



Tourism, renewable energy and CO2 emissions: evidence from Europe and Central Asia

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Abstract

In this study, we explore the relationship between tourism, renewable energy and CO2 emissions in Europe and Central Asia countries over the period 1990–2015. Using two-step GMM estimator, we find that tourism has positive effect on CO2 emissions, while renewable energy reduces carbon emissions. For example, when renewable electricity production increases by 10 percentage points, CO2 per capita emissions decrease by 4.1%. Our results also suggest that GDP per capita has inverted U-shaped relationship with environmental degradation in ECA region, confirming existence of Environmental Kuznets curve (EKC) phenomena in this region.

Keywords Tourism · Renewable energy · CO2 emissions · Europe · Central Asia

1 Introduction

Global CO2 emissions increased by more than 60% from 1990 to 2019. Moreover, the global mean temperature for 2016–2020 is forecast to be warmest in our observed history, nearly 1.1 degrees above 1850–1990 (WMO, 2020). Climate change has numerous implications for quality of life, as it has been linked to life dissatisfaction (Ferreira et al., 2013), global obesity (Kanazawa, 2020) and food insecurity (Hasegawa et al., 2018). The causes

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and correlates of CO2 emissions have been intensively studied over the past two decades. One can distinguish three major streams of empirical studies in this area of research. Firstly, the effect various socioeconomic and political factors on CO2 emissions have been investigated. These factors include democracy, financial development, economic growth, energy consumption, trade and urbanization among others (Lv, 2017; Lv & Xu, 2019; Salahuddin et al., 2018). A second line of research explores the drivers of CO2 emissions in single countries or sub-regions (Magazzino & Cerulli, 2019; Roman-Collado & Morales-Carrion, 2018).

Table 1 provides the trends in CO2 emissions across the globe and in Europe and Central Asia for the period 2000–2015. The data suggest that CO2 emissions in ECA region are substantially above the global averages. Therefore, these differences in emissions levels across two groups of countries demand scholarly research and attention.

Indeed, the research on the antecedents of CO2 emissions in the countries of ECA regions have predominantly focused on economic growth or energy consumption play (Li et al., 2020). The environmental Kuznets curve (EKC) was confirmed for Central and Eastern Europe (Arici, 2009) and for new EU member and candidate countries (Kasman & Duman, 2015). Acaravci and Ozturk (2010) document that energy consumption increases CO2 emissions in 19 nations in Europe, based on autoregressive distributed lag (ARDL) bounds empirical strategy and cointegration. Magazzino (2016) explores the links between energy use, GDP growth and carbon emissions in Italy, using data for 1970–2006. The study finds that there is bi-directional causality between energy consumption and CO2 emissions. In a similar vein, Nguyen (2019) investigate the link between these variables in the sample of nations located in Central Asia covering data for 20 years. The study finds that energy consumption affects GDP per capita, which in turn increases CO2 emissions. Finally, to the best of our knowledge, the role of tourism in the energy-emissions nexus has been explored for Cyprus (Katircioglu et al., 2014) and EU and candidate countries (Dogan & Aslan, 2017).

While tourism is an important aspect of economic growth for countries in this region (Tugcu, 2014), empirical evidence also shows that tourism is an important determinant of carbon emissions (Leon et al., 2014). As suggested by Haseeb et al. (2018 p. 344) “tourism-related activities like air transport, accommodation, food and beverages, need energy consumption and like lead to increased CO2 emissions.” In contrast, other studies argue that tourism may also improve environmental quality through quality investment that leads to adoption of energy efficient technologies, installation of waste management systems or promotion of environmentally friendly eco-tourism. In addition, recent developments in the tourism sector of ECA countries highlight the necessity to further investigate the link between tourism and CO2 emissions on this region. For example, according to World Bank the number of tourist arrivals have increased by more than 22-fold over the period 2000–2019. In a similar vein, ECA countries, excluding high income, have seen more than threefold increase in tourist arrivals over the same period, while globally tourist arrivals have increased by only 80%. Moreover, ECA countries such as Kyrgyz Republic,

Table 1 CO2 emissions per capita in global scale and Europe and Central Asia

	2000	2005	2010	2015
World	4.77	5.02	4.94	4.69
Europe and Central Asia	6.93	7.45	7.07	6.34

Uzbekistan, Armenia, Albania, Georgia and Moldova are in top 10 nation by the growth in tourist arrivals in 2019 compared to 2020.

