BANCA D'ITALIA
EUROSISTEMA

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The series is available online at www.bancaditalia.it .

ISSN 1972-6643 (online)

Designed by the Printing and Publishing Division of Banca d'Italia

AIN'T NO MOUNTAIN NICE ENOUGH: UNESCO LISTING OF THE DOLOMITES AND TOURISM DEMAND

by Michele Cascarano*, Carlo Fezzi** and Nicolas Javier Rodriguez***

Abstract

This paper examines the impact of the 2009 UNESCO World Heritage listing of the Dolomites on local tourism and environmental outcomes. Using data from 349 municipalities in the Italian alpine provinces of Trento, Bolzano, and Belluno between 2005 and 2013, we estimate the effect of the listing by combining a LASSO-logit model for selection adjustment with a difference-in-differences strategy. Results indicate a significant and persistent increase in tourism demand in the designated municipalities, with an average increase of 9.1 per cent over the five years following the listing. On the supply side, compared with the untreated municipalities, we find that the number of tourist establishments remained stable, while total bed capacity decreased. This suggests either a shift towards smaller accommodation units or a deliberate strategy of capacity reduction within the UNESCO-designated area. In line with these assumptions, the increase in visitor flows did not generate measurable environmental costs: we find no significant changes in land consumption and, if anything, we find a reduction in total waste production, driven by a decline in unsorted waste. These findings suggest that the UNESCO listing may have placed local economic development in the Dolomites on a more sustainable trajectory.

JEL Classification: Z32, Q26, C21, R11, Q57.

Keywords: UNESCO World Heritage Sites, tourism demand, difference-in-differences, natural heritage conservation, sustainable tourism.

DOI: 10.32057/0.QEF.2026.1027

* Bank of Italy. Trento Branch.

** University of Trento.

*** University of Exeter Business School.

1 Introduction[1]

The UNESCO World Heritage List provides an international framework for identifying, protecting, and promoting sites of Outstanding Universal Value. While its core objective remains long-term conservation, the designation is also widely seen as a tool for enhancing cultural and environmental tourism, often increasing the visibility and attractiveness of listed areas (Almeida, 2023; Peira et al., 2022). In this dual role, UNESCO recognition not only safeguards natural and cultural assets but can also contribute to local economic development. This potential is particularly salient for natural sites in remote or peripheral regions, where protected status is increasingly leveraged to diversify economic activity and attract tourism-driven demand (Duvivier et al., 2025; Bertacchini et al., 2024; De Simone et al., 2024; Szabó and Ujhelyi, 2024). Yet, whether these benefits materialize without compromising environmental sustainability remains an open empirical question.

Focusing on the Dolomites mountain range in northeastern Italy, this paper investigates the effectiveness of UNESCO World Heritage inscription in June 2009 in promoting local tourism dynamics while simultaneously achieving its core mandate of preserving natural environments through sustainable tourism practices, examining two fundamental dimensions of tourism's environmental impact: land consumption patterns and waste production dynamics. Leveraging an extensive geospatial panel dataset covering 349 municipalities across Trento, Bolzano, and Belluno provinces from 2005 to 2013, we use non-designated localities to construct a credible counterfactual for Dolomitic municipalities through a two-step identification strategy. First, we account for geological and morphological differences by reweighting observations according to inverse probability of treatment, estimated via a LASSO logit model. Unlike classical Propensity Score Matching, this approach handles high-dimensional environmental variables with automatic covariates selection, reduces overfitting in propensity score estimation, and improves efficiency. We then incorporate these weights within several two-way fixed effects Difference-in-Differences specifications to estimate the causal effect on tourism demand while accounting for endogeneity arising from supply-side tourism infrastructure and services, as well as on key measures of tourism's environmental footprint.

Our findings reveal that UNESCO certification successfully fulfilled its dual mandate of fostering local tourism development while ensuring responsible use of natural heritage, thereby promoting genuinely sustainable tourism practices. Municipalities hosting the Dolomites experienced an average increase in tourism demand of approximately +9.1%

[1] We thank the economists of the Economic Research Division of the Bank of Italy, Trento Branch, for their valuable comments, Giuseppe Albanese, Silvia Del Prete, Luca Denis Nota and two anonymous referees as well as the participants of the 2025 Regional Economics Workshop at the Bank of Italy. This paper originates from a traineeship project by Nicolas Javier Rodriguez at the Bank of Italy, Trento Branch. The views expressed are those of the authors and do not necessarily reflect those of the institutions they are affiliated with.

over the four years following World Heritage List inscription. This effect exhibits heterogeneity across tourist origins and provincial boundaries, likely reflecting underlying cultural factors. The result is robust to a range of alternative specifications, and controlling for potential spillover effects onto adjacent municipalities arising from tourist mobility provides no evidence of such externalities. To characterize the result as a demand effect we also analyze the supply-side response. We find that, while the total number of accommodation facilities was unaffected, there was a differential decline in available bed capacity in the treated municipalities relative to controls. This is consistent with a structural shift toward smaller, potentially a higher-price or higher-quality lodging options or a constrained ability to expand capacity. These findings jointly indicate that the UNESCO designation primarily operated as a significant demand-side shock, which was met not by an expansion of supply, but by an adjustment and possible qualitative refinement of the existing accommodation structure. Consistent with the supply-side results, we find no discernible impact on land consumption coupled with a significant reduction in unsorted waste, which represents the most environmentally harmful category, in the years following inscription.

This study builds on previous empirical research examining the ability of UNESCO World Heritage List inscription to positively influence site attractiveness and generate beneficial effects on tourist flows. While such interventions may appear potentially effective in enhancing both national and international site's visibility, the empirical evidence remains inconclusive (Yang et al., 2019). Several studies demonstrate that UNESCO recognition successfully achieves this objective, positively influencing territorial visitation dynamics and contributing to local development (Lazzarotti, 2000; Canale et al., 2019; Yang and Lin, 2014; Kutlu et al., 2024). Conversely, other studies find no effect of inscription on visitor flows (Hardiman and Burgin, 2013; Cuccia et al., 2016; Rogerson and Van der Merwe, 2016; Huang et al., 2012). This disparity reflects the wide heterogeneity that characterises World Heritage Sites in terms of intrinsic attributes and underlying nature. The fundamental distinction between cultural, natural and mixed properties translates into distinct managerial capabilities and operational challenges (Frey et al., 2013; Buckley, 2018; Falk and Hagsten, 2023). Visitor attention also hinges on each site's baseline popularity, creating a tier of "superstar" sites that contrasts with locations of lesser notoriety (Falk and Hagsten, 2021; Panzera et al., 2021). Similarly, accessibility ranges from monuments located in the heart of well-connected metropolitan areas to isolated natural reserves where logistical, economic, or cultural constraints significantly hinder tourist flows (Ababneh, 2021; Agnew and Demas, 2013). When this variation is not explicitly modelled in empirical designs, isolating the net contribution of inscription becomes difficult, and the resulting estimates offer limited guidance to public authorities and local actors.

This paper therefore offers a substantial contribution to the ongoing debate on the effectiveness of UNESCO World Heritage inscription in achieving its conservation objectives while serving as a catalyst for local tourism development. First, similar to Bertacchini et al. (2024) and unlike other studies analyzing UNESCO certification effects, we exploit municipal-level data to maximize spatial granularity while employing robust causal inference methods. However, unlike these authors who focus on purely economic effects, we concentrate on tourism demand and its interrelation with environmental conservation of heritage sites, with particular emphasis on conservation capacity, which constitutes the primary objective of the UNESCO World Heritage List. Second, our focus shifts from urban areas to remote non-urban territories, thereby avoiding gentrification-related factors while spotlighting natural heritage sites, where empirical literature remains comparatively limited relative to cultural counterparts (Zhang et al., 2022), providing the first systematic assessment of UNESCO certification's causal impact on tourist flows across Dolomites municipalities[2]. Third, our study is consistent with and complementary to both Duvivier et al. (2025), who examine supply-side tourism effects, and Andergassen and Guerra (2025), who document property value capitalization in the same Dolomites setting, as both outcomes are closely associated with underlying shifts in tourism demand. By directly analyzing the demand side of the economic equilibrium, we provide the missing link that connects and helps interpret these findings, shedding light on whether UNESCO status merely reallocates visitors or genuinely expands destination appeal. Finally, by looking beyond the formal site boundaries to explore whether UNESCO recognition's influence may extend to neighbouring municipalities, we aim to shed some light on the effect's spatial dimension and contribute to more accurately isolating its causal impact by considering a factor that has received limited attention in earlier empirical studies[3].

The remainder of the paper is structured as follows. Section 2 reviews the Dolomites and their UNESCO inscription. Section 3 describes the data sources. Section 4 outlines the empirical strategy and counterfactual approach, with Section 5 detailing the reweighting procedure. Section 6 presents the main results on tourist flows and tourism supply, followed by robustness checks in Section 7 and heterogeneity analysis in Section 8. Section 9 examines the environmental impacts of UNESCO designation. Finally, Section 10 concludes the paper.

