



Article

# An Evaluation of the Tourism-Induced Environmental Kuznets Curve (T-EKC) Hypothesis: Evidence from G7 Countries

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**Abstract:** This paper analyzes the legitimacy of the Environmental Kuznets Curve (EKC) hypothesis for a group of seven (G7) countries over the period 1995–2015. In addition to testing the EKC speculation, the authors also would like to understand the ways in which increases in renewable energy consumption and the international tourism receipt affect the CO<sub>2</sub> emissions in G7 countries, because the energy and tourism sectors may have considerable direct impacts on CO<sub>2</sub> emissions. In this investigation, a panel bootstrap cointegration test and an augmented mean group (AMG) estimator were applied. The empirical findings indicate that the tourism-induced EKC hypothesis is valid only for France. Additionally, it was detected that a rise in renewable energy consumption has a negative (reduction) impact on CO<sub>2</sub> emissions in France, Italy, the UK, and the US. However, an increase in the receipt of international tourism has a positive (additional) impact on Italy's CO<sub>2</sub> emissions. Hence, this country's decision-makers should re-review their tourism policy to adopt a renewable-inclusive one for sustainable tourism and the environment.

**Keywords:** EKC hypothesis; tourism; G7 countries; panel bootstrap cointegration test; AMG estimator

## 1. Introduction

A rapid growth in the tourism industry mostly includes massive investments in infrastructures and superstructures [1–3]. However, the extensive tourism operations through these kinds of investments may cause several environmental problems that harm environmental sustainability [4]. Along with the expansion of the tourism industry, the consumption of natural resources poses an increased risk of environmental pollution [5]. It is expected that tourism will not only provide a source of income for countries, but also increase energy use, and thus cause CO<sub>2</sub> emissions [6–9]. The tourism sector includes air transportation activities that require high energy use [10], and this sector was responsible for 8% of global CO<sub>2</sub> emissions in 2013 [11]. Tourism activities require the direct use of

fossil fuels, or indirect electricity use that is generally produced from oil, coal, and natural gas [12–15]. Therefore, the tourism industry has been accepted as one of the most energy-consuming sectors. It is also known that a high level of fossil fuel energy consumption causes an increase in CO<sub>2</sub> emissions. However, increasing renewable energy consumption may support the environment and, thereby, support sustainable tourism-sustainable economic growth. Therefore, the tourism industry, sustainable power source utilization, and economic growth (Gross Domestic Product: GDP) may significantly impact CO<sub>2</sub> emissions.

G7 countries are among the leading countries in terms of tourism and renewable energy. However, G7 members are the largest emitters, which are responsible for a quarter of the world's CO<sub>2</sub> emissions [16]. Combating climate change and, therefore, reducing greenhouse gas emissions is an important priority in the agenda of G7 countries [17]. The changes in the receipt of international tourism, renewable energy consumption, per capita CO<sub>2</sub> emissions, and per capita GDP for G7 countries are reported in Table 1 for 2005 and 2015.

**Table 1.** Tourism, renewable energy, pollution, and GDP in G7 countries.

G7 Countries	The Receipt of International Tourism (Million US\$)		Renewable Energy Consumption (% of Total Energy)		CO <sub>2</sub> (MT per Capita)		GDP per Capita (Constant 2010 US\$)	
	2005	2015	2005	2015	2005	2015	2005	2015
Canada	15,887	16,531	20.2	22.0	17.4	15.4	44,471.1	50,262.0
France	52,126	66,441	8.6	9.40	6.1	4.6	40,152.7	41,793.5
Germany	40,518	50,669	6.8	14.2	9.7	8.9	38,835.4	45,321.4
Italy	15,554	27,285	6.7	16.5	8.2	5.3	37,347.6	33,961.4
Japan	38,364	41,415	3.7	6.3	9.7	9.2	44,393.6	47,102.6
United Kingdom	32,948	50,904	1.4	8.7	9.0	6.2	39,984.2	42,017.1
United States	122,077	249,183	5.8	8.7	19.6	16	48,499.8	52,116.7

Source: [18].

