CO_2 Emissions, Real GDP, Renewable Energy and Tourism: Evidence from Panel of the Most-Visited Countries

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Abstract

Previous studies on the energy-environment-growth literature overlook the investigation of the most-visited countries. Since these countries do not only belong to the largest economies and the top carbon dioxide (CO_2) emitters in the world but are also listed in renewable energy country attractiveness index, this study analyzes the impacts of real GDP, renewable energy and tourism on the level of CO_2 emissions for the top 10 most-visited countries. Applying several panel econometric approaches, we find out that renewable energy mitigates the pollution whereas real GDP and tourism contribute to the level of emissions. Thus, regulatory policies are necessary to increase the awareness of sustainable tourism. In addition, the use of renewable energy and the adoption of clean technologies in tourism sector as well as in producing goods and services play a significant role in CO_2 mitigation.

Keywords

Carbon dioxide emissions, tourism, renewable energy, real GDP, heterogeneity, cross-sectional dependence

JEL code

C32, C33, L83, O44, Q20, Z32

INTRODUCTION

The world has experienced a tremendous increase in the amount of greenhouse gas emissions over the last several decades. More than 190 parties have signed the Kyoto Protocol and participated in many meetings about the climate change and the environment to fight the pollution.[2] The last United Nations (UN) Climate Change Conference associated with the Kyoto Protocol took place in Paris in November–December 2015. This protocol aims to reduce the level of emissions by targeted rates. In this regard, several potentials have been discussed to keep track of the projected level of emissions. Increases in the share of renewable sources (environmentally-friendly) in energy mix play an important role in this matter. Recent studies Al-Mulali et al. (2015a), Dogan and Seker (2016), Jebli et al. (2016), and Mehdi and Slim (2017) among others show that increases in renewable energy statistically and significantly

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[2] Please refer to the United Nations website at: <www.un.org> for more information.

reduce emissions. The volume of studies investigating the influence of energy by sources on the pollution is still relatively smaller as compared to studies using the aggregate energy consumption in modeling the energy-environment-growth nexus.

Sustainable tourism is also critical for the climate change as it plays a significant role in reaching goals of the Kyoto Protocol referring to the Second International Conference on Climate Change and Tourism on October 2007 jointly organized by the World Tourism Organization (UNWTO), and the UN Environment Programme. Tourism is a rapidly developing sector that grows each year with more arrival points emerging around the world. The 2016 edition of UNWTO reports that the overall number of tourists travelled around the world increased from 0.025 billion in 1950 to more than 1.2 billion in 2015.[3] The large expansion of tourism sector over this period should be connected to the tremendous increase in global carbon emissions. Tourism activities involve energy consumption directly through fossil fuels or indirectly through electricity power in each step from transportation to accommodation. Depending on the source of energy use (e.g. renewable and non-renewable energy), tourism may either mitigate or contribute to emissions. In addition, the influence of tourism on the pollution can alter by supportive policies and government interventions for low level of emissions, and the use of cleaner technologies in the sector activities. Even though tourism is very much related to the environment, only a few studies in the energy-environment-growth literature consider the possible effect of tourism on the pollution and more importantly their findings are mix (Dogan et al., 2015; De Vita et al., 2015).

This study makes several contributions to the existing pool of knowledge: i) this study for the first time analyzes the effects of real gross domestic production (GDP), renewable energy (REN) and tourism (TOUR) on carbon dioxide (CO_2) emissions for the most-visited 10 countries in the world.[4] Because the top 10 touristic (most-visited) countries have recorded about the half of the worldwide tourist arrivals in late years, we focus on a panel study of these countries. Furthermore, these countries are among the top ones in "Renewables Energy Country Attractiveness Index (RECAI)". This RECAI is calculated based on 3 drivers, 16 parameters and 53 datasets;[5] they are among the largest economies and the top emitters in the world; ii) this study uses a source of energy (renewable energy) instead of aggregate energy; iii) the possible presence of issues of cross-sectional dependence and heterogeneity across cross-sections for variables is among main criticisms to panel studies. If both issues appear in the data, a researcher will produce inaccurate and erroneous estimates if the researcher assumes homogeneity and cross-sectional independence in panel time-series data. Accompanying the information that nearly 99% of studies in the energy-environment-growth literature fail to check the mentioned issues and employ first generation econometric approaches, this study first identifies that cross-sectional dependence and heterogeneity exist in the analyzed data for the top 10 economies, and, accordingly, applies second generation econometric techniques. Thus, the results reported herein are more accurate and robust.

