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ARTICLE

Impact of Sustainable Tourism on Environmental Changes in the Selected European Countries

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ABSTRACT

This study explores the relationship between tourism development and the quality of environment in the top five European economies, including Italy, France, Spain, Greece, and Germany, from 2000 to 2021. In using the Method of Moments Quantile Regression (MMQR), with the assistance of secondary data from the World Bank and the United Nations Development Programme (UNDP), the study provides a vast coverage of the tourism and environment relationship in terms of capturing the relationship between the Human Development Index (HDI), Gross Domestic Product (GDP) per capita Gross Domestic Product Per Capita Gross Domestic Product Per Capita, and the inflow of International Tourists and carbon dioxide (CO2) emissions in various quantiles. The results indicate that HDI is a strong determinant of CO2 emissions and is directly correlated in all quantiles. Conversely, GDP exhibits a consistent negative correlation, suggesting a structural decoupling of economic growth from carbon intensity, suggesting a structural decoupling of economic growth from carbon emissions in these developed nations. Most interestingly, international tourist arrivals exhibit heterogeneous effects which they are insignificant at the lower quantiles while turning to have a significantly negative impact at the 75th and 95th percentiles. These, therefore, present that tourism may add its quotas to emission reduction at higher carbon intensity levels through improving efficiencies. In conclusion, the study finds that government efforts should be directed at ensuring better environmental regulations and enhancing sustainable eco-tourism practices for the long-term ecological viability of the industry.

Keywords: Ecological Footprint; Sustainable Tourism; Human Capital; European Countries; Economic Decoupling

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1. Introduction

The tourism industry is complex and involves domestic and international travel meant for leisure, business, or professional visits. As the main catalyst in global economic integration, tourism development acts as an important tool in attracting international tourist visits to target locations and hence promoting cross-cultural understanding and awareness. As noted by the United Nations Tourism Organization (UNWTO)[1], the tourism sector is among the fastest-growing global industries; academic assessments, such as those by the reference[2], further highlight its contribution of over 7.7 trillion to the global GDP.

Within the European context, tourism has grown to become one of the mainstays of the economy, annually attracting millions of people from all over the world. It ensures a greater inflow of income, provides opportunities for people to get employed, and helps in building important infrastructural facilities such as roads and hospitable accommodations. In countries like Greece and Germany, the money received from tourism is often reinvested in sustainable infrastructure and in the care of the natural environment.

The Mediterranean, the most tourist-visited area around the globe, has faced extreme environmental pressures through unchecked development, symbolized by higher carbon emissions and habitat destruction. European countries, although aiming for the mitigation of economic disparities, face a paradox between establishing a "growth-at-all-costs" model through tourism, contrary to the European Green Deal's target of carbon neutrality by 2050. The key juncture is balancing the pursuit of exploitation with maintaining integrity.

However, despite these socio-economic benefits, it also presents a profound paradox. While it can promote awareness of nature conservation, in contrast, the "mass tourism" model often results in immense ecological degradation. High levels of tourist arrivals can exceed the carrying capacity of a destination, which then results in:

- Atmospheric Pollution: Increase in the level of greenhouse gas emissions from transport.
- Resource Depletion Overconsumption of water and energy.
- Ecosystem Disruption: Habitat destruction, loss of biodiversity, and land degradation caused by unplanned infrastructure development[2, 3].

This conflict between the development of tourism and the integrity of the environment is, in particular, a problem for the main tourist destinations in Europe, namely Germany, Greece, France, Italy, and Spain. The Mediterranean area, as the most visited in the world, is the foremost example where overwhelming development has caused severe environmental stress. The determination of European countries to develop the tourist sector to eliminate economic disparities often adopts a "growth-at-all-costs" culture. This tends to produce major environmental impacts such as:

- Marine Pollution: The issue of waste management and littering resulting from cruise ships.
- Carbon Footprints: Fossil fuel use in transport and infrastructure. This contributes to the greenhouse effect[4].
- Landscape Alteration: Deforestation and land preparation for the establishment of hotels and resort centers.

Even as tourism growth and environmental sustainability are considered a joint paradigm[5, 6], the actual phenomenon underscores the fact that the consequence of unmanaged growth is always irreversible in terms of environmental degradation. This paper explores the clouded paradigm surrounding the broader implications surrounding tourism, economic development, and environmental shifts in the five most prominent European states, namely Germany, Greece, France, Italy, and Spain, in an effort to consolidate a sustainable paradigm while addressing the double meaning associated with tourism development as a money-spinner against the environmental implications of water, diversity, and carbon emissions.

Consequently, further emphasized the non-linear impacts of tourism development on environmental sustainability to maintain terminology consistency throughout the paper. This paper is organized to deal comprehensively with the interplay between tourism and the environment; the organization is as follows. Section 2 explains the conceptual and theoretical framework related to this study. Section 3 delves into existing scholarly debates on sustainable tourism, ecotourism theories, and the "Environmental Kuznets Curve" in relation to the hospitality industry. In Section 4, we describe the process of data collection and specify the analytical framework applied in the assessment of environmental and economic indicators throughout Germany, Greece, France, Italy, and Spain. Section 5 sets out the empirical results with respect to the relationship between tourist arrivals, carbon emissions, and resource depletion in the chosen European countries. Finally, section 6 summarizes the contribution of the study at hand, mentions its limitations, and provides recommendations for future studies on sustainable tourism development.