Our research attempts to fill the gap in the cross-country research by using panel data for 45 countries over the period 2000–2015 to explore the effects of tourism and renewable energy and carbon emissions in ECA region. In line with extant research, our study employs two-step GMM estimator to assess this relationship. The rest of the paper is organized as follows. Section 2 offers a quick review of the most recent empirical evidence. Section 3 discusses data and methodology. Section 4 supplies the empirical results and Sect. 5 concludes the study and offers policy implications.

2 A brief review of the most recent related literature

2.1 Tourism and CO₂ emissions

Extant research attempts to assess the potential implications of different types of tourism for environmental degradation. These studies explore the environmental effects of sports tourism (Pigeassou et al., 1999), leisure tourism (Davenport & Switalski, 2006), rural tourism (Ghaderi & Henderson, 2012), heritage tourism (Xu et al. 2011), convention tourism (Park & Boo, 2010), among others. At the same, due to the lack of cross-country data for different type of tourism, the empirical studies have focused mostly on the effects of aggregate international tourism on economic growth or environmental degradation (Paramati, Alam, et al., 2017; Paramati, Mo, et al., 2017; Paramati, Shahbaz, et al., 2017). The multiple approaches to tourism are mostly considered in single country or case studies in the context of environmental sustainability (Alipour et al., 2017). In this sense, Anser et al. (2020) explore the role of renewable energy, ICT and tourism in CO₂ emission trends in Saudi Arabia, one of the world's biggest religious tourist destinations, over the period 1995–2018. The authors conclude that investment in innovative infrastructure would decrease carbon footprint of tourism sector and the promotion of renewable energy is crucial for sustainable development in the long run. Muhammad et al. (2021) explore the impact of tourism, governance and investment on CO₂ emissions in 13 Muslim countries over the period 2002–2014. The Pedroni tests show that tourism increases emissions, while good governance reduces environmental degradation. The authors use tourism receipts as a proxy for tourism development.

From a theoretical and empirical, angle international tourism can have both positive and negative effect on carbon emissions. A number of studies have explored the effect of tourism on CO₂ emissions across different regions, including Europe. Paramati et al. (2018) find that tourism investments lead to an increase in tourism sector and decrease carbon emissions in a sample of 28 EU member states during the period 1990–2013. The authors argue that tourism investments offer environmental benefits, improve infrastructure and lead to energy efficiency, which in turn decrease environmental degradation. Leitão and Lorente (2020) assess the effect of tourism, renewable energy and economic growth on CO₂ emissions in the EU countries. Using different empirical methods, the authors document that while trade and economic growth lead to environmental degradation, tourism sector and renewable energy are negatively related to CO₂ emissions. Paramati, Shahbaz, et al. (2017) assess the relationship between tourism, FDI, trade and CO₂ emissions. Using Westerlund panel cointegration method, the authors find that results are mixed: tourism development promotes environmental deterioration in Eastern Europe and

reduces in Western Europe. In a sample of EU countries, Lee and Brahmairene (2013) find that tourism is negatively linked with CO2 emissions, using panel cointegration techniques and fixed-effects estimators. The study also documents a long run equilibrium link between tourism, emissions and GDP. Dogan and Aslan (2017) explore the relationship between tourism and CO2 emissions in a set of EU and candidate countries for the years 1995–2011. Using cointegration tests and other empirical methods, the study finds that tourism has causal effect on CO2 emissions in this region.

In a recent study, Balli et al. (2019) using data for Mediterranean countries find that tourism has positive effect on both economic growth and CO2 emissions. Some studies have explored the role of tourism in greenhouse gas emissions, using data for countries in Europe and Central Asia. Katircioglu et al. (2014) investigated the long run relationship between tourism and carbon emissions in Cyprus. Using “tourism-induced model” for the years 1970–2009, the study finds that tourism has direct positive effect on CO2 emissions. Moreover, the authors report that tourism sector is important determinant of energy consumption in Cyprus, thus indirectly increasing carbon emissions in this small island country. Eyuboglu and Uzar (2020) focus on one of the highest CO2 producers in the world—Turkey. The authors use Vector Error Correction Model (VECM) for the data from 1960 to 2014. The study documents that tourism, along with GDP growth and energy consumption both in the short- and long-run lead to increase in CO2 emissions. The positive effect of tourism on CO2 emissions was confirmed for Greece in a study by İşik et al. (2017). The authors using data from 1970 to 2014 find that “tourism, as a leading sector in the Greek economy, has serious negative environmental impacts for Greece in the long run” (p. 665). Perch-Nielsen et al. (2010) estimate the carbon intensity of economic sectors in Switzerland. The authors conclude that “tourism sector is more than four times more GHG intensive than the Swiss economy on average” (p. 131).