This study presents a survey of literature in the next section, provides the model and data in the third section, discusses the issues of heterogeneity and cross-sectional dependence in the fourth section, yields methods and empirical findings in the fifth section, and conclude aims, methods, findings and policy implications in the last section.

1 LITERATURE REVIEW

This section presents and brings together the associated literature in connection with the aim of the current study. The link between tourism and real GDP (or economic growth) is well-established and investigated

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[3] Available at: <www.unwto.org>.

[4] The top 10 countries are China, France, Italy, Thailand, the UK, the USA, Turkey, Germany, Russia and Spain.

[5] Please refer to: <http://www.ey.com/GL/en/Industries/Power---Utilities/Renewable-Energy-Country-Attractiveness-Index---Methodology>.

for single country cases and multi-country cases in the literature (Dritsakis, 2004; Oh, 2005; Kim et al., 2006; Santana-Gallego et al., 2010; Arslanturk et al., 2011; Pablo-Romero and Molina, 2013; Balcilar et al., 2014; Bilen et al., 2015; Pérez-Rodríguez et al., 2015; Aslan, 2015; Shahzad et al., 2017). Several studies including Peeters (2007), Gossling et al. (2010), Scott et al. (2010), Scott et al. (2012), Saenz-de-Miera and Rosselló (2014), Gossling and Peeters (2015), Al-Mulali et al. (2015b), Sharif et al. (2017) and Paramati et al. (2017) discuss the emissions-tourism nexus and indicate that tourism adversely impacts the environment. In other words, tourism activities including transportation contribute to the increased level of emissions. Referring to the aforementioned studies, tourism contributes to the output and pollution.

In addition to these nexus, the energy-economic growth nexus is also analyzed for a variety of cases (Ozturk, 2010; Yildirim et al., 2012; Wolde-Rufael, 2014; Bloch et al, 2015; Dogan, 2015). Furthermore, the link between CO_2 emissions, real GDP, aggregate energy consumption is described in a large number of studies including Say and Yucel (2006), Ang (2008), Soytas and Sari (2009), Apergis and Payne (2009), Du et al. (2012), Ozturk and Acaravci (2010), Hossain (2011), Pao and Tsai (2011), Park and Hong (2013), Cowan et al., (2014), Farhani and Ozturk (2015), Baek (2015), Ajmi et al. (2015), Shahbaz et al. (2015), Kasman and Duman (2015), Dogan and Turkekul (2016), Magazzino (2016), and Bekhet et al. (2017). The state-of-the-art reaches a consensus that increases in aggregate energy consumption contribute to the level of emissions. Of those that focus on a panel study mostly employ first generation econometric approaches (e.g. unit root tests by Levin-Lin-Chu (2002), Hadri (2000), Im-Pesaran-Shin (2003), and Pedroni cointegration (Pedroni, 1999; 2004) and Koa cointegration (Kao, 1999)).

As shown in Table 1, several recent studies focus on a type of aggregate energy; namely, renewable energy, and analyze the renewable energy-environment-growth relationship for single country and panel of countries cases. It is worth-noting that the number of studies in this strand is relatively smaller than that in aggregate energy-environment-growth literature. Studies in table 1 (except Farhani and Shahbaz, 2014; Apergis et al., 2010; Boluk and Mert, 2014) yield that increases in renewable energy detract the pollution in a variety of regions and countries by mostly using first generation econometric approaches. In addition, some studies in this group investigate the validity of the EKC hypothesis by including the square of real GDP (GDP^2) into the model as similar to those in aggregate energy-environment-growth literature. However, the aim of the current study is not to show whether or not increases in real GDP lead to environmental improvements; instead, to narrowly focus on how tourism and renewable energy impact the level of emissions by controlling for the income in the model since real GDP is a strong determinant of CO_2 emissions.