2. Theoretical and Conceptual Framework

2.1. Definitions of Key Concepts

The following definitions shall form the basis of this study, bearing in mind analytical precision:

- Sustainable Tourism: In this work, the UNWTO definition, identified as an integrated management approach, assumes a central role aimed at minimizing negative impacts on the environment and local culture, while generating future employment and income for the host community. It relies on the optimal use of environmental resources that form a key element in tourism development.
- Environmental Change: For the purpose of this research, environmental change is interpreted as measurable anthropogenic alteration of the biophysical environment. More specifically, in this instance, it is measured as Carbon Dioxide (CO_2) emissions, loss of biodiversity because of infrastructure land-use change, and the depletion of natural resources such as water and energy born out of the large number of visitors.

2.2. Theoretical Foundations

The proposed analytical logic of this study is underpinned by two complementary theories:

- The Environmental Kuznets Curve (EKC) Hypothesis provides the main lens through which the impact of economic growth induced by tourism on environmental degradation is viewed. In essence, the theory postulates a curvilinear, inverted U-shaped relationship wherein, during the early stages of tourism development, environmental impact increases, for instance, rapid infrastructure expansion in Greece or Spain. However, beyond a certain level of economic threshold, these nations move toward cleaner technologies and stricter regulations, theoretically resulting in a reduction of environmental pressure.
- Tourism Carrying Capacity (TCC) Theory provides the rationale for "over-tourism," while the EKC focuses on economic growth. It defines the maximum level of visitor use an area can accommodate without high levels of degradation to resources or a decrease in the quality of the visitor experience. The present study uses TCC to explain why high tourist arrivals in Mediterranean destinations often lead to "ecological overshoot," which cannot be regenerated by the environment as quickly as it is being consumed.

2.3. Analytical Logic and Research Flow

The study follows a conceptual, staged analytical path to assess the five European countries: Germany, Greece, France, Italy, and Spain. The logic is organized as follows:

- Drivers: Inbound tourism intensity; International tourist arrivals, and GDP contribution by the industry.
- Mediating Mechanisms: Growth of the hospitality industry (infrastructure); energy use for transportation; development of waste management systems.
- Outputs (Environmental Impact): The environmental change that results, such as degradation of air and water quality and loss of biodiversity.

3. Literature Review

The tourism sector has grown to become a backbone of the European economy, propelling growth as a result of millions of foreign visitor arrivals each year. Yet the connection between tourism and the phenomenon of environmental change remains a complex paradox in various socio-economic aspects.

3.1. The Socio-Economic and Ecological Paradox

Tourism acts as a significant catalyst for economic development, being a major source of local Gross Domestic Product (GDP) and foreign exchange [7]. Beyond direct revenue, the sector infuses improvements in infrastructure and increases a destination's international visibility, which again acts as a stimulant for further international investment [2]. However, these very same economic benefits that might give financial incentives for conservation through waste management facilities and environmental education are very often overshadowed by unmanaged growth, resulting in "ecological overshoot" [2].

In Europe, the industry remains heavily dependent on fossil fuels, particularly in aviation, and thus is a significant challenge to environmental quality [8]. Motorized transportation and unplanned infrastructural development serve as the main transmission channels to pollution, habitat fragmentation, deforestation, and reduced biodiversity [9–11]. These pressures are acutely felt in Mediterranean littoral environments, where cruise ship operations coupled with improper waste disposal result in appreciable degradation of marine resources [12]. Current literature consequently highlights the pressing need for circular tourism patterns that are inclusive and responsible from an environmental perspective [6].

3.2. Environmental Thresholds and Structural Decoupling

Current research literature, moving away from descriptive cases, now addresses assessing the curve of tourism and carbon emissions. Amidst this discourse rests the curve of environmental degradation, known as the Environment-Related Kuznets Curve, which identifies that, at first, negative factors will increase as Human Development Indexes grow. However, as countries adopt better production processes, this degradation decreases [13]. For developed economies, specifically within Europe, there are indications of an "index of diminishing returns" for countries to sustain an improved standard of living while cutting their carbon emissions [14–16].

In fact, structural decoupling makes GDP growth no longer strictly indexed to rising CO_2 emissions [17]. On empirical grounds, decoupling is usually dependent on thresholds of carbon intensity: though tourism may exert pressure on the environment in its initial stages [18], the revenues emanating from mature economies are increasingly channeled for sustainable technologies to cushion these effects [19]. All of the studies confirm the existence of a one-way causality from tourism development to CO_2 levels, which suggests the necessity to conduct a more detailed analysis with regard to how these variables interact across different levels of environmental intensity [20].

3.3. The Scientific Necessity for MMQR (the Methodological Bridge)

Even though a clear relationship has been established in the literature, a rather important lacuna persists in terms of using mean-based estimation approaches. Classical Ordinary Least Squares (OLS) regression analysis concentrates only on the conditional mean. This overlooks complexities and "extremes," as hinted at in tourism and environment interactions. To fill this gap, this study adopts Method of Moments Quantile Regression (MMQR) [21]. In fact, the scientific exigency of MMQR is based on its capability of dealing with different levels of homogeneity. This carries a rather transparent and flexible analysis of different quantiles of carbon intensity. In traditional approaches, asymmetrical tourism and environment interactions can often become difficult; however, in MMQR, these asymmetrical levels become a rather important necessity in understanding tourism and environment interactions at both high and low carbon-emitting regions of Europe.

