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The Impact of Tourism on Energy Consumption: A Sectoral Analysis for the Most Visited Countries in the World

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Abstract: Tourist activity has strategic importance in the global economy. Nevertheless, the tourism activities are linked to increased emissions, due to the sector's energy intensity, especially in the transport and commercial sectors. The aim of this study is to analyze the relationship between final energy consumption in the whole economy, the transport, commercial and public services sectors, and the tourist activity in the 15 countries with the highest number of international tourist arrivals in the world, in 2000–2019 period. The Energy–Environment Kuznets Curve (EKC) hypothesis extended with tourism has been tested. Obtained results show non-linear relationships between energy consumption and production levels. There is evidence in favor of the energy EKC hypothesis, and in favor of an inverted N-shaped relationship for transport and commercial and public services sectors. The results also show a positive, increasing relationship between energy consumption and tourist arrivals for the whole economy. However, there is some evidence of the tourism energy EKC hypothesis when considering the transport, commercial and public services sectors. Therefore, economies of scale are observed in these sectors. Accordingly, it is highly advisable to increase the economies of scale, coupled with a greater awareness on the use of renewable energy. Negative relationships are found between energy consumption and tourism receipts. Therefore, it is advisable to establish policies that encourage high quality tourism to control the economy's energy consumption.

Keywords: energy consumption; tourism; transport; tourism arrivals and receipts; Environmental Kuznets Curve; panel data

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1. Introduction

Tourism is one of the economic sectors with more weight in global production, prior to the COVID pandemic. According to the World Travel & Tourism Council (WTTC 2020), tourism accounted for 10.3% of world GDP in 2019, generating 330 million jobs. Despite the sector's production having decreased to 5.5% of world GDP and losing 62 million jobs in 2020, most experts consider it possible to return to pre-pandemic levels in 2024 (UNWTO 2023). The positive tourism impact on the economy, before 2020, was accompanied by the detrimental effects of environmental degradation by increasing CO_2 emissions (Saint Akadiri et al. 2019a, 2019b). Lenzen et al. (2018) estimated that tourism was responsible for 8% of total CO_2 emissions. This environmental damage makes it, as Dolnicar (2020) states, one of "the most polluting industries globally".

The decline in tourism activities, due to pandemic-related mobility restrictions, has contributed an estimated 8% reduction in CO_2 emissions in 2020 (IEA 2020). However, the gradual return to pre-pandemic situations will once again push up CO_2 emissions if no action is taken to limit their growth. In this regard, it is important to note that although the harmful effects of tourism on the environment and climate are well known and have been extensively relatively little has been done to reduce its impact on the growth of emissions (Scott and Gössling 2022). In fact, it has been recognized that the time has come to act, committing to halve tourism emissions by 2030 (One Planet Sustainable Tourism Programme 2021). To this end, as stated by Scott and Gössling (2022) the scientific community must try and enhance research related to this topic, especially in those areas where there are certain gaps.

In the scientific field, the sustainability of tourism has also been the subject of widespread interest. A large part of the research has focused on measuring the emissions caused by tourism activity, as in Lenzen et al. (2018). Another large body of research has focused on analyzing the links between tourism and emissions, either through causality analysis (as for example in Gokmenoglu and Eren 2020) or through the estimation of macroeconomic models. Among the latter, those that contrast the Environmental Kuznets Curve (EKC) hypothesis extended with tourism stand out (a systematic review is performed by Sun et al. 2022). Some recent studies highlight the possible non-linear effect of tourism on emissions. Thus, they test the extended EKC hypothesis with tourism, including the tourism variable and its squared value (as in Mahmood et al. 2021). Other studies highlight sectoral differences, emphasizing the importance of some sectors such as transport (Debbage and Debbage 2019). Others, emphasize the role of energy in the relationship between tourism and emissions, and include it as an additional independent variable in the model (e.g., Katircioğlu 2014). However, this has recently been criticized, as carbon data are derived directly from energy (Jaforullah and King 2017).

Although many of these studies recognize that tourism generates energy consumption that influences CO_2 emissions, very few have focused on analyzing the relationship between tourism and energy consumption (Bekun et al. 2023). In addition, to our knowledge, there are no precedents that analyze the effect of tourism on energy in the context of the Kuznets curve hypothesis. Despite these few studies, knowing the relationship between both variables is of special relevance. After all, emissions are calculated based on energy consumption and the way in which this energy was generated, something that is often beyond the direct control of the tourism sector.

This may be one of the reasons why the sector has not managed to reduce emissions in recent years. The strategies carried out so far based on the promotion of a more sustainable behavior of tourists, on the one hand, and the adoption of technological improvement in the firms, focused on business eco-innovations on the other hand have had little impact (Geels et al. 2015). Thus, the changes made have not been large enough to offset the growth of tourism and the associated energy consumption (Sun et al. 2020). Knowing which sectors are most affected by energy consumption and the growth of tourism may provide some clues for new policy orientations, not only in the tourism sector, but also in other economic sectors.

This paper aims to contribute to this end, focusing on the link between tourism growth and energy consumption, which contribute to emission growth. In fact, as stated in Debbage and Debbage (2019), "a majority of tourism-related activities require energy directly in the form of fossil fuels (e.g., transportation) or indirectly in the form of electricity often generated from petroleum, coal or gas (e.g., accommodation)". This study is considered relevant since the way to control this negative effect of tourism involves knowing its energy needs, especially in certain specific sectors. Therefore, the objective of this paper is to study the relationship between tourism activity and energy consumption, for the economy as a whole and for the transport and commercial and public services sectors.

To this end, the relationship between tourism and total energy consumption and energy consumption in the transport and commerce and public services sectors, in the period 2000–2019, is analyzed for the 15 countries in the world with the highest number of international tourist arrivals. The period of analysis was chosen considering that the Covid epidemic produced an anomalous contraction in tourism starting in 2020, which distorts the analysis at later dates.

Following Bekun et al.'s (2023) model, the analysis tests the extended energy EKC with tourism hypothesis. However, several novelties are introduced in the model. On the one hand, it is considered that the nonlinear relationship between energy consumption and production can be flexible. Therefore, as in Mahmood et al. (2021), output and its squared and cubed values are included in the model. In this way, the hypothesis of the inverted N-shaped relationship can be tested. In addition, the non-linear effect of tourism on energy is considered. Therefore, both tourism and its squared value are also included in the model. The inclusion of these terms can give us information on whether a higher accumulation of tourism can have positive or negative effects on energy consumption (Pablo-Romero et al. 2019). Finally, two tourism variables have been introduced in the analysis: tourism arrivals and tourism receipts.

