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Exploring the relationship among CO_2 emissions, real GDP, energy consumption and tourism in the EU and candidate countries: Evidence from panel models robust to heterogeneity and cross-sectional dependence

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ABSTRACT

A major criticism to the existing energy-growth-environment literature, we notice, is the selection of methodology. Panel estimation techniques that fail to consider both heterogeneity and cross-sectional dependence across countries may cause forecasting errors. The other concern related to the literature is that only a small number of studies analyze the influence of tourism on CO_2 emissions even though tourism sector has potential for affecting the environment. To fulfill the mentioned gaps in the literature, this study analyzes the relationship among carbon emissions, real income, energy consumption and tourism for a panel of the EU and candidate countries over the period 1995–2011 by using heterogeneous panel estimation techniques with cross-sectional dependence. Results from the CADF and the CIPS panel unit root tests show that the analyzed variables become stationary at their first-differences. The LM bootstrap panel cointegration test indicates the presence of a long run relationship among the analyzed variables. Results from the OLS with fixed effects, the FMOLS, the DOLS and the group-mean estimator reveal that energy consumption contributes to the level of emissions while real income and tourism mitigate CO_2 emissions. The Emirmahmutoglu-Kose panel Granger causality test suggests that there is one-way causality running from tourism to carbon emissions, and two-way causality between CO_2 emissions and energy consumption, and between real income and CO_2 emissions. Policy implications are further discussed.

1. Introduction

There are many academic studies that have investigated the linkage between energy consumption and economic growth in recent decades. Accompanying the common empirical finding that increases in energy consumption lead to increased economic growth (real GDP); the energy-growth nexus is put forward four hypotheses [65]. Neutrality hypothesis emphasizes no causality between energy consumption and economic growth. Feedback hypothesis claims the presence of mutual interdependence of economic growth and energy consumption (bidirectional causality). While conservation hypothesis implies unidirectional causality running from economic growth to energy; growth hypothesis verifies unidirectional causality running from energy consumption to economic growth [13,27].

Another recent popular issue is the investigation of relationship between economic growth and tourism sector [66]. The origin of the relationship between economic growth and tourism sector is based on tourism-led growth hypothesis and growth-led tourism hypothesis. Furthermore, a new relationship between tourism and energy consumption has been examined in very recent studies [48]. The focal point of tourism-energy works is rather based on the energy-growth-environment nexus [28,46]; [92] since tourism sector is substantially associated to energy consumption and the environment. Indeed, tourism activities involve energy consumption directly through fossil fuels or indirectly through electricity power in each step of tourism activities from transportation to accommodation. Depending on the source of energy use (e.g. renewable and non-renewable energy) in tourism sector, it may either decrease or increase the pollution. In addition, the impact of tourism on the environment may differ through supportive policies and government interventions for low level of greenhouse gas emissions, and the use of clean technologies in the sector. On the other hand, the majority of tourists usually swims in the resort, makes sun bathing and wants to spend time in different places through motorized transports. Air pollution caused by the use of fossil fuels and motorized vehicles in countries brings together the greenhouse gases. Another aspect of the subject is the influence of tourism

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on global warming. According to the World Tourism Organization (UNWTO), tourism sector is responsible for 4.6% of global warming; in addition, 5 per cent of CO_2 emissions are due to tourism.[1] These negative effects lead especially developed countries to take measures about tourism. Sustainable tourism concept has emerged as a result of these measures. Even though tourism is very much related to the environment, only a few studies consider the possible effect of tourism on the environment and more importantly their findings are mix [26,28].

According to the UNWTO [85], the Europe is the most famous tourism destination given that it attracted the half of the world's international tourists. Furthermore, the European Union (EU) includes many most-visited countries among the world's top 10 destinations; namely, France, Spain, Italy, Turkey, Germany and the UK.[2] Thus, tourism illustrates a major role in the shaping the indicators of the EU while infrastructure improved for tourism sector provides to development process. The European Commission issued a report titled “A renewed EU tourism policy: towards a stronger partnership for European tourism” in 2006. The statement contains the need to develop more sustainable and environmentally-friendly tourism in the EU. Another report titled “Agenda for a sustainable and competitive European tourism” issued in 2007 highlights more competitive tourism services and sustainable destinations to increase tourist satisfaction and keep the EU's major role around the world.