2 Dolomites UNESCO World Heritage Site

The Dolomites encompass nine geomorphological systems that collectively extend across almost 235,000 hectares of the north-eastern Italian Alps, intersecting the autonomous

[2] In particular, studies such as Bertocchi et al. (2021); Scuttari et al. (2019a,b) and Streifeneder and Omizzolo (2017) have examined different dimensions of tourist flows in the Dolomites. However, none has explicitly assessed the causal impact of inscription on the UNESCO World Heritage List to tourist flows.

[3] In this sense, to the best of our knowledge, only a handful of studies have accounted for potential spatial dependence in the context of UNESCO World Heritage Sites. However, they rely primarily on correlational relationships (Patuelli et al., 2016), examine outcomes other than tourist flows (Hyland and Quinn, 2023), or include World Heritage Sites among other attractions solely as control variables without directly assessing their specific impact (Gong et al., 2023).

provinces of Trento and Bolzano and the provinces of Belluno, Pordenone, and Udine and covering more than one hundred municipalities. Formed during the Triassic period, the range represents an extraordinary aesthetic and natural asset and a site of scientific investigation because of its unique geological attributes. The sharply sculpted landforms and distinctive palette of colors bear witness to more than two hundred million years of Earth history and create a striking visual impact.

These qualities led to the Dolomites being inscribed on the UNESCO World Heritage List (WHL) on 26 June 2009 under criterion (vii) "to contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance" and criterion (viii) "to be outstanding examples representing major stages of Earth history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features" (UNESCO World Heritage Centre, 2009). This designation was accompanied by the establishment of a proper inter-provincial management framework and the Fondazione "Dolomiti - Dolomiten - Dolomites - Dolomitis UNESCO", resulting from collaboration between the concerned provinces for coordinated conservation, sustainable tourism, and unified protection of the site's Outstanding Universal Value (Fondazione Dolomiti UNESCO, 2014, 2015; Franch et al., 2011).

In general, the nomination process of a UNESCO WHS follows different steps defined by the UNESCO World Heritage Centre (2025). The process is initiated by each country by the definition of a so called *Tentative List*, providing the list of all properties that they plan to submit for inscription in the following years. Importantly, this initiative is conducted directly by the national government rather than by the specific local governments where the properties are located. Only the Tentative List has been established can a *Nomination File* for a specific property be formally submitted for evaluation. The evaluation is carried out by two independent Advisory Bodies: the International Union for Conservation of Nature (IUCN) and the Internation Council on Monuments and Sites (ICOMOS) depending con the nature of the property. The final decision on the inscription is then made by the World Heritage Committee, which meets once a year to decide to inscribe, refer, defer (requesting more information) or not inscribe the candidate properties. The entire cycle from the submission of the nomination to the final decision typically lasts about one and a half years, unless the Committee decides to refer or defer the nomination, in which case the process is extended. Importantly, this architecture implies that local administrations can contribute to the result of inscription by providing information and management planning but reduces their ability to control either the final decision or its timing.

The specific inscription process for the Dolomites lasted several years. The first submission in 2006 was deferred by the World Heritage Committee in 2007, asking for a tighter focus on aesthetic and geomorphological values (criteria vii and viii), stronger integrity, and clearer inter-provincial management arrangements (UNESCO World Heritage Committee, 2007). A new submission was sent in early 2008 (Fondazione Dolomiti UNESCO, 2008) and revised by the IUCN, which requested supplementary information. Importantly, this evaluation record also notes that the nominated core areas exclude significant infrastructure mainly associated with tourism (IUCN, 2009). The process ended with the Committee inscribing the property in 2009 (UNESCO World Heritage Committee, 2009).

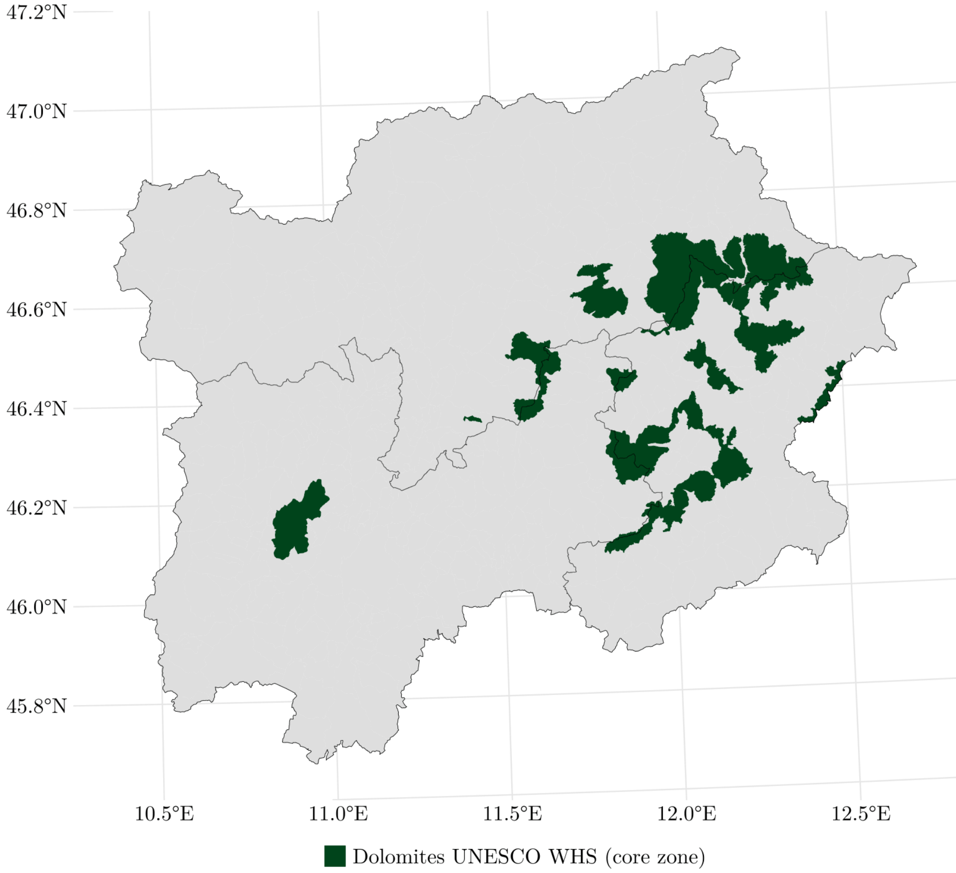
This timeline shows that the outcome and timing of the inscription were outside local control. The technical revisions and the exclusion of tourist infrastructures indicate that the decision was exogenous to local tourism dynamics, supporting our identification strategy, which is based, instead, on a matching procedure based on physical features (see Section 4 below).

Under the approved management framework, the serial property is formally articulated as a double ring comprising core zones and buffer zones. The former cover a total of nearly 142,000 hectares and correspond to the main mountain areas, constituting those subject to greater legal protection, with most of the surface already under various forms of protection such as national or natural park designation, the presence of Natura 2000 sites (SCI/SPA)[4], or landscape constraints. Figure 1 offers a graphical representation of the core zones located within the provinces of Trento, Bolzano, and Belluno. Surrounding these nuclei, buffer zones extend over nearly 90,000 hectares, serving as ecological and visual barriers while enforcing high protection standards and regulating activities to safeguard the site's natural integrity.

Owing to their unique character and outstanding landscape value, the Dolomite mountain system represents a major tourism destination, attracting millions of visitors every year. Tourism became a key economic driver in the 1970s and has grown steadily since, generating jobs, infrastructure, and global visibility for local communities (Franch et al., 2006). This demand comes from not only Italian travelers, but also from a substantial international clientele, and is distributed across every season of the calendar thanks to extensive trekking opportunities and a dense network of ski facilities (Bonzanigo et al., 2016; Bertocchi et al., 2021). The volume of visitors recorded in the municipalities that host the Dolomites was estimated to be roughly 4.9 million in the year of its inscription as a Unesco World Heritage Site (WHS) (Elmi and Wagner, 2013; Scuttari et al., 2019b). This popularity is enhanced by the region's exceptional accessibility infrastructure. More than 100 access points are strategically positioned throughout the mountain system, allowing visitors to reach scenic locations with ease (Streifeneder and Omizzolo, 2017). An extensive road network winds through valleys and mountain passes, connecting major sites, complemented by comprehensive public transport that effectively manages visitor flow (Scuttari et al., 2019b).