The last strand of studies examines the relationship among energy, environment, real GDP and tourism for several cases. As shown in the bottom of Table 1, Lee and Brahmasrene (2013), and Katircioglu (2014a) find that tourism decreases CO_2 emissions for the panel of EU countries, and Singapore, respectively, on the other hand, Katircioglu et al. (2014), Katircioglu (2014b), and De-Vita et al. (2015) indicate that tourism stimulates emissions in Cyprus and Turkey. These studies also suggest that the coefficient estimate on real GDP for CO_2 emissions is positive. There is only one panel study in this strand, and it uses first generation econometric tools in identifying the relationship. Because first generation tests have drawbacks of assuming cross-sectional independence, they may produce inaccurate results. Thus, the results in this study are accurate and reliable since we find the issue of dependence across cross -sections, and accordingly employ second generation approaches.

2 MODEL AND DATA

Inspired by the works of Jebli and Youssef (2015), and Katircioglu (2014b) we propose the following model in which CO_2 emissions are the response variable, and real gross domestic product (GDP), renewable energy (REN) and tourism (TOUR) are the dependent variables:

$$CO_2 = (GDP, REN, TOUR) \tag{1}$$

By including a constant term (β_0) and an error term (e_{it}), we can convert the model in Formula (1) to that in Formula (2) wherein β_k (k = 1, 2, 3) are the coefficients on GDP, REN and TOUR.

$$(CO_2)_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 REN_{it} + \beta_3 TOUR_{it} + e_{it} \quad (2)$$

The data used in this study are described as follow. CO_2 emissions is carbon dioxide gas emissions in metric tons; real GDP is the value of real gross domestic product in constant 2005 US$; TOUR is the number of international tourist arrivals at the sample countries; REN is renewable electricity production measured in kilo-watt hours. Following Apergis et al. (2010), Farhani and Shahbaz (2014), Bhattacharya et al. (2016), and Jebli et al. (2016), renewable electricity is used as proxy for renewable energy. The data for CO_2 emissions, real GDP and tourist arrivals are obtained from the "World Development Indicators",[6] and the data for renewable electricity production are drawn from the "US Energy Information Administration".[7] The annual data cover the period 1995–2011. 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. Even though using a longer data set is an advantage to produce more robust outcome, we believe that this study is still valuable for the literature as it contributes to the existing pool of knowledge by exposing the importance of tourism as well as renewable energy and real GDP for the environment, and by taking into account the issues of heterogeneity and cross-section dependence. The top 10 countries used in this study are China, France, Italy, Thailand, the UK, the USA, Turkey, Germany, Russia and Spain. 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 real GDP, REN and TOUR. Referring to the state-of-the-art, the expected sign of β_1 is positive, and β_2 is expected to be negative; β_3 can be positive or negative depending on the net effect of tourism on the environment that we argue in the introduction section.

3 HETEROGENEITY AND CROSS-SECTION DEPENDENCE

The average annual growth of tourism, carbon emissions, real GDP and renewable energy for the analyzed countries are indicated in Table 2. Because of significant variations in the average annual growth of each variable across countries, one can claim the presence of heterogeneity across the top 10 touristic countries for the analyzed variables. In detail, the average annual growth of tourism arrivals is relatively greater for Turkey, China and Thailand as compared to France, the UK and the USA. Moreover, a similar picture is observed for the average annual growth of real GDP and REN. Furthermore, the average annual growth of carbon emissions is negative for Germany, Italy and the UK whereas it is positive for the rest of sample countries. Furthermore, from the point of view of the development level, countries fall into different groups (i.e. developed countries and developing countries). This also suggests a strong heterogeneity within the panel data. Considering the presence of issue of heterogeneity, we should account for it in panel econometric approaches wherein the parameters are allowed to vary across cross sections.