Although the link among energy consumption, economic growth, tourism and the environment is very important, it has received little attention. The first contribution to the literature of this empirical study is to analyze the long run dynamics of tourism, energy consumption, the real GDP and CO_2 emissions (as a proxy for the pollution) for a panel of the EU and candidate countries. The second contribution is that a large part of the energy-growth-environment literature which examines the relationship with panel data methods assumes that panel time-series data are homogenous and cross-sectionally independent. Unlike the existing literature, we use the homogeneity test and the cross-section independence test developed by Pesaran and Yamagata [73], and Pesaran [71], respectively, in order to show that the panel data that this study uses are heterogeneous and cross-sectionally dependent. Therefore, this study employs heterogeneous panel estimation techniques with cross-sectional dependence. More precisely, we use the CADF and the CIPS unit root tests, the LM bootstrap cointegration test, the Emirmahmutoglu-Kose Granger causality test. Furthermore, the long run estimation results are robust due to the use of several estimators; namely, the group-mean DOLS, the group-mean FMOLS and the mean-group estimator. The panel methods used in this empirical study take cross sectional dependence and heterogeneity into account to produce reliable and robust empirical results. This study is organized as follows: Section 2 provides a comprehensive literature review. Section 3 presents the model and the data. While Section 4 includes methodology and empirical results, the last section presents conclusion and policy implications.

2. Literature review

Many studies have analyzed the long run dynamics of economic growth and tourism for a variety of countries and panels [66]. Katircioglu [45] supports the existence of one-way causality running from economic growth to tourism for Cyprus by employing the autoregressive distributed lag (ARDL) model and Granger causality test in the vector error correction mechanism (VECM) for the years 1960–2005. Payne and Mervar [59] show that growth-led trouism hypothesis is valid in Croatia by applying Toda-Yamamato causality test to quarterly data from 2000 to 2008. In addition, growth-led tourism hypothesis is also validated for Malaysia [51,83], a panel of 12 OECD countries [50], Tunisia [24], a panel of 11 countries [49]. Bilen et al. [93] investigate the tourism-growth nexus for a panel of 12 Mediterranean countries over the period 1995–2012. Results from the Dumitrescu-Hurlin causality test support unidirectional causality running tourism to economic growth while results from the Croux-Reusens causality test suggest bidirectional causal relationship between trouism and growth. Bidirectional causality between economic growth and tourism is supported for a panel of 32 non-OECD countries [52], South Korea [22], Spain [23], panel of developed and developing countries [75], panel of 11 countries [62], panel of European countries [20], Italy [58] and Turkey [14].

The energy-growth nexus has also been extensively investigated [27,30,64]. Fuinhas and Marques [36] analyze the relationship between energy consumption and economic growth for PIGST (Portugal, Italy, Greece, Spain and Turkey) over the period 1965–2008 by using the ARDL model and the VECM causality test. Empirical results indicate that there is bidirectional Granger causality between energy consumption and economic growth, suggesting the presence of feedback hypothesis. The existence of feedback hypothesis is also validated for Philippines and Thailand [12], a panel of high-income countries [65], Lebanon [25], a panel of 90 countries [33], a panel of oil importing Sub-Saharan countries [17], Hungary [21] and a panel of developed and developing countries [56]. On the other hand, one-way causality running from economic growth to energy consumption (conservation hypothesis) is found for Algeria, Congo Dem. Rep., Egypt, Ghana, Ivory Coast, Morocco and Nigeria [88], a panel of 30 OECD countries [60], a panel of 18 developing countries [53], Pakistan [77], majority of OECD members [13], Indonesia, Malaysia and Philippines [90].