Table 1 reveals that the receipt of international tourism increased from 317,474 million USD to 502,428 million USD in ten years. This accounted for 36.1% of the global receipt of international tourism in 2015. While the highest increase in the receipt of international tourism was in the US among the G7, the highest growth in renewable energy consumption was in the UK. Moreover, CO<sub>2</sub> emissions have decreased in all G7 countries. The highest decrease in per-capita CO<sub>2</sub> emissions was in Italy. Furthermore, Italy is the only country whose per capita income decreased in the 10-year period. France, Italy, the UK, and the US are among the top 10 countries visited by the world's highest tourist numbers. Tourism in these countries can have an impact on the environment.

This paper examines the validity of the Environmental Kuznets Curve (henceforth, EKC) hypothesis for G7 countries, considering the tourism sector's impact. The theoretical origin of this hypothesis goes back to 1955. The Kuznets Curve (KC), was introduced in Kuznets (1955) [19], which conjectured an inverted U-shaped connection between economic development and income inequality. According to this hypothesis, in brief, economic growth first increases and eventually decreases income inequality over time. Following Kuznets (1955) [19], Grossman et al. (1991) [20] introduced the EKC hypothesis in the form of an environmental aspect that was inspired by the KC. According to these scholars, the initial phases of economic development lead to a deterioration in environmental quality, but after a certain point, an increase in income level, contributing to a reduction in environmental pollution. The pattern of this time-based directional relationship resembles an inverted U-shape function.

The rationale for the selection of G7 countries as the authors' sample countries is twofold. First, since these countries have already completed the industrialization process, the expectation is that the EKC hypothesis should be verified by all of the G7 countries. Second, these countries generated a total of 25% of the global CO<sub>2</sub> emissions in 2020 [21]. All in all, G7 countries seem to be unique sample countries to examine the validity of the EKC theory. In the investigation of the EKC hypothesis,

the authors will use the receipt of international tourism, renewable energy consumptions, and GDP as the independent variables, and CO<sub>2</sub> emissions as the dependent variable, as shown in Table 1.

## 2. Literature Review

Although the impact of economic sectors on environmental degradation has been widely analyzed, the findings on the impact of tourism on environmental pollution are mixed [9]. Therefore, new researches and findings are needed on the tourism–environmental pollution nexus. Following Grossman et al. (1991) [20], many scholars have empirically investigated the EKC hypothesis (the inverted U-shape relationship that exists between the pollution indicators and GDP per capita) for G7 countries with different methodologies. In some of these studies, this hypothesis was verified for all of the G7 countries; in some, a few were verified; and in others, none of were verified.

In the literature review, the authors will consider only the studies that test this hypothesis specifically for the G7 countries as a group. For instance, Ajmi et al. (2015) [22] applied the time-varying Granger causality analysis for G7 countries, and didn't find the validity of the EKC hypothesis. Nabaee et al. (2015) [23] performed panel cointegration tests, and found empirical evidence of the EKC hypothesis for all of the G7 countries. However, Shahbaz et al. (2017) [24] employed various nonparametric time series methods for the G7 nations, and supported the validity of the EKC hypothesis for only six countries, namely Canada, France, Germany, Italy, the UK, and the US. Chiang et al. (2017) [25] applied the nonlinear panel smooth transition regression, and confirmed the validity of the EKC hypothesis for all of the G7 countries. Raza and Shah (2018) [26] applied the fully-modified ordinary least-squares (FMOLS) regression, the dynamic ordinary least squares (DOLS) regression, and fixed effect ordinary least squares regression for the G7 countries. They supported this hypothesis for all of the countries. Shahbaz et al. (2019) [27] applied the generalized method of moments methodology, and reached evidence of the EKC for all of the G7 countries. Yilanci and Ozgur (2019) [28] used the bootstrap panel rolling window causality test for these countries, and supported this hypothesis only for Japan and the US. Answer et al. (2020) [17] used panel random effects, and confirmed the validity of the EKC for all of the G7 countries. Ari and Senturk (2020) [29] performed various panel cointegration tests and long-term estimators, and didn't find confirmation of the EKC for any G7 country. Ike et al. (2020) [30] utilized FMOLS, DOLS, and panel mean group estimators, and reached evidence of the EKC for all of the countries. Wang et al. (2020) [31] conducted a dynamic seemingly unrelated regression method, and verified the EKC hypothesis for all seven countries.

