632	1.604983
Kurtosis	5.622037	5.734067	5.046007	7.297398	5.868662	7.096640	7.347003	4.150210
Observations	380	380	380	380	380	380	380	380

Pesaran's (2004) post-regression test suggests a simple average of all pair-wise correlation coefficients of the Ordinary Least Squares (OLS) residuals obtained from the individual regressions when implementing the panel data analysis.

This test accommodates single or multiple potential structural breaks in the slope coefficients and the error variances of the individual regressions.

The proposed test provides valid results for small sample properties for both dimensions, namely cross sections (N) and time dimensions (T). The test does not depend on a particular spatial weight matrix, mainly when N is large and T is small.

In the literature, two types of CD have been recognized. The first type is reported as spatial (Anselin, 2001) and deals with the geographical distance explaining the interdependence between countries. The second type is known as long-range dependence or global interdependence (Moscone & Tosetti, 2010). This type of dependence might occur when countries demonstrate the same or similar character (reaction) in front of external occurrences or economic shocks.

3.3 Testing for unit roots

If unit roots are present, then the panels' mean and variance are inconstant over time, indicating that data are not stationary. Moreover, test results will lack robustness if we do not adopt econometric approaches that accommodate potential structural breaks. Since CD is present, we adopt a panel Lagrange Multiplier (LM) unit root test with level and trend shifts proposed by Lee and Tieslau (2019). This contemporary approach to investigating if panel variables are stationary considers heterogeneous structural breaks across panel models in the intercepts and coefficient slopes. This procedure is useful since it treats the nuisance parameter, which offers indications for the location of the structural breaks when trend shifts appear across panel data.

Lee and Tieslau (2019) argue that the test statistic is independent on the location of the structural breaks. For this reason, there is no need to receive different values of the means and variances of the series at different break locations under any other method. The null hypothesis indicates that panel variables have unit roots. Rejection of the null hypothesis suggest that panel variables are stationary.

We adopt the fixed effects (within) regression models to reinforce our methodological approach with Driscoll and Kraay's (1998) standard errors procedure. The model is processed in two steps (Hoechle, 2007).

First, the panel variables are within transformed with the within estimator corresponding to the OLS regression. The second step of the analysis concerns estimating the transformed regression model "by pooled OLS estimation with Driscoll Kraay standard errors" (Hoechle, 2007, p. 288). The proposed approach allows for heteroscedastic error structure, autocorrelation, and cross-sectional dependence across panel units.

3.4 Testing for causalities

Causality tests proposed by Dumitrescu and Hurlin (2012) provide evidence concerning the direction of the established relationship across panel variables. It is the most widely used test to detect Granger causalities when processing panel data (Minorics et al., 2022). Furthermore, as indicated by Dumitrescu and Hurlin (2012), the Monte Carlo experiments carried out disclose that test has very good properties for small samples, for instance, with very small T and N dimensions, even for cross-sectionally dependent panel data.

Table 3 Results of CD tests

CD test for (1)
Dependent variable: loggdp
Independent variables: logenergyf, logdioxide, logrittc, logrinvest
Pesaran's test of cross-sectional independence = 24.050
P value = 0.0000
CD test for (2)
Dependent variable: logdioxide
Independent variables: logrinvest, logrbts, logrlts, logrtcgdp
Pesaran's test of cross-sectional independence = 47.313
P value = 0.0000

Additionally, the estimated standardized average Wald statistics are simple to calculate and depict a standard normal asymptotic distribution. This test offers a more comprehensive interpretation of the underlying causal linkages among tested panel variables. Tugcu (2014) claims that the test is better than the traditional causality approach because it permits for different lag orders for each cross section. This test creates dependable results and has been employed to test causalities for various contemporary and recent research efforts in many stands in the empirical literature concerning the environment, energy, and the economy (e.g., energy growth nexus discussion, Environmental Kuznets Curve hypothesis) (indicatively see, Addai et al., 2023; Ekonomou & Halkos, 2023a, 2023b; Halkos & Ekonomou, 2023; Liu et al., 2022; Menegaki & Tugcu, 2018; Saldivia et al., 2020). This approach tests the H_0 that there is no causality between the tested pairs of panel variables. Rejection of the null hypothesis indicates that the exploratory variable Granger causes the dependent variable. The test provides the causality relationship among panel units related to the null Homogeneous Non-Causality (HNC) hypothesis. It concerns the individual Wald statistics for the ith cross-sectional unit corresponding to the individual test $H_0 : \beta_i = 0$. Such causality tests can be processed when T is greater than N and vice versa.