In addition to heterogeneity, the possible presence of cross-sectional dependence in panel time-series data is another potential issue that should be taken into account in panel models. The correlation among the time-series data for the top 10 countries may be exposed because of common shocks (e.g. great recession, global energy and environmental policies, global credit crunch) that potentially have spill-over effects on cross sections. If a researcher assumes no cross-sectional dependence in a panel data but the panel data definitely show cross-section dependence, this incorrect assumption can cause forecasting errors and incorrect estimations. Henceforth, we use the Pesaran's CD-test (Pesaran, 2004) to indicate

6 <http://data.worldbank.org>.
7 <www.eia.gov>.

as to whether or not cross-sectional dependence exists within each panel time-series data. The results from the Pesaran's CD-test for testing cross-sectional dependence are posted in Table 3. Referring to the output, we have enough evidence to reject the null hypothesis of cross-section independence in favor of the alternative hypothesis of cross-section dependence for carbon emissions, real GDP, renewable energy and tourism at 1% level of significance. In short, the analyzed variables have cross-sectional dependence.

4 METHODS AND FINDINGS

Since we show the presence of issues of heterogeneity and cross-sectional dependence across the top 10 countries for CO_2 emissions, real GDP, renewable energy and tourism, we should use econometric techniques that account for these problems accordingly.

4.1 Panel unit root tests

The first generation unit root tests (e.g. ADF, IPS, LLC, Hadri unit root tests) do not account for possible existence of cross-sectional dependence in the panel data. Thus, this study employs the second generation unit root tests; namely, the CADF and the CIPS unit root tests (Pesaran, 2007), which consider both heterogeneity and cross-section dependence in identifying stationary process of the panel time-series data. The results from the CADF and CIPS unit root tests are reported in Table 4. The results suggest that although we cannot reject the null hypothesis of unit root at level values, we have enough evidence to reject the null hypothesis of unit root in favor of the alternative hypothesis of no unit root at first-differenced values. In other words, CO_2 emissions, real GDP, renewable energy and tourism contain unit root at their levels but become stationary at their first-differences. Last, we can conclude that the analyzed variables are I (1).

4.2 Panel cointegration tests

The estimation results of non-stationary variables will be economically and statistically unmeaningful and inaccurate unless they are cointegrated and thus show a long-run relationship. Accordingly, this study uses several panel cointegration tests to find whether or not carbon emissions, real GDP, renewable energy and tourism are cointegrated for the sample countries since the analyzed variables are detected to be non-stationary at levels. The Pedroni panel cointegration test (Pedroni, 1999; 2004) is carried out as the first because it is applicable for heterogeneous panels. Pedroni (1999) indicates that there are seven tests statistics shown in Table 5. According to the output posted in table 5, two out of seven tests imply the validity of a long-run relationship among carbon emissions, real GDP, renewable energy and tourism. Although the ADF-statistic has good small sample properties and is more reliable, the outcome is somewhat doubtful. Hence, we need more tests to apply to reach a robust conclusion.

The second panel cointegration test that this study uses is the Kao panel cointegration test (Kao, 1999). This test follows a similar procedure as the Pedroni test but includes cross- homogeneous coefficients on the first-stage regressors. Referring to the results from the Kao panel cointegration test in Table 6, the analyzed variables are cointegrated and have a long-run relationship since we have enough evidence to reject the null hypothesis of no cointegration in favor of the alternative hypothesis of cointegration at 5% level of significance.