The first part of the study provides some information about the tourism-CO<sub>2</sub> emissions nexus and the EKC literature in G7 countries. The remainder of this study is organized as follows. Section 2 describes the model and the methodology used in the study. Section 3 provides empirical results. Finally, Section 4 concludes the paper.

This study contributes to the existing knowledge by employing a series of advanced econometric methods to analyze the EKC hypothesis in G7 countries. To this end, the cross-sectional dependence (CD) approach, the panel bootstrapping cointegration approach, and the augmented mean group (AMG) estimator were employed. In this way, it allowed the possibility of the heterogeneity of the panel for robustness purposes. The AMG estimator deals with the non-stationary variables and multifactor error terms correlated with the explanatory variables, and also considers the CD issues, which is a pre-requisite for a sound panel analysis. This study included the renewable energy consumption and tourism receipts as the independent variables in order to identify the influence of GDP on CO<sub>2</sub> emissions, given the inclusion of those variables. Additional independent variables could be included to test the sensitivity of the empirical findings. Additionally, the independent variables used in this study were considered and selected based on the potential most direct impacts of these variables on CO<sub>2</sub> emissions based on the suggestion of the existing literature. However, this can be addressed by the future research, and can thus be taken as the limitation of this study.

### 3. Empirical Model and Methodology

In order to test the validity of the EKC hypothesis in G7 countries from 1995 to 2015, the following model was used in regression form, as follows:

$$\ln CO_{2it} = \beta_{0i} + \beta_{1i} \ln GDP_{it} + \beta_{2i} (\ln GDP_{it})^2 + \beta_{3i} \ln RE_{it} + \beta_{4i} \ln T_{it} + \varepsilon_{it} \quad (1)$$

where  $CO_2$  is the carbon dioxide emissions (measured in metric tonnes per capita), GDP (constant 2000 US\$) and  $GDP^2$  are per capita real income and its square, respectively. RE is the renewable energy consumption as a percentage of the total energy, T is the receipt of international tourism, and  $\varepsilon$  denotes the error term. All of the factors are expressed in the logarithmic scale in order to capture long-run elasticities. The signs of  $\beta_1$  and  $\beta_2$  are expected to be positive and negative, respectively. This means that a rise in per capita real GDP will first lead to an increase in  $CO_2$  emissions, and then will eventually lead to a decrease in it over time. This time-based directional relation will signify the legitimacy of the EKC speculation for a nation. At the same time, the signs of  $\beta_3$  and  $\beta_4$  are expected to be negative and positive, respectively. This means that, while a rise in renewable energy will pioneer to decrease in  $CO_2$  emissions, a rise in the receipt of international tourism will pioneer to increase in it. The data of all of the variables were obtained from the World Bank's *World Development Indicators* [32], and the authors used the longest available time-series data.

