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Nonlinear impact of environmental pollution on international tourism, the role of institutional quality, economic complexity, trade, and exchange rates: evidence from G7 and E7 nations

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Abstract
This study, to the best of our knowledge and understanding, is the first to explore the impact of environmental quality on international inbound tourist arrivals. The heterogeneous panel sample set of E7 and G7 countries was considered, and the period of observations was based on annual frequency between 1995 and 2019. To account for endogeneity, the study also included control variables whose impact is in tune with the conventional findings. The empirical outcomes, based on robust estimation techniques, propose a "U" behavior between carbon emissions and international tourist arrivals and between suspended particulate matter and international tourist arrivals. Thus, after a certain rise in the pollution level threshold, international tourist inflows fell significantly in both sets of panel observations. However, this was more pronounced for the E7 countries. Our findings suggest some policy prescriptions that are crucial for sustainable development and the expansion of tourism.

Keywords International tourists · Carbon dioxide emissions · Suspended particulate matter · Economic complexity · Institutional quality · Trade openness

1 Introduction

The exploration of the nexus amid tourism and the environment is an emerging area of research (Gössling, 2013; Simo-Kengne, 2022; Tsai et al., 2014). In particular, increasing air pollution can be a foremost limitation for international tourism demand in the main global tourist destinations. Xu and Reed (2019) demonstrate that the international tourist's perception of the adverse effects of pollution can encumber inbound tourist flows. Ruan et al. (2020) and Churchill et al. (2022) have, for instance, investigated how smog pollution caused by PM2.5 or PM10 (suspended particulate matter) may adversely impact international tourist inflows owing to protective behavioral motives. According to reports by the

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WHO (2018), air pollution is strongly associated with respiratory disorder, lung cancer, and cardiovascular deaths: In 2016, about 4.2 million deaths globally were due to rising air pollution.

Explorations in tourism studies related to environmental factors and tourism satisfaction can be based on the theoretical underpinnings of destination image, which includes, apart from natural attractions, quality of air and travel atmosphere. A well-maintained environment with high levels of air quality can have a competitive edge as far as choice of travel destinations are concerned. It is assumed that high levels of air quality would add to the building of a favorable destination image and hence enhance the choice of tourist's destinations (Churchill et al., 2022; Lee & Xue, 2020; Xu & Reed, 2019); international travelers' decisions are not only influenced by brand imaging but also by perceptions about a destination (Lee & Xue, 2020).

Wide-ranging studies in the literature report that the tourist's choice of destination is impacted by destination image satisfaction. International travelers' decisions are not only influenced by brand imaging but also by perceptions about a destination (Lee & Xue, 2020). The same authors rightly advocate that brand image marketing for the destination may influence travelers' choices, but the net demand of a travel destination is based on the consumer/tourist's perception of the destination expressed in terms of environmental, socio-economic, and cultural factors.

The protection motivation theory is used to explain the motivations of individuals in relation to threats in particular: "people appraise the severity and likelihood of being exposed to a depicted noxious event, evaluate their ability to cope with the event, and alter their attitudes accordingly". According to this theory, individuals respond to threats through two main processes: threat appraisal and coping appraisal (Rogers & Prentice-Dunn, 1997). Threat appraisal comprises a risk assessment based on vulnerability and severity. Based on the above theoretical premise, this study tries to capture how the threat of environmental degradation will affect tourists' motivation to travel.

Building on the theoretical work on destination brand imaging and the protection motivation theory of travel (Lee & Xue, 2020; Rogers & Prentice-Dunn, 1997; Ruan et al., 2020), we add to the empirical literature on tourism demand and environmental nexus theory. As international tourists understand the severity of and their high vulnerability to the threat of smog pollution/carbon emissions, they may alter their choice of destination. Such behavior may be explained by the protection motivation theory, which was originally postulated to explain travelers' motivations in response to threats from severe hazards. Travelers' appraisals of the severity of the hazard and their likelihood to be exposed to such hazards determine the demand for traveling to a particular destination. In sum, when the perception of a deleterious environmental quality is high, then protection motivation may overpower concerns as to the choice of destination.

1.1 On the choice of the sample of countries

The present study makes an innovative contribution to the extant tourism literature by investigating the dynamic nexus between air pollution and international tourist arrivals based on dynamic panel data from 1995 to 2019 for the set of G7 and E7 countries, respectively. The G7 and E7 countries are currently developing policies concerning dependence on renewable sources of energy for sustainable economic prosperity. However, there is still a dearth of study concerning the concerns of these countries in relation to economic diversification, pollution, climate welfare, and tourism. The major tourism activities of these member nations are having a considerable impact on the climate. Greenhouse gas (GHG) emissions for the E7 countries (consisting of China, Brazil, Mexico, India, Turkey, Russia, and Indonesia) from the tourism sector have been higher than the global average (Gyamfi et al., 2022a). According to the reports of the BP Global Energy Reports of 2017, China's tourism-related GHG emissions have continued to be enormous. Such stark reflections on preliminary statistics enable us to establish the sensitivity of the tourism sector to emissions.

The G7 countries (comprising France, Canada, Japan, Germany, Italy, the UK, and the USA) are leading contributors in the share of global output of trade and globalization (Pata & Yilanci, 2020). In addition, this group of nations is a major contributor to the travel and hospitality sector, the world's third-largest industry (Gyamfi et al., 2022b); the member nations of the G7 group are among the top ten in the international ranking of tourist arrivals. France (89.4 million), followed by the USA (83.5 million), attracted many tourists in 2019 (Gyamfi et al., 2022b). These statistics reveal the importance of tourism as far as its share in economic prosperity is concerned.

1.2 Motivation and uniqueness of the present study

This study contributes to the extant literature in several ways:

(i) This research relates to contributions to the literature that investigate the links between tourism and the environment in particular (Bhutto et al., 2021; Churchill et al., 2022; Xu & Reed, 2019). However, except for Churchill et al. (2022), our study is distinct from the earlier contributions because it explores how concerns about pollution may affect demand for international tourism in the long run for the major member nations of the G7 and E7 groups. Diverse from the earlier studies, this study explores the impact of pollution, the major explanatory variable for tourist arrivals, as the dependent variable in the study using dense time series data based on annual observations from 1995 to 2019.

(ii) To add insights to our findings two distinct measures of pollution were utilized: (a) carbon dioxide (CO2) discharges denoted in metric tons per capita and (b) population exposed to suspended particulate matter (PM2.5) in micrograms/cubic meter. It was expected that there would be varying levels of impact from the emitters according to tourism demand for the member nations of both the G7 and E7 groups. The alternate specifications of the explanatory variables strengthened the main empirical outcomes of this study.

(iii) Additionally, the impact of major macroeconomic variables was also considered as the control to minimize the difficulties associated with endogeneity and omitted variable bias. How exchange rate, trade openness, and institutional quality impact tourism demand, along with pollution levels, was explored analogously to the earlier literature (Altinoz & Aslan, 2021; De Vita, 2014; Ghalia et al., 2019; Shahbaz et al., 2017). Furthermore, the role of economic complexity in the impact on tourism demand was also included in the model specification. The role of economic complexity and levels of technological sophistication (Hidalgo & Hausmann, 2009) in impacting climate welfare remain unexplored in tourism studies (Abbasi et al., 2021).