A large number of studies have investigated the energy-growth-environment nexus [6]. Say and Yücel [74], one of the pioneering studies, finds that energy consumption and income contribute to the level of emissions in Turkey by using the ordinary least squares (OLS) with data from 1970 to 2002. By using the ARDL model and the VECM Granger causality methods, Ang [7] support the presence of unidirectional causality from the real GDP to energy consumption and the level of emissions. By using the Levin-Lin-Chu (LLC) and the Im-Pesaran-Shin (IPS) panel unit root tests, the Pedroni and the Johansen panel cointegration tests, and the panel Granger causality test for a panel of newly industrialized countries, Hossain [39] shows that energy consumption and economic growth boost the level of emissions, and Granger causality runs from energy consumption and real income to CO_2 emissions. By applying the Johansen cointegration test, the OLS and the VECM Granger causality technique for Russian data, Pao et al. [67] present that increases in energy consumption and economic growth lead to higher pollution, and support the feedback hypothesis between energy consumption and economic growth, between energy consumption and CO_2 emissions and between real income and carbon emissions. Alam et al. [3] analyze the effects of real GDP and energy consumption on CO_2 emissions for Bangladesh over the period 1972–2006 by employing the Johansen cointegration test, the ARDL model and the VECM causality test. Results show that energy consumption increases carbon emissions, and one-way causality runs from energy consumption to CO_2 emissions and from carbon emissions to economic growth. Omri [63] examine the energy-growth-environment nexus for a panel of Middle East and North Africa (MENA) members for the years 1990–2011. Empirical results reveal bidirectional causality between real income and CO_2 emissions, and one-way causality running from energy consumption to carbon emissions. Shahbaz et al. [81] indicate that energy consumption and economic growth lead to environmental degradation in a panel of 99 countries for the years 1975–2012 by using the IPS and CADF panel unit root tests, the Pedroni and the Johansen cointegration test and the fully-modified OLS (FMOLS) estimator. Kasman and Duman [44] find that energy

[1] Available at http://sdt.unwto.org/content/faq-climate-change-and-tourism (accessed on January 13, 2016).

[2] Available at http://www.e-unwto.org/doi/pdf/10.18111/9789284416226 (accessed on January 13, 2016).

consumption Granger causes CO_2 emissions and real income causes energy consumption, and increases in real income lead to environmental improvements for a panel of the European Union (EU) members and candidate countries over the period 1992–2010 by using the IPS and the Hadri panel unit root tests, the Pedroni cointegration test, the FMOLS and the panel Granger causality test. Al-Mulali et al. [4] investigate the energy-growth-environment nexus for a panel of 93 countries over the period 1980–2008 by using the IPS and ADF panel unit root tests, the OLS estimator. Empirical results show that energy consumption contributes to the level of emissions whereas increases in real income mitigate CO_2 emissions for high-income economies. Wang et al. [86] find that energy consumption and real output cause higher level of pollution in China by applying the Augmented Dickey-Fuller (ADF) unit root test and the Johansen cointegration test to annual data from 1990 to 2012. Dogan and Turkekul [29] analyze the determinants of CO_2 emissions for the USA over the period 1960–2010 by using the ADF unit root, the ARDL model and the VECM causality test. Empirical results show that increases in energy consumption and real income lead to environmental degradation, and there is bidirectional causality between CO_2 emissions and energy consumption, and between the level of emissions and real income, and one-way causality running from economic growth to energy consumption.