In the methodology section of this study, the authors applied various cross-sectional dependence (CD) and homogeneity tests, the panel bootstrap cointegration approach introduced by Westerlund and Edgerton (2007) [33], and the augmented mean group (AMG) estimator proposed by Eberhardt and Teal (2010) [34]. The panel estimation methods that do not consider the CD and heterogeneity can lead to biased and inconsistent estimates. Therefore, the CD is one of the essential diagnostics that a researcher should investigate before performing a panel data analysis. Panel data can be subject to the CD (all of the units in the same-section are correlated). In order to test this, the LM CD test, given in Breusch and Pagan [35], can be applied when  $T > n$  (this is the case of author's research), and a CD test can be performed when  $n > T$  [36], or a corrected LM test can be performed. These tests can be employed for both balanced and unbalanced panels [29]. The LM test is reliable in any event when the CD test elaborated by Pesaran (2020) [36] is not consistent. The CD can be shown in the following equation:

$$y_{it} = \alpha_i + \beta_i x_{it} + \varepsilon_{i,t}; \text{cov}(\varepsilon_{i,t}, \varepsilon_{i,j}) \neq 0 \quad (2)$$

The null hypothesis ( $H_0$ ) states that no relations exist between the cross-sections. When  $n$  is fixed and  $T \rightarrow \infty$ , the LM statistic is fitted [34].  $H_0$  states that the t statistic is asymptotically Chi-square distributed with  $n(n-1)/2$  degrees of freedom. The LM test determines the sum of the correlation coefficient squares among the cross-section residuals ( $\rho_{ij}$ ,  $j$ ) (from OLS):

$$LM_{BP} = T \sum_{i=1}^{N-1} \sum_{j=i+1}^N \rho_{ij}^2 \quad (3)$$

However, the Breusch–Pagan LM test statistic is not valid when  $N \rightarrow \infty$ . In this case, [36] developed a scaled form of the given  $LM_{BP}$  statistic, namely, the  $CD_{LM}$  statistics for checking the CD. Finally, the  $CD_{LMadj}$  test is a modified version of the LM test (elaborated by Pesaran et al. (2008) [37]).

$$LM_{adj} = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^N \left( \frac{(T-k)\rho_{ij}^2 - \mu_{Tij}}{v_{Tij}^2} \right); \quad d \sim n(0,1) \quad (4)$$

The exact mean of the LM adj is zero if first  $T \rightarrow \infty$ , and then  $N \rightarrow \infty$ , for many board models, including heterogeneous ground-breaking models that can present multiple breaks in their bias/skew coefficients and error variances. The problems of these models have been identified in many studies.

The covariate-augmented Dickey–Fuller (CADF) test was elaborated by Hansen (1995) [38], who believed that the economic processes are variate or multi-dimensional. If more information is used in the unit root tests, this can increase the regression tests' efficiency and allow more concise assumptions. In order to remove the CD, the standard ADF test is enhanced with the cross-section averages of lagged levels and the first-differences of the individual series for the CADF statistics. The CADF test is applied when  $n > T$ , and also gives reliable results when  $T > n$  (this is the case in the author's research). In the CADF test proposed by Pesaran (2007) [39], the bootstrap method is not used to determine critical values. Another difference of this test is that the unit root test can be used for every panel unit and for the entire panel, which is a real advantage in the empirical analysis. A CADF test can be calculated by using the following equation:

$$\Delta y_{it} = a_i + g_it + b_i y_{i,t-1} + c_i y_{i,t-1} + \sum_{j=0}^p d_{ij} \Delta y_{i,t-j} + \sum_{j=0}^p \delta_{ij} \Delta y_{i,t-j} + e_{it} \quad (5)$$

where  $i = 1, 2, 3 \dots t$ ,  $a_i$  is the constant term,  $t$  denotes a trend,  $y_{i,t-j}$  shows lag period, and  $e_{it}$  represents the standard error term. In order to analyze the results of the CADF test for the whole panel, a cross-sectionally Im–Pesaran–Shin (CIPS) test can be applied as follows:

$$CIPS(N, T) = N^{-1} \sum_{i=1}^N CADF_i \quad (6)$$

The null hypothesis of the CADF test implies that the series have a unit root. The series' stationarity property can be analyzed by comparing the CIPS and CADF statistics with the critical values provided by Pesaran (2007) [39]. The CADF test considers dependence both inside and between the cross-sectional units, and works well in small samples, too.