[4]Natura 2000 corresponds to the European Union's principal designation instrument for conserving and safeguarding habitats and species of conservation concern. It encompasses Sites of Community Importance (SCI), Special Areas of Conservation (SAC), and Special Protection Areas (SPA) (European Commission and Directorate-General for Environment, 1997)

Figure 1: Spatial extent of the Dolomites serial property's core zones within the provinces of Trento, Bolzano, and Belluno.



3 Data

To evaluate how the Dolomites' addition to the UNESCO World Heritage List affected tourism, our primary outcome is the annual number of overnight stays recorded at the municipal level in the provinces of Trento, Bolzano and Belluno, obtained from the corresponding statistical offices ISPAT, ASPAT and SISTAR. Because tourist flows in the Dolomites occur throughout the calendar year, we aggregate monthly counts to an annual metric and analyse the period from 2005 to 2013. This window covers a sufficient number of years before and after inscription into UNESCO WHL, providing enough temporal variation while limiting confounding influences that might arise over a longer horizon. Aggregation at the annual level also improves coverage of smaller municipalities, which often lack complete data at higher temporal frequencies. After excluding those with missing information, the final panel dataset comprises 349 unique municipalities, with 176 in Trento, 116 in Bolzano and 57 in Belluno, providing a sufficiently large set of units despite the study's local scale. For the same annual panel of municipalities, we also collect information on total bed capacity and the number of tourist facilities, measured at the end of each year. These data are obtained from the provincial statistical offices mentioned above.

Environmental characteristics essential for capturing spatial heterogeneity across our study area are drawn from multiple sources. In particular, land-cover information comes from the Corine Land Cover dataset of the Copernicus Land Monitoring Service coordinated by the European Environment Agency (European Union, Copernicus Land Monitoring Service, 2006). This dataset provides standardized raster with a 100x100 meters grid and vector data with a minimum mapping unit of 25 hectares for polygons and a minimum width of 100 meters for linear features. Each cell is categorized into thematic classes hierarchically organized on three levels that describe in detail the type of land, for example distinguishing between different types of artificial surfaces, agricultural areas, forests and semi-natural areas, wetlands, and water bodies. These data are considered by taking into account the year 2006 to obtain a pre-treatment snapshot of municipal land composition. Furthermore, to maximise thematic detail and morphological accuracy, we exploit the full 44-class level-3 Corine Land Cover subdivision. On this basis, we compute for each municipality the total area (in hectares) occupied by every land-cover class.

Geospatial data on elevation profiles are obtained from TINITALY/1.1 digital model (Tarquini et al., 2023), which provides a high resolution Digital Elevation Model (DEM) on a continuous grid of 10x10 metres for the whole Italian territory. Additionally, from this DEM we derive the Terrain Ruggedness Index (TRI), following Riley et al. (1999) and Wilson et al. (2007). This metric measures elevation variation between contiguous DEM cells, enriching the municipal morphological composition with information on the spatial variability of relief and the micro-discontinuities. In detail, three TRI alternatives are calculated. The first one (*TRI (Mean)*) is measured as the mean absolute elevation difference between each grid cell and its eight neighbours. The second metric (*TRI (Riley)*) is computed as the square root of summed squared differences between a cell and those neighbours. Finally, the third measure (*TRI (RMSD)*) is calculated as the root-mean-square of the same squared differences, thereby normalizing the magnitude of elevation variations. The linear form of TRI offers greater robustness to outliers but can understate roughness where abrupt local changes occur, whereas its quadratic forms, by emphasizing squared deviations, more effectively highlight sharp topographical discontinuities. Considering the three indices jointly yields a more comprehensive representation of landform morphology, capturing both gradual undulations and pronounced relief variations. Altitude and terrain-roughness values are then aggregated at the municipal level through areal weighted interpolation, producing mean values for each administrative unit.

A complete list of all variables used in the empirical analysis, together with their corresponding data sources, is provided in Table A.1 in the Additional Materials. Summary statistics for the main variables are reported in Table A.2.

4 Empirical strategy

The key empirical challenge in estimating the effect of the Dolomites' UNESCO World Heritage inscription lies in developing a credible counterfactual for the tourism trajectory these municipalities would have experienced in absence of UNESCO designation.

This problem can be formalized following the Rubin Causal Model (Rubin, 1974, 2005; Holland, 1986). For $i = 1, \ldots, N$ municipalities and $t = 1, \ldots, T$ time periods, let Y_{it}^{UNESCO} be the number of overnight stays that municipality i would record at time t had it obtained UNESCO World Heritage status in 2009 (henceforth also referred to as the treatment period), and by Y_{it}^{N} the corresponding number of overnight stays in the complete absence of such certification. The causal effect of interest for municipality i at time t is therefore defined as $\tau_{it} = Y_{it}^{\text{UNESCO}} - Y_{it}^{N}$, while the average effect we aim to estimate is the mean of τ_{it} across municipalities. Clearly, it is impossible to observe both Y_{it}^{UNESCO} and Y_{it}^{N} for the same municipality, because the only outcome actually observed corresponds to Y_{it}, which equals exactly Y_{it}^{UNESCO} for Dolomite municipalities and Y_{it}^{N} for all other municipalities in the provinces of Trento, Bolzano, and Belluno that do not host the Dolomite mountain system.

The Difference-in-Differences (DiD) design (Ashenfelter and Card, 1984; Card and Krueger, 1993) approximates the unobserved counterfactual Y_{it}^{N} for treated municipalities after 2009 by exploiting the observed outcomes of never-treated municipalities. Under the crucial parallel-trends assumption that, in absence of UNESCO certification the evolution of overnight stays in Dolomite (treated) and non-Dolomite (control) municipalities would have been identical, such an effect can be estimated through an event study model that takes into account the temporal dynamics of UNESCO certification effects on tourist flows.

Specifically, we consider the following two-way fixed effects specification:

$$\ln\big(Y_{it}\big) \;=\; \alpha + \sum_{\ell \neq -1} \tau_\ell^{\mathrm{DiD}} \big(D_i \mathbf{1}\{t - T^{UNESCO} = \ell\}\big) + \delta_i + \delta_{ct} + \varepsilon_{it} \tag{1}$$

Where the outcome variable is represented by the natural logarithm of overnight stays at the municipal level, and D_i treatment indicator equal to one for any municipality containing a non-zero fraction of the UNESCO core zone, as defined by the Dolomites' World Heritage designation[5]. The expression $t - T^{UNESCO} = \ell$ measures the lead ($\ell > 0$) or lag ($\ell < 0$) of calendar year t relative to the treatment year $T^{UNESCO} = 2009$. To avoid perfect multicollinearity, we set $\ell = -1$ as the reference category. This corresponds to the year 2008, the final pre-treatment year, after which the UNESCO status could start producing its influence on tourist flows. The coefficients of interest, τ_ℓ^{DiD}, therefore quantify the differential percentage change in overnight stays between treated and control municipalities ℓ years away from the treatment year relative to this baseline.

This specification expands the baseline event-study DiD by incorporating two types of fixed effects, thereby absorbing major sources of confounding variation. Municipality fixed effects δ_i control for all time-invariant municipality-specific characteristics. These are complemented by additional fixed effects δ_{ct}, defined as the interaction between the inter-municipal group c (namely, Unioni Montane in the province of Belluno, Comunità di Valle in Trentino, and Comunità Comprensoriali in Alto Adige) and year t. These bodies centralize key tourism promotion and governance functions, implementing decisions and investments that almost uniformly affect all affiliated municipalities within the same year[6]. Accounting for these fixed effects therefore allows us not only to control for perma-

[5] Although municipalities with only marginal core zone coverage may in principle experience weaker direct effects, this classification is justified by the fact that core zones are invariably embedded within extensive buffer areas. Consequently, even those municipalities with minimal core inclusion are subject to the same regulatory safeguards, promotional programs, and management regimes that accompany the World Heritage designation, making it reasonable to assume comparable treatment intensity across all treated units.

[6] In the three provinces under study, municipalities are grouped into intermediate administrative bodies that play a significant coordinating role in tourism policy and local development. In Trentino, the Comunità di Valle were established by Legge provinciale 16 giugno 2006, n. 3 (Norme in materia di governo dell'autonomia del Trentino) and became fully operational around 2010. They are entrusted with coordinating functions across municipalities, including territorial marketing, tourism promotion, and the management of local infrastructure and services. In South Tyrol (Alto Adige), the corresponding institutions are the Comunità Comprensoriali (Bezirksgemeinschaften), created under Legge provinciale 20 marzo 1991, n. 7 (Ordinamento delle comunità comprensoriali), with analogous competences in spatial planning, environmental protection, social services, and tourism-related activities. In Belluno, inter-municipal coordination is ensured by the Unioni Montane, introduced by Legge regionale Veneto 28 settembre 2012, n. 40 (Norme in materia di Unioni montane), which replaced the former Comunità Montane. These entities are responsible for promoting integrated development in mountain areas, including the planning and

nent structural differences across municipalities but also to capture coordinated changes in tourism governance and infrastructure at the inter-municipal level. In total, there are 33 such inter-municipal bodies, each comprising, on average, ten municipalities; the majority of these bodies contain at least one treated unit. As a result, identification of the treatment effect relies on the within-municipality variation in overnight stays net of these sources of bias, bringing the interpretation of the estimated coefficient closer to a demand-driven effect, as some supply-side components are likely absorbed by these fixed effects.