Several recent studies investigate the influence of tourism on CO_2 emissions. Lee and Brahmasrene [54] examine the effect of tourism on economic growth and CO_2 emissions for a panel of the EU countries for the period 1988–2009 by using the IPS and the LLC panel unit root tests, the Johansen cointegration test and the OLS estimator. Empirical results reveal that while tourism and CO_2 emissions have statistically significant and positive effect on real GDP, tourism has a negative impact on CO_2 emissions. Katircioglu et al. [48] explore the long run equilibrium relationship among tourism, carbon emissions and energy consumption for Cyprus by applying the ARDL model to annual data from 1970 to 2009, and show that international tourism has a positive and statistically significant influence on CO_2 emissions and energy consumption. Solarin [82] considers the linkage between carbon emissions and tourism expansion in Malaysia. The results expose a long run relationship between the variables and a positive unidirectional long run causality running from tourism expansion to the level of emissions. For Turkey, Katırcioglu [46] explores the long run equilibrium relationship between tourism, energy consumption and CO_2 emissions by using the ARDL method. Empirical results indicate that tourism leads to environmental degradation. Dogan et al. [28] investigate the long run dynamics of tourism, CO_2 emissions, energy consumption and real GDP for a panel of the OECD countries over the period 1995–2010 by using the CIPS and CADF unit root tests, the LM bootstrap cointegration test, the dynamic OLS (DOLS), and the Dumitrescu-Hurlin causality method. Results suggest that one-way causality is valid from tourism to CO_2 emissions, from economic growth to tourism, from tourism to energy consumption. Zaman et al. [91] examine the relationship among economic growth, tourism, carbon emissions and energy demand for a panel of East Asia & Pacific, the EU and high-income OECD and non-OECD countries over the period 2005–2013 by using the two-stage technique and the Dumitrescu-Hurlin causality test. Results conclude that there is one-way causality running from real income to tourism, from tourism to CO_2 emissions, and from energy consumption to carbon emissions.

Overall, even though a number of studies explore the energy-growth-environment literature, only a small number of the existing studies investigate the effect of tourism on CO_2 emissions. Furthermore, a major criticism to the existing studies in the related literature, we notice, is the selection of methodology. Because countries within the panel are most likely subject to heterogeneity and cross-sectional dependence, the use of econometric methods that fail to consider cross-sectional dependence and heterogenity across the panel may cause forecasting errors. Therefore, estimation techniques robust to heterogeneity and cross-sectional dependence are of recent interest for researchers so as to obtain more accurate and consistent results and policy implications for sample countries. To overcome the above-mentioned shortcomings of the literature, this study analyzes the relationship between CO_2 emissions, energy consumption, real income and tourism for a panel of the EU and candidate countries by using heterogenous panel estimation techniques with cross-sectional dependence.

3. Model and data

As similar to that of Katircioglu [46], this study uses the following function wherein CO_2 emissions are the response variable, and gross domestic product (Y), energy consumption (EGY) and tourism (TOUR) are the dependent variables:

$$CO_2 = (Y,\ \mathrm{EGY},\ \mathrm{TOUR}) \tag{1}$$

The function in Eq. (1) can be transformed into an econometric model by including a constant term (β_0) and an error term (e_{it}) given in Eq. (2):

$$(CO_2)_{it}=\beta_0 + \beta_1 Y_{it} + \beta_2 EGY_{it} + \beta_3 TOUR_{it} + e_{it} \tag{2}$$

where β_k (k=1, 2, 3) are the coefficients on Y, EGY and TOUR. The data used in this study are described as follow. CO_2 emissions is carbon dioxide gas emissions in metric tons; Y is the value of real gross domestic product in constant 2005 US$; TOUR is the number of international tourist arrivals at the sample countries; EGY is the kg of oil equivalent energy use. The data are obtained from the "World Development Indicators" (http://data.worldbank.org). The annual data are from 1995 to 2011. It should be noted that we use the longest available data given the fact that the data for TOUR are not available before 1995, and CO_2 emissions are not available after 2011. Due to availability of data, this study considers 25 EU and candidate countries; namely, Austria, Belgium, Bulgaria, Cyprus, Germany, Denmark, Spain, Estonia, France, Greece, Croatia, Ireland, Italy, Lithuania, Luxemburg, Latvia, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Turkey and United Kingdom. Since the panel time-series data are converted into their natural logarithm, β_k (k=1, 2, 3) can be interpreted as the elasticities of CO_2 emissions with respect to Y, EGY and TOUR.