(iv) This study is, to the finest of our understanding, among the few in the existing research that explores the impact of emissions in a nonlinear framework. The closely related study in the literature is that by Wang and Chen (2021). According to Wang and Chen

(2021), there exists a threshold level beyond which microorganisms cannot tolerate pollution. Such a threshold level, then, becomes environmentally unsuitable and affects human health conditions. Thus, this study adds to the theoretical literature on the postulate of the environmentally related Kuznets curve (Grossman & Krueger, 1995).

(v) This study adds to the empirical research by adopting unique panel estimation methods. Second generation panel estimation techniques have been applied, which overcomes the difficulties related with cross-sectional dependency and slope homogeneity.

The findings from the study confirmed the upturned “U”-shaped relations amid pollution and international tourism demand for the two sets of sample observations. Our results suggest that E7 countries need to make concerted efforts in minimizing their emissions of both PM2.5 and CO2; otherwise, they will have a dampening effect on international tourism demand.

The remainder of the paper is organized as follows: Section 2 gives an overview of the background literature. Section 3 explains the choice of data sets, model, and estimation methodology. Section 4 provides the empirical results and discussion, while Sect. 5 makes concluding observations.

2 Review of Literature

There is a wide-ranging literature that comprehensively discusses the modeling of international tourism demand (Kumar et al., 2020; Peng et al., 2015). Given the scope of the present study, the review of the extant literature has been divided into four possible comprehensive components:

(i) Economic Complexity and Emissions
(ii) International Tourism and Emissions
(iii) Institutional Quality and International Tourism
(iv) Trade, Exchange Rate, and International Tourism

2.1 Economic complexity and emissions

Given the concerns regarding global warming and environmental degradation, an emerging number of studies in the recent decade have explored the nexus between environmental pollution and the Economic Complexity Index (ECI) (Can & Gozgor, 2017; Chu, 2021). Can and Gozgor (2017) explored how in France, the ECI has reduced the impact of environmental pollution, whereas energy consumption leads to the augmentation of environmental pollution. Based on the findings, we may infer that the ECI provides a comprehensive explanation of the interconnections between pollution and major macroeconomic variables (Doğan et al., 2021; Romero & Gramkow, 2021; Wang et al., 2021). As it provides more diversity compared to the predictive ability of GDP, the ECI's predictive ability is ample for the multivariate model specification (Abbasi et al., 2021).

2.2 International tourism and emissions

Abbasi et al. (2021) opine that the tourism industry is one of the largest polluting sectors at the international level, contributing to about 8% of GHG emissions. Accordingly, there is a growing discussion in the literature exploring how climate change, pollution, and carbon tax impact the tourism and hospitality sectors (Gössling, 2013; Paramati et al., 2017; Selvanathan et al., 2021; Zhang & Zhang, 2019). Selvanathan et al. (2021) and Gyamfi et al. (2022a) have recently explored the nexus between tourism and emissions using panel data. In conformity with the earlier studies, Abbasi et al. (2021) demonstrated the existence of the tourism emission hypothesis for the G7 panel set of countries for the period 1995–2018. Their paper confirms the future need for further empirical research in the context of G7 nations in order to expand tourism alongside sustainability needs. The empirical outcomes of these studies highlight the crucial prominence of the tourism industry in impacting the national-level carbon emissions for these individual sets of countries. In contrast, Wang and Wu (2022) reported that the expansion of tourism has fostered environmental welfare in the top five tourist destinations for the period 1995–2018. These empirical outcomes, based on novel estimation techniques, suggest the need for policies to implement sustainable tourism development. Given the major inferences in the literature, it can be postulated that there is a strong underlying nexus between the tourism industry and pollution levels.

2.3 Institutional Quality and International Tourism

Institutions in a country determine the underlying rules based on which people behave and interact with their fellow citizens (North, 1990). Well-developed institutions foster economic development and macroeconomic stability (Chaudhry et al., 2022; Ghalia et al., 2019; Musa et al., 2021; Oad et al., 2022). A lot of research in the empirical literature concludes that institutional quality is a major determinant of international tourism demand (Ghalia et al., 2019; Tang, 2018). Further, the findings based on empirical exercises suggest that institutional reforms boost tourism development. Developing countries that are highly dependent on tourism can make immense gains with a well-developed institutional set-up (Bekun et al., 2022; Rej et al., 2022).

2.4 Trade, exchange rate, and international tourism

A handful of studies have explored the trade–real exchange rate–international tourism nexus (De Vita, 2014; Karimi et al., 2019; Ongan et al., 2017; Tang, 2013). According to De Vita (2014), the currency exchange rate represents the ability of international tourists to purchase tourism-related products in the destination country. In the novel study, Crouch (1994) deliberates that tourism revenue is being increasingly impacted by the currency exchange rate and that its impact on tourist arrivals can either be positive or negative. Recently, Shi et al. (2022) evaluated the attitude of international inbound tourist arrivals to exchange rates in the context of Australia based on monthly data sets from M31998 to M32020. The results, based on the conditional value at risk model, reported that different types of international tourists to Australia were significantly responsive to exchange rate variations. These empirical results ascertain the role that the exchange rate plays as a major driver of international tourism, thereby renewing the scope of further research in relation to the panel set of observations.

3 Research Gaps and the Directions of Current Research

To abridge the aforementioned findings in the literature, ample literature has explored the energy–environment–growth–tourism nexus, but few studies have explored the impact of economic complexity on tourism in the presence of the environment,

Table 1 Description of variables and data

	Description	Unit	Source
LTA	Logarithm of the international tourist arrivals	Number	World Bank
LCO2	Logarithm of emissions of carbon dioxide	Metric tons	
LPM2.5	Logarithm of mean population exposed to particulate matter	Micrograms per cubic in GDP	OECD Database
LECI	Logarithmic of Economic Complexity Index	An index based on the diversity and structural transformation of the country and its ubiquity	Observatory of economic complexity
LTR	Logarithm of trade openness	Value of exports plus imports (constant in 2015 US dollars) divided by GDP (constant in 2015 US dollars)	World Bank
LINSQ	Logarithm of institutional quality index	Index developed through panel principal component analysis	International Country Risk Guide
LREX	Logarithm of real effective exchange rate which	expressed as the nominal exchange rate with base year (2015), divided by the price deflator	World Bank

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particularly for the G7 and E7 countries. This paper addresses this major gap in the literature. Again, most of the earlier studies explored the impact of tourism on the environment, yet explorations of environmental quality on international tourists' arrivals continue to be scant (Churchill et al., 2022). Our study seeks to address this gap by exploring the impact of environmental quality on the international tourist arrivals in the G7 and E7 countries through proxy indicators PM2.5 and CO2 emissions in the presence of major macro-regressors and institutional quality indicators. This study has similar dimensions to the work by Churchill et al. (2022); however, unlike that study, non-monetary indicators like economic complexity and institutional quality have been included, among others. The ECI, used to measure complexity, was introduced by Hidalgo and Hausmann (2009) and encompasses a complex system of production associated with building "capabilities," accumulation of knowledge, research, and innovation (Dogan et al., 2022; Hidalgo, 2021). The ECI index essentially demonstrates production characteristics while taking into consideration the "capabilities" of an economy (Chu, 2021). The high value of the index denotes product specialization and technological sophistication, which measure manufacturing capabilities and are energy efficient, thereby enhancing the welfare of the environment. Another major divergence of this study from earlier studies is its exploration of the impact of environmental quality on international tourist arrivals in a nonlinear framework. We argue, following Wang and Chen (2020), that the risks of health hazards owing to pollution rise with the increase in the intensity of emissions in the air.