This study is then novel for several reasons. On the one hand, to our knowledge, there are no precedent analyses that test the relationships between energy use and tourism activity considering the sectoral perspective. On the other hand, there are no previous studies that test the extended EKC hypothesis with tourism, when the dependent variable is total energy consumption and none when it is energy consumption at the sectoral level. Also, in this context, the non-linear relationships between energy consumption and tourism activity have not been previously analyzed.

This paper is structured as follows. After this introduction, Section 2 offers a review of the literature. Section 3 presents the methodology used. The model analyzed is detailed and justified, the data are presented, and the econometric procedure is explained. Section 4 presents the results. Section 5 discusses the results and finally concludes.

2. Literature Review

The growth of global CO_2 emissions has aroused the interest of the scientific community, which has dedicated great efforts to studying the ways through which it may be possible to limit its growth. In this sense, an increasing number of economists have focused their interest on better understanding the relationship between economic activity, energy consumption and CO_2 emissions. Likewise, given the worldwide growth rate in tourism activity, recent studies have started focusing on the relationship between economic growth, CO_2 emissions, energy consumption and tourism activities (Pablo-Romero et al. 2019). These studies fit within the branch pointed out by Scott and Gössling (2022) that seek to estimate the greenhouse gas emissions from the tourism sector. Various approaches have been used for this purpose.

Some of these studies have focused on measuring the emissions caused by tourism activity. One of the most recent studies in this respect is that carried out by Lenzen et al. (2018), which calculates that tourism generates 8% of total greenhouse gas emissions. The authors use a Leontiefh's standard model by integrating tourism satellite accounts into a global multi-region input–output (MRIO) database.

Beyond the studies focusing on determining the value of emissions caused by this sector, other researchers have focused their attention on analyzing the links between tourism, energy use and emissions. Two types of studies stand out in this area.

The first seeks to determine the causal relationships between several variables, among which are those mentioned above. These studies can be considered the pioneers. Among them can be cited the study by Lee et al. (2009), in which the causality between tourism, emissions and air and water quality indicators, are studied. More recently, the studies by Saint Akadiri et al. (2020), Mishra et al. (2020), and Teng et al. (2021) focus exclusively on the causal relationships between tourism and CO_2 emissions. Likewise, the studies by Pegkas (2020) and Sharif et al. (2020) analysed the causality between CO_2 emissions, energy consumption and tourism. Additionally, studies can also be found that analyze the causality between tourism and energy consumption. Among them, for example, the studies carried out by Liu et al. (2016) and Tang et al. (2016), or the more recent studies by Gokmenoglu and Eren (2020) and Amin et al. (2020).

The second type of studies goes further, estimating econometric functions in which emissions and/or energy and tourism variables enter the econometric function in different ways. Often, the function's dependent variable is the level of CO_2 emissions, while tourism and production are included among the independent variables, as for example in Lee and Brahmasrene (2013), or the recent studies by Juwita et al. (2021), Yassin et al. (2021), Wangzhou et al. (2022), and Razzaq et al. (2023). Therefore, the main objective of this line research is to analyze the link between tourism and emissions, using econometric functions that recognize the role of economic growth as a driver of these emissions. The results of these studies are not conclusive, as they show that tourism can have both positive and negative effects on the environment. Some of these studies include energy as an additional independent variable, as for instance in Katircioğlu (2014). However, this fact has been criticized recently, as carbon data are directly derived from those for energy (Jaforullah and King 2017). Therefore, it may be more appropriate to avoid these.

In these studies, it should be noted that several advances have taken place, specifying the estimated functions more precisely. In this vein, there are studies in which CO_2 emissions depend, not only on tourism activity and on income or production, but also on the squared (and even cubic) value of the latter variable. The purpose of this group of studies is to contrast what has come to be known as the Environmental Kuznets Curve (EKC) hypothesis extended with tourism, that is, the EKC hypothesis is tested in a context in which tourism activity is specifically considered. Some of the recent studies in this line are for example those by Iswan et al. (2021), Le and Nguyen (2021), Tian et al. (2021), and Ghosh (2022). The recent study by Satrovic and Adedoyin (2023) also tests the EKC hypothesis in order to analyze the effect of international tourism, among other variables, on environmental degradation, measured by using two indicators, namely, ecological footprint and carbon intensity. The EKC hypothesis states that when the level of income is low, environmental damage is also low. However, as income increases, environmental damage tends to increase until a threshold at which the increase in income begins to reduce environmental damage. This relationship can be captured by introducing in the regressions the squared levels of the income variable. Furthermore, by including cubed terms, the function can be made more flexible, allowing other possible non-linear relationships to be tested. In many recent papers, among one the study by Azam et al. (2018) can be cited, this nonlinearity does not affect the relationship between tourism and emissions. The results of these studies are also inconclusive, as again both positive and negative effects of tourism on emissions are found. It is interesting to note the conclusions obtained in the study by Le and Nguyen (2021). The authors indicate that while tourism contributes to reducing the consumption of emissions derived from the use of electricity and heat, those related to the transport sector increase.

Some recent studies have come to recognize the possible non-linear effect of tourism on emissions, which improves knowledge of the effects of tourism on them. Thus, some recent studies include the tourist variable and its squared value, in addition to including the production or income squared variable, to test the EKC hypothesis. Among them, the study by Paramati et al. (2017) tests the EKC hypothesis extended with tourism, including tourism revenue and its squared value. Likewise, Ozturk et al. (2016) test this hypothesis for the carbon footprint of tourism, by including tourism income, and its squared value, as independent variables in the econometric function. The analysis by Pablo-Romero et al. (2017a, 2017c, 2019) tests the tourism non-linearity effect on electricity use in the Spanish hospitality sector, adding tourism and its squared value as independent variables. The study by Ehigiamusoe (2020) tests the EKC hypothesis finding that tourism has a U-shaped non-linear effect on CO_2 emissions in African countries. Tourism development and environmental degradation also exhibit the inverted U-shape relationship. On the contrary, Raza et al. (2021) find that tourism and environmental degradation present the inverted U-shape relationship for 20 top tourist arrival destinations. Similarly, Yıldırım et al. (2021) find an inverted U relationship between tourist arrivals and emissions, although they find a negative relationship between tourism receipts and emissions.

Likewise, other advances in the literature are associated with the choice of the dependent variable associated with emissions. Thus, the dependent variable is no longer the level of CO_2 emissions but, alternatively, the level of specific CO_2 emissions associated, for instance, with the transport sector (Al-Mulali et al. 2015). In this sense, there are studies that recognize that tourism have more negative effects on emissions, in certain sectors, which is related to the energy consumption that tourism provoke, as in Le and Nguyen (2021). Thus, there has been special interest in analyzing these relationships in the air travel sector since its emissions account for 20% of the global carbon footprint of tourism (Debbage and Debbage 2019). Moreover, the analysis by Shabir et al. (2022) studies the impact of transport energy consumption on CO_2 emissions testing the EKC hypothesis and results clearly showed the significant adverse effect of consuming transport energy on emission levels. Additionally, the recent study by Satrovic et al. (2023) analyzes the influence of transport energy consumption and other variables on the ecological footprint under the prism of EKC, and outcomes found a significant adverse environmental impact of transport energy consumption.