4. Methods and empirical results

In advance to detecting stationary properties of real income, energy consumption and tourism, the characteristics of the panel data should be further elaborated in order to make to use appropriate panel unit root tests. In case that a panel time-series data is not homogenous and cross-sectionally independent, the conventional panel unit root tests such as IPS [40], LLC [55], HT [38] and Hadri [37] produce inconsistent and unreliable results. In order to check for whether or not slope coefficients are homogenous, we use the method of Pesaran and Yamagata [73]. This approach builds on the Swamy approach estimate the delta ($\tilde{\Delta}$) and the adjusted delta ($\tilde{\Delta}_{adj}$) so as to test null hypothesis of the slope homogeneity, H_0: $\beta_i=\beta$ for all individual, against the alternative hypothesis of slope heterogeneity, H_A: $\beta_i \neq \beta_j$ for a non-zero fraction of pair-wise slopes for $i \neq j$. According to results posted in Table 1, we have enough evidence to reject the null hypothesis of

Table 1
Results from homogeneity tests.

test	Y	EGY	TOUR
$\tilde{\Delta}$	16.34*	11.32*	12.45*
$\tilde{\Delta}_{adj}$	17.90*	12.40*	13.65*

Note:
* denotes the statistical significance at 1% level.

Table 2
Results from cross-section independence test.

	CO_2	Y	EGY	TOUR
Statistic	8.84*	67.78*	16.44*	46.31*
p-value	0.00	0.00	0.00	0.00

Note:
* denotes the statistical significance at 1% level. This test assumes the null hypothesis of cross-section independence.

homogeneity in favor of the alternative hypothesis of heterogeneity, and thus conclude that the analyzed panel data are heterogeneous.

In addition to heterogeneity (HTR), we also apply the cross-section independence test [71] to data for carbon emissions, economic growth, energy consumption and tourism so as to reveal the characteristic of error terms across sample countries. Test statistics from the Pesaran's test reported in Table 2 show that the panel time-series data have cross-sectional dependence (CD). Overall, we pin down the presence of CD and HTR across the EU countries for the analyzed variables.

For the purpose of using panel unit root tests robust to the issues of CD and HTR, we use the CADF and the CIPS unit root tests [72]. These tests produce consistent and reliable results in the presence of both HTR and CD. According to output given in Table 3, carbon emissions, real income, energy consumption and tourism include unit root at their levels but become stationary at their first differences. The results are statistically significant at 1% level. Overall, we can conclude that the analyzed variables are integrated of order one.

In case where variables are not stationary at levels, long run coefficient estimates are not economically meaningful and statistically accurate unless they are cointegrated. Because the analyzed panel data are found to be non-stationary at levels, this study employs the LM bootstrap cointegration test developed by Westerlund and Edgerton [87] so as to check whether or not the level of emissions, economic growth, energy consumption and tourism are cointegrated. The LM bootstrap cointegration test used in this study takes into account of both issues of CD and HTR in estimation procedure. Test statistics obtained from the cointegration test shown in Table 4 indicate that the null hypothesis of cointegration cannot be rejected because associated p-values are close to one. Overall, we find that CO_2 emissions, real income, energy consumption and tourism are cointegrated and thus have a long run relationship. Therefore, coefficients on energy consumption, real output and tourism for the level of emissions are taken as economically and statistically meaningful.

This study further applies the OLS with fixed effects, the group-mean DOLS [69], the group-mean FMOLS [68,69] and the mean-group estimator [70] in order to post accurate and robust long run coefficient estimates of economic growth, energy consumption and tourism for carbon emissions. Pedroni [68] suggests that the group-mean estimators produce more consistent estimates than the pooled and weighted estimators in case where heterogeneity exists in cointegrated panel data. Since the variables are converted into their natural logarithm, the

Table 3
Results from panel unit root tests.