4 Results

4.1 Results for CD

Test results based on Pesaran's (2004) CD tests indicate that for all regression models, residuals are correlated since the H_0 is rejected at a 1% confidence level (Table 3). This incident is common when analyzing cross-sectional time series at a microeconomic or macroeconomic level. In essence, the CD indicates the presence of unobserved common factors that affect panel data. This means that the countries under consideration have same, similar patterns. Eberhardt and Teal (2011) argue that CD suggests that countries experience common shocks, and their reaction to them has similar features. Hoechle (2007) states that spatial dependence is commonly present when performing panel data analysis.

4.2 Results from unit roots tests

We adopted panel LM unit root tests with level and trend shifts relying on the process developed by Lee and Tieslau (2019). Research findings suggest that unit roots are not

Table 4 Unit roots test results

Variables tested	Statistic	Break 1	Break 2	Lags
loggdp	− 11.184	2018	2003	0
logenergyf	− 9.089	2018	2002	0
logdioxide	− 8.320	2018	2012	1
logrittc	− 11.871	2018	2003	0
logrinvest	− 10.906	2018	2003	0
logrbts	− 9.860	2018	2003	0
logrlts	− 12.337	2018	2003	0
logrtcgdp	− 11.080	2018	2003	0
Panel LM test statistic	PDLM: − 36.552 *P* value: 0.0000			

Table 5 Results of fixed effects regression with Driscoll–Kraay standard errors

Dependent variable	Independent variables	Coefficients	Drisc/Kraay Std. Err	t	*P*>|t|	95% confidence interval	
(a) (Dependent variable: loggdp)							
loggdp	logenergyf	.8906825	.2120104	4.20	0.001	.4452651	1.3361
	logdioxide	.8742828	.1058169	8.26	0.000	.6519698	1.096596
	logrittc	.1836811	.064907	2.83	0.011	.0473165	.3200458
	logrinvest	.0645789	.0171449	3.77	0.001	.0285588	.100599
	Constant	7.021025	.4781341	14.68	0.000	6.016502	8.025547
(b) (Dependent variable: logdioxide)							
logdioxide	logrinvest	.1296464	.035384	3.66	0.002	.0553075	.2039854
	logrbts	.188485	.0988902	1.91	0.073	− .019275	.3962455
	logrlts	.3329781	.0895951	3.72	0.002	.1447458	.5212103
	logrdcgdp	.2009846	.1153454	1.74	0.098	− .041347	.4433163
	Constant	− 7.551799	1.101737	− 6.8	0.000	− 9.86646	− 5.23713

present, meaning that panels under investigation are stationary. Results show that two structural breaks are present for the time range 2000–2019. Furthermore, the null hypothesis of the presence of unit roots is rejected since *P* values are lower than 0.01 (Table 4). The tested panel variables are stationary, allowing for further regression analyses.

4.3 Results of fixed effects regression with Driscoll–Kraay standard errors

In all econometric models, exploratory variables positively and significantly impact dependent variables indicating interpretable and dependable results. In Table 5a, we provide results of fixed effects regression with Driscoll–Kraay standard errors when the dependent variable is loggdp. Test results indicate that if we increase final energy consumption by one unit, we expect GDP to increase by 0.89%, whereas if we increase carbon dioxide emissions by one unit, we expect GDP to increase by 0.87%. In addition, regression results suggest that if we raise internal travel and tourism consumption, GDP is expected to increase by 0,18%. Furthermore, GDP is expected to increase by 0.064% if we increase capital investment spending by all industries directly involved in travel and tourism by one unit.