4 Choice of Variables, Data, Models and Estimation Techniques

4.1 Variables Description and Data Sources

In this study, we explore the impact of major emissions like CO2 and PM2.5 on the international tourist arrivals for the G7 and E7 countries for the period 1995 to 2019. Description of the dependent variables and the set of selected independent variables along with the source of data are found in Table 1. We have converted the data series into their natural logarithmic components to confirm that the estimated coefficients can be explained as elasticities. Additionally logarithmic transformation enables to circumvent the problems related with the distributional properties of the underlying series of observations (Churchill et al., 2022).

Further Table 2 shows the descriptive statistics. From Table 2, we obtain some salient features of the underlying data series. For the G7, the mean of LTA (international tourist arrivals) is 7.64 while the minimum and the maximum values stand at 6.52 and 8.32, respectively. Likewise, as reported in Table 2 (lower panel) in the context of the E7 countries, the mean of LTA stands at 7.27, while the maximum and the minimum values are 8.21 and 6.29 sequentially.

4.2 Model Specification

To explore the impact of pollution on international tourist arrivals in the G7 and E7 countries, respectively, following the literature for instance (Churchill, Pan, and Paramati 2022; Chaudhry et al., 2021), we augment the traditional model of determinants of international tourist arrivals by including the variables of pollution alongside the major covariates like economic complexity, trade openness, real effective exchange rates and institutional quality, respectively, in Eq. (1).

$$LTA_{i,t} = f(_{Pollutants_{it}}, LECI_{it}, LTR_{it}, LINSQ_{it}, LREX_{it}) \tag{1}$$

Here, Pollutants denote the proxy for quality for the environment. In this study, we have chosen the variables LCO2 & LPM2.5, respectively.

Equation (1) is rephrased as in Eq. (2) in the functional form as of the following:

$$LTA_{i,t} = (\beta_0 Pollutants_{it}^{\beta 1i} LECI_{it}^{\beta 2i} LTR_{it}^{\beta 3i} LINSQ_{it}^{\beta 4i} LREX_{it}^{\beta 5i}) \tag{2}$$

Further in Eq. (3), the logarithmic transformation of Eq. (2) is obtained:

$$LTA_{i,t} = \beta_0 + \beta_{1i} Pollutants_{i,t} + \beta_{2i} LECI_{i,t} + \beta_{3i} LTR_{i,t} + \beta_{4i} LINSQ_{i,t} + \beta_{5i} LREX_{i,t} + \mu_{i,t} \tag{3}$$

Further to specify the nonlinear impact of the pollutants upon the international arrival of tourists, Eq. (3) is modified as in Eq. (4) to include the squared component of the pollutants as follows:

$$\begin{aligned} LTA_{i,t} =& \beta_0 + \beta_{1i} Pollutants_{i,t} + \beta_{2i} LECI_{i,t} + \beta_{3i} LTR_{i,t} \\ &+ \beta_{4i} LINSQ_{i,t} + \beta_{5i} LREX_{i,t} + \beta_{6i} {Pollutants_{i,t}}^2 + \mu_{i,t} \end{aligned} \tag{4}$$

Here, the dependent variable $LTA_{i,t}$ is impacted by pollutants which indicates the quality of environment, as mentioned earlier the major pollutants used here are LCO2 & LPM2.5,

Table 2 Descriptive statistics

Variables	No of observations	Mean	Median	Maximum	Minimum	SD	Skewness	Kurtosis
G7 countries								
LTA	175	7.64	7.59	8.32	6.52	0.45	− 0.31	2.63
LPM2.5		1.06	1.07	1.41	0.79	0.13	− 0.05	2.48
LREX		2.00	2	2.13	1.84	0.05	− 0.36	3.40
LTR		1.67	1.72	1.94	1.22	0.18	− 0.69	2.43
LECI		1.65	1.60	2.62	0.41	0.49	− 0.16	2.56
LCO2		0.98	0.96	1.31	0.66	0.18	0.20	2.00
LINSQ		0.60	0.56	2.60	− 1.77	0.77	− 0.03	3.39
E7 countries								
LTA	175	7.27	7.24	8.21	6.29	0.55	0.12	1.69
LPM2.5		1.42	1.34	1.98	1.05	0.28	0.51	2.06
LREX		1.94	1.95	2.11	1.68	0.78	− 0.74	3.72
LTR		1.64	1.68	1.98	1.19	0.15	− 0.85	3.29
LECI		0.37	0.37	1.16	− 0.54	0.39	0.08	2.47
LCO2		0.48	0.49	1.06	0.11	0.31	0.22	2.15
LINSQ		− 0.09	− 0.09	2.36	− 3.04	0.98	− 0.06	2.92

Compilation: Author

respectively. We argue that the expected sign of β_1 is positive but after the levels of pollution cross a certain threshold the impact on tourism is negative, accordingly the expected sign of β_6 is negative. Building on the earlier studies which describes the negative impacts of environmental damage on tourism (Becken et al., 2017; Xu and Reed 2017; Deng et al., 2017; Wang et al., 2018), this research examines the nonlinear impacts of pollution on international tourism demand. Tourists are likely to perceive the impact of pollution differently on choice of destinations over time, as the intensity of pollution aggravates. So, at lower levels of pollution, tourist arrivals may increase, but at higher levels of pollution, the perception of tourists may change and the demand for international tourism falls. We thus conjecture the nonlinearity in the underlying association.

Again, the expected sign of β_2 upon international tourist arrivals is positive. Following the literature (Wang et al., 2021; Romero & Gramkow, 2021; Doğan et al., 2021), the complexity of production structure expressed through ECI leads to product specialization and energy efficiency and competitiveness which is expected to attract tourist in the destination countries. The expected sign of β_3 & β_5 is expected to be positive following the studies by (Ongan et al., 2017; Shi et al., 2022). Trade enhances the international competitiveness of a country, and hence, it may be attractive for tourism for business purposes apart from holiday reasons. Finally, the impact of institutional quality is positive on tourist arrivals (Chaudhry et al., 2022; Usamn et al., 2020). Thus, the expected sign of β_4 is positive. Stringent legislations create less corruptive practices builds international trust and hence is tourism resilient. Last μ_i denotes the usual error term. i = 1….N denotes the countries and t = 1….T describes the time span.

4.3 Econometric estimation techniques

To empirically evaluate Eq. (4), our study follows five major econometric steps of evaluation see Fig. 1. The major steps include (1) cross-sectional dependence test and Slope homogeneity tests, (2) panel unit root tests to check the order of integration of the variables, (3) panel cointegration tests, (4) long-run estimation process based on panel D-OLS, panel F-MOLS and canonical cointegration regression (C.C.R) and (5) the (Dumitrescu & Hurlin, 2012) panel causality tests.