In summary, though the economic benefits of tourism cannot be denied, the extent to which tourism is a "smokeless industry" seems to be increasingly questioned by evidence-based research into its contribution to the problem of global warming and resource depletion. The following section will apply the "Method of Moments Quantile Regression" to examine these trends in the context of Germany, Greece, France, Italy, and Spain.

4. Data and Methodology

4.1. Data

For the proposed research, the selection of the independent variables encompasses three factors: Gross Domestic Product per capita (LGDP), the Human Development Index (HDI), and the natural logarithm of international tourist arrivals (LTOUR). To ensure the variance of the variables is stable and eliminate any heteroscedasticity, a natural logarithm transformation has been applied to the variables of GDP and TOUR. A dependent variable for the research will be carbon dioxide emissions (CO_2). The selected indicators include data gathered from the World Bank's World Development Indicators [22] and the UNDP Human Development Database [23] (**Table 1**) for the years 2000 to 2021 for the following European nations: France, Germany, Italy, Spain, and Greece.

Table 1. Data sources, definition, and their units.

Variable	Full Name	Data Source	Units
CO_2	Carbon Emission per capita	WB	Metric tons per capita
HDI	Human development index per capita	UNDP	Index (0–1)
GDP	Gross domestic product per capita	WB	Constant 2015 USD
LTOUR	Natural Logarithm of International Tourist Arrivals	WB	Number of arrivals

Note: UNDP: United Nations Development Programme and WB: World Bank.

4.2. Methodology

4.2.1. Cross-Sectional Dependence (CSD) and Unit Root Tests

In recent panel data analysis, cross-sectional dependence (CSD) typically appears because of unobservable common factors or economic links affecting panel parameters. The consideration of CSD is important because conventional panel unit root tests, like the IPS method proposed by Im et al. [24], neglect such issues, providing potentially misleading estimates. However, to guarantee robust results, this analysis will apply more advanced unit root tests that are reliable in situations with heterogeneity as well as CSD. The first step in the diagnostic process is to determine if CSD exists within the model. A significant outcome of the CSD tests calls for second-generation econometric methods to rid the data of their misrepresentation. We therefore utilize the Cross-sectional Augmented IPS test for stationarity as it is ideal in identifying unit roots with consideration for the identified dependencies among the five European economies.

4.2.2. Panel Cointegration and Causality

After carrying out stationarity tests, it is important to examine the equilibrium relationship based on economic variables. In this study, the panel cointegration analysis framework is used [25]. This framework allows for four statistics based on a panel and three statistics based on a group. These statistics include Augmented Dickey-Fuller test (ADF), v, ρ, and Phillips-Perron test (PP). Additionally, it also allows for three statistics based on a group, which include ADF, ρ, and PP. To make the findings even more robust, the Westerlund bootstrap panel cointegration test is applied [26]. This test is more reliable since it does not contain the 'common factor restrictions' that are usually embedded in the tests carried out using residuals. Failure to accept the null hypothesis in these tests ensures that there is a long-run relationship between the variables under investigation. Furthermore, the Dumitrescu and Hurlin panel causality test is applied to test the relationship between tourism activities and the indicators of the environment.

4.2.3. Method of Moments Quantile Regression (MMQR)

In order to evaluate the elasticity levels as well as differential effects in the distribution of CO_2 emissions, the approach used in this study is the "Method of Moments Quantile Regression" [21]. Standard methods of estimation are generally concerned with the conditional mean (average), which may disregard the nuances of the tourism-environment relationship. The proposed approach has several advantages:

- Robustness to Outliers: It prevents the estimate from being led astray by outliers within the data.
- Handling Heterogeneity: It allows the analysis of conditional heterogeneous covariance effects in different quantiles.
- Flexibility: It enables the scientist to adapt the method to particular research questions for the different levels of carbon intensity.

4.2.4. Model Specification

This function estimates the conditional τ-th quantile of the dependent variable Y (CO_2) given the predictor variables X (HDI, TOUR, GDP).

Equation (1):

$$Q_y(\tau \vdots X) = \alpha + X\beta + [\delta + X'_{\Upsilon}]q(\tau) \quad (1)$$

Where, $Q_y(\tau \vdots X)$ denotes the conditional τ-th quantile of Y on X, while $q(\tau)$ is the τ-th quantile of the error distribution.

To account for regional heterogeneity, we specify the empirical model as Equations (2) and (3):

$$CO_{2,it} = \alpha_i + \beta_1 HDI_{it} + \beta_2 LGDP_{it} + \beta_3 LTOUR_{it} + \varepsilon_{it} \quad (2)$$

$$Q_{CO_{2,it}}(\tau) = (\alpha_i + \delta_i q(\tau)) + \beta_1(\tau) HDI_{it} + \beta_2(\tau) LGDP_{it} + \beta_3(\tau) LTOUR_{it} \quad (3)$$

In this final form, α_i represents the region-specific fixed effects, while $\beta(\tau)$ captures the varying impact of tourism and development across different carbon intensity levels.