The energy intensity of some sectors closely linked to tourism has determined that few researchers have focused their interest on knowing the relationship between tourism and energy consumption, which is ultimately what can cause the growth of emissions. Perhaps one of the first studies to analyze the relationship between tourism and energy consumption was the one by Tabatchnaia-Tamirisa et al. (1997) which explores the link between energy use and a rapidly growing tourism destination through input-output analysis. Other recent studies analyze the energy use of some steps of the tourism supply chain, including energy efficiency in hotels (Salehi et al. 2021), transportation (Rauf et al. 2021) or tourism behavior (Bajracharya et al. 2020), among others. Based on econometric techniques, some few studies as that by Sun et al. (2021) analyze the effect of tourism on energy consumption. They do so within a context in which emissions are also analyzed. To the best of our knowledge, and beyond the studies that analyze the causality between tourism and energy consumption, the only studies that focus specifically on analyzing this relationship are those related by Pablo-Romero et al. (2017a, 2017c) and recently Bekun et al. (2023). However, these studies refer only to the electricity consumption. In addition, to our knowledge, there are no preceding studies that analyze the EKC extended with tourism when energy is the depended variable (that is the Energy-EKC hypothesis extended with tourism). In fact, the Energy-EKC hypothesis testing is limited globally (Mahmood et al. 2021).

Despite the few studies that have focused their interest on the relationship between tourism and energy consumption (as stated in Bekun et al. 2023), knowing the relationship between both variables is of special relevance. After all, emissions are calculated based on energy consumption and the way in which this energy was generated, something that is often beyond the direct control of the tourism sector. This may be one of the reasons why the sector has not managed to reduce emissions in recent years. The strategies carried out so far based on the promotion of a more sustainable behavior of tourists, on the one hand, and the adoption of technological improvement in the firms, focused on business eco-innovations on the other hand have had little impact (Geels et al. 2015). Thus, the changes made have not been large enough to offset the growth of tourism and the associated energy consumption (Sun et al. 2020). Knowing which sectors are most affected by energy consumption and the growth of tourism may provide some clues for new policy orientations, not only in the tourism sector, but also in other economic sectors.

Taking these previous studies into account, this paper advances on the previous research by examining the relationship between energy use and tourism activity, in the countries with greater tourist affluence within a triple scenario, for the whole economy, and related to the transport, commercial and public services sectors. This relationship is analyzed by testing the so-called energy EKC hypothesis extended with tourism, considering that energy consumption is the dependent variable which can be influenced by the economic activity and, specifically, by tourist activity. To consider the probable non-linear links between variables, the income variable and its square (and even its cubed value), and the tourist variable and its square value, are included in the function as independent variables. Consequently, this analysis follows past research by testing the EKC hypothesis extended with tourism, but also follows the more recent studies by Ozturk et al. (2016), Pablo-Romero et al. (2017a, 2017c, 2019), Paramati et al. (2017), Ehigiamusoe (2020), Raza et al. (2021) and Yıldırım et al. (2021), by considering that tourism activity may have a non-linear influence on the dependent variable (emissions, carbon footprint or energy consumption).

This study is novel for several reasons. On the one hand, to our knowledge, there are few precedent analyses that econometrically test the relationships between energy use and tourism activity, and none of them consider the sectoral perspective. On the other hand, there are no previous studies that test the EKC hypothesis extended with tourism, when the dependent variable is total energy consumption (nor for energy consumption at sectoral levels). Likewise, in this context, the non-linear relationships between energy consumption and tourist activity have not been previously analyzed.

3. Methodology

3.1. The Model and Main Hypothesis of the Study

Currently, tourism activity is considered to have an impact on the environment (Balsalobre-Lorente and Leitão 2020). One of the ways in which this impact is produced is through the energy consumption it generates. Thus, tourism is considered an activity that impacts on energy consumption (Brida et al. 2023). However, energy consumption is also affected by other economic activities (Tang et al. 2016). Therefore, as in Bekun et al. (2023), energy consumption is considered depending on the economic production and tourism activity. This relationship can be expressed as follows:

$$E_{it} = f(T_{it}, Y_{it}), \tag{1}$$

where E is the final per capita energy consumption, T is a variable that indicates per capita tourism activity, Y refers to production per capita, and the sub-indices i and t denote countries and time, respectively. The variables E, T and Y are in per million inhabitants and in logs.

The starting hypothesis is that both variables have an impact on energy consumption. However, previous studies have shown that the relationship between income and energy consumption is not linear. The analysis of this non-linear relationship has led to the testing of the Energy-EKC (Jahanger et al. 2023) and more recently to the testing of more flexible forms of relationship between variables, such as the inverted-N hypothesis. Thus, given that the introduction of the income and squared income variables has been considered insufficient to explain this non-linear relationship in some previous analyses (for example, Pablo-Romero et al. 2017b), the income cubed value is also included in the model as in Mahmood et al. (2021).

In the context of the Kuznets curve contrast, tourism has been considered as an additional variable affecting this relationship. The extension of this analysis has led to testing the tourism-EKC hypothesis (a systematic review is performed by Sun et al. 2022). For the most part, the dependent variable of the analysis has been CO_2 emissions, and less frequently some air pollutants (as in Ciarlantini et al. 2023 and Zhang and Lu 2022). However, in this context, the energy variable has not been previously used. In this study, the Energy-EKC extended with tourism is then tested.

Additionally, the non-linear relationship between tourism and energy consumption (and even CO_2 emissions) has been poorly addressed in previous literature. Following the pioneering study by Ozturk et al. (2016) analyzing the nonlinear effect of tourism on emissions, in this study, both T and its squared value are included additionally in the function as independent variables. As stated in the previous studies by Pablo-Romero et al. (2017a, 2017c, 2019), and Paramati et al. (2017), the inclusion of these terms can give us information about whether a greater accumulation of tourism can have positive or negative effects on energy consumption, and therefore on the emissions generated.

Thus, the function to be estimated may be expressed as follows:

$$E_{it} = A_{it} + \beta_1 T_{it} + \beta_2 T_{it}^2 + \beta_3 Y_{it} + \beta_4 Y_{it}^2 + \beta_5 Y_{it}^3 + \beta_6 U_{it} + e_{it} \tag{2}$$

A symbolizes the sum of the temporal and individual effects, *e* is the random error term, and *U* is a control variable. The degree of urbanization of each country is introduced as a control variable since, in previous studies, urbanization has been considered a variable that may affect both energy consumption and CO_2 emissions (see, for example, Zaman et al. 2016). The β values are the coefficients to be estimated.