4.4 Preliminary econometric estimation techniques

As discussed earlier in the literature (Kim et al., 2016; Sharma et al., 2021), the high nature of socio-economic integration across the panel set of observations in the G7 and E7 countries, respectively, may lead to the increasing possibility of cross-sectional dependence across the countries. Thus, the preliminary step toward the empirical estimation includes testing for cross-sectional dependency (Dogan et al., 2019). The present study uses the Lagrange multiplier (L.M.) testing methods, (Pesaran, 2021) and the (Breusch & Pagan, 1980) bias-adjusted tests to tackle the cross-sectional dependence problems. Another preliminary test applied in this panel study is the slope coefficient homogeneity test following (Pesaran and Yamagata, 2008).

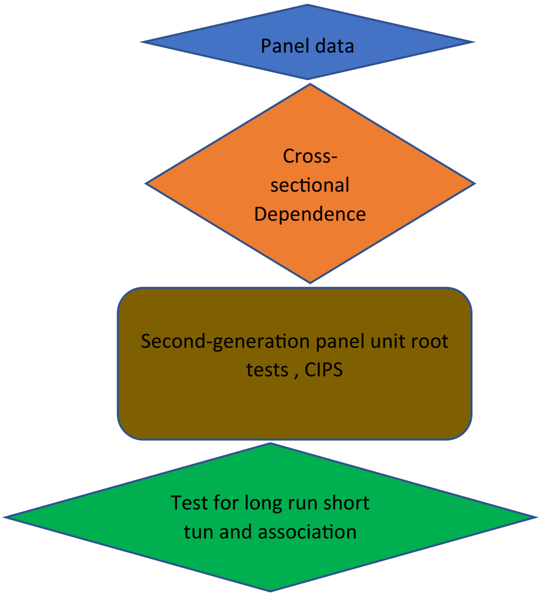
Subsequently, this study applies the stationary tests for the underlying time series. We conduct the (Levine-Lin-Chu, 2002) with the null hypothesis that all the panels of the observations have a unit root. Further to accommodate the problems of cross-sectional dependence (Pesaran, 2007), the Pesaran), cross section augmented unit root test (Im et al., 2003; CIPS unit root test) is done. The null of the hypothesis presupposes that the given series has unit root against the alternative hypothesis that the series may be stationary. The subsequent stage is to check the co-integrating order among the panel variables. In order to do so, we follow the approach by Pedroni (1999;2001) and that by (Kao, 1999), in tune with the applications in tourism economics literature (Churchill, et al., 2022; Chaudhry et al., 2021; Gyamfi et al., 2020).

4.5 Long-run econometric estimation techniques

After the cointegrating tests of the observations, the next most important step is the empirical estimation of the long-run coefficients of Eq. (4). Our study uses the panel F-MOLS methodology (Fully Modified Ordinary Least Squares) and the panel D-OLS method (Dynamic Ordinary Least Squares) and C.C.R (Canonical Cointegrating Regression) method, respectively. It is widely argued applying the OLS methods may lead to endogeneity and serial-based correlations. These issues may be solved with the F-MOLS and D-OLS methods, (Pedroni, 1999; Phillips and Hansen 1990).

According to (Pedroni, 1999), both the D-OLS and the F-MOLS methods tackle the between group-estimation and are more preferable than the within group-measures. These measures also consider endogeneity by allowing the leads-lags and the standard errors. Aligning to the F-MOLS method, C.C.R (Park, 1992) method follows a normal-mixed distribution and lets asymptotically Chi-square test, and further it also allows to tackle the non-scalar nuisance in the parameter's problems. These estimation

Fig. 1 Flowchart illustrating the estimation techniques between international tourist arrivals and pollutants and control variables, G7 and E7 countries



techniques address the problems based on serial correlation and endogeneity (Pedroni, 2001).

4.6 Heterogeneous panel causality estimation method

We argue that though the long-run estimations reveal intricate associations between the dependent and independent variables, nonetheless for policy analysis it is crucial to explore the underlying causality nexus in the short-run. We apply for such purposes the (Dumitrescu & Hurlin, 2012) causality test to establish the causal relationship between the underlying variables. This test proposes the null hypothesis of homogeneous-non-causality against the alternate hypothesis of heterogeneity in non-causality. The (Dumitrescu & Hurlin, 2012) panel causality test can be applied in stationary series with coefficients being fixed in VAR model. This test method allows for potential cross-sectional heterogeneity and the tests allows the cross-sectional dependency in the observations.

5 Estimation results

5.1 Preliminary explorations

As a prerequisite for panel analysis, we first perform the cross-sectional dependency tests (Table 3) and slope homogeneity test (Table 4). As evident from Table3, all the test statistics have a p value lower than 5 percent thereby implying the cross-sectional dependency in the panel data. Alternatively speaking that the environmental quality indicators and macro-variables alongside the tourism variables are strongly correlated. This implies a shock to any one regressor in one country (among the panel either G7 or E7) would lead to the propagation of shocks in other member countries.

Again, from Table 4, we confirm the absence of slope homogeneity in the coefficients for both G7 panel set of countries and E7 panel set of countries. These results motivate for testing on the long-run cointegration properties of the underlying observations.

Table 5 describes the results on the panel unit root tests. The results obtained from Table 5 show that the series under consideration are integrated in I (1) or stable in the first-differenced. These results imply that there exists the possibility of the long-run balance under the observations.

Table 6 describes the panel cointegrating results for the G7 and E7 countries, respectively. As evident from the test statistics results, there exist long-run cointegrating behavior.

5.2 Major results

5.2.1 Long-run estimation

5.2.1.1 Impact of carbon dioxide on international tourism (G7 & E7 countries): Model I To estimate the long-run impact of CO2 emissions on international tourist arrivals for the G7 countries (Model I), we apply the panel F-MOLS and panel D-OLS and further C.C.R estimation methods (available in Table 7). As evident from Table 7, there exists a significant and a nonlinear association between international tourist arrivals and emission of LCO2. The coefficient of LCO2 on LTA is 0.03(F-MOLS), 0.02(D-OLS) and 0.04(CCR), respectively. The coefficients of squared component of LCO2 on LTA are -0.56 (F-MOLS), -0.36 (D-OLS) and -0.47 (CCR), respectively. Such results demonstrate that the relationship between carbon emissions and international tourist arrivals in the G7 countries is nonlinear and describes an inverted 'U' shaped behavior. A well-maintained environment quality can offer high degree of tourist attractions and builds a favorable destination image ((Churchill et al., 2022; Lee & Xue, 2020; Xu & Reed, 2019).

To explore whether the responsiveness of international tourists to the quality of environment differs across developed or emerging countries, we next explore the impact of carbon emissions on international tourist inflows for the E7 countries (Table 7, Panel in the right). The results continue to demonstrate a significant and a nonlinear association between carbon emissions and international tourist arrivals for the E7 countries. Specifically, the coefficient of LCO2 on LTA is 2.42 (D-OLS), 2.32 (F-MOLS) and (1.81) (C.C.R). Likewise, the coefficient of the squared component on LTA is -1.54 (F-MOLS), -1.46 (D-OLS) & -1.11 (CCR), respectively.