4.3. Discussion on Implicit Control Mechanisms

Although the empirical model is dominated by the necessity to estimate HDI, GDP, and tourism arrivals, these variables are considered as they play a pivotal role in functioning as a comprehensive proxy for major socio-economic transitions within the European framework. In the case of advanced countries like France, Germany, and Italy, the role of GDP is intricately coupled with major industrial transformations, as the growing GDP allows for an easy shift towards clean service-based economic activities. Moreover, HDI indicators are a very efficient measure identifying human capital and urban development. Moreover, HDI allows for adjusted acknowledgment of higher demands of energy and CO_2 emissions in regions having a very advanced economic standard, as depicted by the urban infrastructure of such countries. At the same time, all five countries are bound by the major European Union-enforced direct mandates, including carbon neutrality by 2050.

5. Results and Discussion

5.1. Findings

Figure 1 shows the CO_2 emissions trends for five countries (France—FRA, Spain—ESP, Italy—ITA, Greece—GRC and Germany—GER)) from 2000 to 2021. There is a general downward trend in CO_2 emissions across all countries and the GER country from 2000 to 2021. The decline is more pronounced in some countries compared to others.

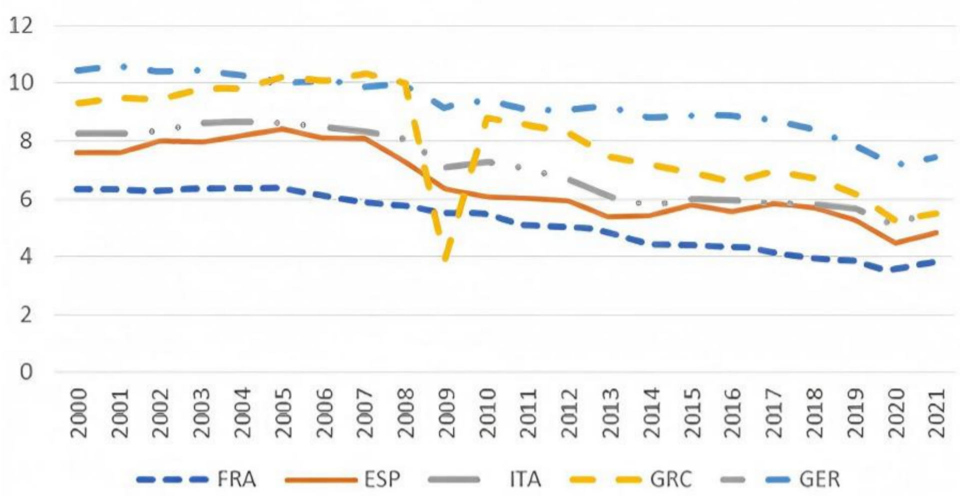

Figure 1. CO_2 Emission.

France (FRA): Represented by the dashed blue line, CO_2 emissions start relatively high but show a consistent decrease over the years. By 2021, France has one of the lowest CO_2 emissions among the compared countries. Spain (ESP): Represented by the solid orange line. Emissions peak around 2007–2008 and then sharply decline. The drop in emissions continues more gradually after 2008, maintaining a lower level similar to that of France by 2021.

Italy (ITA): Represented by the solid grey line. Shows a slight upward trend until around 2007 and then starts to decrease. Italy's CO_2 emissions follow a pattern similar to Spain, with a significant drop after 2008 and stabilizing at a lower level thereafter. Greece (GRC): Represented by the dashed yellow line. Greece exhibits high CO_2 emissions from 2000 to 2007, with a notable peak in 2007. There is a sharp decrease after 2008, which continues to decline until 2021. Germany: Represented by the dotted blue line. The GER country had the highest emissions in 2000. There is a significant decrease over time, particularly noticeable after 2008, although it remains higher than that of the individual countries by 2021.

Figure 2 displays tourism trends (presumably the number of tourists) from 2000 to 2021 for five entities: France (FRA), Spain (ESP), Italy (ITA), Greece (GRC), and Germany (GER). France (FRA): Represented by the red line. France experienced a steady increase in tourism numbers up to around 2017, peaking significantly, and then a steep decline in 2020. By 2021, the tourism numbers for France had significantly dropped. Spain (ESP): Represented by the solid green line. Spain shows a gradual increase in tourist numbers from 2000 to 2017, followed by a slight decline, and then a dramatic drop in 2020. The decline continues into 2021, reflecting the impact of travel restrictions during the pandemic. Italy (ITA) is represented by the solid grey line. Italy's tourism numbers remain relatively stable over the period, with a minor peak around 2017. There is a significant decline starting in 2020, consistent with the pandemic's impact on travel. Greece (GRC): Represented by the blue line. Greece shows relatively low and stable tourism numbers compared to the other countries, with a slight upward trend until 2019. A sharp decline is evident in 2020, with minimal recovery in 2021. GER (Germany): Represented by the yellow line. Germany (GER) shows a high and stable number of tourists from 2000 to around 2006, followed by a peak and then a drastic decline in 2020. By 2021, the number of tourists in Germany (GER) had decreased significantly, aligning with the trends observed in the individual countries.