In order to ensure the exogeneity of the treatment and the validity of the identification strategy, it is necessary to emphasize several aspects of the assignment of the UNESCO certification itself. First, as discussed in Section 2, the nomination procedure extended over a considerable period: the first application of the Dolomites to the World Heritage List was publicly deferred in 2007, and the approval was obtained two years after, in 2009. Moreover, as stated by Zunjic (2023), historically only slightly more than 50% of deferred nominations are subsequently directly inscribed. Thus, both the outcome and the timing of the approval could not be perceived as "almost certain". Additionally, the IUCN evaluation of the nomination was not made public until less than five days before the Committee's decision. Taken together, these elements support the assumption that there were no anticipation effects prior to the UNESCO inscription. In other words, this uncertainty is unlikely to generate tourism-driven hype, while simultaneously preventing municipalities from exploiting the promotional value of the brand under a "quasi-UNESCO" status. This no-anticipation assumption is crucial, as it ensures the exogeneity of the treatment and implies that pre-treatment differences in outcomes between UNESCO and non-UNESCO municipalities reflect pre-existing structural gaps, allowing the DiD design to attribute post-2009 differentials to the treatment itself. Second, the only relevant criterion for inscription on the UNESCO World Heritage List was the presence of geomorphological features. Accordingly, the definition of treated municipalities is based on whether their territory overlaps with the designated core zone, rather than on administrative boundaries. Third, the initiative to nominate the area as a World Heritage Site originated directly from the national government rather than from specific local governments, which reduces the scope for local actors to influence the treatment assignment.

5 Inverse probability weighting

Importantly, the distinctive features of the municipalities hosting the Dolomite mountain system are themselves a direct reflection of the very attributes that motivated the UNESCO inscription. These differences in baseline tourism potential, infrastructures and natural landscapes may therefore compromise the validity of the parallel trends assumption

implementation of tourism and environmental initiatives. In all three provinces, these inter-municipal bodies have historically overseen shared projects—such as trail networks, visitor infrastructure, and tourism marketing—implemented uniformly across affiliated municipalities.

by creating pre-existing divergences in the evolution of overnight stays between treated and control municipalities. If, for example, Dolomite municipalities were already experiencing faster growth in tourism prior to 2009 due to some unobserved or intrinsic factor, then a naïve DiD comparison would undermine the credibility of the estimated effect. To mitigate this concern and thus enhance comparability between groups, it is essential to account for these baseline disparities. One effective strategy is to re-weight observations by the inverse probability of treatment (Rosenbaum and Rubin, 1983; Robins et al., 1994; Hirano et al., 2003) Specifically, the weights are defined as:

$$w_i = \begin{cases} \dfrac{1}{p_i} & \text{if } D_i = 1 \\ \dfrac{1}{1 - p_i} & \text{if } D_i = 0 \end{cases} \tag{2}$$

With p_i the propensity score, that is the conditional probability of of receiving Dolomites UNESCO WHS certification given the vector of pre-treatment covariates X_i:

$$p_i = \Pr(D_i = 1 \mid X_i) \tag{3}$$

Using inverse probability weights, treated municipalities with relatively low propensity scores are assigned larger weights, and untreated municipalities with relatively high propensity scores are likewise up-weighted. This re-weighting balances the distribution of X_i across treated and control groups, creating a "pseudo-population" in which treatment assignment is independent of observed covariates.

5.1 LASSO Logit

We estimate the propensity score in Equation 3 via a penalized logit model incorporating the Least Absolute Shrinkage and Selection Operator (LASSO) algorithm developed by Tibshirani (1996). This approach provides a transparent data-driven rule for variable selection and offers three main advantages for our analysis. First, it reduces the high dimensionality and complexity typical of environmental data with spatial structure (Cui et al., 2023; Pak et al., 2025; Handorf et al., 2020), resulting in a more parsimonious specification. Second, in settings in which the number of observational units is not large relative to the pool of candidate covariates, LASSO helps in improving finite sample efficiency and guards against overfitting (Goller et al., 2020). Third, the penalization step eliminates covariates that are only weakly related to treatment assignment or that exhibit strong multicollinearity, thereby enhancing both the stability and interpretability of the estimated propensity scores.

In practice, regularization is imposed by adding a penalty term to the log-likelihood function, yielding the following minimization problem:

$$\hat{\beta}(\lambda) \;=\; \arg\min_{\beta \in \mathbb{R}^k} \left\{ -\sum_{i=1}^{N} \Big[Y_i \, X_i^{\top} \beta \;-\; \log\big(1 + e^{X_i^{\top} \beta}\big) \Big] \;+\; \lambda \sum_{j=1}^{k} |\beta_j| \right\} \tag{4}$$

where $j = 1, \ldots, k$ indexes the set of environmental and geomorphological regressors included in the model and discussed in Section 3. The term $\lambda \sum_{j=1}^{k} |\beta_j|$ introduces a penalty that depends on λ and on the absolute magnitude of each coefficient. As a result, coefficients associated with regressors having low predictive power are automatically shrunk toward zero, simultaneously achieving variable selection and reducing the model's dimensionality. This approach reduces random variability due to sample partitions and ensures greater robustness in the choice of the penalty parameter[7]. Once $\hat{\beta}(\lambda)$ is obtained, the propensity score for each municipality i is calculated as:

$$\hat{p}_i \;=\; \frac{e^{\,X_i^{\top} \hat{\beta}(\lambda)}}{1 + e^{\,X_i^{\top} \hat{\beta}(\lambda)}} \tag{5}$$

5.2 Results

The propensity score estimates are reported in Table 1. The table lists the estimated coefficients for the variables selected by the Penalized LASSO Logit together with their corresponding odds ratios. The shrinkage parameter, optimized at $\lambda = 0.0037$ by minimizing the prediction error through cross-validation, yields a model that is less parsimonious than other settings and prevents the use of higher λ values that, while enhancing coefficient sparsity, would have reduced the predictive accuracy and compromised the overall quality of the propensity score. This selection criterion reduces the set of geomorphological and environmental covariates to 25 predictors used to estimate the probability of obtaining UNESCO certification.

Consistent with the rationale underlying the designation of the Dolomites as World Heritage Site, the selection mechanism convincingly mirrors the theoretical determinants of the classification by assigning greater weight to the geomorphological uniqueness of each municipality. Longitude receives the largest weight, which is expected because the Dolomite heritage is geographically concentrated within a narrow longitudinal range that defines its geological singularity. Similarly, topographic ruggedness confirms that morphological characteristics explain a substantial portion of certification probability. The credibility of the estimates is further supported by the negative coefficients associated with land cover

[7]In our analysis, in order to tune λ, we carry out 10-fold cross-validation for 1,000 repetitions. In each iteration we partition the data into training and validation sets and identify the λ that minimizes the out-of-sample prediction error. From the resulting empirical distribution of λ values we choose the median as our final regularization parameter.

Table 1: LASSO Logit propensity score estimates.

Variabile	$\hat{\beta}$	**Odds ratio**
Discontinuous urban fabric	0.0009	1.0010
Permanent grasslands	0.0005	1.0010
Heterogeneous agricultural areas	0.0014	1.0010
Former cultivated land	–0.0022	0.9980
Coniferous forests	–0.0000	1.0000
Mixed forests	0.0003	1.0000
Heathlands	0.0005	1.0010
Transitional woodland scrub	–0.0007	0.9990
Bare rock and cliffs	0.0013	1.0010
Vineyards	–0.0035	0.9960
Orchards	0.0016	1.0020
Sparse vegetation	–0.0010	0.9990
Watercourses	0.0332	1.0340
Industrial areas	–0.0029	0.9970
Road networks	–0.0072	0.9930
Rainfed arable land	0.0038	1.0040
Glaciers and perennial snow	–0.0105	0.9900
Construction sites	–0.0446	0.9560
Peatbogs	0.0937	1.0980
Mixed crops	–0.0004	1.0000
Elevation	0.0026	1.0030
TRI (Riley)	0.2057	1.2280
TRI (RMSD)	0.0000	1.0000
Latitude	–2.5058	0.0820
Longitude	2.3397	10.3780

$\boldsymbol{\lambda}$	**N. of selected variables**	**Pseudo-R^2**	**In-sample AUC**	**N. of observations**
0.0037	25	0.5	0.937	349

Notes: Coefficients are returned on the original scale; covariates were internally standardized before penalization. Coefficient, odds-ratio, and λ values are rounded to four decimal places. Displayed coefficients whose rounded value equals zero were nevertheless selected by the model, as their unrounded estimates were non-zero but of very small magnitude.

variables measuring the level of anthropogenic influence, since more intense human activity, such as industrial areas, construction sites, or crops, lowers the probability that the site will receive the certification, reflecting how greater human pressure diminishes natural site characteristics and reduces the likelihood of UNESCO protection. In general, predictors related to different land-cover categories exhibit coefficients of limited magnitude. Once location and morphology are controlled for, they contribute only residual information, making the variation in certification probability associated with these characteristics relatively marginal. The model also shows solid predictive capacity, evidenced by an Area Under the Receiver Operating Characteristic Curve (AUC)[8] of 0.937 and a McFadden pseudo-R^2 of 0.50, indicating that the model is able to explain about half of the null deviance.

