Tourist Spending Capacity and Greenhouse Gas Emissions: Evidence from European NUTS2 Regions

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February 28, 2026

Abstract

This paper examines the relationship between tourism intensity and greenhouse gas (GHG) emissions across 238 NUTS2 regions in the European Union over 2014–2023, distinguishing tourism segments by spending capacity, proxied by nights spent in hotels (high-spending) versus nights in other short-stay accommodation (low-spending). We combine regional emissions and economic accounts with tourism statistics and estimate two–way fixed effects models and, to account for spatial interdependence that tipically affects these phenomena, we also consider spatial error and spatial lag panel specifications based on a k-nearest-neighbours weights matrix. Sectoral results indicate that differences between the two segments are most evident for Buildings emissions, whereas high-spending tourism correlates positively with Transport and Waste emissions. Overall, the findings suggest that the tourism–emissions nexus is source-specific and depends on the composition of tourism demand, with implications for targeted and spatially coordinated sustainable tourism policies.

Keywords: Tourism, Energy, GHG emission, spatial statistics.

JEL code: Q50 Environmental Economics; R11 Regional Economic Activity: Growth, Development, Environmental Issues, and Changes; Z30 Tourism Economics.

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1 Introduction

Tourism has become one of the most dynamic components of the global economy. International tourist arrivals have grown steadily over recent decades, generating income, employment, and investment opportunities. At the same time, the expansion of tourism has raised increasing concerns about its environmental consequences, particularly greenhouse gas (GHG) emissions and energy use. Once transport, accommodation, and ancillary services are considered, tourism accounts for a non-negligible share of global emissions, making the sector a critical element in the broader climate-change mitigation debate (Gössling, 2013). Understanding whether and to what extent tourism development contributes to environmental degradation has therefore become a central research and policy question.

A large empirical literature has examined the tourism–environment nexus using cross-country panel data. Many studies find that tourism expansion is associated with higher energy consumption and CO_2/GHG emissions within STIRPAT, EKC, and related frameworks (León et al., 2014; Nepal et al., 2019; Salahodjaev et al., 2022; Khan et al., 2019). At the same time, the magnitude and even the sign of the estimated effect can vary with income levels, energy mix, and institutional characteristics, as suggested by recent meta-analytical and model-averaging evidence (Aller et al., 2021). Beyond correlations, country-specific time-series and dynamic panel approaches also point to causal links running from tourism growth to higher energy demand and emissions, while allowing for feedback mechanisms whereby environmental quality can in turn affect tourism demand (Katircioglu et al., 2014; Eyuboglu and Uzar, 2020; Jayasinghe and Selvanathan, 2021; Qureshi et al., 2017; Shi et al., 2020; Kuldasheva et al., 2023; Zikirya et al., 2021).

Complementary contributions use sectoral, regional, and accounting-based methods to identify channels and source contributions. Input–output and life-cycle assessments show that indirect emissions and transport-related components can dominate the tourism footprint (Sharp et al., 2016; Cai, 2016; Konan and Chan, 2010). Other regional studies document that tourism-related electricity use, waste generation, and local energy intensity can be important drivers of emissions, and that the tourism–emissions relationship may display spatial spillovers (Robaina-Alves et al., 2016; Algieri et al., 2022; Liu et al., 2024; Zhou et al., 2023). These findings reinforce the view that tourism can generate substantial environmental pressures, but that impacts depend on destination characteristics and the composition of tourism demand.

Recent research has begun to explicitly account for spatial interdependence in the tourism–emissions relationship. Using a panel of 95 countries, Li and Lv (2021) show that national emissions exhibit significant spatial dependence and that tourism development in one country can affect environmental outcomes in neighboring economies. At the regional level, Dong et al. (2023) analyze carbon transfers embodied in tourism flows across Chinese provinces and demonstrate that interregional linkages play a crucial role in determining the overall carbon footprint of tourism. These studies underline that ignoring spatial interactions may lead to biased estimates and that tourism-related emissions often spill over administrative boundaries, a feature that is particularly relevant in integrated areas such as Europe.