In Table 5b, we provide fixed effects regression results regression with Driscoll–Kraay standard errors when the dependent variable is carbon dioxide emissions. Specifically, suppose we increase capital investment spending by all industries directly involved in travel and tourism by one unit. In that case, we expect carbon dioxide releases to rise by 0.13%, whereas if we raise business tourism spending by one unit, we expect carbon dioxide emissions to increase by 0.19%. Furthermore, test results indicate that if we increase leisure tourism spending by one unit, we expect carbon dioxide emissions to increase by 0.33%, whereas if we increase the direct contribution of tourism to GDP by one unit, we expect carbon dioxide releases to increase by 0.20%.

Research findings (Models 1 & 2) indicate that all exploratory variables provide evidence for their impact on GDP and carbon dioxide emissions. These findings motivate researchers to explore further and test for possible causal links and practical implications for relevant management plans and strategies.

4.4 Results of Granger non-causality tests

We processed causality tests developed by Dumitrescu and Hurlin (2012) (Table 6). We used the Schwarz criteria (BIC) to define the appropriate (maximum) number of lags. For Model 1, where GDP is the dependent variable, causality tests indicate three unidirectional and one bi-directional causal relationship. Specifically, research results suggest that log-transformed final energy consumption does not Granger cause log-transformed GDP, whereas log-transformed carbon dioxide emissions do not Granger cause log-transformed GDP. For these cases, results indicate that economies are less dependent on energy consumption and are more sustainable, confirming the conservation hypothesis. In an economy where the conservation hypothesis holds, conservation measures can occur without upholding growth (Menegaki & Tugcu, 2018).

Although there is a unidirectional relationship between GDP and final energy consumption, we have included final energy consumption as an independent variable in our first specification, considering that we do not want to reduce the output production but to consider apart from the desirable output also the related inseparable undesired output. In the same perspective, although we have one direction of causality between GDP and carbon dioxide emissions, we have included carbon dioxide emissions as an independent variable in our first specification, keeping in mind that we do not want to reduce the output of production but to consider apart from the desirable output also the related inseparable undesirable output. The third unidirectional relationship was confirmed in the case of internal travel and tourism consumption. Log-transformed GDP Granger causes log-transformed internal travel and tourism consumption since the null hypothesis is accepted. The bi-directional causality was identified in the case of log-transformed capital investment spending within the travel and tourism sector. More specifically, log-transformed capital investment spending Granger causes log-transformed GDP and vice versa. Such causality indicates that an increase in capital investment spending will cause an increase in a nation's GDP and vice versa, confirming the feedback hypothesis. The feedback hypothesis suggests complementarities between capital investment spending and economic growth.

In the second specification (Model 2), where the log-transformed carbon dioxide emissions are present, we identified two unidirectional and two bi-directional cause-and-effect relationships. Specifically, the first unidirectional causality concerns the log-transformed carbon dioxide emissions and capital investment spending. Results indicate that capital investment spending does not Granger cause carbon dioxide emissions. Such a result

Table 6 Results of Granger non-causality tests

Dependent variable	Null hypothesis	Z-bar tilde (Wald stat)	*P* values	Decision for H_0
loggdp	logenergyf does not Granger cause loggdp Lags optimal number (BIC): 1 (lags tested: 1–4)	1.5104	0.1309	Accept
	loggdp does not Granger cause logenergyf Lags optimal number (BIC): 1 (lags tested: 1–4)	8.8679	0.0000	Reject
	logdioxide does not Granger cause loggdp Lags optimal number (BIC): 1 (lags tested: 1–4)	0.3315	0.7402	Accept
	loggdp does not Granger cause logdioxide Lags optimal number (BIC): 1 (lags tested: 1–4)	14.2017	0.0000	Reject
	logrittc does not Granger cause loggdp Lags optimal number (BIC): 1 (lags tested: 1–4)	1.0821	0.2792	Accept
	loggdp does not Granger cause logrittc Lags optimal number (BIC): 1 (lags tested: 1–4)	5.0666	0.0000	Reject
	logrinvest does not Granger cause loggdp Lags optimal number (BIC): 1 (lags tested: 1–4)	3.5367	0.0004	Reject
	loggdp does not Granger cause logrinvest Lags optimal number (BIC): 1 (lags tested: 1–4)	5.3669	0.0000	Reject
logdioxide	logrinvest does not Granger cause logdioxide Lags optimal number (BIC): 1 (lags tested: 1–4)	− 0.4621	0.6440	Accept
	logdioxide does not Granger cause logrinvest Lags optimal number (BIC): 1 (lags tested: 1–4)	4.5520	0.0000	Reject
	logrbts does not Granger cause logdioxide Lags optimal number (BIC): 1 (lags tested: 1–4)	0.1823	0.8554	Accept
	logdioxide does not Granger cause logrbts Lags optimal number (BIC): 1 (lags tested: 1–4)	2.5997	0.0093	Reject
	logrlts does not Granger cause logdioxide Lags optimal number (BIC): 1 (lags tested: 1–4)	3.8344	0.0001	Reject
	logdioxide does not Granger cause logrlts Lags optimal number (BIC): 1 (lags tested: 1–4)	4.8622	0.0000	Reject