The hypotheses tested in this study are the following:

H1. *There is a nonlinear relationship between tourism and energy consumption. It may be an inverted U-shaped.*

The value and sign of the estimated coefficients β_1 and β_2 provide information about the relationship between final energy consumption and tourism (depending on the type of energy considered and the tourist variable used). If both coefficients are positive ($\beta_1 > 0$ and $\beta_2 > 0$), the relationship between *T* and *E* is progressively increasing. If $\beta_1 > 0$ and $\beta_2 < 0$, then the increase in tourism promotes higher energy consumption, initially, although after a certain level of tourism, energy consumption will decrease. Thus, this result supports the Energy-EKC hypothesis for tourism. Finally, if $\beta_1 > 0$ and $\beta_2 = 0$, the relationship between both variables will be positive and linear.

H2. *There is a nonlinear relationship between GDP and energy consumption. It may be an inverted U-shaped or inverted N-shaped.*

On the other hand, the value and sign of the coefficients β_3, β_4 and β_5, provide information about the relationship between production and energy consumption. There are different possible relationships between these variables. In this sense, it can be highlighted that if all the coefficients are positive ($\beta_3 > 0$, $\beta_4 > 0$ and $\beta_5 > 0$), there is a progressively increasing positive relationship between the variables. Likewise, if $\beta_3 > 0$, $\beta_4 < 0$ and $\beta_5 = 0$, then, according to Dinda (2004), the EKC hypothesis is verified. If ${\beta_4}^2 - 3^*\beta_3\beta_5 > 0$ and $\beta_5 < 0$, an inverted *N* shape is observed, and if ${\beta_4}^2 - 3^*\beta_3\beta_5 > 0$ and $\beta_5 > 0$, an *N* shape may be obtained (Pablo-Romero et al. 2021).

H3. *The relationship between tourism and energy consumption and between GDP and energy consumption differs for total energy consumption and for the economic sectors most closely linked to tourism.*

In this study, three alternative energy variables are used: the total final energy consumption (denoted by *E*), the final energy consumption of the transport sector (*ET*), and the final energy consumption of the commercial and public services sectors (*EC*). The sectoral analysis is a novel aspect of this study, which nevertheless may be of interest, since, as mentioned above, tourism requires energy for transportation activities and in accommodation services, an energy demand that directly or indirectly induces the generation of emissions (Debbage and Debbage 2019). In fact, although the transport sector is the sector that demands the most energy linked to tourism, the analysis of energy consumption derived from tourist transport has not been specifically analyzed in previous studies (Osorio-Molina et al. 2023). Likewise, although a few previous studies have analyzed the effect of tourism on the energy consumption of hotels and lodgings, their study has not been addressed in a general framework, such as that of this study (Pablo-Romero et al. 2019).

H4. *The number of tourists does not affect energy consumption in the same way as tourism receipts.*

Likewise, two alternative tourism variables are used: the number of international tourist arrivals (*TA*) and international tourism receipts (*TR*). Both variables have been previously used in the literature as indicators of tourism. For example, in the recent study by Zeng et al. (2021), which analyzes the role of tourism in CO_2 emissions, *TA* is used as an indicator. Similarly, recent literature has also used *TR* to analyze the same impact, as for example in the study by Işik et al. (2020). However, studies using the latter indicator in general tourism studies are much less common. The use of both indicators is nevertheless appropriate, since previous studies such as Zaman et al. (2017) that have used both indicators show that the results may differ depending on the indicator used.

3.2. Data

This study analyzes the effect of tourism on energy consumption in the 15 countries that, from 2000 to 2019, have been in the top ten ranking of the most visited countries in world, according to the data offered by UNWTO (2019). The period of analysis was chosen considering that the Covid epidemic produced an anomalous contraction in tourism starting in 2020, which distorts the analysis at later dates. It should be recalled that tourism is expected to fully recover in 2024 (UNWTO 2023).

Table 1 shows the ten most visited countries in the world in 2019. Added to this list were five other countries that have occasionally been in that ranking, throughout the period 2000–2017. These added countries are Russia, Malaysia, Ukraine, Austria, and Canada.

Table 1. Ten most visited countries in the world 2019.

Ranking	Tourist Arrivals (Millions)	Country
1	90.0	France
2	83.7	Spain
3	79.3	United States
4	65.7	China
5	64.5	Italy
6	51.2	Turkey
7	45.0	Mexico
8	39.6	Thailand
9	39.8	Germany
10	39.43	United Kingdom

Source: UNWTO (2023).

Data from two database sources have mainly been used. The economic and social data come from the World Bank database (World Bank 2023), while the energy consumption data have been obtained from the International Energy Agency (IEA 2023).

The main socioeconomic data used in the study refer to tourism and production. Two alternative indicators are taken for the tourism variable: international tourist arrivals and international tourism receipts. Both indicators are the most frequently used in previous studies. The international tourism arrivals variable is expressed in terms of number of tourists visiting per million inhabitants. The tourism receipt variable is expressed in constant 2010 US Dollars per million inhabitants. The production variable is measured as per capita GDP and expressed in constant 2010 US Dollars per million inhabitants. Furthermore, these variables have been converted into natural logarithms. Additionally, the percentage of urban population to the total population of each country, is used as a control variable.

All energy consumption data were obtained from the Energy Balance offered by IEA (2023), for every year and country. The energy data used are the total final energy consumption, the final energy consumption corresponding to the transport sector, and the final energy consumption related to the commercial and public services sectors. These data are in logs of thousands of tons of oil equivalent per million inhabitants.

Table 2 displays the main series statistics. The "overall" rows represent the statistics of the variables for all years and countries. Those corresponding to the "between" rows, refer to the variation of the averages for each country, and the "within" rows show the variation of each year of study, with respect to its mean. N shows the total sample, n the individuals (15 countries) and T the time horizon (23 years). In general, it can be observed that the variables present greater variance between the countries of the sample than throughout the study period. Therefore, there is less variability over time.

Table 2. Main descriptive statistics.