Another stream of research examines policy instruments aimed at reducing tourism-related emissions. Transport is widely recognized as a major source of tourism emissions, especially in mass-tourism destinations (Cavallaro et al., 2017). Evidence also suggests that tourists may support greener services, implying scope for environmental pricing and incentives (Bigerna et al., 2019). A key challenge is measurement of willingness to pay under preference uncertainty; Voltaire et al. (2013) propose an approach that allows respondents to provide intervals when uncertain and show how uncertainty-adjusted valuations can be computed. Related work indicates that energy and fuel-price policies can affect tourism-related behavior (e.g., cross-border fuel tourism) (Bergantino et al., 2025), and that environmental stringency may influence tourism demand in the short run while supporting higher expenditures and sustainability in the longer run (Tunçel et al., 2026). However, these contributions rarely differentiate tourists by spending capacity or consumption profile.

Despite the breadth of existing research, important gaps remain. First, most empirical studies rely on national-level data, masking substantial within-country heterogeneity in economic structure, energy systems, and tourism specialization. Regional analyses are still relatively scarce for Europe, where cross-border mobility and dense economic integration make spatial interactions especially relevant. Second, the literature typically treats tourism as homogeneous, relying on aggregate indicators such as arrivals or receipts. Yet tourists differ markedly in spending capacity, consumption patterns, and environmental preferences. High-expenditure tourists may demand more energy-intensive services, but they may also be more willing to pay for sustainable options; the net effect of these opposing forces has not been systematically investigated.

This project addresses these gaps by analyzing the relationship between tourism and regional GHG emissions in Europe at the NUTS2 level. Detailed regional data allow us to move beyond country averages and capture heterogeneity across destinations. We distinguish between tourism segments with different spending capacities, proxied by nights spent in hotels (NACE I551) versus nights in other short-stay accommodations such as B&Bs, hostels, and camping sites (NACE I552–I553). This proxy is supported by micro-level evidence showing that accommodation type is strongly associated with total travel expenditures and broader consumption patterns (Park et al., 2020). This distinction enables us to assess whether a shift toward higher-spending visitors increases or decreases the environmental footprint of regions.

Furthermore, given that emissions and economic activities are spatially correlated across neighboring areas, we explicitly incorporate spatial dependence into our empirical models, following recent advances in spatial econometrics and the First Law of Geography (Tobler, 1970; Elhorst, 2024). By combining a regional perspective with a disaggregated view of tourism demand, this study provides new evidence on how different types of tourists contribute to emissions and how these effects propagate across space, offering relevant insights for the design of more targeted and effective sustainable tourism policies.

2 Data and Methodoloy

The empirical analysis is based on a panel dataset of 238 NUTS2 regions in the European Union observed over the period 2014–2023. The core variables are drawn from the ARDECO database, which provides harmonised regional accounts, productivity indicators and GHG emissions, complemented with regional tourism statistics from Eurostat. The dependent variable is the logarithm of total GHG emissions from human activities in each region and year, measured in thousand tonnes of CO_2 equivalent, denoted by $\ln E_{it}$, where i indexes regions and t years. The set of controls follows the models used in the literature (Vagnini et al., 2024; Lodi and Bertarelli, 2024; Ketenci, 2021). To capture the scale of economic activity, we include the logarithm of real GDP per region and its square. The economic structure is summarised by value added per capita in agriculture (NACE A) and in industry and energy (NACE B–E). Labour productivity is measured as real GDP per hour worked, reflecting differences in technology and efficiency across regions. Tourism intensity is proxied by the annual number of tourist nights in each region, disaggregated by type of accommodation. We distinguish between hotel nights (NACE I551) and nights spent in other short-stay accommodation such as B&Bs, camping sites and hostels (NACE I552–I553). After taking logarithms, these two variables, denoted T^H_{it} and T^O_{it}, are interpreted as proxies for the intensity of "higher-budget" and "lower-budget" tourism segments, respectively.