Importantly, the accuracy of inverse probability weighting (IPW) in yielding unbiased causal effect estimates depends on the calibration of the propensity score, especially when calculated through ML techniques[9], which requires that predicted probabilities match the empirical frequency of treatment. Severe calibration errors, especially at extreme score values, inflate the IPW weights, raise their variance, and distort the resulting estimates (Kallus, 2020; Deshpande and Kuleshov, 2023; Rabenseifner et al., 2025; Gutman et al., 2024). In our analysis, however, the assessment of propensity score calibration suggests good overall alignment, with only minor deviations at the extremes of the distribution. This finding supports the accuracy and reliability of the model's predicted probabilities[10].

On the other side of the coin, IPW's validity hinges on achieving comparability between treated and control units. To this end, we assess covariate balance in Figure 2, which plots the Standardized Mean Differences (SMDs) for each covariate before and after weighting. The estimated weights succeed in substantially rebalancing the morphological and environmental characteristics between treated and control units, reducing the average SMD across all covariates by over 60%, from 0.3077 to 0.1132[11]. While a few features still show slightly larger residual imbalances, most of them experience a substantial reduction. This is particularly true for the variables that received the largest weights in the LASSO-based propensity score, namely longitude and TRIs. Moreover, the persistence of some differences between the adjusted and unadjusted samples should be expected given the large number of predictors included in the model.

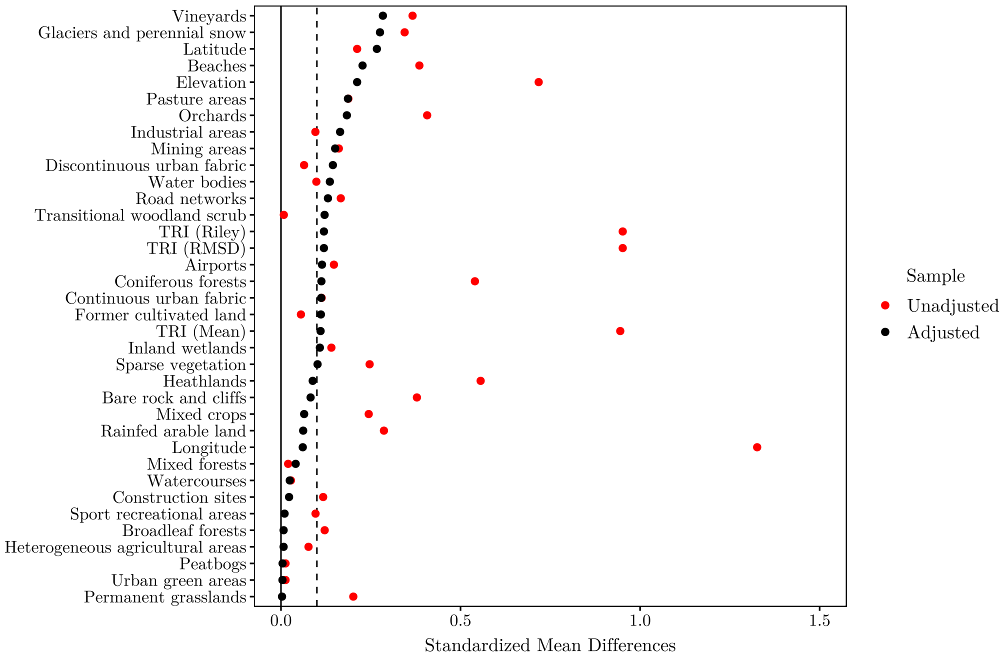
[8] Formally, the AUC measures the probability that the model assigns a higher score to a randomly chosen UNESCO site (positive case) than to a randomly chosen non-UNESCO site (negative case). A value of 0.5 signals random guessing, while a value of 1 indicates perfect discrimination (Çorbacıoğlu and Aksel, 2023; Fischer et al., 2003)

[9] In this sense, Machine Learning algorithms exacerbate this issue, as they often generate propensity score estimates that substantially deviate from their true values, tending either to overestimate or underestimate them (Ballinari and Bearth, 2024; Niculescu-Mizil and Caruana, 2005).

[10] See Additional Materials – Calibration and quality of the Propensity Score for further details on the calibration assessment, including the specific statistical indices and diagnostic measures used.

[11] Quantitative details of the SMDs for each variable, together with the average SMD before and after re-weighting, are provided in Additional Materials – Calibration and quality of the Propensity Score.

Figure 2: Covariate balance before (Unadjusted sample) and after (Adjusted sample) Inverse Probability Weighting.



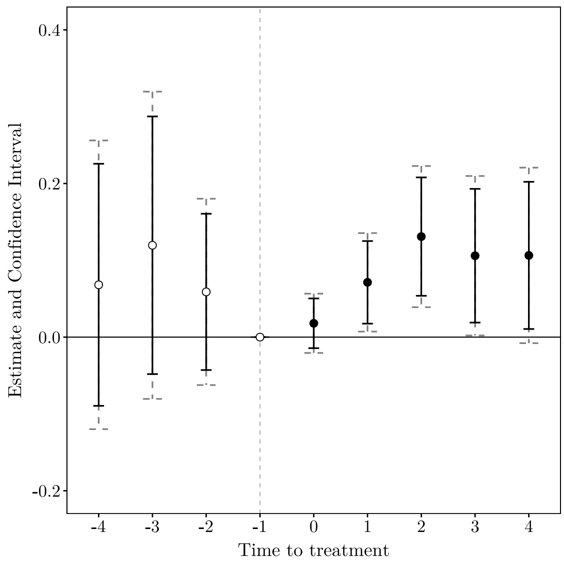
Notes: Land-cover covariates that exhibited zero values in both treated and control groups, and thus yielded a null Standardized Mean Difference in both samples, were excluded from the figure to ensure greater clarity and conciseness.

6 Main results

6.1 Overnight stays

Figure 3 shows the event study Difference-in-Differences estimates from Equation 1 on the re-weighted sample. The plot shows each point estimate together with its 90% and 95% confidence intervals, calculated using standard errors clustered at the municipality level to account for serial autocorrelation within each territorial unit. Importantly, the pre-treatment trend analysis reveals that the treated–control differential prior to 2009, while slightly positive, is not statistically different from zero at either the 90% or 95% confidence level. The pattern of coefficients supports the parallel-trends assumption, as tourist overnights in Dolomite municipalities moved closely in line with those of the control group before 2009, despite the higher variability of pre-event estimates, thereby validating our identification strategy.

Figure 3: Event-study Difference-in-Differences estimates of the effect of UNESCO World Heritage inscription on log overnight stays.



Notes: White dots correspond to all pre-intervention periods, while black dots represent all post-intervention periods. Solid black bars depict 90% confidence intervals, grey dashed bars depict 95% confidence intervals. Standard errors are clustered at the municipality level.

The analysis of the post-UNESCO designation period, on the other hand, reveals a significant impact on tourism demand, averaging approximately +9.1% over the entire 2009–2013 period. Specifically, certified municipalities exhibit an initially modest effect that grows over time, stabilizing at more than +10% in the later periods. The effect is sizeable given a standard deviation of 1.88 of the dependent variable in the estimation sample. Moreover, except for the year of inscription on the World Heritage List, all subsequent coefficients are statistically significant at both 90% and 95% confidence levels. The last year, while significant at the 90% level, just narrowly misses the more conservative threshold. The observed gradual pattern suggests that UNESCO recognition's capacity to enhance the attractiveness of the Dolomites site exhibits a lagged impact. This temporal pattern likely reflects the progressive nature of information dissemination, whereby tourist behavior adjusts incrementally as awareness of the UNESCO designation spreads and becomes integrated into travel decision-making processes. At the same time the borderline significance in the final year of the study, despite a stable magnitude of the effect, warrants a cautious interpretation of its long-term durability.

6.2 Supply-side effects

The baseline results indicate an increase in tourist stays following the UNESCO inscription. A key interpretative issue is whether this effect reflects an increase in demand or a change in the local accommodation supply. To shed light on this, we analyze two supply-side indicators: the number of accommodation establishments and the total bed capacity at the municipal level.