The bootstrap LM cointegration test proposed by Westerlund and Edgerton (2007) [33] can be used to investigate long-run relationships. This method has good small sample properties. The LM test can provide deviations in the results in the case of CD. The asymptotically standard normal distribution depends on the serial correlation. In order to solve this issue, the bootstrap method can be applied Ari and Senturk (2020) [29]. The autoregressive model is:

$$\sum_{j=0}^{\infty} (\varphi_{ij} w_{it-j}) = e_{it} \quad (7)$$

After first estimating  $\varphi_{ij}$  (the deterministic term), the authors can estimate the residuals:

$$\hat{e}_{it} = \sum_{j=0}^{pi} (\varphi_{ij} \hat{w}_{it-j}) \quad (8)$$

The following equation was used by Westerlund and Edgerton (2007) [33] to calculate the LM statistics. In this test, the null hypothesis indicates the presence of cointegration.

$$LM_N^+ = \frac{1}{NT^2} \sum_{i=1}^N \times \sum_{i=1}^T \omega_i^{-2} S_{it}^2 \quad (9)$$

The Augmented Mean Group (AMG) approach allows unbiased estimations in every case of CD. The AMG estimator was elaborated by Eberhardt and Teal (2010) [34] as a substitute to Pesaran (2006) [40], the common correlated effects mean group (CCEMG) estimator. The AMG and Common Correlated Effects (CCE) estimate both the data time-series properties and the differences. A bootstrap test asserts the invalid theory of co-ordination in board data. The test considers dependence both inside and between the cross-sectional units across the panel [41]. The AMG deals with non-stationary variables and multifactor error terms, and especially considers CD. The AMG estimator's advantage

over the CCE approach is that it deals with common unobservable variables, and treats them as a common dynamic process.

The AMG is an unbiased and efficient estimator for different values and combinations of  $n$  (cross-section) and  $T$  (time-series) dimensions, especially when they are moderate to large. This estimator [42] is used to analysis the macro panel data in the presence of slope heterogeneity, non-stationary variables, and CD (an unobserved correlation across panel members). The coefficients on the (differenced) year's dummies represent an estimated cross-group average of the development of unobservable common factors in time across all of the countries [43]. This represents the so-called common dynamic process:

$$y_{it} = \beta_i x_{it} + u_{it} \quad (10)$$

where  $u_{it} = \alpha_{1i} + \lambda_i f_t + \varepsilon_{it}$  and  $x_{it} = \alpha_{2i} + \lambda_i f_t + \gamma_i g_t + e_{it}$ , where:  $i = 1, \dots, n, t = 1, \dots, T$ ,  $x_{i,t}, y_{i,t}$  are observable variables,  $\beta_i$  = a country's specific slope on the observable regressors,  $u_{i,t}$  = unobservable regressors,  $\varepsilon_{i,t}, e_{i,t}$  = error terms (white noise),  $\alpha_{1,i}$  = the fixed effects group (time-invariant heterogeneity across groups),  $f_t, g_t$  = unobserved common factors that can present nonlinearity and nonstationary, and  $\lambda_i$  = heterogenous factor loadings that expose time-variant heterogeneity and CD.

The group regression model is further enhanced with reminders of a typical powerful impact for the nation relapse. A pooled relapse upgraded with fakers is assessed by first contrast normal least squares, or with a unit coefficient (for every group member), by subtracting the estimated process from the dependent variable. The group model specifications are then averaged for the panel (weights may be applied) [43].

#### 4. Empirical Findings

In order to check the CD among countries and the slope homogeneity, firstly, the authors applied the various tests and report results in Table 2.