5.2.1.2 Impact of Suspended Particulate matter on international tourism (G7 & E7 countries): Model II Now coming to Panel B (Table 7) (Model II), we explore the impact of LPM2.5 on LTA for G7 countries. The results based on F-MOLS demonstrate that impact of LPM2.5 on LTA is negative and significant, while the impact of LPM2.5 based on the D-OLS measure and CCR measure in tune to the results based on Model I continue to be positive and significant. Again, for the G7 countries, the squared component of LPM2.5 on LTA is significant and negative for the D-OLS and CCR methods. The coefficient of squared component of LPM2.5 on LTA is -11.06 (D-OLS) and -1.11 (CCR) method, respectively. Coming to the impact of LPM2.5 on the E7 countries, the impact is positive

Table 3 Cross-sectional dependency test

Variables	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
G7 countries				
LTA	197.77* (0.00)	83.52* (0.00)	23.20* (0.00)	8.92* (0.00)
LPM2.5	194.34* (0.00)	56.19* (0.00)	11.92 * (0.00)	11.85* (0.00)
LREX	60.34* (0.00)	71.25* (0.00)	17.25* (0.00)	13.93* (0.01)
LTR	168.92* (0.00)	81.59* (0.00)	19.69* (0.00)	10.01* (0.00)
LECI	149.82* (0.00)	94.95* (0.00)	22.13* (0.00)	14.87* (0.00)
CO2	122.72* (0.00)	82.85* (0.00)	23.23* (0.00)	15.09* (0.00)
LINSQ	68.09** (0.03)	82.85* (0.00)	23.23* (0.00)	22.42* (0.01)
E7 countries				
LTA	93.12* (0.00)	33.05** (0.04)	133.33* (0.00)	11.56* (0.00)
LPM2.5	148.92* (0.00)	46.46* (0.00)	19.53* (0.00)	3.69* (0.00)
LREX	69.79* (0.00)	40.69* (0.00)	16.69* (0.00)	12.24* (0.00)
LTR	95.32* (0.00)	49.36* (0.00)	10.68* (0.00)	13.28* (0.00)
LECI	162.76* (0.00)	105.08* (0.00)	33.55* (0.00)	4.77* (0.00)
LCO2	58.02* (0.00)	36.87* (0.01)	15.26* (0.00)	16.36* (0.00)
LINSQ	70.28* (0.00)	130.87* (0.00)	120.22* (0.00)	12.29* (0.00)

The null hypothesis states no cross-sectional dependency. Values in () denotes the p values, (*) level of significance of 1 percent and (**) level of significance of 5 percent. Compilation: Author

and significant under all three measures. Further in line with the earlier results in Model I, the impact of the squared component of LPM2.5 on LTA for the E7 countries continue to be significant and negative. The effect is more pronounced for the E7 countries.

5.2.2 On control variables

As far as the impact of control variables on the international arrival of tourists is concerned, see (Table 7, Model I), for the G7 countries under all three estimation techniques, the impact of exchange rate is negative and significant; specifically, it is -0.15 (D-OLS), -0.60 (F-MOLS) and (-0.53) C.C.R. Further as per expectations, the impact of institutional quality is positive and significant under all three estimation techniques. These results confirm the earlier works by (Usamn et al., 2020; Musa et al., 2021). In conformity with conventional wisdom, the impact of trade openness on tourism is

Table 4 Slope homogeneity tests

Test	LTA	LPM2.5	LREX	LTR	LECI	LCO2	LINSQ
G7 countries							
Δ^	11.74* (0.00)	11.06* (0.00)	9.21* (0.00)	9.05* (0.00)	5.37* (0.00)	12.09* (0.00)	13.40* (0.00)
$Δ^{\wedge}_{adj}$	13.47* (0.00)	12.36* (0.00)	10.57* (0.00)	10.67* (0.00)	6.01* (0.00)	13.51* (0.00)	19.01* (0.00)
E7 countries							
Δ^	11.92* (0.00)	8.59* (0.00)	8.27* (0.00)	9.40* (0.00)	8.43* (0.00)	8.93* (0.00)	7.86* (0.00)
$Δ^{\wedge}_{adj}$	13.33* (0.00)	10.12* (0.00)	9.75* (0.00)	10.48* (0.00)	9.19* (0.00)	10.52* (0.00)	9.26* (0.00)

Δ^ and $Δ^{\wedge}_{adj}$ denotes the Swamy(1970) modification as suggested by Pesaran and Yamagata (2008). The null hypothesis states the existence of slope homogeneity. Values in () are denoting the p values. (*) shows the level of significance at 1 percent. Compilation: Author

Table 5 Unit root test

	G7 countries				E7 countries			
	Levin-Lin-Chu		Im-Pesaran-Shin		Levin-Lin-Chu		Im-Pesaran-Shin	
	At Level	Δ	At Level	Δ	At Level	Δ	Level	Δ
LTA	– 0.06	– 11.58*	– 0.83	– 6.81*	– 0.36	– 7.12*	0.27	– 2.81**
LPM2.5	– 0.02	– 12.47***	– 0.36	– 8.03*	– 0.72	– 8.64*	0.21	– 4.24*
EX	– 0.27	– 8.49*	– 2.06	– 5.57*	– 2.07	– 5.91*	– 1.05	– 2.64**
TR	– 0.94	– 7.00*	– 1.47	– 5.52*	– 0.35	– 8.16*	0.19	– 4.27*
ECI	– 0.25	– 11.62*	– 1.04	– 6.82*	– 2.97	– 6.51*	– 1.50	– 2.47**
CO2	– 0.03	– 7.34*	– 0.76	– 6.90*	– 2.24	– 5.14*	1.11	– 2.04**
INSQ	– 0.67	– 11.55*	– 0.32	– 8.20*	– 0.40	– 5.97*	– 1.11	– 3.84*

The null hypothesis is series non-stationary. (*). (**), (***) denotes levels of significance at 1 percent, 5 percent and 10 percent levels, respectively. Compilation: Author

positive and significant for the G7 countries under all three estimation techniques. International trade fosters the advertisement of goods and services which may attract the consumers and the desire to travel in the country of production (Chaudhry et al., 2021).

Referring to the E7 countries (Table 7, Model I), the impact of trade openness and real exchange rates on international tourism in the E7 countries is positive and significant. The coefficient of LREX on LTA is 2.29 (F-MOLS), 2.26 (D-OLS) and 1.88 (C.C.R), respectively. Likewise, the coefficient of LTR on LTA is 1.03 (F-MOLS), 1.04 (D-OLS) and 1.11 (C.C.R) method, respectively. These results are in tune with the studies by (De Vita, 2014; Ongan et al., 2017; Tang, 2018). The impact of institutional quality in tune with expectations is significant and negative under all three methods of estimation. This essentially reflects the weak nature of implementations of the legislations in the emerging countries that may deter the international tourists. Thus, our findings