Variable	Description		Mean	Stand. Dev.	Min.	Max.	Observations
E	Total final energy consumption p.c. (ln)	overall	7.865	0.579	6.428	8.778	N = 300
		between		0.567	6.851	8.689	n = 15
		within		0.124	7.195	8.241	T = 20
ET	Final energy consump. p.c. in transport sector (ln)	overall	6.298	0.775	3.627	7.567	N = 300
		between		0.767	4.635	7.576	n = 15
		within		0.195	5.278	7.561	T = 20
EC	Final energy consump. p.c. in comer. & p. services (ln)	overall	5.123	1.089	3.022	6.824	N = 300
		between		1.078	3.462	6.656	n = 15
		within		0.276	3.903	5.999	T = 20
Y	GDP p.c. (ln)	overall	23.554	1.054	20.556	25.943	N = 300
		between		0.987	21.747	24.599	n = 15
		within		0.399	22.151	26.010	T = 23
TA	Tourist arrivals p.c. (ln)	overall	12.856	1.076	9.7188	15.132	N = 300
		between		1.054	10.365	14.865	n = 15
		within		0.319	11.539	13.823	T = 23
TR	Tourism receipts p.c. (ln)	overall	19.765	1.198	16.283	22.743	N = 300
		between		1.145	17.012	21.576	n = 15
		within		0.399	18.172	22.322	T = 23
U	% Urban population	overall	68.999	12.907	30.276	83.254	N = 300
		between		12.864	38.877	80.465	n = 15
		within		3.655	55.956	83.001	T = 23

3.3. Econometric Procedure

To properly estimate Equation (2), all the variables in the equation have been transformed in deviations from the geometric mean, to avoid multicollinearity problems (Jaccard and Turrisi 2003), derived from the inclusion of the squared and cubed variables. The variance inflation factor (VIF) statistic has been used to study this problem. Table 3 shows the VIF values of the transformed variables. As higher values are near 5, the multicollinearity problem between variables disappears when transforming the variables.

Table 3. Analysis of multicollinearity.

Variable	VIF Transformed Variables					
E	2.13			2.26		
ET		3.25			1.63	
EC			1.67			3.24
Y	4.60	4.92	4.64	4.69	4.68	4.96
Y^2	4.53	4.55	4.45	4.51	4.61	4.59
Y^3	5.14	5.23	5.17	4.98	5.01	4.97
TA	1.58	1.64	1.63			
TA^2	1.83	1.93	1.85			
TR				4.25	4.06	4.03
TR^2				2.82	2.75	3.00
U	2.85	2.80	3.24	2.52	3.05	2.62

As variables are expressed in logarithms, this transformation determines that the coefficient β_1 now expresses the elasticity of energy consumption to tourism, at the central point of the sample. Also, the coefficient β_3 is now the elasticity of energy use to income, at the same point. The change of the variables is denoted by using a line above them.

Additionally, the series nature was studied. Firstly, the cross-sectional dependence and heterogeneity analysis was performed. The Pesaran (2004) CD test was used, and the cross-sectional independence null hypothesis was rejected for all cases, as shown in

Table 4. Additionally, to study the heterogeneity of the potential slope. Swamy's test for slope homogeneity (Pesaran and Yamagata 2008) was run. The results shown in Table 5 indicates that the null hypothesis on slope homogeneity was rejected. Therefore, second generation panel data unit root tests are used to study the stationarity of series.

Table 4. Pesaran CD tests.

Variables	CD Test
E	2.52 **
EC	5.43 ***
ET	2.75 ***
Y	16.36 ***
Y^2	2.29 **
Y^3	18.27 ***
TA	24.39 ***
TA^2	4.37 ***
TR	9.41 ***
TR^2	6.82 ***
U	33.38 ***

Note: *** denotes significance at the 1% level, and ** at the 5% level.

Table 5. Slope homogeneity test.

Dependent Var.	Independent Variables	Slope Homog. (Delta)
E	Y, Y^2, Y^3, TA, TA^2	4.624 ***
EC	Y, Y^2, Y^3, TA, TA^2	2.692 ***
ET	Y, Y^2, Y^3, TA, TA^2	6.303 ***
E	Y, Y^2, Y^3, TR, TR^2	6.312 ***
EC	Y, Y^2, Y^3, TR, TR^2	2.330 **
ET	Y, Y^2, Y^3, TR, TR^2	7.331 ***

Note: *** denotes significance at the 1% level, and ** at the 5% level.

According to previous results, the second-generation Im-Pesaran-Shin root tests (CIPS) (Pesaran 2007) were performed in levels and first differences, considering intercept and trend. The findings indicate that series are $I(1)$ as test hypothesis is rejected at 10% significance level (Table 6).

Table 6. CIPS test.

Variables	Level	First Differences
E	1.243	−2.443 ***
EC	−1.392 *	−4.646 ***
ET	1.640	−5.281 ***
Y	−0.287	−4.231 ***
Y^2	−0.403	−4.355 ***
Y^3	−0.903 *	−5.183 **
TA	1.207	−2.312 ***
TA^2	−0.085	−2.451 ***
TR	− 0.884	−5.734 ***

Note: *** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level. Iterative process from 0–3 based on F-joint test used to calculate lags.

Taking previous results into consideration, one option is to estimate in first differences. In doing that, Equation (2) is expressed in growth rates, eliminating all fixed effects. In this case, the general equation to be estimated for each type of energy and tourism variable is the following:

$$\Delta\overline{E}_{it} = \Delta\overline{A}_{it} + \beta_1\Delta\overline{T}_{it} + \beta_2\Delta\overline{T}^2_{it} + \beta_3\Delta\overline{Y}_{it} + \beta_4\Delta\overline{Y}^2_{it} + \beta_5\Delta\overline{Y}^3_{it} + \beta_6\Delta\overline{U}_{it} + e_{it} \quad (3)$$

where: $\Delta\overline{A}_{it} = \delta_{t-1} = \delta_t$ and Δ denotes first differences.

Another option is testing for the existence of a structural long-run relationship as, in the case that this exists, it may also be adequate to estimate in levels. Therefore, the Westerlund (2007) test has been implemented, the cross-sectional dependence being accommodated by bootstrapping (200 replications). Table 7 shows that there is some evidence for cointegration of variables, making it also appropriate to estimate in levels.

Table 7. Westerlund co-integration tests.

Dependent Variable	Independent Variables	Cointegration tests			
		Gt	Ga	Pt	Ga
E	Y, Y^2, Y^3, TA, TA^2	−3.118 ***	−8.324	−7.425	−8.226 ***
EC	Y, Y^2, Y^3, TA, TA^2	−3.521 ***	−8.675 ***	−8.932 ***	−8.843 ***
ET	Y, Y^2, Y^3, TA, TA^2	−3.986 **	−4.467	−8.340	−5.243
E	Y, Y^2, Y^3, TR, TR^2	−3.854 ***	−5.699	−6.543	−4.876
EC	Y, Y^2, Y^3, TR, TR^2	−3.762 ***	−9.670 ***	−8.102	−6.539 **
ET	Y, Y^2, Y^3, TR, TR^2	−3.683 **	−5.873	−3.679	−2.997

Note: *** denotes significance at the 1% level, and ** at the 5% level. Test performed with constant and trend. Kernel bandwidth in accordance to 4(T/100)2/9.