	CIPS		CADF	
	Level	Δ	Level	Δ
CO_2	−1.97	−3.60**	−1.42	−3.60**
Y	−1.72	−2.30*	−1.31	−2.26*
EGY	−2.46	−3.82**	−1.81	−3.40**
TOUR	−2.64	−3.32**	−2.44	−2.84**

Note: * and ** denote the statistical significance at 5% and 1% level, respectively. Δ denotes for the first differences. The option of constant and trend is used for levels, and the option of constant only is used for differences. The critical values can be provided upon request.

Table 4
Results from the LM bootstrap panel cointegration test.

Tests	Constant		Constant and trend	
	Statistic	Bootstrap p-value	Statistic	Bootstrap p-value
LM bootstrap cointegration	4.99	0.99	16.49	0.99

Notes: The bootstrap test statistics are calculated using 5000 replications. This test performs the null hypothesis of cointegration in the panel for all units against the alternative hypothesis of no cointegration in the panel (at least for a cross-sectional unit).

posted coefficients in Table 5 are also equal to the elasticities of carbon emissions with respect to economic growth, energy consumption and tourism. It should be firstly noted that all of the reported coefficients are statistically significant at either 1% level or 5% level. Secondly, the sign of coefficients of variables is the same across the four estimators even though their magnitudes slightly vary across the estimators.

The elasticity of carbon emissions with respect to economic growth is negative and ranging from −0.10% to −0.20%, implying that increases in real income lead to lower level of emissions in EU countries. The negative coefficient for real income is indirectly connected to the Environmental Kuznets Curve (EKC) hypothesis which claims that increases in real income lead to environmental improvements in a country after the country passes the threshold level of income. Given the fact that the sample 25 EU countries are among either high-income economies or upper middle-income economies according to classification made by World Bank, they should be beyond the threshold income level. The presence of the EKC hypothesis is also supported by many studies focusing on the EU countries and high-income countries. The EKC is validated for France [11,41], Turkey [76,89], Spain [32], Romania [78], panel of Central and Eastern European countries [15], panel of the EU and candidate countries [44], panel of 27 advanced economies [6] and panel of upper-income economies [4]. The negative impact of economic growth on CO_2 emissions is also consistent with Baek and Pride [16] which find that increases in real income decrease the level of emissions in three high-income economies; the USA, France and Canada. The EU countries should continue to produce goods and services to stay beyond the threshold level of income for environmental improvements.

As opposed to the sign of coefficient on economic growth, the elasticity of carbon emissions with respect to energy consumption is significantly positive and ranging from 1.13% to 1.36%. This result suggests that increases in energy consumption lead to environmental degradation. It is consistent with existing studies such as Ang [11], Apergis and Payne [8], Atici [15], Acaravci and Ozturk [1], Shahbaz et al. [78], Shahbaz et al. [80], Farhani et al. [34], Yavuz [89], Kasman and Duman [44], Dogan et al. [28], Seker et al. [76], Al-Mulali et al. [4], Farhani and Ozturk [35], Dogan and Turkekul [29], Javid and Sharif [42], and Zhang and Gao [92]. In case where energy consumption stimulates carbon emissions, the first step towards lower level of emissions is to increase energy efficiency. Although it is important for sustainable efficiency to financially support scientific institutions to develop projects on the topic of energy efficiency, public awareness is essential for lower energy consumption. For instance, the EU countries should more focus on public awareness of energy efficiency, energy saving and environmental pollution by encouraging households to buy energy efficient products such as refrigerator and dryer, to take public transportation, to turn off and unplug devices (i.e. televisions) and bulbs while not used, and use as much renewable energy as possible. Indeed, the adoption and use of renewable energy is very important for the environment as they are free of pollution. Moreover, the governments should increase the share of renewable sources in energy mix by installing more solar panels, wind tribunes and etc. Last, the negative effect of renewable energy on carbon emissions is found by [57] and Al-

Table 5
Results from long run estimators.