Table 6 Pedroni (2004) and Kao (1999) Cointegration

	Statistic	G7 Countries	E7 Countries
Model I: Cointegrating relationship: (LTA, LCO2, LTR, LREX, LECI, LINSQ)			
Pedroni residual cointegration test	Panel v statistic	1.70**	4.18**
	Panel rho statistic	– 0.22	0.42
	Panel PP statistic	– 1.92*	– 2.62*
	Panel ADF statistic	– 2.08**	– 2.49**
	Group rho statistic	0.50	1.28
	Group PP statistic	– 2.44**	– 2.05**
	Group ADF statistic	– 2.72**	– 2.24*
Kao residual cointegration test	ADF stat	– 5.92*	– 7.11*
Model II: Cointegrating relationship: (LTA, LPM2.5, LTR, LREX, LECI, LINSQ)			
Pedroni residual cointegration test	Panel v statistic	– 2.11*	– 4.78**
	Panel rho statistic	– 1.69*	0.04
	Panel PP statistic	– 2.78**	– 3.28**
	Panel ADF statistic	– 3.24*	– 3.38*
	Group rho statistic	– 0.72	1.24
	Group PP statistic	– 2.88*	– 1.96*
	Group ADF statistic	– 2.79**	– 2.43**
Kao residual cointegration test	ADF stat	– 2.78*	– 5.99*

(*) and (**) explains the levels of significance at 1% and 5%, respectively. Compilation: Author

lend credence to the theoretical underpinning –destination brand imaging and protection motivation theory of travel (Lee & Xue, 2020; Rogers & Prentice-Dunn, 1997; Ruan et al., 2020). While the destination brand imaging may impact the tourism sector positively, the ultimate choice of travel is dependent on the net of brand imaging and protection motivation theory. Protection motivation theory assumes that a traveler will avoid destinations which are vulnerable to uncertainties and instabilities.

Now referring to the discussion on the impact of control variables Model II for the G7 countries (Table 7), our empirical results demonstrate that in line with the findings based on Model I, trade expansion has positive and significant impact on international tourism for the G7 nations. The impact of foreign exchange continues to be negative and significant under all three estimation methods for G7 countries. This lends credence to the hypothesis that most developed countries like the G7 member nations are characterized by travel account balances which run in deficit. The opposite is true for the developing countries. The travel account balance in the E7 countries is persistently surplus. Our findings support the conventional idea that the residents from the richer countries create the bulk of the global tourism expenditure.

Unarguably the impact of other control variables on the E7 countries are similar to that of Model I; thus, our findings strengthen the robustness of our modeling building exercises. Likewise, building on the earlier arguments the direction and significance of impact of LECI, LTR, LREX and LINSQ on LTA for E7 countries are similar to that in Model I. These findings demonstrate the need to explore air quality with alternative proxy to render comprehensive in the econometric analysis.

Table 7 Estimation results for emissions on tourism

Explanatory variables	(1) G7 countries	(2)	(3)	(4) E7 countries	(5)	(6)
	FMOLS	CCR	D-OLS	F-MOLS	CCR	D-OLS
Model I.$LTA = (LCO2, LCO2^2, LREX, LECI, LTR, LINSQ)$						
LCO2	0.03** (0.00)	0.02** (0.00)	0.04** (0.00)	2.42** (0.00)	2.32** (0.00)	1.81** (0.00)
Squared level of LCO2	− 0.56** (0.00)	− 0.37* (0.00)	− 0.47** (0.00)	− 1.54* (0.00)	− 1.46* (0.00)	− 1.11* (0.00)
LREX	− 0.15* (0.01)	− 0.60** (0.01)	− 053** (0.00)	2.29** (0.00)	2.26** (0.00)	1.88** (0.00)
LTR	0.05* *(0.00)	0.02* (0.01)	0.06* (0.00)	1.03* (0.00)	1.04* (0.00)	1.11* (0.00)
LECI	− 0.18*(0.12)	− 0.16* (0.01)	− 0.19** (0.01)	0.42** (0.00)	0.42** (0.00)	0.39** (0.00)
LINSQ	0.05** (0.03)	0.01** (0.02)	0.02** (0.81)	− 0.07** (0.00)	− 0.84** (0.00)	− 0.1**1 (0.00)
Constant	6.01**(0.09)	2.80** (0.01)	3.22** (0.01)	0.01** (0.002)	− 0.08** (0.02)	0.14** (0.81)
Model II. $LTA = (LPM2.5; LPM2.5,^2 LREX, LECI, LTR, LINSQ)$						
LPM2.5	− 0.11** (0.02)	5.22* (0.01)	2.77** (0.01)	3.68** (0.01)	3.57** (0.00)	0.40** (0.00)
Squared level of LPM2.5	5.51** (0.23)	− 11.06* (0.01)	− 1.11** (0.83)	− 1.29** (0.00)	− 1.25** (0.00)	− 0.22** (0.01)
LREX	− 0.17** (0.91)	− 0.21* (0.89)	− 0.43* (0.02)	1.73* (0.00)	1.72* (0.00)	1.37* (0.00)
LTR	0.83** (0.00)	0.84** (0.05)	0.68** (0.00)	1.26** (0.00)	1.15** (0.00)	1.26** (0.00)
LECI	− 0.78* (0.00)	− 0.78* (0.00)	− 0.82* (0.00)	0.83** (0.00)	0.82** (0.00)	0.83* (0.00)
LINSQ	0.51* (0.01)	0.6* 2 (0.02)	0.25* (0.001)	− 0.05(0.01)	− 0.05(0.08)	− 0.11(0.01)
Constant	11.07* (0.02)	11.28* (0.05)	4.07* (0.54)	− 1.82* (0.31)	− 1.75* (0.17)	− 0.59* (0.01)

(*) and (**) explains the levels of significance at 1% and 5%, respectively. Values in () denotes the p values. Compilation: Author

5.3 Panel causality tests: estimates

The results of the heterogeneous panel causality test postulated by (Dumitrescu & Hurlin, 2012) for defining the direction of the relationship amid the variables are described in Table 8. According to the results, there is two-way causality between carbon dioxide emissions and international tourists' inflows to the concerned destinations in the context of the G7 and E7 countries. There is unidirectional relationship between carbon dioxide and exchange rates for the G7 countries but bidirectional relationship between carbon dioxide and exchange rates for the E7 countries. As far as institutional quality index is concerned for the G7 countries, there is the one-way flow from institutional quality indicator to carbon emissions. However, for the E7, the causality between institutional quality and carbon emissions is bidirectional.

5.4 Robustness tests

In the "Appendix," we provide the robustness tests for the model specification. The results based on Dynamic Common Correlated Effects method show that the signs and magnitudes of long-run coefficients are not deviating in comparison with the coefficients reported in Table 7. It validates the robustness of the empirical model behavior.

6 Discussion

This study makes a novel contribution to the literature on tourism research by recommending an inverted U–shaped relationship between environmental quality (proxy in carbon dioxide emissions and suspended particulate matter) and international in bound tourist arrivals for the G7 and E7 nations in particular. The results reflect interesting findings.