Even though the Pedroni and the Kao panel cointegration tests have been frequently used in various literature including the energy-environment-growth nexus, both have drawbacks of assuming cross-section independence, and thus are considered as first generation cointegration tests. Failure of considering the presence of cross-section dependence in panel models has consequences of causing loss of power in the procedure of first generation cointegration tests. Therefore, this study also employs a second generation cointegration test; namely, the LM bootstrap panel cointegration test due to Westerlund and Edgerton (2007) in order to check the verdicts of former tests. The LM bootstrap panel cointegration test accounts for both issues of cross-sectional dependence and heterogeneity in identifying the cointegration relation among the variables, and thus is superior to the first generation cointegration tests. In addition, this test differs from the former tests in that the LM bootstrap cointegration test assumes the null hypothesis of cointegration. The results from the LM bootstrap panel cointegration test are reported in Table 7. Because there is no evidence to reject the null hypothesis of cointegration, this study indicates that CO_2 emissions, real GDP, renewable energy and tourism are cointegrated and have a long-run relationship. The conclusion is that the cointegration relation between the analyzed variables for the top 10 countries become more robust and stronger since the second generation panel cointegration test accounts for heterogeneity and cross-sectional dependence across cross sections for the analyzed variables.

4.3 Long-run estimates

Long-run estimators should produce economically and statistically meaningful, reliable and accurate coefficients on real GDP, renewable energy and tourism for CO_2 emissions since this study in the preceding section confirms that they are cointegrated and moving together in the long-run. The question on which long-run estimator(s) should be used arises from the fact there are many estimators available. This study runs the FMOLS and the DOLS because Lee (2007) suggests that the ordinary least squares (OLS) technique involves invalid standard errors due to second order asymptotic bias. In addition, the weighted DOLS estimator allows for heterogeneity in the long-run variances (Mark and Sul, 2003) and the weighted FMOLS technique is based on heterogeneous cointegrated panels (Kao and Chiang, 2000).[8] Moreover, Herrerias et al. (2013) suggest that the DOLS approach is the least sensitive one to the issue of cross-sectional dependence.

The results from the FMOLS and the DOLS estimators are posted in Table 8. Because the panel time-series data are transformed into their natural logarithm, the coefficient estimates in the table is equivalent to the elasticities of CO_2 emissions with respect to real GDP, renewable energy and tourism. Both approaches produce identical results in terms of sign and significance, but yield a bit different results in terms of magnitudes and goodness of fit of the model (R^2). More precisely, the FMOLS reports that 1% increase in real GDP and tourism raises the pollution by 0.72% and 0.17%, respectively; on the other hand, a 1% increase in renewable energy mitigates carbon emissions by 0.26%. Referring to the DOLS, 1% increases in real GDP and tourism contribute to the amount of carbon emissions by 0.64% and 0.12%, respectively; on the contrary, a 1% increase in renewable energy decreases the pollution by 0.18%. As in line with many studies including Apergis et al. (2010), Lee and Brahmasrene (2013), and Katircioglu (2014b) increase in production leads to bigger carbon emissions. In addition, the adverse of renewable energy on CO_2 emissions is consistent with that of studies including Chiu and Chang (2009), Sulaiman et al. (2013), Shafiei and Salim (2014), Lopez-Menendez et al. (2014), Al-mulali et al. (2015a), Boluk and Mert (2015), Dogan and Seker (2016), and Jebli et al. (2016). The identification of damaging effect of tourism on the environment is in line with that of Katircioglu (2014b), Katircioglu et al. (2014), Solarin (2014), De Vita et al. (2015), Sharif et al. (2017) and Paramati et al. (2017).

Tourism sector in the top 10 most-visited countries boosts the amount of carbon emissions through several links such as transportation, building of touristic facilities, and local and government services. Some policies for the sake of low emissions may be active in sample countries but clearly not sufficient to fight for the environment. One obvious solution to control for the level of carbon emissions is the adoption of the use of more renewable energy and cleaner technologies in not only overall production process but also tourism sector in particular. In this regards, touristic facilities (e.g. hotels) may build their solar panel system for producing energy to meet their needs accompanying the information that solar is a clean

[8] For more information, please refer to the references.

energy and a type of renewable energy. In addition, a bicycle-oriented tourism should be supported and adopted in replacement of motorized and environmentally unfriendly transport. Furthermore, the top 10 countries should aim to increase the share of renewable sources in energy mix, and financially support institutions, universities, researchers to work for the invention of cleaner technologies, particularly, those directly related to tourism sector. Last, policy makers should impose policies in regard to environmental protection and awareness of renewable energy and sustainable tourism.