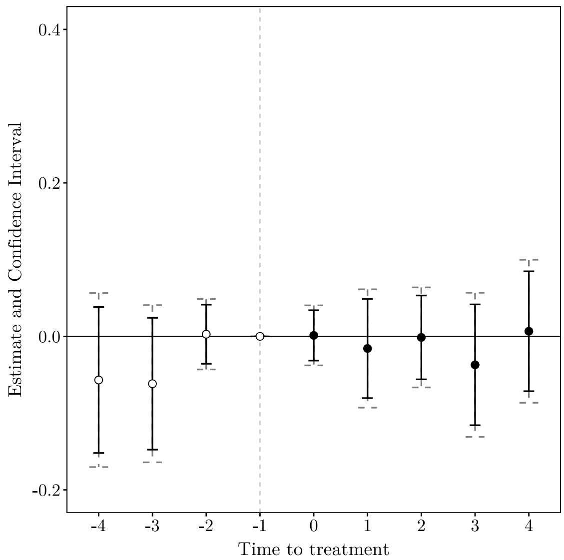
The first exercise uses the number of accommodation establishments as the dependent variable in an event-study specification analogous to the baseline model. The estimated coefficients, shown in Figure 4, display no statistically significant effects either before or after the inscription. The stability in the number of facilities suggests that the UNESCO recognition did not trigger entry or exit dynamics among accommodation providers.

The second exercise focuses on total bed capacity (Figure 5). The results reveal a negative effect emerging after the inscription, pointing to a contraction in average establishment size in treated municipalities. This pattern is partly expected: UNESCO designation typically introduces stringent land-use and construction constraints, which structurally limit capacity expansion among registered providers. Beyond this mechanical channel, the contraction may reflect a broader re-composition of local supply: a shift toward smaller, higher-quality or higher-priced establishments within the traditional sector, and potentially a diversion of supply toward the informal short-term rental market, with property owners renovating residential units and listing them on informal short rentals platforms. Both mechanisms, whose analysis goes beyond the scope of this paper, are consistent with Andergassen and Guerra (2025), who document a significant increase in residential property values in Dolomites municipalities following UNESCO inscription, suggestive of a broader upgrading process affecting both the accommodation supply and the local real estate market.[12].

[12] As for the magnitude of the effect, it reaches a maximum of minus 29 percentage points. However, its practical relevance and statistical precision must be assessed against the large standard errors associated with the estimate and the fact that its size is relatively small compared to the standard deviation of 1.68.

Taken together, the absence of any expansion in the number of facilities and the observed contraction in bed capacity reinforce the interpretation that the observed pattern in tourist stays is primarily demand-driven. The UNESCO inscription appears to have driven the increase in tourist stays mainly through a demand-side effect, with supply adjustments reflecting an adaptation to the new tourism conditions.

Figure 4: Event-study Difference-in-Differences estimates of the effect of UNESCO World Heritage inscription on log accommodation establishments.



Notes: White dots correspond to all pre-intervention periods, while black dots represent all post-intervention periods. Solid black bars depict 90% confidence intervals, grey dashed bars depict 95% confidence intervals. Standard errors are clustered at the municipality level. The term 'accommodation establishments' refers to both hotel and non-hotel facilities.

7 Robustness checks

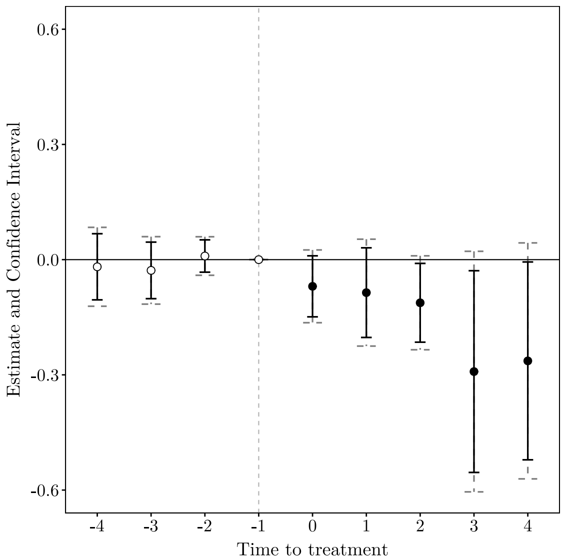
In order to verify the robustness of our conclusions, we conduct a series of robustness checks that test our results against alternative assumptions and modeling hypotheses.

7.1 Alternative specifications

For the estimation of the UNESCO effect, we employed a carefully chosen fixed effects model estimated on a re-weighted sample to isolate demand-side impacts on tourism from supply-side factors and other confounders. Robustness checks using alternative fixed-effects

Therefore, while a pattern of reduced average establishment size is evident, the high variability warrants caution regarding the exact magnitude of the observed shift.

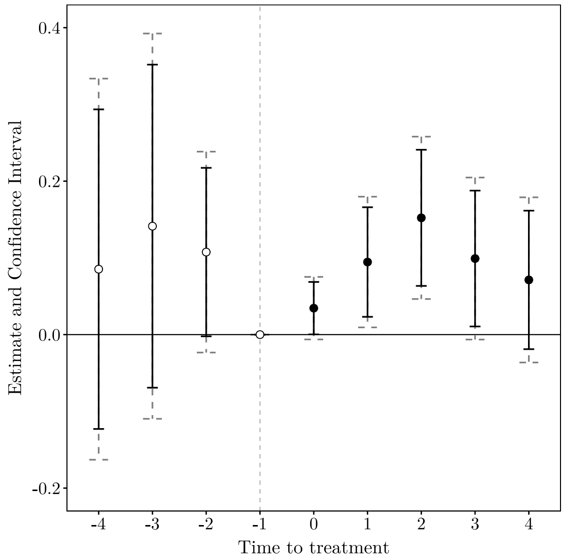
Figure 5: Event-study Difference-in-Differences estimates of the effect of UNESCO World Heritage inscription on log bed capacity in accommodation establishments.



Notes: White dots correspond to all pre-intervention periods, while black dots represent all post-intervention periods. Solid black bars depict 90% confidence intervals, grey dashed bars depict 95% confidence intervals. Standard errors are clustered at the municipality level. The term 'accommodation establishments' refers to both hotel and non-hotel facilities.

structures or weights further substantiate the robustness of our findings. In particular, replacing inter-municipal-group-by-year fixed effects with simple year effects yields similar positive impacts on tourist flows. When community-by-year fixed effects are included, however, a larger portion of the supply-side variation is absorbed, bringing the interpretation of the estimated effect closer to a demand-driven one. Additionally, employing the main specification excluding the inverse probability weighting or with IPW estimated through a Standard Logit, again demonstrates consistency and robustness, reinforcing evidence of UNESCO designation's positive impact on tourism demand, albeit at the cost of reduced comparability across groups [13]. Detailed results of these alternative model specifications are discussed further in Additional Materials – Alternative Event Study Difference-in-Differences specifications and reported in Table A.4 and Figure A.2.

Figure 6: Event-study Difference-in-Differences estimates of the effect of UNESCO World Heritage inscription on log arrivals.



Notes: White dots correspond to all pre-intervention periods, while black dots represent all post-intervention periods. Solid black bars depict 90% confidence intervals, grey dashed bars depict 95% confidence intervals. Standard errors are clustered at the municipality level.

Similarly, we re-estimate Equation 1 using an alternative outcome variable. In this sense, tourist arrivals represent a distinct measure to overnight stays for capturing tourism flows, as they focus exclusively on the capacity to attract individual tourists while dis-

[13] While the results based on standard logit weights are broadly consistent with those obtained from the LASSO logit, the standard logit suffers from quasi-complete separation, leading to estimated probabilities collapsing to 0 or 1. When this occurs in a PSM context estimated propensities cluster near 0 or 1, reducing overlap between treated and untreated units, generating unstable inverse-probability weights, and biasing the comparison toward a smaller, less representative sample. This further supports the use of the LASSO approach in this context.

regarding the ability to retain visitors for extended periods and the broader economic impacts typically associated with longer stays. Consequently, Figure 6 repeats the event study analysis, using the logarithm of arrivals instead of overnight stays. The results are consistent with our primary findings. Although the estimates exhibit lower precision in this case, yielding wider confidence intervals, the effect of World Heritage List inscription on tourist arrivals remains positive, averaging slightly above +9.4% for the 2009-2013 period, and the overall evidence still supports the conclusions drawn from the main specification.

7.2 Conley Standard Errors

In our main model, Standard Errors are clustered at the municipality level, under the assumption that potential unobserved shocks may exhibit temporal autocorrelation within each municipality. This approach requires errors to be independent across different municipalities, which is justified if administrative boundaries also delimit the extent of such shocks. If disturbances spill across these borders, this creates spatial dependence which, when ignored, leads to an underestimation of Standard Errors, resulting in optimistic p-values and narrower confidence intervals.