In this case, the general equation to be estimated for each type of energy and tourism variable, is the following:

$$\overline{E}_{it} = \overline{A}_{it} + \beta_1\overline{T}_{it} + \beta_2\overline{T}^2_{it} + \beta_3\overline{Y}_{it} + \beta_4\overline{Y}^2_{it} + \beta_5\overline{Y}^3_{it} + \beta_6\overline{U}_{it} + e_{it} \quad (4)$$

Finally, before estimating (3) and (4), it is also necessary to test for the presence of heteroskedasticity and, in the case of levels estimates, for fixed effects. Therefore, the modified Wald test (Greene 2000) and the Hausman test were performed, respectively. Table 7 shows the presence of heteroskedasticity and the appropriateness to estimate by using the random effects model. Additionally, it is necessary to study the heterogeneity of the potential slope. Swamy's test for slope homogeneity (Pesaran and Yamagata 2008) was run. The results shown in Table 8 indicate the slope heterogeneity.

Table 8. Autocorrelation, heteroskedasticity and fixed effects.

Dependent Var.	Independent Variables	Tests			
		Heterosk. Levels	Heterosk. First Diff.	Hausman (Levels)	Slope Homog. (Delta)
E	Y, Y^2, Y^3, TA, TA^2	867.45 ***	134.45 ***	8.02	4.624 ***
EC	Y, Y^2, Y^3, TA, TA^2	765.43 ***	2077.32 ***	0.34	2.692 ***
ET	Y, Y^2, Y^3, TA, TA^2	5761.54 ***	3189.34 ***	3.16	6.303 ***
E	Y, Y^2, Y^3, TR, TR^2	1201.40 ***	128.34 ***	7.01	6.312 ***
EC	Y, Y^2, Y^3, TR, TR^2	1103.47 ***	2401.43 ***	0.39	2.330 **
ET	Y, Y^2, Y^3, TR, TR^2	1002.43 ***	3701.45 ***	3.02	7.331 ***

Note: *** denotes significance at the 1% level, and ** at the 5% level.

Considering the previous results, feasible generalized least squares (FGLS) are performed to estimate Equation (3) considering heteroscedasticity and contemporary correlation. Meanwhile, random effects ordinary least squares with Driscoll and Kraay standard errors (OLS-DK) is performed to estimate (4) as according to Hoechle (2007) this econometric procedure is robust to heteroskedasticity and cross-sectional dependence. In addition, in this analysis the dynamic ordinary least square (DOLS) is also performed.

4. Results

Tables 9–11 show the results of estimating Equation (3) and (4), by FGLS, OLS-DK and DOLS, respectively. Estimates by FGLS and OLS-DK include temporary dummies, while DOLS estimates include a trend. Table 9 shows the estimates of Equations (3) and (4), performed for final energy consumption for all sectors of the economy, when using tourist arrivals or tourism receipts as tourism indicators. All the estimates shown in Table 9 have been performed, without considering the term of cubed production. The elimination of the variable Y^3 has been considered adequate, since the results of the coefficient β_5 (corresponding to Y^3) are, in all cases, not significant, and the exclusion of the variable Y^3 does not significantly alter the value, sign and significance of the rest of the estimated coefficients. The reported results in columns 1, 3 and 5 are obtained when Equations (3) and (4) are estimated by using the tourist variable referring to visitor arrivals, while those in columns 2, 4 and 6 are obtained by using the number of tourism receipts.

The first differences estimate results presented in Table 9 indicate that the relationships between total final energy consumption and the production level in the economy (Y), are not linear. The coefficients relative to the variables Y and Y^2 are significant in all cases. According to the signs obtained for the coefficients of these variables ($\beta_3 > 0$ and $\beta_4 < 0$), the relationship between total final energy consumption and production is compatible with the EKC hypothesis. In this sense, starting from a production level, as production activity increases, the total final energy consumption decreases, which may be associated with improvements in energy efficiency. However, when estimating by levels, β_3 and β_4 coefficients are both positives and significant, indicating that positive and increasing relationships are observed between both variables. Therefore, in this case the Energy-EKC is not supported.

Table 9. Estimate results for total final energy consumption.

Variable	1 FGLS F. Dif. Arrivals	2 FGLS F. Dif. Receipts	3 OLS-DK Level Arrivals	4 OLS-DK Level Receipts	5 DOLS Level Arrivals	6 DOLS Level Receipts
TA	0.058 *** (0.015)		0.012 ** (0.001)		0.091 ** (0.045)	
TR		0.024 (0.017)		−0.117 *** (0.026)		−0.167 *** (0.041)
TA^2	0.006 *** (0.008)		0.010 *** (0.001)		0.013 (0.022)	
TR^2		−0.011 * (0.006)		−0026 *** (0.008)		−0.051 *** (0.015)
Y	0.034 *** (0.013)	0.034 *** (0.008)	0.327 ** (0.001)	0.504 *** (0.003)	0.382 *** (0.022)	0.494 *** (0.040)
Y^2	−0.036 *** (0.004)	−0.048 ** (0.002)	0.049 *** (0.001)	0.100 *** (0.013)	0.070 *** (0.009)	0.100 *** (0.019)
U	0.020 ** (0.002)	0.020 *** (0.002)	0.012 * (0.001)	0.005 *** (0.002)	−0.000 (0.004)	−0.000 (0.005)

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

The results related to tourism vary depending on the tourist variable used. Results for Equations (3) and (4) in columns 1 and 3 show that coefficients β_1 and β_2 are positive and significant. Therefore, the relationship between energy use and the number of tourists is not linear. The relationship is positive and progressively growing. Thus, as the number of visitors increases, so does the total final energy consumption, although there is a steeper rate of increase in total final energy consumption with increased tourist arrivals. Nevertheless, in the DOLS estimate results, the squared variable is not significant. Thus, only a linear positive relationship is observed. These results are not in line with those obtained by Jebli and Hadhri (2018) and Shaheen et al. (2019) for emissions. The authors find that tourism decreases carbon emissions in the top 10 tourism destination countries. However, as stated by Sun et al. (2022), the results in similar studies for countries with higher number of tourists are not homogeneous. Thus, in the recent study by Fethi and Senyucel (2021) for the top 50 destinations the relationship between the variables is neutral.

When the variable relative to tourism receipts is incorporated for estimating Equation (3), instead of the number of tourists, the coefficient is not significant for the variable and negative (but barely significant) for the squared variable. Then, Equation (3) is re-estimated eliminating the squared tourist variable (column 2), but β_1 is still not significant. Therefore, a significant relationship between total final energy consumption and income derived from tourism is not found. Nevertheless, it is worth noting that when it is estimated in levels, the tourism variable becomes negative and significant, indicating that more tourism receipts may reduce the final energy use. This result is consistent with that reported in similar studies using tourism receipts for measuring tourism, as in Muhammad et al. (2021), Qureshi et al. (2017), Tiwari et al. (2013) and Zaman et al. (2017). In addition, this result is reinforced when estimated by DOLS (columns 5 and 6). In this case, the squared variable also turns out to be negative and significant. Therefore, the progressive increase in tourist income decreases energy consumption.