Another strand of research explores the effect of tourism on CO2 emissions for other regions such as South Asia (Chishti et al., 2020), top 10 tourism dependent countries (Shaheen et al., 2019) and Antarctic region (Amelung & Lamers, 2007).

2.2 Renewable energy and CO2 emissions

Another strand that has received considerable attention in the empirical literature is the role that renewable energy plays in predicting carbon emissions using various empirical methods and samples. For example, the negative effect of renewable on CO2 emissions has been documented for African countries (Zoundi, 2017), OECD region (Shafiei & Salim, 2014), Thailand (Boontome et al., 2017), EU (Dogan & Seker, 2016), the USA (Jaforullah & King, 2015), Sub-Saharan Africa (Inglesi-Lotz & Dogan, 2018), G20 countries (Paramati, Alam, et al., 2017; Paramati, Mo, et al., 2017; Paramati, Shahbaz, et al., 2017). Özbuğday and Erbas (2015) attempt to explore the role that efficiency of energy use and renewables sector play in decreasing air pollution in the long run, using data for 36 nations over the period 1971–2009. Their results suggest CO2 emissions decrease in the long run in the countries that shift from conventional energy sources to renewable energy. At the same time, GDP and industrial sector have positive effect on carbon emissions.

In a similar vein, the negative link between renewable energy and carbon emissions was confirmed using Augmented Mean Group (AMG) estimator (Nathaniel & Iheonu, 2019), panel dynamic ordinary least squares method (Mahmoodi, 2017), common correlated effects mean group (CCEMG) estimator (Dong et al., 2018), generalized method of

moments (Bhattacharya et al., 2017), FMOLS and panel DOLS estimators (Bilgili et al., 2016) and unrestricted error-correction model (Koengkan & Fuinhas, 2020).

On the other hand, Cherni and Jouini (2017), using Autoregressive Distributed Lag method for the Tunisian data explores the link between GDP, renewable energy and CO₂ emissions. The study finds that while there is bi-directional causality between GDP and carbon emissions, renewable energy has no effect on CO₂ emissions. Charfeddine and Kahia (2019) explore the effects of two sectors (renewables and finance) on carbon emissions in Middle East and North Africa countries. Using panel VAR regression and variance decomposition, the study finds that renewable energy and financial development have only moderate predicting power in CO₂ emissions modeling.

Another group of studies can be extracted from extant research that focuses specifically on a sample of countries in Europe and Central Asia. For example, Dogan and Seker (2016) test the EKC for the EU countries over the period 1980–2012. The results from Dumitrescu-Hurlin tests suggest that renewable energy use reduce carbon dioxide emissions. In a similar vein, while testing the existence of EKC framework in Central Asia, Zhang (2019) finds that renewable energy reduces CO₂ emissions in the region. In another study, Bilan et al. (2019) assess the relationship between renewables and CO₂ emissions focusing on the candidate and potential candidate countries for the EU over the period 1995–2015. The role of energy efficiency in predicting CO₂ emissions trends in Post-Communist countries of Europe and Central Asia has also been considered by Li et al. (2020) and Salahodjaev and Isaeva (2021).

3 Data and methodology

3.1 Data

The goal of the study is to explore the effect of international tourism and renewable energy on CO₂ emissions in Europe and Central Asia countries. The sample covers 45 nations for the years 2000–2015. Data on tourist arrivals, GDP per capita, foreign direct investment (FDI), renewable energy, trade and urbanization come from World Bank. CO₂ emissions per capita are obtained from Carbon Atlas dataset. The dependent variable in this study is carbon emissions per capita. The main independent variables are renewable energy and tourism development. Renewable energy is measured as renewable electricity output as percent of total electricity output. In line with tourism studies, we use several tourism indicators: international tourism receipts per capita, international tourism receipts as % of GDP, international tourism receipts as % of total exports. The control variables are FDI as % of GDP, GDP per capita adjusted for purchasing power parity, trade as % of GDP and share of urban population (%). It is important to mention that all per capita variables (CO₂ and GDP) are expressed in log their forms.