Figure 1 presents three maps of European NUTS2 regions reporting, for each region, the annual average number of tourist nights over 2014–2023.

The starting point is a two–way fixed effects panel model of the form

$$\begin{aligned}\ln E_{it} = \alpha_i + \tau_t + \beta_1 \log(\mathrm{GDP}_{it}) + \beta_2 \big[\log(\mathrm{GDP}_{it})\big]^2 + \beta_3 \mathrm{GVA}^A_{it} \\ + \beta_4 \mathrm{GVA}^{BE}_{it} + \beta_5 \mathrm{Prod}_{it} + \beta_6 T^H_{it} + \beta_7 T^O_{it} + u_{it},\end{aligned} \tag{1}$$

where α_i are region fixed effects, τ_t year fixed effects and u_{it} is an idiosyncratic error term. The coefficients on the tourism variables, β_6 and β_7, are of primary interest.

Equation (1) is estimated by within (fixed effects) regression using the `plm` package with two–way effects.

In addition, in the specifications that follow we explicitly account for spatial dependence, as regional emissions data are well known to exhibit strong spatial autocorrelation. Descriptive evidence based on Moran's I indices computed for sectoral

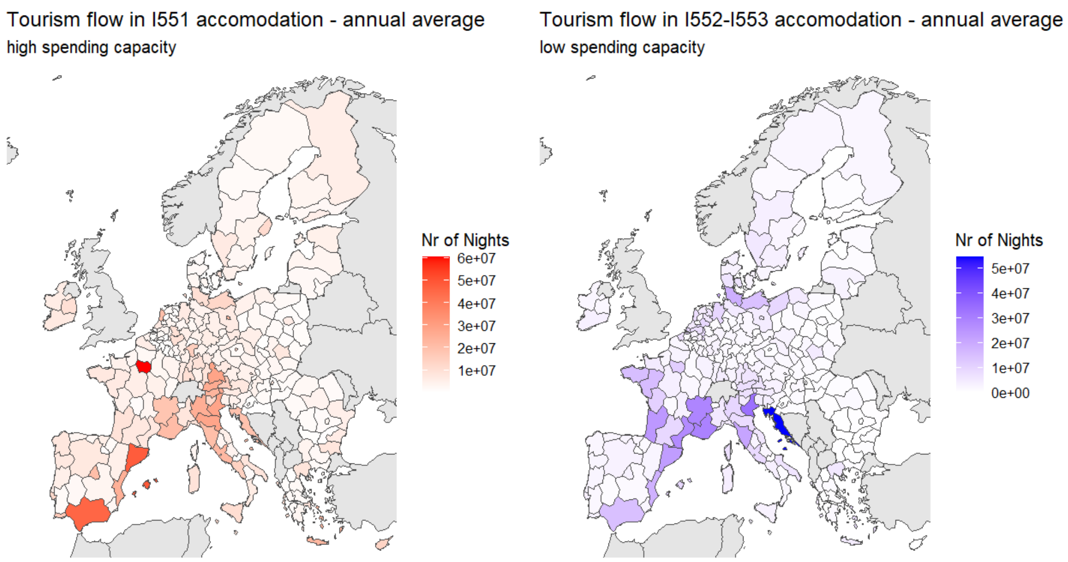

Figure 1: Tourism intensity at the NUTS2 level in the EU (annual average, 2014–2023): on the left, nights spent in hotels as a proxy for the higher-spending tourism segment (high spending capacity), and, on the right, nights spent in other short-stay accommodation (e.g., B&Bs, camping sites and hostels) as a proxy for the lower-spending segment (low spending capacity).

emissions and for different types of greenhouse gases at yearly frequency highlights pervasive spatial clustering in European regional emissions, underscoring the importance of modelling the spatial component when handling these data (Morelli et al., 2026). This motivates the use of spatial panel specifications alongside the baseline two–way fixed effects model, allowing both for correlated shocks across neighbouring regions and for potential spillovers in emission outcomes. Spatial dependence is introduced through a row–normalised geographic weights matrix W based on the 20 nearest neighbours for each region. For each region i, the 20 closest neighbours (excluding itself) are assigned a raw weight of 1 and all others 0 (Elhorst, 2010). The matrix is then row normalised so that $\sum_j w_{ij} = 1$. This matrix captures spatial proximity and is used both in spatial error and spatial lag specifications. As a robustness check, we also use the 10 nearest neighbours matrix.