Table 6 (continued)

Dependent variable	Null hypothesis	Z-bar tilde (Wald stat)	*P* values	Decision for H_0
	logrdcgdp does not Granger cause logdioxide Lags optimal number (BIC): 1 (lags tested: 1–4)	4.3409	0.0000	Reject
	logdioxide does not Granger cause logrdcgdp Lags optimal number (BIC): 1 (lags tested: 1–4)	6.3196	0.0000	Reject

P values < 0.10 indicate rejection of H_0 at a 10% significance level

P values < 0.05 indicate rejection of H_0 at a 5% significance level

P values < 0.01 indicate rejection of H_0 at a 1% significance level

demonstrates that investments in the travel and tourism sector adopt environmentally friendly technologies, reducing their ecological footprint in the economic system. On the same wavelength, business tourism spending does not Granger cause carbon dioxide emissions indicating that the concept of sustainability is present when spending on business tourism.

Moreover, a bi-directional relationship concerning leisure tourism spending confirms the feedback hypothesis. More specifically, an increase (decrease) in leisure tourism spending causes an increase (decrease) in carbon dioxide emissions, indicating the necessity to increase environmental awareness among leisure visitors and follow sustainable paths to develop the leisure industry further. Finally, the last feedback hypothesis was identified in the case of the direct contribution of tourism to GDP and carbon dioxide emissions. Results suggest that an increase (decrease) in the direct contribution of tourism to GDP causes an increase (decrease) in carbon dioxide emissions, bringing the need to expand tourism within a safe and clean natural environment at first sight.

Most studies do not consider the heterogeneous nature of tourism. Instead, they employ tourist arrivals, receipts, and expenditures received in the host economies in the tourism sector as a whole (Godil et al., 2020; Khan & Hou, 2021; Mikayilov et al., 2019). For instance, Khan and Hou (2021) found that tourism growth improves environmental quality, whereas Godil et al. (2020) and Mikayilov et al. (2019) found that tourism development increases the ecological footprint.

5 Practical implications and conclusions

More importantly than ever, energy consumption patterns should stay consistent with sustainable development to preserve the environment, which keeps the global economy running. The modern reality of competing within the natural environment imposes the need to continuously get things done in an environmentally friendly mode without losing much from business goals and pursuits.

The present study evidenced how tourism (e.g., business and leisure market segments) impacts energy consumption and greenhouse gas emissions. These two market segments constitute an example of how tourism demand beyond the economic concerns connects with energy consumption patterns and greenhouse gas emissions, namely environmental quality and quality of the offered tourism experience.

The escalating demand for energy by the tourism sector results in the degradation and depletion of natural resources. The amount of spending provides the consumption rates achieved within the relevant market, which provides the demand created within the relevant economy. Therefore, spending patterns should be altered toward goods and services produced based on energy-efficient technologies. For instance, hotel owners should cover their energy needs by generating electricity from renewable sources.

Unsurprisingly, the tourism industry's success depends on effective energy policies (Chuchu, 2020). Furthermore, it is essential to perceive how tourism stakeholders should reinvent their actions to comply with the new challenges imposed by the COVID-19 outbreak (Sigala, 2020).

Despite the promising character of such endeavors, there are obstacles in managing energy issues within a new but demanding potential. Comprehensive energy management (from production to consumption) still faces notable challenges. Specifically, in 2020, the energy consumption in the EU was 5.8% below the 2020 energy target and 9.6% above the

2030 target. Notably, the amount of energy consumed in the EU-27 fell sharply to 1236 million tons of oil equivalent, which is 5.8% better than the efficiency target for 2020. However, this is still 9.6% away from the 2030 target (Eurostat Statistics, 2021).