**Table 2.** CD and heterogeneity test results.

Test	Statistic	p-Value
CD tests		
LM	1843.102 <sup>a</sup>	0.000
CD <sub>LM</sub>	55.107 <sup>a</sup>	0.000
CD	22.524 <sup>a</sup>	0.000
LM <sub>adj</sub>	13.751 <sup>a</sup>	0.000
Heterogeneity tests		
$\widetilde{\Delta}$	114.531 <sup>a</sup>	0.000
$\widetilde{\Delta}_{adj}$	138.147 <sup>a</sup>	0.000

**Note:** <sup>a</sup> indicates statistical significance at the 1% level.

According to the test results, the null hypothesis of no CD is strongly rejected at a 1% significance level. In addition, the delta and adjusted-delta test statistics revealed the presence of slope heterogeneity. For this reason, the authors used methods that take into account the CD and heterogeneity in the panel data. In the next step, the authors analyzed the stationarity properties of variables using the CADF unit root test; the results are reported in Table 3.

The CADF test results show that all of the series are stationary at first differences, since the t-statistics values of all of the panel units are lower than the critical values. In other words, the data series are integrated of the order  $I(1)$ . Therefore, the long-term relationships between the series can be analyzed using cointegration tests. In this context, the authors performed the bootstrap panel cointegration test developed by Westerlund and Edgerton (2007) [33] and showed the results in Table 4.

**Table 3.** CADF unit root test results.

Variable	CIPS	
	I(0)	I(1)
lnCO <sub>2</sub>	−2.012	−2.654 <sup>a</sup>
lnGDP	−2.008	−2.623 <sup>a</sup>
(lnGDP) <sup>2</sup>	−2.001	−2.603 <sup>b</sup>
lnRE	−2.229 <sup>b</sup>	−3.306 <sup>a</sup>
lnT	−2.002	−3.295 <sup>a</sup>

Notes: <sup>a</sup> and <sup>b</sup> illustrate statistical significance at the 1% and 5% levels, respectively.

**Table 4.** Bootstrap panel cointegration test results.

LM Statistic	Bootstrap <i>p</i> -Value
9.433	0.99

The results in Table 4 reveal that the null of the cointegration is validated. The LM bootstrap panel cointegration test shows the existence of a long-run association among GDP, tourism, renewable energy, GDP, and CO<sub>2</sub> emissions. In order to estimate the long-run elasticities, the authors performed the AMG estimator. The test results of the AMG estimator are reported in Table 5.

**Table 5.** AMG estimation results.

Country	lnGDP	(lnGDP) <sup>2</sup>	lnRE	lnT
Canada	16.754 [0.90]	−0.087 [−0.79]	−0.041 [−0.10]	−0.020 <sup>c</sup> [−1.89]
France	85.433 <sup>b</sup> [2.29]	−4.901 <sup>b</sup> [−2.28]	−0.142 <sup>c</sup> [−1.81]	0.128 [1.59]
Germany	4.451 [0.22]	−0.198 [−0.20]	−0.119 [−1.45]	0.014 [0.18]
Italy	56.456 [1.11]	−3.290 [−1.10]	−0.123 <sup>a</sup> [−2.78]	0.117 <sup>c</sup> [1.88]
Japan	−59.847 [−0.58]	3.103 [0.59]	−0.019 [−0.24]	−0.012 [−0.36]
UK	−26.778 [−1.39]	1.588 [1.41]	−0.088 <sup>a</sup> [−3.29]	−0.014 [−0.15]
US	−4.124 [−0.20]	0.302 [0.22]	−0.208 <sup>b</sup> [−2.28]	−0.056 [−0.91]

Notes: values in brackets show t-statistics. <sup>a</sup>, <sup>b</sup> and <sup>c</sup> indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