To allow for spatial autocorrelation in the disturbances, we estimate a spatial error model where the error term follows a spatial autoregressive process:

$$\ln E_{it} = \alpha_i + \tau_t + X_{it}\beta + u_{it}, \tag{2}$$

$$u_{it} = \rho \sum_j w_{ij} u_{jt} + \varepsilon_{it}, \tag{3}$$

with X_{it} collecting all regressors in equation (1). The parameter ρ measures the degree of spatial correlation in the composite errors.

As an alternative, we consider a spatial lag specification where the dependent variable enters with a spatial lag:

$$\ln E_{it} = \alpha_i + \tau_t + \lambda \sum_j w_{ij} \ln E_{jt} + X_{it}\beta + \varepsilon_{it}, \tag{4}$$

where λ is the spatial autoregressive coefficient. In this case, emissions in each region depend directly on emissions in neighbouring regions, for example due to shared technologies, policy spillovers or physical diffusion of pollutants. This model is estimated with `spml` (Millo, 2014).

To shed light on the mechanisms behind the baseline effect, we also estimate the models using source-specific GHG emissions as dependent variables, considering separately emissions from Agriculture, Buildings, Energy, Industry, Transport and Waste. In addition, we formally test whether the coefficients on high-spending (hotel) and low-spending (other accommodation) tourism flows differ, to enable a direct comparison of their impacts across emission sources.

3 Empirical findings

The two-way fixed effects regression (column 1 of Table 1) confirms the expected role of core economic drivers.

In all specifications, the coefficient on the log of hotel nights is negative, and it is statistically significant at the 5% level in the fixed effects and spatial lag models, and close to the 10% threshold in the spatial error model. By contrast, the coefficient on nights spent in other, typically lower-cost, forms of accommodation is positive but not statistically significant, with p-values between 0.09 and 0.16 depending on the specification. Conditional on income, sectoral structure, productivity and time and region fixed effects, these results suggest that regions attracting relatively more high-cost hotel tourism tend to exhibit slightly lower total emissions than otherwise comparable regions, whereas the intensity of low-cost accommodation does not display a clear association with emissions. The spatial models in columns 2 and 3 confirm the importance of spatial dependence. In the spatial error specification, the estimated spatial error coefficient is positive and highly significant, indicating that unexplained shocks to emissions are correlated across neighbouring regions. In the spatial lag specification, the spatial autoregressive coefficient is likewise positive and significant, implying that emissions in one region co-move with emissions in nearby regions, in line with the presence of spatial spillovers. The results hold using 10 nearest neighborhood spatial matrix.

This pattern is consistent with the idea that high-spending tourists may generate a relatively smaller environmental impact at the regional level, possibly because they choose less emission-intensive options or concentrate expenditure in sectors with a lower emissions intensity, but the evidence is not strong enough to support a definitive claim.

Table 1: Determinants of regional GHG emissions

	(1) Panel Model	(2) Spatial Error	(3) Spatial lag
log(GDP)	2.346***	2.231***	2.205***
	(0.241)	(0.232)	(0.227)
$[\log(\text{GDP})]^2$	-0.092***	-0.086***	-0.087***
	(0.012)	(0.011)	(0.011)
GVA_A per capita	-2.369***	-2.463***	-2.271***
	(0.365)	(0.357)	(0.344)
GVA_{BE} per capita	0.177	0.223*	0.275*
	(0.114)	(0.112)	(0.108)
Labour productivity	-0.00337**	-0.00362***	-0.00316**
	(0.00107)	(0.00105)	(0.00101)
log(hotel nights)	-0.0283*	-0.0230†	-0.0273*
	(0.0133)	(0.0129)	(0.0124)
log(other nights)	0.00835	0.00958†	0.00880
	(0.00597)	(0.00573)	(0.00560)
Spatial error ρ	–	0.240***	–
		(0.041)	
Spatial lag λ	–	–	0.215***
			(0.039)
Region and Year FE	Yes	Yes	Yes
Observations	2380	2380	2380
Regions n	238	238	238
Years T	10	10	10