CONCLUSIONS

This study aims to investigate the relationship of CO_2 emissions, real GDP, renewable energy and tourism for the top 10 most-visited countries for the period 1995–2011. Moreover, we also consider the validity of issues of cross-sectional dependence and heterogeneity in panel data while analyzing stationary properties, cointegration relationship and the long-run estimates. Thus, the results found in the current study are more robust and reliable as compared to those in previous studies. The findings and policy recommendations can be summarized as follow:

- By looking at the average annual growth rates of each variable, and applying the Pesaran's CD test to the panel time-series data, we detect the presence of heterogeneity and cross-sectional dependence across countries for the analyzed data.
- The CADF and the CIPS unit root tests report that the analyzed variables are not stationary at levels but become stationary at first differences.
- The LM bootstrap cointegration test shows that CO_2 emissions, real GDP, renewable energy and tourism are cointegrated and hence have a long-run relationship.
- The DOLS and FMOLS estimators indicate that increases in renewable energy lead to environmental improvements whereas increases in real GDP and tourist arrivals lead to environmental degradation in the top 10 most-visited countries.
- Regulatory policies should be introduced to increase the awareness of renewable energy and sustainable tourism.
- The use of renewable energy and the adoption of renewable energy technologies should be implemented more in production processes and tourism sector in particular.
- Bicycle-oriented tourism should be supported and adopted in replacement of motorized and environmentally-unfriendly transport.
- More projects on the development of environmentally-friendly technologies, especially those in relation with tourism sector, should be sponsored by governments.

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TABLES

Table 1 A survey of literature

Study	Case	Period	Variables	Methodology	Conclusion
Chiu and Chang (2009)	Panel of OECD countries	1996–2005	CO_2, GDP, CPI, REN	Threshold effect	GDP and REN increase CO_2 for lower threshold; REN decreases CO_2 for upper threshold
Sadorsky (2009)	Panel of G7 countries	1980–2005	REN, GDP, CO_2, P(Prices)	Breitung, IPS, LLC, ADF, PP, Pedroni cointegration, FMOLS, DOLS	GDP and CO_2 are major determinants of REN
Iwata et al. (2010)	France	1960–2003	CO_2, GDP, GDP^2, nuclear, URB, TR	PP, ARDL model	Nuclear decreases CO_2
Apergis et al. (2010)	Panel of developed and developing countries	1984–2007	CO_2, GDP, Nuclear, REN	LLC, IPS, ADF, PP, LLL cointegration	Nuclear decreases CO_2, REN and GDP increase CO_2
Bengochea and Faet (2012)	Panel of EU countries	1990–2004	REN, GDP, CO_2, P	OLS with FE and RE, FGLS	GDP and CO_2 increase REN
Sulaiman et al. (2013)	Malaysia	1980–2009	CO_2, GDP, GDP^2, REN, TR	ADF, PP, ARDL model	TR and REN decrease CO_2
Boluk and Mert (2014)	Panel of EU countries	1990–2008	CO_2, GDP, GDP^2, REN, NREN	OLS with FE	REN and NREN contribute to CO_2
Farhani and Shahbaz (2014)	Panel of MENA countries	1980–2009	CO_2, GDP, GDP^2, REN, NREN	Breitung, IPS, Pedroni cointegration, FMOLS, DOLS	REN and NREN increase CO_2;
Lopez-Menendez et al. (2014)	Panel of EU countries	1996–2010	CO2, GDP, GDP^2, GDP^3, REN	OLS with FE and RE	REN decreases CO_2
Shafiei and Salim (2014)	Panel of OECD countries	1980–2011	CO_2, GDP, GDP^2, REN, NREN, POP	ADF, PP, Breitung, Johansen cointegration, Westerlund cointegration, GMM, AMG	REN decreases CO_2; NREN increases CO_2
Baek and Pride (2014)	USA, Japan, France, Korea, Spain, Canada	1970–2007	CO_2, GDP, nuclear	DFGLS, Johansen cointegration	Nuclear decreases CO_2 in all countries, GDP decreases CO_2 in USA, Canada and France
Apergis and Payne (2014)	Panel of Central American countries	1980–2010	CO_2, REN, GDP, P	LLC, IPS, ADF, PP, non-linear panel cointegration, FMOLS	GDP, CO_2 and P increase REN
Al-Mulali et al. (2015c)	Vietnam	1982–2011	CO_2, REN, NREN, GDP, IM, EXP, CA, L	ARDL model	NREN and IMP increase CO_2; REN is insignificant
Boluk and Mert (2015)	Turkey	1961–2010	CO_2, GDP, GDP^2, REN	ADF, KPSS, ARDL model	REN decreases CO_2
Jebli and Youssef (2015)	Panel of North Africa	1971–2008	GDP, CO_2, combustible and waste (CRW)	Breitung, LLC, IPS, Pedroni cointegration, FMOLS, DOLS	CO_2 and CRW increase GDP
Al-mulali et al. (2015a)	Panel of European countries	1990–2013	CO_2, GDP, TR, URB, FD, REN by sources (wind, solar, hydro, nuclear, and CRW)	IPS, ADF, PP, Pedroni cointegration, FMOLS	Five sources of REN decrease CO_2; GDP increases CO_2