3.2 Methodology

To explore the links between our variables of interest, namely, renewable energy, tourism and CO₂ emissions, following earlier empirical studies, we rely on two-step GMM estimator. The use of two-step GMM approach is dictated by a number of aspects: (1) in our study the number of countries exceeds the number of years ($N > t$); (2) the correlation between the dependent variable and its lagged value exceeds 0.8; (3) it is important to take into

account the cross-country differences in the data; (4) the simultaneity in the independent variables may affect the results; (5) the system estimator fixes the biases that arise in the difference estimator. The two-step GMM estimator alleviates the expansion of instruments and takes into consideration cross-sectional dependence in the data. Our model can be expressed as:

$$CO2_{i,t} = \sigma_0 + \sigma_1 CO2_{i,t-\tau} + \sigma_2 T_{i,t} + \sigma_3 RE_{i,t} + \sum_{h=1}^5 \delta_h X_{h,i,t-\tau} + v_{i,t} \tag{1}$$

$$CO2_{i,t} - CO2_{i,t-\tau} = \sigma_1 (CO2_{i,t-\tau} - CO2_{i,t-2\tau}) + \sigma_2 (T_{i,t} - T_{i,t-\tau}) + \sigma_3 (RE_{i,t} - RE_{i,t-\tau}) + \sum_{h=1}^5 \delta_h (X_{h,i,t-\tau} - X_{h,i,t-2\tau}) + (v_{i,t} - v_{i,t-\tau}) \tag{2}$$

where $CO2_{i,t}$ represents CO2 emissions in i th country at year t , T is tourism development proxy, RE is the renewable energy production, X is the set of control variables (GDP per capita, GDP per capita squared, FDI, trade, urbanization), τ is the parameter of auto-regression (we use 1 due to limited degrees of freedom) and v is the error term. In line with Asongu et al. (2018), we regard our independent factors as suspected endogenous.

4 Results

Table 2 offers baseline results by estimating a reduced regression between tourism, renewable energy and CO2 emissions, using conventional fixed effects regression model. These results suggest that overall tourism is positively related to CO2 emissions, while renewable energy is negatively after controlling for inertia in the carbon emissions.

Table 2 Baseline results

	I	II	III
CO2 _{t-1}	0.7861 (22.21)***	0.7762 (19.18)***	0.7657 (18.60)***
Tourism receipts as % of GDP	0.0078 (2.18)**		
Tourism receipts per capita		0.0127 (1.15)	
Tourism receipts as % of exports			0.0030 (2.03)**
Renewable energy	-0.0039 (4.62)***	-0.0042 (4.62)***	-0.0045 (6.24)***
Constant	0.4589 (5.23)***	0.4443 (4.62)***	0.5027 (5.54)***
R ²	0.74	0.73	0.74
N	692	692	575

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 3 now reports the main empirical results based on two-step GMM estimator. These results suggest that all measures of tourism are positive and statistically significant in our models. For instance, if causal, a 10% increase in per capita tourism receipts leads to 0.5% increase in CO₂ emissions (Model 2). Renewable electricity production is negative and significant, suggesting that renewable energy sector is an important aspect of environmental sustainability in our sample. If renewable electricity production increases by 1 percentage point, CO₂ per capita emissions decrease by 0.41% (column 3). Our results are similar to de Souza Mendonca et al. (2020) which show that 1% increase in renewable energy leads to 0.13% decrease in CO₂ emissions in a sample of 50 largest markets. The negative effect of renewable energy on CO₂ emissions is also confirmed for Africa (Njoh, 2021) and Thailand (Abbasi et al., 2021).