Notes: all models include region and year fixed effects. Standard errors in parentheses. $^\dagger p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

We further estimate the same specifications by replacing total emissions with source-specific GHG emissions from Agriculture, Buildings, Energy, Industry, Transport and Waste. Figure 2 summarises the estimated coefficients for hotel nights (high-spending) and other nights (low-spending), together with 90% and 95% confidence intervals. Importantly, we test whether the coefficients on hotel nights and other nights differ across sectors. The difference is statistically significant in the models for total emissions and Buildings, as well as for Transport and Waste. Consistent with the baseline results, high-spending tourism is associated with lower average total emissions relative to low-spending tourism, and this gap is largely driven by the Buildings component. This pattern is suggestive of heterogeneity in the emissions intensity of accommodation types: hotels may, on average, operate with comparatively higher energy efficiency than other lodging arrangements, for instance because larger facilities can exploit economies of scale in heating/cooling and hot-water provision, maintain higher and more stable occupancy rates, and adopt standardised energy-management systems. In addition, hotels—particularly those integrated in chains or subject to stricter certification schemes—may face stronger incentives or regulatory pressures to invest in efficiency upgrades (e.g., insulation, heat pumps, LED lighting, smart controls), potentially reducing emissions per overnight stay relative to more fragmented or heterogeneous forms of accommodation.

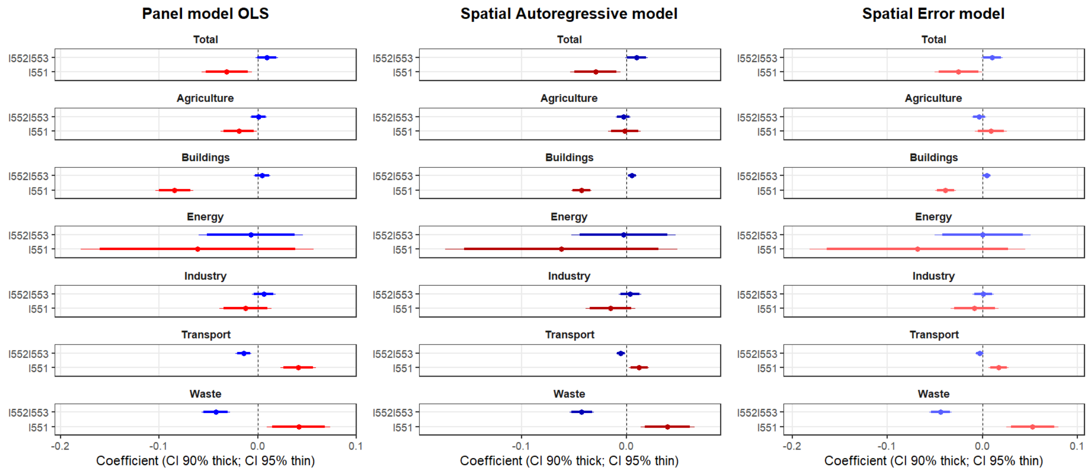

Figure 2: Impact of high- and low-spending tourism flows on GHG emissions by source. Red (blue) intervals refer to the estimated coefficients for hotel nights (other short-stay nights). Thick (thin) lines denote 95% (90%) confidence intervals.