The first finding is that the quality of environment measured by LCO2 and LPM2.5 has a significant and inverted U-shaped impact for both the G7 and E7 countries. The theoretical framework grounded on destination image branding, competitiveness and development of the infrastructure of the tourism industry supports the empirical results. We argue that as these factors grow, international tourists' inflows enhance. Our findings further lend credence to the supposition that as tourism industry continues to develop, the air quality

Table 8 Dumitrescu and Hurlin (2012) Panel causality test

Null hypothesis	G7 Countries		E7 Countries	
	$\tilde{Z}$ statistics	Causality flow	$\tilde{Z}$ statistics	Causality flow
$CO_2 \neq> TA$	4.72*	CO2 ↔ TA	5.18*	CO2 ↔ TA
$TA \neq> CO_2$	9.22*		5.13	
$CO_2 \neq> EX$	6.16*	CO2 → *EX*	6.54*	CO2 ↔ EX
$EX \neq> CO_2$	1.24		2.49**	
$CO_2 \neq> TR$	3.44**	CO2 ↔ TR	8.52*	CO2 ↔ TR
$TR \neq> CO_2$	10.12*		7.57*	
$CO_2 \neq> INSQ$	1.69	INSQ → *CO*	3.72**	CO2 ↔ INSQ
$INSQ \neq> CO_2$	5.76*		6.32*	
$CO_2 \neq> ECI$	0.46	ECI → *CO*	0.37	$CO_2 \neq ECI$
$ECI \neq> CO_2$	3.39**		0.53	$ECI \neq CO_2$
PM ≠> TA	2.41**	PM → *TA*	0.46	PM ≠ TA
TA ≠> PM	− 1.43		0.30	TA ≠ PM
PM ≠> EX	3.02	PM → *EX*	3.73*	PM → *EX*
EX ≠> PM	0.85		1.26	
PM ≠> TR	4.56*	PM → *TR*	4.88*	PM → *TR*
TR ≠> PM	− 0.76		0.07	
PM ≠> INSQ	0.78	PM ≠ INSQ	2.03**	PM → *INSQ*
INSQ ≠> PM	1.87	INSQ ≠ PM	0.93	INSQ ≠ PM
PM ≠> ECI	1.73	PM ≠ ECI	1.37	PM ≠ ECI
ECI ≠> PM	− 1.40	ECI ≠ PM	0.87	ECI ≠ PM

(*) & (**)) shows the significance level at the 1%, 5%, levels, respectively. Compilation: Author deteriorates in these countries. As the concentration of the pollutants rises and exceeds a certain threshold level the environmental hazards rise. This empirical behavior supports the theoretical framework based on the protection motivation theory.

The second interesting finding is international trade has favorable impact on international tourism for these major panel set of countries. Our findings support the works by (Karimi, et al., 2019; Ongan et al., 2017). The literature increasingly deliberates that rapid expansion of international trade fosters international tourism.

The third interesting finding is the variation of impact of institutional quality index across the G7 and E7 countries. Institutional quality positively impacts the international tourist inflows in the G7; nonetheless, it negatively impacts the E7 countries. These findings confirm the observations in the extant literature (Ghalia et al., 2019; Meo et al., 2021). As discussed by (Tang, 2018; Ghalia et al., 2019; Adedoyin et al., 2021), good quality institutions and stringency in legislations foster tourism development. For the emerging economies /developing countries to reap the benefits from tourism, these economies need to upgrade the quality of institutions and combat corrupt practices.

The empirical outcomes throw important insights for policy prescriptions for the G7 and E7 countries. These set of countries need to take special steps to control poor air quality and thus reduce the negative impact on international inbound tourism. For sustainable development, the tourism authorities need to develop strategies to mitigate the negative impact of poor quality environment. The government of the E7 countries should develop green technologies to lower the impact on pollution. These processes will foster positive perception of travel among international tourists. Tourism is a highly energy intensive sector so a judicious mix of green technologies will reduce emissions and enhance the positive perception among the international travelers. Proper planning for investments in renewables particularly in transport and accommodation needs to be accelerated.

The G7 countries need to implement a judicious energy mix consisting of renewables that will reduce the harmful effects on the environment. These countries can utilize the tourism revenue to promote sustainable development practices. Such practices include smart tourism destinations and eco-tourism practices. The G7 countries need to develop stringent environmental laws and carbon pricing to develop sustainable tourism in line with the recently held talks on climate change at COP26. We further advise development of research on investment and capital formation by national governments in partnerships with tourism business houses to foster the mainstreaming of the sector toward green development and climate mitigation.

A fistful of studies have discussed that domestic tourists hold negative opinions about the influence of pollution and suspended particulate matter on tourism activities; nonetheless, little research is available on international tourism. The present study offers empirical analysis about how carbon dioxide and suspended particulate matter indeed affects the international tourist activities in the G7 and E7 countries. International tourists may avoid visiting places where pollution and outdoor environment could affect the travel behavior. Our empirical research extends the deliberations in the prior research that unlike the present research focused on domestic tourism.

Individual travelers' protective behavioral objectives are likely to increase when the levels of pollution rise. Protective behavior may include cancelation of outdoor tourism activities, shortening the duration of stay and avoid visiting places which are highly polluted. Furthermore, our results suggest that the severity and vulnerability of pollution could play more important roles in explaining the international tourists' avoidance.

To recover the international tourism in G7and E7 countries, governmental efforts should be directed toward reducing the levels of pollution by the adoption of renewables. Such processes is likely to improve the intentions to revisit and also improve recommendations. Nonetheless, the major role of the governments in G7 and E7 countries lies in managing pollution in tourism destinations.

The empirical evidence from this study explained how institutional quality impacts tourists travel decision. Grounded on the empirical findings, we advocate the governments of the E7 countries in particular, to take steps to remove the negative effects of poor institutional quality. Based on the study by the governments of the concerned countries can provide with real-time air quality index search service.

Such findings in the context of G7 and E7 countries can be applied to other countries where the atmospheric condition is detrimental. The governments of these countries should pay specific attention to control pollution to boost international tourism. Unarguably the government should create an early warning mechanism to monitor air pollution and take stringent steps to counter the influence of pollution on tourism. Distinct steps should be taken to recover the destination brand image owing to pollution. Governments of the E7 and G7 countries can take advantage of the media platforms to disseminate policies and measures of promoting the destination and promote the ecology.

7 Conclusion: policy suggestions and further research directions

This study is the first in exploring the impact of air quality on international inbound tourist arrivals to the panel set of G7 and E7 countries. The period of observation is based on annual frequencies running from 1995 to 2019. For a comprehensive analysis, we explored the impact of air quality through two proxy variables: carbon dioxide emissions and suspended particulate matter. To control for endogeneity bias, the study included control regressors like trade openness, real exchange rates, and institutional quality. Additionally, the study included an economic complexity indicator to gauge the impact of complexity in the production processes and structural transformations that may impact international tourism. The major empirical findings based on a panel of fully modified least square estimates, panel dynamic ordinary least squares, and canonical cointegration regression techniques describe an inverted "U"-shaped behavior across poor environmental quality and international inbound tourist inflows for both G7 and E7 panel countries. However, the impact is more distinct for the E7 countries. The empirical findings add to the hypothesis that brand imaging may increase tourism competitiveness. Also, as the inflow of tourists rises, there also occurs over time a rise in the levels of emissions. After a certain rise in the threshold level of emissions, the protection motivation overpowers travel decision-making behavior. Hence, we found a decline in the international visits beyond a certain threshold.