	OLS with fixed effects		Group-mean DOLS		Group-mean FMOLS		Mean-group estimator	
Regressors	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value
Y	−0.10**	0.00	−0.20**	0.00	−0.19**	0.00	−0.20**	0.00
EGY	1.13**	0.00	1.30**	0.00	1.36**	0.00	1.32**	0.00
TOUR	−0.03**	0.00	−0.07*	0.02	−0.10**	0.00	−0.08*	0.04
Hausman test	9.41*	0.02						

Note: * and ** denote the statistical significance at 5% and 1% level, respectively.

Mulali et al. [5] for panel of European countries, Bento and Moutinho [18] for Italy, Iwata et al. [41] for France, Boluk and Mert [19] for Turkey, and Al-Mulali and Ozturk [6] for panel of 27 advanced economies.

The elasticity of CO_2 emissions with respect to tourism is negative and ranging from −0.03% to −0.10%. This implies that tourism sector is not a concern for environmental pollution in the sample countries. Moreover, increases in tourist arrivals reduce the level of emissions. This result is consistent with that of Lee and Brahmasrene [54], Katircioglu [47] and, Zhang and Gao [92]. It seems that tourism sector mostly use renewable energy and environmentally-clean technologies in their operations. On the other hand, the empirical finding indicates that tourism sector decrease environmental pollution but at a small rate. The European countries should continue to regulate necessary policies in regard to environmental protection and awareness of renewable energy and sustainable tourism. For further environmental improvements, a bicycle-oriented tourism and tourist transport by environmentally-friendly vehicles should be supported and adopted in replacement of motorized and environmentally-unfriendly transports.

This study lastly uses the bootstrap panel Granger causality test developed by Emirmahmutoglu and Kose [31] in order to reveal causal relationship among CO_2 emissions, energy consumption, economic growth and tourism for the sample countries. The Emirmahmutoglu-Kose causality test accounts for both issues of CD and HTR, thus produces reliable and robust causal linkages among the analyzed variables. Results from the bootstrap causality test are reported in Table 6. We have enough evidence to conclude that there is bidirectional Granger causality between real income and carbon emissions, and between CO_2 emissions and energy consumption; there is unidirectional causality running from tourism to the level of emissions, from economic growth to energy consumption, from economic growth to tourism; there is no Granger causality between tourism and energy consumption.

The feedback hypothesis between carbon emissions and economic growth is in line with Apergis et al. [9], Pao et al. [67], Apergis and Payne [10], Dogan et al. [28], Kasman and Duman [44], Jebli et al. [43] and Dogan and Turkekul [29]. The tourism-led emissions hypothesis is also found by Ang [11], Ajmi et al. [2], and Dogan et al. [28]. The conservation hypothesis between energy consumption and economic growth is also supported by Wolde-Rufael [88], Narayan and Prasad [60], Lee and Chang [53], Shahbaz and Feridun [77], Aslan [13], Yildirim et al. [90], Tang and Tan [84], and Dogan and Turkekul [29]. The growth-led tourism hypothesis is also shown by Katircioglu [45], Payne and Mervar [59], Lean and Tang [51], Tang [83], Pablo-Romero and Molina [66], Dogan et al. [28], and Zaman et al. [91]. The feedback hypothesis between energy consumption and CO_2 emissions in consistent with Pao et al. [67], Nasir and Rehman [61], Shahbaz et al. [79], Ajmi et al. [2], Dogan et al. [28], Kasman and Duman [44], Shahbaz et al. [81], and Dogan and Turkekul [29]. Overall, our empirical findings are in line with many studies. Furthermore, it is worth pointing out that the directions of Granger causality found in this study are reliable for policy recommendations due to the use of the Emirmahmutoglu-Kose test which is based on the bootstrap technique robust to the presence of CD and HTR. As regards to policy implications, the governments of EU countries can decrease the use of energy for lower level of emissions without harming economic growth because we show the presence of conservation hypothesis between energy consumption and real income, and also show that decreases in energy consumption mitigate carbon emissions. Together both the tourism-led emissions hypothesis and the fact that tourism mitigates emissions imply that the enlargement of tourism sector is no danger for the environment. On the other hand, necessary measures and regulations (i.e. high share of renewable sources in energy mix and the use of environmentally-friendly machines and vehicles in tourism activities) should also be taken to maintain clean and sustainable tourism in the EU countries. In addition, the existing of feedback hypothesis between CO_2 emissions and economic growth with the information of negative coefficient on real income suggests that the sample countries should impose regulatory policies and encouragement acts to reach higher level of real income for decreased pollution. Furthermore, increases in economic growth also indirectly-through tourism-decrease the level of emissions.