Table 2: Event-study Difference-in-Differences estimates with Conley (1999) Standard Errors (cutoffs = 10, 20, 30 km).

		Cutoff	
	10 km	**20 km**	**30 km**
τ_{-4}^{DiD}	0.068	0.068	0.068
	(0.049)	(0.072)	(0.045)
τ_{-3}^{DiD}	0.120 ·	0.120	0.120 ·
	(0.066)	(0.083)	(0.070)
τ_{-2}^{DiD}	0.059 ·	0.059	0.059 ·
	(0.035)	(0.043)	(0.035)
τ_{0}^{DiD}	0.018	0.018	0.018
	(0.015)	(0.014)	(0.021)
τ_{+1}^{DiD}	0.071*	0.071 ·	0.071
	(0.035)	(0.038)	(0.044)
τ_{+2}^{DiD}	0.131*	0.131*	0.131 ·
	(0.054)	(0.061)	(0.074)
τ_{+3}^{DiD}	0.106**	0.106**	0.106*
	(0.037)	(0.040)	(0.046)
τ_{+4}^{DiD}	0.106*	0.106*	0.106*
	(0.051)	(0.049)	(0.051)
N. of Obs.	3,044	3,044	3,044
R^2	0.990	0.990	0.990

Notes: · significant at the 10% level, * significant at the 5% level, ** significant at the 1% level, *** significant at the 0.1% level. Conley (1999) Standard Errors in parentheses. Reference period ℓ = -1.

To test whether our inference is sensitive to such spatial correlation in the error structure, we re-estimate Equation 1 using the variance-covariance matrix proposed by Conley

(1999). Specifically, this approach requires selecting a critical distance beyond which spatial correlation is assumed to be negligible. Table 2 therefore presents the event study results when Standard Errors are computed with cutoffs of 10, 20, 30 km, calculated as Euclidean distances between municipalities based on their latitude and longitude, thereby covering scenarios that range from highly local spillovers to broader spatial links. The comparison shows that Conley Standard Errors exceed municipality-clustered standard errors in some of the periods examined. This upward adjustment signals some residual spatial correlation, but the increase is not large enough to compromise the empirical evidence. Hence, the main findings remain statistically significant even when the restrictive assumption of cross-municipality independence is relaxed[14].

7.3 Treatment intensity and spillover effects

The treatment indicator described in Section 4 classifies as treated every municipality that contains any portion of the Dolomites' core zone, regardless of the size of this fraction. To assess whether our results depend on this definition, we re-estimate our main model by tying treatment status to the relative size of the core zone share. Specifically, we split the sample into two groups, first considering as treated exclusively those municipalities whose core zone share is at least as large as the median among those with a positive share, while excluding the others. We then reverse this classification, treating only the municipalities that fall below the median. This approach allows us not only to check robustness but also to explore potential heterogeneity in the treatment effect. Figure 7 maps the geographical distribution of municipalities across these two categories.

Figure 8 plots, for each coverage subgroup, the post-treatment linear combination of event study coefficients (leads $\ell = 0$–4), whose Standard Error is computed via the delta method from municipality-level clustered standard errors, along with the corresponding 95% confidence intervals. Municipalities with the largest Dolomites coverage exhibit a positive coefficient of about 7.5% that is only marginally non-significant at the 95% level. Municipalities below the median share display a stronger and statistically significant effect of over 11.6%. Nevertheless, the overlapping confidence bands suggest that these two point estimates are not meaningfully different from one another, indicating that the variation in magnitude may reflect sampling variability rather than substantively distinct treatment effects.

Besides treatment intensity, a combination of factors related, for instance, to economic conditions, spatial accessibility and potentially unobservable characteristics, may have diverted part of the tourism demand toward municipalities located outside the Dolomites area, yet close enough to allow easy access to the World Heritage Site. If this holds true,

[14]Since the correction affects only the variance–covariance matrix, the point estimates remain exactly identical to before and across the four thresholds considered. The only difference therefore concerns the width of the confidence intervals.

Figure 7: Classification of municipalities with Dolomites serial property's core zones above and below the median, within the provinces of Trento, Bolzano, and Belluno.

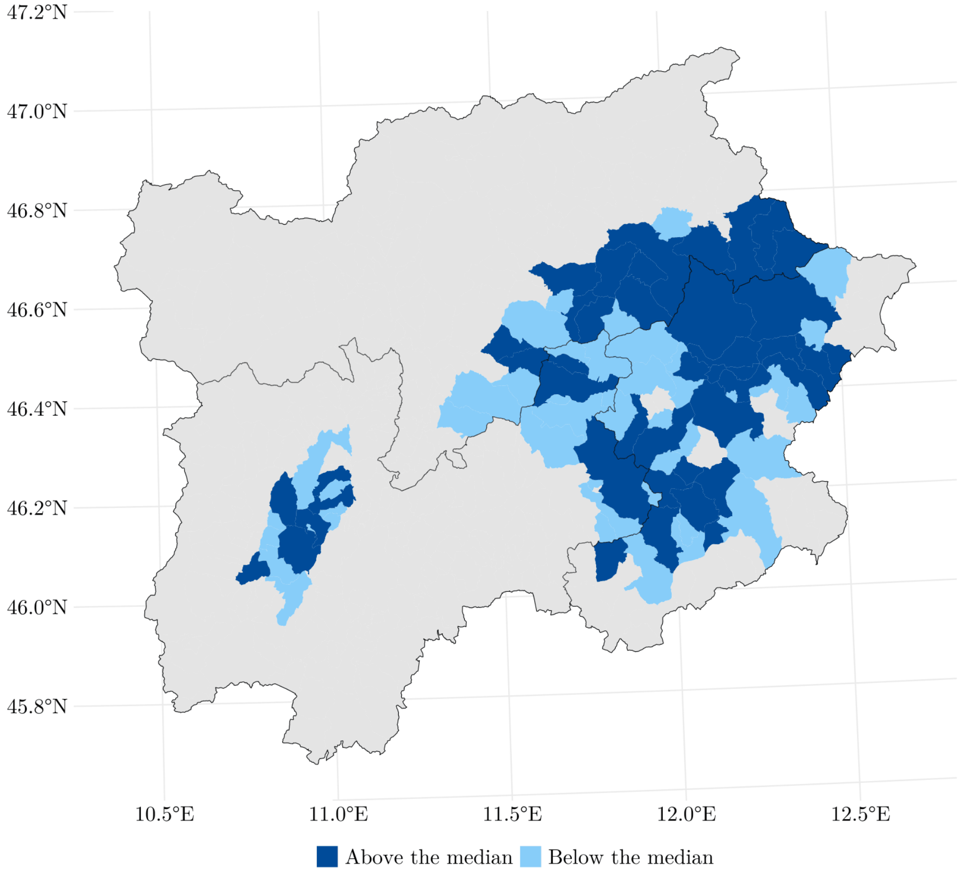
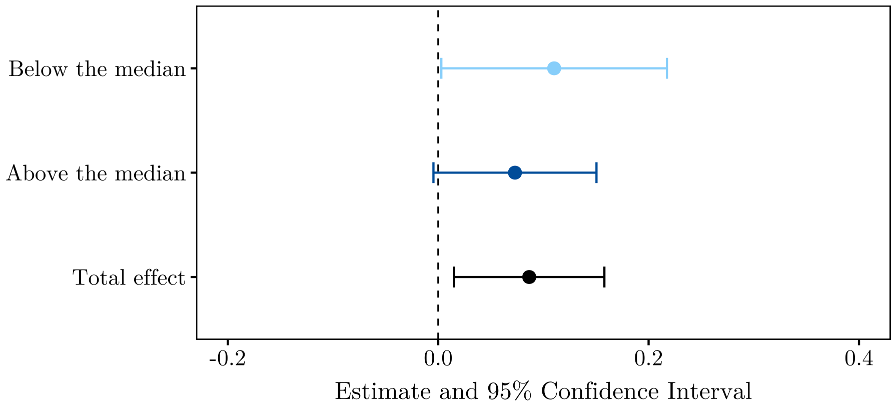


Figure 8: Linear combination of post-UNESCO designation event study Difference-in-Differences coefficients for municipalities with Dolomites serial property's core zones above and below the median.



Notes: The linear combination is obtained by linearly interpolating the event study coefficients for the post-intervention period (leads $\ell = 0$ to 4). The corresponding Standard Error is derived with the delta method, using the variance–covariance matrix clustered at the municipality level. The total effect is reported for comparison and corresponds to the estimates derived from the main specification whose results are presented in Section 6. The F-test on the pre-intervention coefficients for the split samples yields the following p-values: 0.210 for the sample with municipalities below the median and 0.247 for the sample with municipalities above the median.