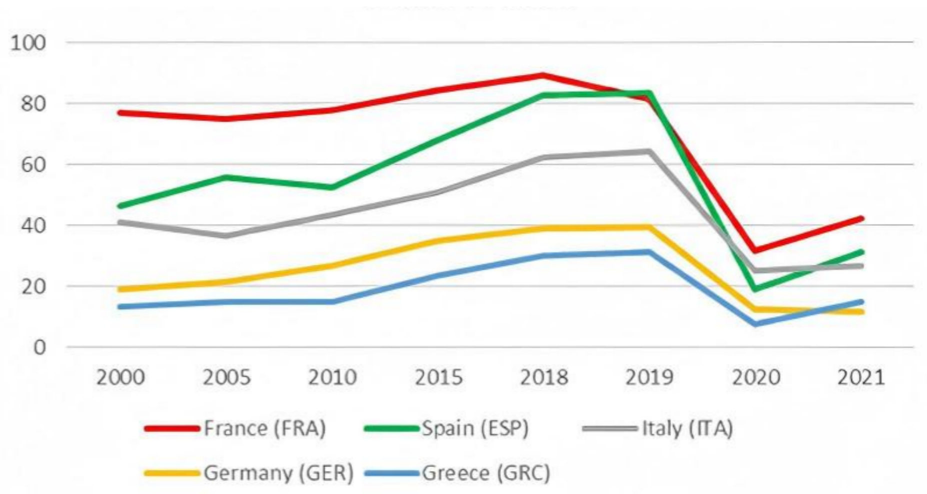

Figure 2. Tourist Arrivals.

The historical patterns shown in **Figure 2** are an important empirical basis for the interpretation of the MMQR findings. The presence of such high variability, which includes the shocking arrival decline in 2020 brought on by the global COVID-19 crisis, clearly shows why more conventional methods, including Ordinary Least Squares, are not applicable for this particular study. Rather, by applying the Method of Moments Quantile Regression, this study is impervious to such externalities, thereby guaranteeing that the findings are not affected by short-term phenomena. Moreover, the results bring into perspective the disparity that exists between the tourist intensities of the countries chosen for this research. France, with arrival intensities close to 90 million, along with Spain at around 83 million, performs greatly above Germany, followed by Greece, with arrival intensities around 50 million.

The cross-sectional dependence (CSD) test [27] shows that all economic indicators reject the null hypotheses and no cross-sectional dependence. According to **Table 2**, purpose of the Breusch-Pagan LM Test is to detect the presence of cross-sectional dependence in panel data models. Cross-sectional dependence means that there is correlation among the residuals of different cross-sectional units. The test statistic is 194.298 and the *p*-value is 0.000, which is highly significant (typically, $p < 0.05$ is considered significant). Since the *p*-value is less than 0.05, we reject the null hypothesis of no cross-sectional dependence. This implies that there is no cross-sectional dependence in panel data.

Table 2. Cross-section dependence test.

Test	Statistic	Prob.
Breusch-Pagan LM	194.298	0.000
Pesaran scaled LM	41.210	0.000
Pesaran CD	13.927	0.000

The Pesaran scaled LM test checks for cross-sectional dependence in panel data. It adjusts for large cross-sectional dimensions (N) and is more robust in the presence of heteroscedasticity. The test statistic is 41.210, and the *p*-value is 0.000. The significant *p*-value indicates rejection of the null hypothesis of no cross-sectional dependence. The Pesaran Cross-Sectional Dependence test is designed to detect cross-sectional dependence in panel data. It is particularly effective in panels with a large number of cross-sectional units (N) relative to the time periods (T). Statistic: The test statistic is 13.927. The *p*-value being less than 0.05 again indicates rejection of the null hypothesis.

Table 3 presents the results of the Pesaran Panel Unit Root Test, which investigates the stationarity and non-stationarity in panel variables across cross-sections (countries, firms, etc.). A variable is said to be stationary if its statistical properties-that is, mean or variance-have been time-invariant. Non-stationary variables may give misleading results in a regression analysis; hence, this test gives an idea whether a series has to be differenced or some other technique applied.

Table 3. Pesaran Panel Unit Root Test.

Variable	Statistic
CO_2	−2.240
HDI	−2.641
GDP	−3.217
TOUR	−2.351
Critical values at	α = 10%: −2.21 α = 5%: −2.33 α = 1%: −2.57

Note: Null hypothesis: homogeneous non-stationary.

CO_2 is significant at the 10% level. Hence, we reject the null hypothesis of non-stationarity at the 10% level of significance, which implies that CO_2 is stationary at this level. HDI is significant at 1% level. Therefore, HDI is stationary at 1%. The test statistic of GDP is less than all the critical values; therefore, rejecting the null hypothesis at all levels of significance 1% and implies that GDP is stationary. It can be observed that the test statistic of TOUR is less than the critical value at the 10% level of −2.21 and 5% level of −2.33, implying TOUR is stationary at these levels of significance. These results indicate that, practically speaking, GDP is the most reliably stationary variable at these significance levels, while others, such as CO_2, HDI, and TOUR, show mixed levels of stationarity depending on what level of significance you want to use. In any case, you would want to differentiate the non-stationary variables depending on the context of your analysis.