The results in the previous models, related to tourism, seem to show that the relationship, between tourism and total final energy consumption is associated with the higher consumption derived from the greater population that is accumulated in a tourist area (due to the increase in the number of visitors), rather than the activities or spending that they undertake. In this sense, overtourism is related to an energy increase that can produce a worsening of the environmental conditions of localities, which may be combined with other negative impacts. Nevertheless, as stated in Butler and Dodds (2022), there is a lack of willingness to accept this problem and to manage it effectively.

Finally, the coefficient of the control variable (urban population) is positive and significant in all models. Thus, the trend towards urbanization in these countries increases final energy consumption.

Table 10 shows the results of estimating Equation (3) and (4) when the final energy consumption in the transportation sector is considered. The results reported in columns 7, 9, and 11 are obtained when using visitor arrivals, while the rest are obtained by using tourism receipts.

The FGLS estimate results presented in Table 10, related to the production variables (β_3, β_4 and β_5), are significant and have the same sign and similar values. These results indicate that the relationships between final energy use in the transport sector and the production level in the economy (Y), are not linear. The result reflects an inverted N relationship. Therefore, as the production level increases, the consumption of energy related to the transport sector increases to a point where the path of the curve is reversed. These results are also observed when estimating in levels. These results are in consonance with those obtained by Gyamfi et al. (2022) for all air and rail passengers.

Regarding the tourism variable, the estimate results depend again on the model used. All tourism variable coefficients are significant when estimating using tourism arrival (columns 7, 9 and 11), indicating that there is evidence in favor of a non-linear relationship between variables. The sign of these coefficients indicates that there is a positive relationship between variables. However, as the squared tourist arrivals variables are significant and negative, a decreasing relationship is observed from a certain level of tourist arrivals; that is, an inverted U shape is observed, supporting the tourism-EKC hypothesis. Therefore, tourist arrivals may reduce (at least proportionally) the transport energy consumption, if the number of passengers is large enough to take advantage of the efficiency gains that occur, when the number of passengers is high.

Table 10. Results of estimates for energy consumption in the transport sector.

Variable	7 F. Dif. FGLS Arrivals	8 F. Dif. FGLS Receipts	9 Level OLS-DK Arrivals	10 Level OLS-DK Receipts	11 Level DOLS Arrivals	12 Level DOLS Receipts
TA	0.048 *** (0.016)		0.118 *** (0.036)		0.077 * (0.006)	
TR		0.027 (0.025)		−0.090 *** (0.028)		−0.129 *** (0.044)
TA^2	−0.020 ** (0.009)		−0.062 *** (0.004)		−0.078 ** (0.032)	
TR^2				−0.035 *** (0.008)		−0.027 * (0.017)
Y	0.046 *** (0.017)	0.038 *** (0.019)	0.340 *** (0.039)	0.518 *** (0.007)	0.255 *** (0.043)	0.380 *** (0.056)
Y^2	−0.021 *** (0.005)	−0.019 * (0.012)	−0.038 *** (0.003)	−0.003 *** (0.003)	−0.083 * (0.042)	−0.004 * (0.003)
Y^3	−0.012 *** (0.003)	−0.010 ** (0.005)	−0.018 *** (0.078)	−0.033 *** (0.002)	−0.045 ** (0.029)	−0.007 *** (0.002)
U	0.024 *** (0.005)	0.027 *** (0.007)	0.013 *** (0.001)	0.009 *** (0.001)	0.013 *** (0.001)	0.009 ** (0.004)

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

Regarding tourism receipts, different results are obtained. The tourism coefficient shown in column 8 (by FGLS) is not significant. Therefore, no relationship is found between tourism receipts and transport energy consumption. Nevertheless, column 10 and 12 in Table 8 show the existence of a negative relationship between tourism and energy use. Therefore, once again, it seems that tourism drives energy consumption (to a certain level), due to the increase in population at the tourist destination, regardless of tourist expenditure, which could diminish the transport sector energy use. A quite similar result is obtained for Zaman et al. (2017), when analyzing the tourism expenditure on travel on energy consumption.

Finally, results in Table 11 show the estimates when final energy consumption in the commercial and public services sectors is considered as the dependent variable. Initially, Equation (3) was estimated including all the variables, using both *TA* and *TR*, alternatively. However, the lack of significance of some of the coefficients obtained motivated the decision to re-estimate them by successively eliminating the variables whose coefficients were not significant, first by eliminating Y^3, and then T^2 and Y^2. Alternatively, it has also been estimated considering T^2 and eliminating Y^2. In all cases, the obtained coefficients were similar in terms of significance and sign. Table 9 only shows those estimates referring to the simplest model (with *Y* and *T*), since it is the only case in which obtained coefficients are significant.

FGLS results show that coefficient β_3 is significant and positive. Therefore, a positive and significant linear relationship exists between final energy consumption in the commercial and public services sectors and the production level (*Y*). Thus, as the production increases, energy consumption in the commercial and public services sectors increases proportionally. On the other hand, coefficient β_1 is positive and significant for tourist arrivals (column 13) and not significant for tourism receipts (column 14). Therefore, it can be stated that a linear relationship exists between tourist arrivals and energy consumption in the commercial and public services sectors, while no significant relationship is found in this sector between tourism receipts and energy consumption.

Table 11. Results of estimates for energy consumption in the commercial and public services sectors.

Variable	13 F. Dif. FGLS Arrivals	14 F. Dif. FGLS Receipts	15 Level OLS-DK Arrivals	16 Level OLS-DK Receipts	17 DOLS Level Arrivals	18 DOLS Level Receipts
TA	0.190 *** (0.003)		0.105 *** (0.003)		0.098 ** (0.023)	
TR		0.058 (0.025)		−0.006 *** (0.004)		−0.020 ** (0.008)
TA^2			−0.088 *** (0.002)			
TR^2				−0.060 *** (0.014)		
Y	0.065 *** (0.040)	0.089 *** (0.007)	0.804 *** (0.092)	1.090 *** (0.070)	1.142 *** (0.142)	1.167 *** (0.182)
Y^2			−0.003 * (0.001)	−0.115 *** (0.010)	−0.048 * (0.032)	−0.060 ** (0.027)
Y^3			−0.064 *** (0.027)	−0.144 *** (0.594)	−0.120 *** (0.230)	−0.134 *** (0.040)
U	0.033 *** (0.007)	0.033 *** (0.006)	0.045 *** (0.004)	0.002 (0.000)	0.055 ** (0.25)	0.055 ** (0.026)

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

Columns 16 to 19 show the results when estimating in levels. Some differences are observed from previous estimates. Firstly, an inverted N shape is observed for the relationship between production levels and energy consumption, in commercial and public services sectors (in all estimates). Therefore, although there is a great positive elasticity for the greatest production levels, a trend to reduce the energy consumption is observed, which may be related to some efficiency gains. Secondly, the tourist arrivals and energy use relationship in this sector is compatible with the tourism EKC when estimating by OLS-DK, so an inverted U-shaped relationship is observed. Nevertheless, a linear relationship is observed when estimating by DOLS. Finally, the relationship between tourism receipts and the sectoral energy consumption is negative. Therefore, while tourist arrivals may increase energy consumption (at least up to a certain level), the increased tourism receipts may reduce this energy consumption.