Table 6
Results from Emirmahmutoglu-Kose Granger causality test.

Hypothesis	Fisher-statistic	p-value	Conclusion
$Y \rightarrow CO_2$	77.46***	0.00	Two-way causality between Y to CO_2
$CO_2 \rightarrow Y$	149.79***	0.00	
$EGY \rightarrow CO_2$	93.38***	0.00	Two-way causality between EGY and CO_2
$CO_2 \rightarrow EGY$	81.47***	0.00	
$TOUR \rightarrow CO_2$	64.51*	0.08	One-way causality from TOUR to CO_2
$CO_2 \rightarrow TOUR$	50.52	0.45	
$EGY \rightarrow Y$	55.33	0.28	One-way causality from Y to EGY
$Y \rightarrow EGY$	67.81**	0.04	
$TOUR \rightarrow Y$	56.86	0.23	One-way causality from Y to TOUR
$Y \rightarrow TOUR$	108.31***	0.00	
$TOUR \rightarrow EGY$	54.26	0.31	No causality between TOUR and EGY
$EGY \rightarrow TOUR$	50.92	0.43	

Note: ***, **, * denote the statistical significance at 1% level, 5% level and 10% level, respectively.

5. Conclusions and policy implications

A major criticism to the existing energy-growth-environment literature, we notice, is the selection of methodology. More precisely, panel estimation methods that fail to take account into both heterogeneity and cross-sectional dependence across countries may cause forecasting errors. Furthermore, only a small number of studies analyze the influence of tourism on CO_2 emissions even though tourism sector has potential for affecting the environment. To overcome the mentioned shortcomings of the energy-growth-environment literature, this study analyzes the relationship among carbon emissions, real income, energy consumption and tourism for a panel of the EU and candidate countries over the period 1995–2011 by using heterogeneous panel estimation techniques with cross-sectional dependence. Results from the CADF and CIPS panel unit root tests show that the analyzed variables become stationary at their first-differences. The LM bootstrap panel cointegration test indicates the presence of a long run relationship among the analyzed variables. Results from the OLS with fixed effects, the FMOLS, the DOLS and the group-mean estimator reveal that energy consumption contribute to the level of emissions while real income and tourism mitigate CO_2 emissions. The Emirmahmutoglu-Kose panel Granger causality test suggests that there is one-way causality running from tourism to carbon emissions, from economic growth to energy consumption, and from growth to tourism, and two-way causality between CO_2 emissions and energy consumption, and between real income and CO_2 emissions. As regards to policy implications, regulatory policies should be implemented to increase energy efficiency and share of renewable sources in energy mix. Researchers and scientific institutions should be supported by the EU governments to work on the incremental energy efficiency. Because the coefficient on tourism is quite small, more actions should be introduced to increase the effects of tourism sector on the environment. Bicycle-oriented tourism should be supported and adopted in replacement of motorized and environmentally-unfriendly transport. The use and the adoption of energy efficient and clean technologies should be implemented more in tourism sector. More projects on the development of environmentally-friendly technologies, especially those in relation with tourism sector, should be sponsored by the EU governments.

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