Before the results of the MMQR are interpreted, a diagnostic check for multicollinearity using the VIF was performed. Since the European nations selected are highly developed, it is expected that HDI and LGDP would not have effects that are collinear; this needs empirical verification. From **Table 4**, the VIFs of all regressors are well below the conventional threshold of 10, indicating that each variable adds unique information to the model.

Table 4. VIF Test.

Variable	VIF	1/VIF (Tolerance)
HDI	5.24	0.19
LGDP	4.62	0.216
LTOUR	1.59	0.628
Mean VIF	3.82	

Table 5 reflects the result of the Westerlund Cointegration Test, applied to a panel data set in order to determine whether the variables are related in a long-run equilibrium [26]. This test is immune to cross-sectional dependence in contrast to other tests. The four test statistics indicate that there is no support for the null of no cointegration at the 5% significance level ($p < 0.05$). This indicates that a long-run equilibrium relation among CO2, HDI, LGDP, and LTOUR does exist among the chosen European countries.

Table 5. Westerlund Cointegration Test.

Gt	Ga	Pt	Pa
−3.12**	−9.45	−8.17**	−10.04

Note: Null hypothesis: No Cointegration. ** presents the significance level at 5%.

The results of the Method of Moments Quantile Regression (MMQR) approach for the period between 2000 and 2021 are presented in **Table 6** below. The results have identified some definite trends in the distribution of carbon emissions among the selected European economies.

Table 6. MMQR Model.

Variable	Coefficient	Std. Error.	z-Stat	*p* > z	[95% Conf. Interval]	
qtile__05						
HDI	79.056	23.614	3.350	0.001	32.774	125.338
LGDP	−19.373	6.855	−2.830	0.005	−32.809	−5.937
LTOUR	1.562	1.218	1.280	0.200	−0.825	3.950
_cons	11.030	13.353	0.830	0.409	−15.141	37.201
qtile__25						
HDI	70.798	18.108	3.910	0.000	35.307	106.289
LGDP	−18.391	5.206	-3.530	0.000	−28.594	−8.187
LTOUR	0.493	0.979	0.500	0.614	−1.425	2.412
_cons	23.166	10.699	2.170	0.030	2.196	44.136
qtile__50						
HDI	59.540	12.060	4.940	0.000	35.903	83.176
LGDP	−17.051	3.445	−4.950	0.000	−23.804	−10.298
LTOUR	−0.964	0.672	−1.430	0.152	−2.281	0.353
_cons	39.712	7.351	5.400	0.000	25.304	54.120
qtile__75						
HDI	52.782	10.651	4.960	0.000	31.906	73.658
LGDP	−16.247	3.068	−5.290	0.000	−22.261	−10.233
LTOUR	−1.839	0.570	−3.220	0.001	−2.956	−0.721
_cons	49.643	6.236	7.960	0.000	37.420	61.867
qtile__95						
HDI	47.847	11.470	4.170	0.000	25.366	70.328
LGDP	−15.660	3.296	−4.750	0.000	−22.121	−9.199
LTOUR	−2.477	0.624	−3.970	0.000	−3.700	−1.255
_cons	56.896	6.842	8.320	0.000	43.487	70.305

HDI is a significant and positive determinant of CO_2 emission for all quantiles (5th to 95th). The positive relationship between the two variables indicates that as the indicators of human development increase, the use of energy and consequently the emissions increase at first. The gradually decreasing coefficient in the higher quantiles reveals the diminishing return to the variable of human development; this may suggest that the developed countries are at a stage where the welfare of the residents can be ensured with less additional cost to the environment. The decline in the coefficient value in higher quantiles implies an aspect of diminishing returns to human development, indicating that the developed countries can sustain the welfare of citizens residing in them at a declining environmental cost. This view is in tandem with recent findings by Oben et al.[18], who found that even though developing countries require higher emissions to attain a high level of HDI, top emitters display a stable state. In particular, the strength of possibly negative correlation in high-income economies supports what they call the "Pollution Halo Hypothesis," according to which high-quality human capital promotes "clean" technological transitions. By contrast, as underlined in the reference[28], in emerging economies, a sharper "emission trajectory in early stages of HDI growth is likely to be driven by early challenges in environmental protection." Such findings stress the importance of comprehensive global warming policies responsive to stages of development and to technological innovation–environment interactions.

The finding that the coefficient of LGDP is negative and significant for all quantiles from the 5th to the 95th has been one of the main outcomes of this study. It indicates a strong form of "Decoupling" in the chosen European countries that economic growth can no longer be seen as a contributor to the increase in carbon emissions in the aforementioned mature economies. This can be ascribed to the advanced stage of the Environmental Kuznets Curve, where the materialization of economic prosperity provides for the implementation of the complete transition into a clean and technology-based economic system. This negative and stable effect signifies a structural decoupling of economic growth and carbon emissions in the case of Germany, Greece, France, Italy, and Spain. This defies conventional results in the case of developed OECD nations, whereby a 1% increase in economic growth led to a corresponding increase of 0.86–1.07% in emissions [29, 30]. The findings confirm the advanced stages of the Environmental Kuznets Curve, thereby supporting the fact that these countries have achieved a certain level of prosperity, enough for the transition towards cleaner technologies. The successful execution of tools like ecological taxes or trading systems on emissions has been portrayed through this complex form of the Environmental Kuznets Curve.