The test findings in Table 5 show that the EKC hypothesis is verified only for France, since the coefficients of GDP and GDP<sup>2</sup> are significantly positive and negative, respectively. This means that an upsurge in the real per capita GDP initially added to the CO<sub>2</sub> emissions, followed by a subsequent emissions reduction in France. It aligns with the inverted U-shape association between the two variables. This result is in line with the findings of [44], who also confirmed the validity of the tourism-induced EKC hypothesis for France. The authors did not observe significant relationships between the per capita genuine GDP and per capita CO<sub>2</sub> emissions for other countries. Furthermore, increases in RE lead to decreases in CO<sub>2</sub> emissions in France, Italy, the UK, and the US. The most substantial negative impact (−0.208) of renewable energy on CO<sub>2</sub> emissions was observed in the US. In regards to T, increases in the receipt of international tourism lead to increases in CO<sub>2</sub> emissions in Italy. More specifically, the long-run elasticities of T with regard to CO<sub>2</sub> emissions is 0.117, implying that a 1% increase in the receipt of tourism will raise the CO<sub>2</sub> emissions by 0.117%. At this point, this country's policymakers should consider this result, and maybe change the country's tourism policy somehow. These findings for Italy affirm the results of the empirical studies of Shakouri et al. (2017) [10], Tovar and Lockwood (2008) [18], Solarin (2014) [45], León et al. (2014) [46], Danish and Wang (2018) [47], and Zhang and Gao (2016) [48]. However, the authors could not detect relationships between the receipt of international tourism and CO<sub>2</sub> emissions for other country except Canada, which had a very slight relationship intensity.

## 5. Conclusions

This study aimed to examine the validity of the tourism-led EKC hypothesis for G7 countries. The empirical findings confirm the validity of this hypothesis only for France. This means that increases in real per capita GDP first pioneer increases in CO<sub>2</sub> emissions, and eventually lead to decreases in it over time (shown with an inverted U-shaped relationship and pattern) [49–55].

Additionally, the authors also investigated the impacts of the tourism and energy sectors on CO<sub>2</sub> emissions, since they dominate the G7 economies and potentially directly impact environmental quality. The authors found that the tourism sector increases CO<sub>2</sub> emissions in Italy, while it decreases environmental degradation in Canada, with a slight impact intensity. For this reason, the policymakers of Canada must create new jobs in the tourism sector and continue to contribute to the environment with their current tourism policy. However, Italy's policymakers should review their country's tourism policy, and replace it with a sustainable one. The tourism sector in Italy dominates this country's economy. Therefore, the current tourism policy may cause millions of job losses in this country if this sector continues to pollute the environment. The non-verification of the EKC hypothesis for this country clearly shows that increases in the tourism-dominated economy (GDP) cannot reduce Italy's CO<sub>2</sub> emissions, unlike in France.

Furthermore, the authors found that renewable energy consumption reduces CO<sub>2</sub> emissions in France, Italy, the UK, and the US. This implies that these countries use the renewable energy sources, including solar photovoltaic energy sources, wind energy, hydro-based power production, and geothermal energy for heating systems and for the generation of electricity, or for transport electricity. The use of clean and environmentally friendly energy resources in the tourism sector should be encouraged in these countries, particularly France. For this, the cost of production and the use of renewable energy should be reduced by technological upgradation [56,57]. Renewable energy sources invested in tourism resorts can increase tourist arrivals, mainly due to their modern design or uniqueness, and could also help to create jobs [58–69]. As noted by Pata & Terzi (2017) [70], renewable energy consumption supports economic growth in G7 countries. Therefore, a win–win strategy can be followed by increasing the economic growth and environmental quality simultaneously with incentives to use renewable resources in tourism, as well as in other sectors.

The present research estimated the EKC's validity for overall CO<sub>2</sub> emissions; however, the sectoral calculation of CO<sub>2</sub> emissions would provide a deep understanding of the sectoral situation of EKCs. Moreover, it would provide insights regarding the impacts of the under-analysis variables on sectoral emissions in order to target sector-specific policies. In view of this, future research may take this research as a guideline in the pursuit of further investigations in this research domain. Additionally, this research considered renewable energy consumption and the receipt of tourism as the additional independent variables. Future studies should include other determinants of CO<sub>2</sub> emissions in order to check the sensitivity of the EKC's existence in response to those different variables.

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