With regards to control variables, GDP per capita has non-monotonic relationship with the CO₂ emissions, suggesting the presence of environmental Kuznets curve. The FDI and urbanization rates are positive and significant only in Model 3. Trade openness is insignificantly related to CO₂ emission in our study. The soundness of two-step

Table 3 Main results

	I	II	III
CO ₂ _{<i>t-1</i>}	0.7590 (17.07)***	0.7932 (21.28)***	0.7788 (19.92)***
Tourism receipts as % of GDP	0.0137 (4.48)***		
Tourism receipts per capita		0.0509 (4.42)***	
Tourism receipts as % of exports			0.0029 (3.10)***
Renewable energy	-0.0033 (5.40)***	-0.0028 (5.52)***	-0.0041 (5.92)***
FDI as % of GDP	-0.0001 (1.39)	-0.0000 (0.29)	0.0003 (4.05)***
GDP per capita	0.6056 (3.63)***	0.6332 (3.04)***	0.7011 (2.49)**
GDP per capita squared	-0.0233 (3.05)***	-0.0322 (3.44)***	-0.0313 (2.38)**
Trade as % of GDP	0.0001 (0.67)	0.0002 (1.26)	-0.0002 (0.95)
Urbanization rate	0.0002 (0.22)	0.0016 (1.54)	0.0029 (2.29)**
Constant	-3.3769 (4.09)***	-3.1255 (2.93)***	-3.5533 (2.49)**
AR(1)	0.002	0.002	0.003
AR(2)	0.897	0.994	0.684
Hansen OIR	0.124	0.091	0.237
<i>N</i>	686	686	575

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

GMM estimator is confirmed by the 2nd order Arellano and Bond autocorrelation test (AR(2)) criteria and Hansen overidentification restriction (OIR).

5 Conclusion

The tourism sector occupies a vital role in the GDP growth of nations in Europe and Central Asia. For example, in 2018 tourism receipts accounted for nearly 12.5 of exports in this region. Considering that tourism sector is an important source of tax revenue, income and employment scholars have also explored the impact of this sector on environmental degradation across countries and regions. However, none of the published papers have considered the relationship between tourism, renewable energy and CO2 emissions in the ECA region. Moreover, policymakers in the EU member countries have set up numerous measures to support the sustainable development by fostering investments aimed at reducing the harmful impact of tourism sector on ecology (Paramati et al., 2018). Therefore, we have used panel data for 45 countries over the period 2000–2015 to explore the link between tourism, renewable energy and carbon emissions.

The regression estimates show that various proxies for the tourism development have positive effect on CO2 emissions. Further, our findings also show that renewable electricity production is negatively and statistically significantly linked to carbon emissions. Our results also suggest that per capita gross domestic product has nonlinear link with environmental degradation in ECA region. These results are obtained using two-step GMM estimator that accounts for the problem of endogeneity.

Considering these results, our study offers important contribution to extant research and to the development of policies for sustainable development in the region. First, considering that tourism sector is one of the energy-consuming industries, the policies should be channeled to promote renewable energy adoption in the sub-regions of ECA countries with the highest levels of tourist arrivals. It is important to modernize the tourism infrastructure (transport, air, roads) to increase the energy efficiency, thus, reducing carbon footprint of the sector. In addition, policymakers should use various incentives to promote the growth of renewable energy sector, for example, low interest rate loans, tax deductions for renewable energy investments or provide subsidies to cover expenses that arise by renewable energy facilities installation. For example, recently the government of Uzbekistan has signed an agreement to construct a 1500 MW wind farm in the country. This would not only increase energy security of the country but also contribute the sustainable development.

Our study has a number of limitations. Due to the nature of data collected by international agencies our research does not consider the multiple approaches to tourism. Thus, we cannot classify the different types of tourism such as mass tourism, community-based tourism, contemplation tourism, gastronomic tourism, event tourism, religious tourism, etc. In this sense, our work explores the effect of overall international tourism on environmental degradation. In addition, due to the nature of the data on renewable energy, we did not explore the long-run relationship between tourism, renewable energy and carbon dioxide emissions.

Prospective studies may extend our results in a number of ways. First, it is important to assess the cultural values, human capital and other social factors that are associated with renewable energy sector development and environmental degradation in the countries of the ECA region, using survey data (Cai et al., 2020; Eshchanov et al., 2021; Isaeva et al., 2021; Omanbayev et al., 2018). Second, it is important to assess what role other factors

along with tourism may play in predicting CO₂ emissions across other regions such as rapid growing countries, small islands, top air polluting economies (Janpolat et al., 2021; Shahbaz et al., 2017).

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