The findings in **Table 6** show that the nonlinear effect of international tourism is insignificant for lower quintiles (5th to 50th percentiles), but becomes considerably negative at the 75th and 95th percentile. Notably, the negative effect of tourism at relatively high carbon intensities (75th to 95th percentiles in the graph below) has significant implications. It suggests that when the background emissions tend to be high, the tourism industry may be enhancing efficiency. On the other hand, negative impacts at high carbon intensities indicate that a tourism sector may be promoting efficiency in a rather green and advanced manner within a more industrialized or high-emissions environment. Contrary to the view of León et al. [31] that the contribution of tourism in terms of climate change mitigation in developed countries is greater, our results agree with the view of Paramati et al. [32] and imply that the reduction of emissions in the tourism sector in developed economies takes place at a faster rate because of the EKC approach. Our findings support Koçak et al. [19], who showed that although basic arrivals can exert a pressure effect on the counterpart component, earnings from tourism often have a reducing impact on emissions through investment in low-carbon production. Notably, the negative influence of CO_2 emissions on world tourism in the specified regions of developed countries listed in Nademi [33] confirms that the production-consumption approach should aim at low emissions.

In summary, HDI and GDP are both influential factors for CO_2 emissions in all quantiles, although their effects are quite different: while HDI remains a positive driver, GDP seems to have a decoupling effect. Tourism represents a threshold variable for high levels of carbon, given its significant role in accelerating the decrease of CO_2 emissions by improving sectoral efficiencies.

5.2. Discussion

The empirical results using the MMQR method present a detailed view of the tourism-environment nexus in the European perspective, showing trends that sometimes go along with and at other times are different from global patterns.

5.2.1. Comparative Analysis of Economic Decoupling

One of the key results from this analysis is that, across all quantiles, LGDP is negatively correlated with CO_2 emissions. Such "structural decoupling" suggests that economic growth is no longer a main driver of environmental degradation within mature European economies such as Germany and France. Comparatively speaking, against emerging regions such as the ASEAN countries or South Asian economies, this brings about a complete change in results. For these countries, many studies often find evidence on the positive association between GDP and emissions, indicating that they have not yet passed through the carbon-intensive stages of EKC. Our results reinforce how these five European nations have reached the latter stages of the EKC, where prosperity provides the chance to adopt cleaner technologies.

5.2.2. Quantile Sensitivity and Tourism Efficiency

As such, the non-linear impacts and heterogeneous effects of LTOUR, international tourist arrivals, signify an important deviation from general global reports. Showing insignificance at the lower quantiles while being significantly negative at the 75th and 95th percentiles, arrivals in many developing tourism hubs are synonymous with increased emissions on account of underdeveloped green infrastructure. However, our results seem to indicate that the tourism sector is an agent of green efficacy in high-intensity European environments. At higher quantiles of arrival volumes, the resultant revenue and regulatory pressure drive investments in sustainable infrastructure and carbon-neutral transportation. The "efficiency effect" at higher quantiles, therefore, suggests that the European model of tourism is tending towards a more sustainable equilibrium compared with less developed global contexts.

5.2.3. Human Development vs. Environmental Cost

Despite these positive trends in GDP and tourism, the steady positive HDI highlighted another issue. Though these countries are capable of maintaining their welfare standards with a growing, but relatively, decreased environmental price tag, indicated by the smaller coefficients at higher quartiles, their absolute price tag of high living standards contributes to emissions. Essentially, this reflects the global reality that "the scale effect associated with high human development will usually counterbalance technological advances". Hence, our results suggest, for European policy, "decoupling plus, not just greater efficiency, but absolute reductions in emissions in HDI environments".

5.3. Robustness and Reliability of the Estimations

However, to mitigate concerns about small sample size (N = 5, T = 21) and the precision of extreme values of the 5th and 95th quantiles, robustness analysis is conducted. Though MMQR is an asymptotic estimator, it performs extremely well in small panel data because this estimator ignores individual effects without adding significantly to the number of model parameters to be estimated.

To check the robustness of our results, we compare the median MMQR outcomes with Fully Modified Ordinary Least Squares (FMOLS) results. As shown in **Table 7** below, the negative and significantly different LGDP parameter remains the same in the two cases, hence rejecting the hypothesis of no "structural decoupling" for these countries. Moreover, the sign of LTOUR remains consistent with our findings in the upper quantile, so that the efficiency in the tourism sector remains a characteristic of the intensive market of Europe. This shows that in 110 observations, the MMQR approach provides efficient results in the context of Europe.

Table 7. Robustness Check—Comparison of MMQR (Median) and FMOLS.

Variable	MMQR (50th Quantile)	FMOLS (Mean Effect)
HDI	59.54	62.115
LGDP	−17.051	−18.42
LTOUR	−0.964	−1.102

6. Conclusions

6.1. Conclusions

In this research, the relationship between tourism development and the state of the environment in Germany, Greece, France, Italy, and Spain can be explained by the complex economic and environmental paradox. It appears that the immense development potential of tourism as the main element in the economies of the mentioned European countries, contributing to the influx of money and the promotion of intercultural knowledge, often turns out to be environmentally destructive to the extent of resource depletion and destruction. In this context, the results mentioned in the MMQR method demonstrate the heterogeneous effects and non-linear impacts of the tourism sector as an agent of green efficacy in high-emitting environments. It must be noted, in any case, that the negative impact of the Gross Domestic Product factor on the CO_2 in all cases informs us that the mentioned countries successfully proceed to the final stages of the Environmental Kuznets Curve.