5. Discussion

The obtained results show that tourism is an economic activity that may drive final energy consumption growth. For the whole economy, energy consumption tends to increase progressively (or at least linearly), as the number of tourists visiting the considered countries increases. Nevertheless, this progressive positive relationship becomes proportional and can even show an inverted U-shape when considering transport and commercial and public services sectors, if tourist arrivals are high enough to take advantage of energy efficiency, related to economies of scale.

This relationship between both variables may raise the environmental problem in the future if the way in which the activity is carried out does not change. The tourism recovery after the pandemic may have a consequence in energy consumption. On the one hand, the tourism increases may increase the current total energy consumption link to tourism, while in the recovery process it is possible that the scale economies disappear as the number of tourists is not yet big enough. Less tourist activity in the future does not seem to be the solution considering the added value and employment it generates. Therefore, changes in the mode of tourism production and consumption seem to be the only possible solution to reach net zero emissions in the sector.

On the production side, two alternatives may be appropriate: increasing the sector energy efficiency, either through more efficient capital investments or in organizing work in such a way that reduces energy consumption. However, these measures have been limited in the past (Sun et al. 2020), as even though new technologies can reduce energy consumption, the growth of the sector has more than offset such gains (Sun 2016). Thus, as stated in Sun et al. (2022), only if efficiency gains are faster and greater than the growth of the tourism sector, will these efficiency gains be able to decrease energy expenditure. This is something that has not happened in the past, so only relevant policy interventions can have an effect in achieving this end. Along these lines, it may be appropriate to carry out in-depth studies that analyze more efficient modes of production in specific fields and how the scale economies could be better exploited.

On the other hand, the energy change in the sector seems essential, either by increasing the use of renewable energy, directly in tourist establishments and means of transport, or by changing the country's energy mix, which allows, among other results, an increase in the use of renewable energies to produce electrical energy. This measure goes beyond the tourism sector and involves the energy exchange of the countries.

On the consumption side, awareness campaigns aimed at persuading tourists to carry out responsible energy consumption can help control and optimize its use. However, once again, encouraging tourists to be pro-media environmentalists has been found to be ineffective (Higham et al. 2016). Tourist behavior does not seem to respond to more sustainable consumption patterns (Sun et al. 2020) Despite this, new research such as that conducted by MacInnes et al. (2022), emphasizes habit as a driver of environmentally sustainable behavior among tourists. In this sense, providing information on environmental impact and asking for behavioral change will have little impact among tourists (Orbell and Verplanken 2010). However, generating automatism through habits can improve tourists' environmental behavior.

The obtained results also show that tourism affects energy consumption, when measured in terms of tourist arrivals. However, their spending does not seem to be related to that energy consumption. In this sense, it seems that energy expenditure is related to the volume of people who are concentrated in a certain place. For this reason, it may be advisable, at the national level, to carry out policies that tend to promote quality tourism, rather than quantity. Promoting higher spending per tourist, with the same level of tourism, would have positive effects on national income, avoiding an increase in energy consumption and even reducing it.

6. Conclusions

In this study, the relationship between energy consumption and tourist activity has been analyzed for the 15 countries with the highest number of international tourist arrivals in the 2000–2019 period by testing the energy EKC extended with tourism and the tourism EKC.

The results show some evidence in favor of the energy EKC hypothesis (but also in favor to a linear relationship) for the whole economy, and in favor of an inverted N-shaped relationship between energy and GDP for transport and commercial and public services sectors. The results also show a positive, increasing relationship, between energy consumption and tourist arrivals for the whole economy. However, there is some evidence of the tourism energy EKC hypothesis, when considering the transport, commercial and public services sectors. Most estimates reflect a negative relationship between tourism receipts and energy consumption, both in the economy as a whole and in the sectors analyzed.

These results indicate that the positive relationship between tourism and energy consumption seems to be associated with higher consumption derived from the increased population of the tourist destination rather than the spending undertaken by the tourists. Thus, the foreseeable growth in the number of tourists in 2024 at pre-pandemic levels could lead, at least in these countries under consideration, to an increase in total energy consumption. Thus, if the goal is to advance in the decarbonization and not to slow down the tourism growth, then it is appropriate to promote the use of non-polluting energy. A greater commitment to the use of renewable energies is therefore advisable. On the other hand, and with a view to avoiding the growth of energy consumption in the future, it may be appropriate to establish measures that favor the adoption of technologies or processes that contribute to reducing energy consumption per tourist. Nevertheless, the adoption of these potential gains must be faster and more important than the inflow of tourists, so only relevant policies can be useful for this purpose.

Furthermore, and given that the increase in tourism revenues seems to contribute to the decrease in energy consumption, it would also be advisable to promote higher quality tourism, with higher spending by tourists, which, with the same volume of tourism, would have positive effects on national income, avoiding the increase in energy consumption and level of emissions. Supporting sustainable and quality tourism becomes the key to maintaining a strategic economic sector, in a way that is compatible with environmental conservation, and the control of global warming.

It is important to note that this study is based on energy consumption data recorded until 2019. It is possible that from then until now, some of the activities developed by the sectors linked to tourism have adopted energy efficiency measures that have allowed the reduction of their consumption per unit produced or per tourist. The results offered here therefore do not contemplate these possible improvements in these years.

In future research, it may be convenient to advance in the knowledge of the relationship between energy consumption and tourism by disaggregating visitor demand into multiple groups. In this way, it will be possible to study which tourist profile generates greater energy expenditure and define the policies to be applied. Likewise, given that the growth of tourism seems to contribute to lower energy consumption, a study disaggregated by types of tourism that generate different levels of income may also be useful. In this way, it will be possible to determine which of these should be encouraged to a greater extent to reduce energy consumption. This will help to assess which tourism demand profile can reduce energy consumption and assist in the decarbonization process.

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