By contrast, for Transport and Waste emissions, high-spending tourism is associated with higher average emissions, with coefficients that are significantly larger than those for low-spending tourism. A plausible channel is that tourists with greater spending capacity may systematically choose more carbon-intensive mobility options within and around the destination, such as rental cars, private transfers, or taxis/ride-hailing, valuing flexibility and time savings. Lower-spending visitors, instead, may rely more on public transport or shared mobility, which typically spreads emissions over a larger number of passengers and can be less emissions-intensive on a per-capita basis. Similarly, differences in consumption patterns could translate into different waste footprints (e.g., higher volumes of packaged goods, dining out, and premium services), which would be consistent with the positive association observed for the Waste component.

Finally, the estimates for Agriculture, Industry, and Energy are broadly consistent with the idea that tourism-related variation is less directly mapped into these emission sources at the local level. Sectoral emissions from Agriculture and Industry are largely driven by production processes and structural factors that may not respond contemporaneously to short-run fluctuations in visitor numbers. Likewise, the Energy category in our decomposition captures emissions tied to public-use energy demand (e.g., public lighting and other municipal electricity uses), which may be relatively insensitive to marginal changes in tourist inflows, at least within the temporal and spatial resolution of our data. Overall, this sectoral breakdown helps pinpoint where the tourism–emissions relationship appears most salient (Buildings, Transport, and Waste) and where it is comparatively muted, while also highlighting the value of richer information on accommodation characteristics and transport mode choices for interpreting the underlying mechanisms.

4 Conclusion and next steps

This paper investigates the relationship between tourism intensity and GHG emissions across European regions, with a focus on heterogeneity in tourism demand and on spatial interdependence. A central contribution is to move beyond aggregate tourism indicators by distinguishing tourism segments with different spending capacities, we proxy higher-spending tourism with nights spent in hotels (NACE I551) and lower-spending tourism with nights spent in other short-stay accommodation (NACE I552–I553). Across specifications, hotel nights exhibit a small but robust negative association with total regional emissions, statistically significant in the fixed effects and spatial lag models and close to conventional thresholds in the spatial error model. By contrast, nights in other accommodation types display a positive but generally imprecisely estimated coefficient. These patterns suggest that, conditional on regional income, structure, productivity, and fixed effects, regions receiving relatively more hotel-based tourism tend to have slightly lower total emissions than otherwise comparable regions, while lower-cost accommodation is not clearly linked to total emissions.

To shed light on channels, we also estimate the same models using source-specific GHG emissions as dependent variables. The sectoral decomposition indicates that differences between hotel and non-hotel nights are most pronounced for Buildings, and that high-spending tourism is associated with higher emissions from Transport and Waste. In contrast, coefficients for Agriculture, Industry, and public-use Energy are comparatively muted and not precisely estimated, consistent with these sources being driven primarily by production structures and public infrastructure that are less responsive to short-run fluctuations in tourist flows at the regional level. Taken together, the results underscore that tourism-related environmental pressures are not uniform across emission sources, and that the composition of tourism demand matters for where and how emissions change.

These findings point to several promising directions for further research. First, unpacking the accommodation channel would benefit from more granular information on the energy performance of lodging facilities (e.g., hotel category, size, occupancy rates, renovations, and certification schemes), which would allow a direct assessment of whether differences in building-related emissions reflect efficiency, scale effects, or composition within accommodation types. Second, interpreting the positive association for Transport and Waste requires data that better capture tourists' mobility choices (public transport versus private vehicles, rental cars, ride-hailing, and transfer services), trip distances, and activity patterns, as well as more detailed waste-generation metrics. Third, heterogeneous effects across destination types (coastal versus inland, urban versus rural, tourism-specialised versus diversified regions) and interactions with local energy mixes and environmental policies are likely to be important in Europe and could be formally tested within the spatial framework. Finally, as a next step we are collecting province-level data for Italy on energy consumption and tourist presences, which will enable a sharper analysis of tourism-related energy demand by source and carrier and provide a closer link between tourist behaviour, local infrastructure, and observed emissions. Overall, our results suggest that policies aimed at sustainable tourism should be targeted to specific channels—particularly buildings, transport, and waste—and that accounting for spatial spillovers is essential when designing regional and cross-border mitigation strategies.

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