Moreover, the result that the global arrival of tourists affects the emission of CO_2 in a negative manner but only for the 75th and 95th percentiles also shows that the tourism sector can act as an agent of green efficacy in high-emitting environments. It also shows that as different environments increase in their emission level, the tourism sector tends to move towards infrastructure development and enhance its standards of green efficacy. In the end, this paper shows that even if human development (HDI) is the major factor in the emission level in these environments, the key to green efficacy necessarily lies in using the tourism sector as an agent of green innovation and not just a money-spinner.

6.2. Policy Recommendations

The transition towards sustainable tourism has to be supported by a complex and progressive approach to policy, which combines economic incentives and strict ecological criteria. On account of the empirical result showing decoupling in GDP growth and emission levels, governments need to focus on "decoupling-plus" policies, which extend beyond efficiency-oriented decoupling and focus on actual emission reduction. This requires the adoption of an overall green energy requirement in the tourism industry itself, targeting hotel and resort construction and operation in relation to the use of renewable energy sources rather than fossil fuels. Regarding tourism's "Achilles heel," transportation, it is essential to promote the adoption of carbon-neutral transportation modes like electric or hybrid transportation fleets in relation to transportation of customers through the adoption of high-speed transportation links consolidated as an alternative mode for short-haul flights.

Moreover, based on the strong environmental impact noted in other Mediterranean countries such as Greece and Spain, it is imperative to implement "Tourism Carrying Capacity" protocols. Such protocols must go beyond estimating tourism in areas of biodiversity to avoid environmental overload, while they should also have environmental taxes levied to support local conservation programs addressing environmental issues such as waste. Moreover, in order to address marine and natural environmental pollution, concrete "zero-plastic" measures should be applied in cruise ship services and hotels, besides advocating for environmental portfolios in local education programs to encourage responsible tourism practices. With such initiatives, European countries will be able to achieve environmental sustainability in tourism while still enjoying economic benefits in this sector.

6.3. Limitations and Future Research

While this study identifies robust empirical evidence using the Method of Moments Quantile Regression approach, there are several methodological and data-related limitations that mark the boundary of findings from this study.

The analysis is exclusively confined to the top five European economies, namely Germany, Greece, France, Italy, and Spain. These are representative countries for the major global tourism hubs; therefore, results may not be applicable to emerging economies or small island developing states, since there the tourism-environment nexus may take a different route altogether.

This study quantifies environmental change, primarily through Carbon Dioxide (CO_2) emissions. While CO_2 is an important indicator of atmospheric pollution, it falls short in fully capturing other important dimensions of environmental impact, such as biodiversity loss, plastic waste in marine ecosystems, and/or localized land degradation due to tourism infrastructure.

The time series considered for the study runs from 2000 to 2021. The data period covers a uniquely disruptive event, the COVID-19 pandemic, that brought abrupt, non-structural changes to tourist arrivals and emissions rates in 2020. Although MMQR models are efficient at handling outliers, more drastic external shocks can create short-term distortions to trend lines.

Even though the MMQR method successfully handles heterogeneity and cross-section dependence, the accuracy of the nonprimary data, in this case, the World Bank and UNDP, can affect the robustness of the coefficients. If the five countries have differing standards in the presentation of the data, there might be possible effects on the estimates of the coefficients.

Moreover, although HDI and GDP are good proxies for social and economic structure, the omission of disaggregated data concerning energy composition (for instance, the share of renewable energy sources to fossil fuels) could be viewed as a deficiency in this analysis since it may affect the level of detail in the results. The two high-resolution factors could be integrated in subsequent research to improve the outcome of the Tourism-Environmental Kuznets Curve.

Future studies should focus on using a wider range of environmental indicators, like the ecological footprint, and attempt to conduct geographic analysis over both developed and developing areas in a comparative study in order to verify the Tourism-Environmental Kuznets Curve (T-EKC) hypothesis.

Author Contributions

Conceptualization, M.S.; methodology, M.S.; software, M.S.; validation, M.S.; formal analysis, M.S.; investigation, M.S. and N.T.G.; resources, N.T.G.; data curation, N.T.G.; writing—original draft preparation, N.T.G.; writing—review and editing, M.S.; visualization, M.S.; supervision, M.S. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

Since the research does not consider human participants, animal subjects, or sensitive human data, the study does not need an Institutional Review Board (IRB) statement, as the study exclusively involves secondary data found in the public domain.

Informed Consent Statement

Not applicable, as no human subjects were involved in the data collection process.

Data Availability Statement

The economic and tourism data parameters (GDP, TOUR, and CO_2) have been sourced from the World Bank, whereas human development parameters (HDI) have been sourced from the UNDP. See references 22 and 23 for database versions and access links.

Conflicts of Interest

The authors declare that they have no competing interests or financial conflicts that could have influenced the outcomes of this research.

AI Use Statement

The authors used Grammarly for language refinement and take full responsibility for verifying the accuracy and integrity of the manuscript.

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