Additionally, greenhouse gas emissions in the EU were down by 24% between 1990 and 2019 (Eurostat Statistics, 2021). These figures suggest that efforts to improve efficiency must be maintained in the years to come. The concept of efficiency when using resources is fundamental to reach better energy savings rates and release reduction (Bambatsou & Halkos, 2019).

In essence, destinations should use cutting-edge technologies and innovations and adopt the energy efficiency perspective when practicing business and executing investment plans. The central role of this endeavor belongs to Destination Management Organizations (DMOs). Effective destination management promotes sustainable development from both supply and demand perspectives (Foris, 2020). In this context, one alternative would be to reduce energy-intensive recreational activities and save energy by advancing the large-scale development of renewable sources. Moreover, big players in the tourism market, such as hotel entrepreneurs and investors, should challenge their potential to incorporate innovations and energy-efficient technologies in accommodation facilities, transport, infrastructure, and other tourism establishments. For instance, earthwork projects directly connect with environmental performance issues, and cleaner production methods should be used to achieve high sustainability levels (Cabello Eras et al., 2013). Additionally, infrastructure investments should be implemented based on their expected sustainability performance to avoid negative environmental and societal impacts (Hosny et al., 2022).

DMOs can put climatic mitigation information campaigns into the process as a stimulus to wisely use energy and secure/improve natural resource abundance. They can widely advertise their initiative to invest large amounts of money in protecting the environment without missing the appeal of the offered experience. In this effort, local authorities and communities significantly transfer the climate change message when implementing policies to reduce GHGs (Hens & Stoyanov, 2014).

Therefore, applying effective sectoral policies and achieving efficient resource allocation is vital. Also, income distribution should be accompanied by efficient and equally distributed resource allocation (Tugcu, 2014). If resources of the overall economy will not be allocated efficiently concerning high-impact tourism sub-sectors, their share of the overall economic output will be restricted.

What matters most is the type of growth we wish to pursue. For instance, economists describe climate change as an example of market failure (emissions of CO_2) due to uncontrolled and unplanned development in the name of 'growth,' whereas relevant strategies should prevent energy poverty issues (Halkos & Gkampoura, 2021). Supportively, decisions must take into serious consideration sustainability assessment results, which in turn should incorporate a set of criteria/indicators concerning a wide range of dimensions, including not only the economic, environmental, and social dimensions but also other dimensions (e.g., the technological, political, and cultural dimensions) (Liu & Ren, 2022; Ren & Toniolo, 2021).

Research findings might be a part of the scientific debate in academia concerning decoupling growth from environmental degradation. Additionally, the present study offers a complete scientific view concerning the set of explanatory variables used in the econometric models. We propose a new set of growth variables that have been unobserved so far. This approach uses core, discrete, and dynamic economic sub-sectors as explanatory variables to investigate relevant causalities and impacts on growth and environmental proxies. Tourism spending is not only a pure number in the context of tourism receipts or

expenditures. It might be considered an indicator to structure sustainable growth patterns and improve environmental quality levels. Also, researchers scarcely tested the predictive power of investments directly related to tourism in the context of the energy growth nexus discussion.

Furthermore, this paper's findings provide inputs for relevant decision-making processes by tourism stakeholders toward integrated energy management plans. Market players within the tourism industry should direct and collaborate their efforts toward sustainable energy use produced by renewable sources by advancing the offered tourism experience. This high-leverage intervention demands concerted action among tourism stakeholders to reap economic-social benefits in the long run.

The present study highlights the need to further investigate the tourism energy growth nexus discussion. Including all involved parties, namely scientists/researchers, spatial planners, policymakers, authorities, and visitors, will help structure a holistic and integrated approach to efficiently using energy and expanding a nation's growth. Furthermore, different econometric methods, sets of variables, and groups of countries should be in the process in light of a better understanding of the causal relationships at the interface of energy and tourism.

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Declarations

Conflict of interest The authors declare no competing interests.

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