7.1 Policy implications

Our findings have important policy implications. Given the evidence of the adverse impact of pollution on international tourist inflows, we advocate effective environmental taxation, especially for G7 countries. The tax revenue can be effectively utilized to invest in sophisticated technologies and eco-tourism, which may attract tourist inflows. In addition, we advocate the application of subsidy schemes in the ancillary sectors of tourism that rely on green technologies. However, there may be country-specific variations in the proper balancing of tax subsidy schemes in order to generate optimal outcomes. In tune with these recommendations, further emphasis should be placed on the development of green tourism projects in the G7 countries. Moreover, revenues from tourism can be channeled into the stimulation of the expansion of renewables that are energy efficient and produce less emissions. To ensure that environmental concerns do not impede sustainable tourism, the policy analysts of the G7 member nations can engage in dialog with major business stakeholders. These policy steps will enhance sustainable tourism and enable nations to attain Sustainable Development Goal-13 on climate action. We argue that to foster sustainable tourism, there is an urgent need to apply a mix of green technology development and improvements in tourism infrastructure that are environmentally friendly.

As for the E7 countries, they must have clear and focused goals to combat corruption because of the negative effects of poor institutional quality on international inbound tourist inflows. In addition, it is crucial for the governments of these countries to proceed with investments in energy-efficient technological innovations. Such a venture can assist in curbing carbon dioxide emissions and reduce levels of suspended particulate matter. Thus, the E7 countries need to invest judiciously in low-carbon, climate-friendly technologies for the expansion of their tourism sector and move toward sustainable development. In addition, many of the E7 countries are heavily reliant on tourism to augment economic growth. The inability to combat the rising emissions of pollutants like carbon dioxide and suspended particulate matter will, in the long run, adversely impact the economic growth of such countries, given that the empirical findings demonstrate the negative effects of pollution on international tourist inflows.

Since trade openness has a positive impact on international tourism for both G7 and E7 countries, the local governments of these countries can enhance infrastructure support to expand its exports. Trade openness can be increased by reducing tariff and non-tariff barriers. Although the empirical findings and recommendations of this study exist in the context of the sample set of observations, they can be extended to other tourism-dependent countries. Additionally, policymakers can develop stringent regulatory frameworks to control the levels of pollution in the environment. For example, economic incentives can create an environment with low carbon dioxide emissions and suspended particulate matter. The concerned governments can stimulate the development of clean technology for tourism activities to decarbonize the environment and enhance international tourist inflows. Furthermore, tourism revenue can be used to improve the quality of infrastructure to control environmental degradation. These sets of countries can implement a more sustainable mix of energy containing renewable sources to reduce the harm caused to the environment. In the same line of argument, it is crucial to check economic activities that lead to large emissions of carbon dioxide and suspended particulate matter. This can be done if an appropriate dose of tax and subsidy schemes is implemented.

The governments of the concerned countries should further reform in the proper pricing of renewable energy and other resources. Further, the government should severely punish those who do not abide by environmental laws. The government needs to develop policies for the successful implementation of laws on environmental protection. Thus, there is the urgent need for strong willpower from governments, given that the operation of the industrial enterprises must seek approval from them. The government can protect the environment by not only punishing the offender but also providing incentives to firms to act for the welfare of the environment. The central government of the country also needs to set up and monitor a clear set of guidelines for protecting the environment. It should frame laws to punish corrupt officials because under the backdrop of such severe punishment they would apply the environmental standards in their localities. The senior officials can similarly punish junior staff if they commit a violation of environmental standards.

In the context of tourism development, the government must develop strategies to optimize the quality and efficiency of the environment. The local government in various departments should improve the supervision of various tourist attractions and strictly implement punishment and reward measures. It should also conduct inspections at regular intervals and evaluate the ecological standards and management of tourist spots. Tourist attractions that perform outstandingly in terms of environmental quality should be adequately rewarded, while those performing poorly in terms of environmental standards should be urged to improve. The relevant department in the government must severely punish the tourist organizations that do not maintain environmental standards. Such steps will ensure the need to recognize the importance of environmental protection.

To support low-carbon, climate-friendly technologies, policy instruments should focus on the introduction of environmental protection laws, the conservation of energy, and development of new and renewable energy. These should be stressed during industry restructuring to support the development of low-carbon economic development. New industrial standards to support the relevant laws and regulations also need to be framed since industrial standards are missing in many countries. Provisions can be made for green labels and the standardization for market entry to help regulate the market for low-carbon technologies.

Finally, the governments of most countries need to provide tax incentives and financial assistance to boost low-carbon, climate-friendly technologies. There can be projects on low-carbon tourism cities and provinces. Here, the government needs to fix the criterion for a low-carbon city and province. Moreover, there is an urgent need to develop renewable energy to ensure the expansion of low-carbon, climate-friendly technologies.

7.2 Future directions

A caveat of the current study is that it does not include the role of uncertainty, employment, and taxes. Future research could explore the relevance of these parameters. In addition, as far as the methodological front is concerned, explorations of the tourism–environment nexus can be investigated using quantile modeling tools. This study relied on annual observations to gauge the impact of pollution on tourists' destinations, yet if monthly or quarterly time series data are available across major cities, then the optimal value of threshold pollution could be determined separately. Again, our study points out that there is an urgent need to raise the level of quality in the air to attract international tourists. However, how the quality of air can be improved is beyond the scope of the current study. Likewise, data on overnight stays and length of the duration of stay are not available. Such data sets may provide interesting insights as to how tourists may alter travel plans against the backdrop of rising pollution. In addition, quality of atmosphere indicators like rain (Falk, 2014; González-Gómez, 2010) or storms (Smith et al., 2016) could also be considered in future studies. Further, future research can explore if weather conditions significantly impact international tourists' arrivals in the G7 and E7 countries. Again, apart from using tourists' arrivals, other indicators like tourism receipts, expenditure, and investments can be utilized to explore the underlying nexus between pollution and tourism. Last but not least, the availability of dense time series data is critical for future perspectives on tourism and the environment. Overall, there is an urgent need to develop disaggregated data to critically explore the nexus between emissions and the environment for environmental sustainability in the E7 and G7 countries.

Appendix

See Table 9.

Table 9 Long-run estimates: dynamic common correlated effects

Explanatory variables	ARDL	
	Coefficient	Prob
Model I $LTA = (LCO2, LCO2^2 LREX, LECI, LTR, LINSQ)$		
G7 countries		
LCO2	0.07**	0.00
Squared level of LCO2	− 0.12*	0.03
LREX	− 0.60**	0.008
LTR	0.26*	0.01
LECI	− 0.05	0.25
LINSQ	0.01**	0.02
E7 countries		
LCO2	4.04*	0.00
Squared level of LCO2	− 0.85*	0.01
LREX	0.21**	0.01
LTR	0.54*	0.001
LECI	0.21	0.99
LINSQ	− 0.25	0.002
Model II. $LTA = (LPM2.5; LPM2.5,^2 LREX, LECI, LTR, LINSQ$		
G7 countries		
LPM2.5	0.079*	0.00
Squared level of LPM2.5	− 0.18*	0.002
LREX	− 0.25*	0.001
LTR	0.21*	0.02
LECI	− 9.65	0.08
LINSQ	0.79*	0.01
E7 countries		
LPM2.5	0.21*	0.003
Squared level of LPM2.5	− 4.03*	0.00
LREX	0.21*	0.00
LTR	0.96*	0.001
LECI	− 5.23	0.11
LINSQ	− 0.63*	0.00

(*) &(**) denotes one percent and five percent of the level of significance

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