Note: IPS (Im-Pesaran-Shin test), LLC (Levin-Lin-Chu test), PP (Phillips-Perron test), ADF (Augmented Dickey-Fuller test), KPSS (Kwiatkowski–Phillips–Schmidt–Shin test), FE (Fixed effects), RE (Random effects), REN (renewable energy), NREN (non-renewable energy), FMOLS (Fully Modified Ordinary Least Squares), DOLS (Dynamic Ordinary Least Squares), TR (trade), FD (financial development), URB (Urbanization).
Source: Own construction

Table 1 A survey of literature (continuation)

Study	Case	Period	Variables	Methodology	Conclusion
Apergis and Payne (2015)	Panel of South America	1980–2010	CO_2, GDP, REN , P	ADF, PP, FMOLS	GDP, CO_2 and P increase REN
Jebli et al. (2016)	Panel of OECD countries	1980–2010	CO_2, GDP, GDP^2,REN, NREN, TR	Breitung, IPS, LLC, ADF, PP, Pedroni cointegration, FMOLS, DOLS	REN decreases CO_2, NREN increases CO_2
Lee and Brahmasrene (2013)	Panel of EU countries	1988–2009	CO_2, GDP, FD, TOUR	Breitung, IPS, LLC, ADF, PP, Johansen cointegration, OLS with FE	GDP increases CO_2, TOUR decreases CO_2
Katircioglu (2014a)	Singapore	1971–2010	CO_2, GDP, GDP^2, EGY, TOUR	Unit root by Carrion-i-Silvestre et al. (2009), Maki cointegration (Maki, 2012), DOLS	EGY increases CO_2, TOUR decreases CO_2.
Katircioglu et al. (2014)	Cyprus	1970–2009	CO_2, EGY, TOUR	KPSS, ARDL model	TOUR and EGY increase CO_2
Katircioglu (2014b)	Turkey	1960–2010	CO_2, GDP, EGY, TOUR	Zivot-Andrews unit root (Zivot and Andrews, 2002), ARDL model	TOUR, GDP and EGY increase CO_2
De-Vita et al. (2015)	Turkey	1960–2009	CO_2, GDP, GDP^2, EGY, TOUR	Unit root by Carrion-i-Silvestre et al. (2009), Maki cointegration (Maki, 2012),	TOUR and EGY increase CO_2

Note: IPS (Im-Pesaran-Shin test), LLC (Levin-Lin-Chu test), PP (Phillips-Perron test), ADF (Augmented Dickey-Fuller test), KPSS (Kwiatkowski–Phillips–Schmidt–Shin test), FE (Fixed effects), RE (Random effects), REN (renewable energy), NREN (non-renewable energy), FMOLS (Fully Modified Ordinary Least Squares), DOLS (Dynamic Ordinary Least Squares), TR (trade), FD (financial development), URB (Urbanization).
Source: Own construction

Table 2 Average annual growth of each variable 1995–2 011 (in %)

Country	TOUR	CO_2	GDP	REN
China	6.39	5.69	8.82	8.83
France	1.61	0.15	1.65	0.25
Germany	3.71	–0.88	1.15	8.89
Italy	2.13	–0.38	0.81	3.91
Russia	4.83	0.40	3.45	–0.32
Spain	2.57	0.71	2.62	8.74
Thailand	5.19	3.60	2.79	1.31
Turkey	9.30	3.44	3.61	2.71
UK	1.65	–0.56	2.3	8.36
USA	2.1	0.32	2.34	0.89

Note: The average annual growth rates are calculated by author.
Source: Own construction

Table 3 Results from cross-sectional independence test

	CO_2	GDP	REN	TOUR
CD-test	4.45**	25.91**	12.36**	22.50**
p-value	0.00	0.00	0.00	0.00

Note: ** denotes the statistical significance at 1% level. The CD-test performs the null hypothesis of cross-section independence.
Source: Own construction

Table 4 Results from panel unit root tests

	CADF		CIPS	
	Level	Δ	Level	Δ
CO_2	–1.54	(–3.14)**	(–1.72)	(–4.60)**
GDP	–1.94	(–2.99)*	(–1.35)	(–3.02)*
REN	–1.98	(–4.37)**	(–2.22)	(–4.37)**
TOUR	–1.69	(–3.32)**	(–2.02)	(–3.54)**

Note: Δ represents the first-differences. **, * denote the statistical significance at 1% level and 5% level, respectively.
Source: Own construction

Table 5 Results from Pedroni cointegration test

Common AR coefficients (within-dimension)

	Weighted statistic	p-value
Panel v-statistic	–1.52	0.93
Panel rho-statistic	2.39	0.99
Panel PP-statistic	–0.29	0.38
Panel ADF-statistic	–0.75	0.22

Individual AR coefficients (between-dimension)

	Statistic	p-value
Group rho-statistic	3.39	0.99
Group PP-statistic	–5.29**	0.00
Group ADF-statistic	–4.69**	0.00

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

Table 6 Results from the Kao panel cointegration test

	t-statistics	p-value
ADF	–1.78*	0.03

Note: * denote the statistical significance at 5% level.
Source: Own construction

Table 7 Results from the LM bootstrap panel cointegration test

Tests	LM statistic	Bootstrap p-value
LM bootstrap	Feb-64	1.00

Note: The LM bootstrap test is calculated using 5 000 replications. The LM bootstrap cointegration approach tests the null hypothesis of cointegration against the alternative of no cointegration.
Source: Own construction

Table 8 Results from the panel DOLS and FMOLS

FMOLS

Regressors	Coeff.	t-stat	p-value
GDP	0.72**	74.01	0.00
REN	–0.26**	–8.59	0.00
TOUR	0.17**	5.18	0.00
R^2	0.994		
Coefficient Diagnostic (Null Hypothesis: β_3=0)			
Statistic	Value	d.f.	p-value
t-statistic	5.18	147	0.00
Chi-square	26.83	1	0.00

DOLS

Regressors	Coeff.	t-stat	p-value
GDP	0.64**	8.5	0.00
REN	–0.18**	–7.6	0.00
TOUR	0.12**	3.36	0.00
R^2	0.997		
Coefficient Diagnostic (Null Hypothesis: β_3=0)			
Statistic	Value	d.f.	p-value
t-statistic	3.36	150	0.00
Chi-square	11.29	1	0.00

Note: ** denotes the statistical significance at 1%. Coefficient diagnostic test evaluates the null hypothesis that the coefficient on tourism is equal to zero. It shows that the inclusion of tourism to the model is statistically significant, and thus increases the goodness of fit of the model.
Source: Own construction