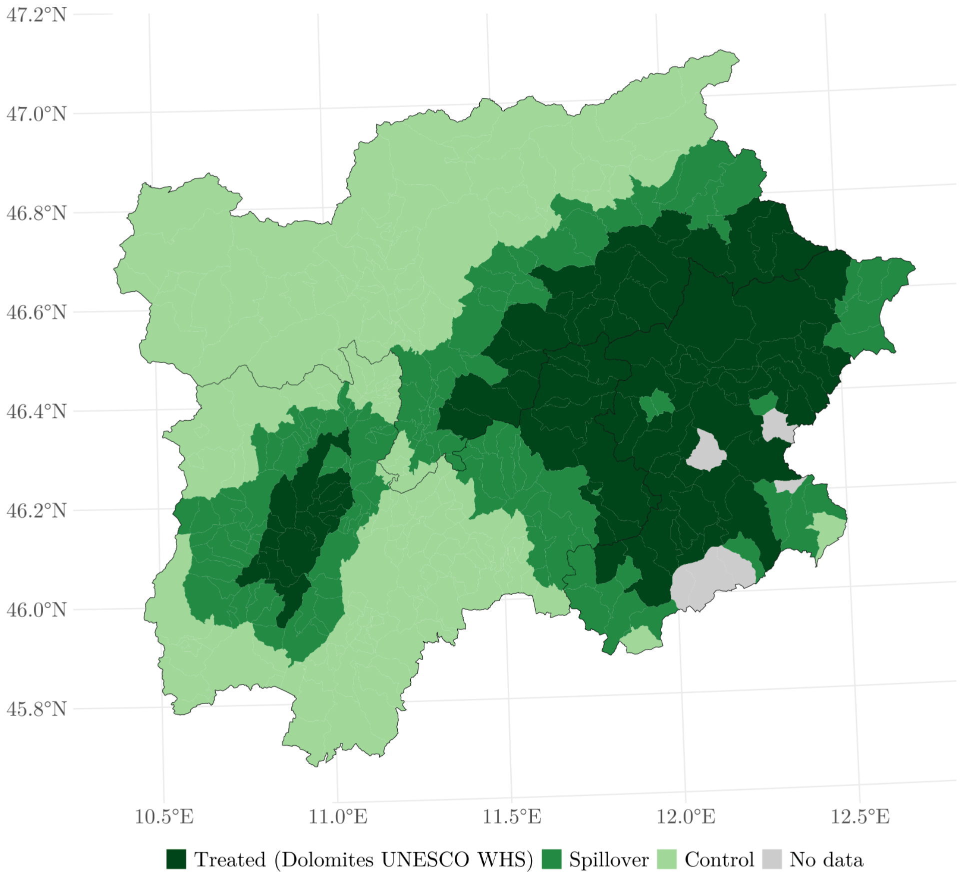
the inclusion of such neighboring municipalities in the control group used to approximate the counterfactual and UNESCO certification effect estimation would generate spillover effects and invalidate the main model estimates due to violation of the Stable Unit Treatment Value Assumption (SUTVA) (Rubin, 1978, 1990; Angrist et al., 1996). Should the neighbouring areas have benefited from (or been harmed by) the Dolomites' inscription on the World Heritage List, the treatment–control differential would be downward (upward) biased. To mitigate this issue, the present analysis seeks to detect the potential presence of spatial spillovers. Following Butts (2021), we therefore subsequently augment the Difference-in-Differences specification in Equation 1 with an indicator for adjacent municipalities. Specifically, we define a dummy variable S_i that takes the value one for any municipality that is not directly treated but whose administrative boundary lies within 4 km of a treated municipality's boundary, and zero otherwise. Figure 9 shows the three-province area, with municipalities shaded according to their status.

We then estimate:

$$\ln(Y_{it}) = \alpha + \sum_{\ell \neq -1} \tau_\ell^{\text{Direct}} \big(D_i \, \mathbf{1}\{t - T^{\text{UNESCO}} = \ell\}\big) + \sum_{\ell \neq -1} \tau_\ell^{\text{Spillover}} \big(S_i \, \mathbf{1}\{t - T^{\text{UNESCO}} = \ell\}\big) + \delta_i + \delta_{ct} + \varepsilon_{it} \tag{6}$$

In this framework, $\tau_\ell^{\text{Direct}}$ captures the (dynamic) direct effect of UNESCO inscription on treated municipalities, while $\tau_\ell^{\text{Spillover}}$ identifies any (dynamic) spillover effect on adjacent municipalities, using those with $D_i = 0$ and $S_i = 0$ as the control group.

Figure 9: Classification of municipalities as treated, spillover, or control within the provinces of Trento, Bolzano, and Belluno.

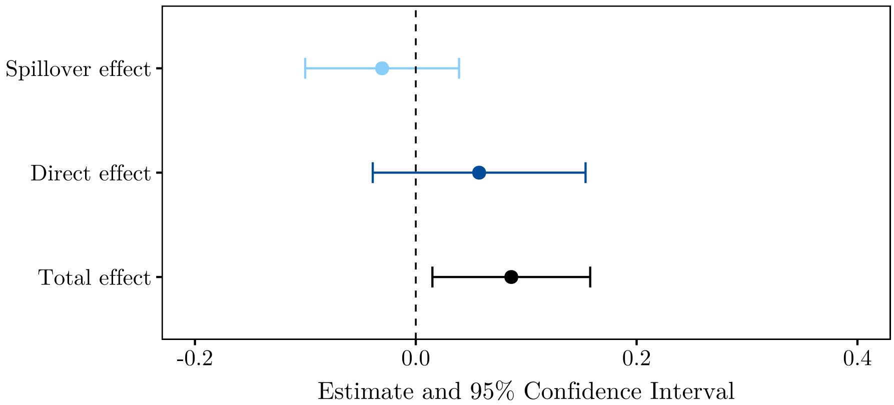


The linear combinations of the estimated post-treatment coefficients for both spillover and direct effects are presented in Figure 10. For adjacent municipalities, the post-inscription effect is slightly negative, around –3%, but it is not statistically different from zero at the 95% confidence level. The direct effect for treated municipalities is positive and nearly +6%, yet it also fails to reach conventional levels of statistical significance.

The negative point estimate for spillovers, if taken at face value, could suggest a modest displacement effect, where tourism flows may have partially shifted from adjacent areas toward more distant or newly designated destinations, that could in principle contribute to the overall effect. While the lack of statistical significance limits our ability to confirm a SUTVA violation, these results suggest that any potential indirect impacts on neighbors are likely contained.

Although the F-test on pre-treatment coefficients is marginally significant for spillovers, the overall evi-dence supports the validity of our main specification and our findings while acknowledging the difficulty of fully satisfying SUTVA in spatial settings.

Figure 10: Linear combination of post-UNESCO designation event study Difference-in-Differences coefficients for the Direct and Spillover effects.

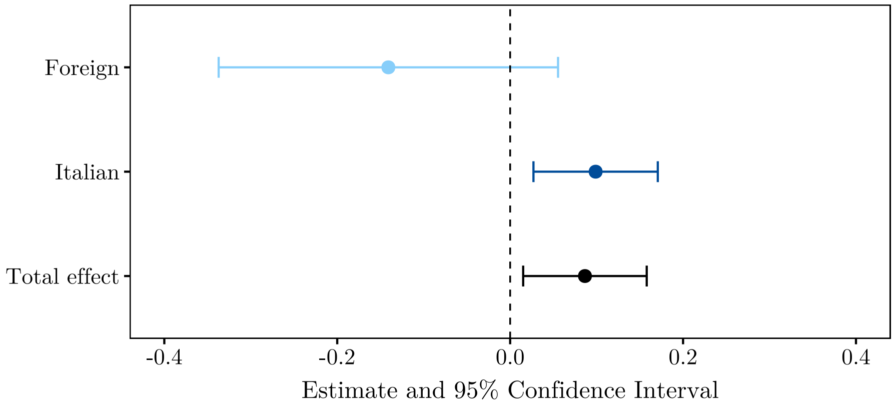


Notes: The linear combination is obtained by linearly interpolating the event study coefficients for the post-intervention period (leads $\ell = 0$ to 4). The corresponding Standard Error is derived with the delta method, using the variance–covariance matrix clustered at the municipality level. The total effect is reported for comparison and corresponds to the estimates derived from the main specification whose results are presented in Section 6. The F-test on the pre-intervention coefficients for the split samples yields the following p-values: 0.330 for the direct effect coefficients and 0.044 for the spillover coefficients.

8 Heterogeneities

To assess whether the impact of the UNESCO World Heritage designation differs according to specific characteristics, we conduct a set of heterogeneity analyses. As a first step, to examine whether the effect varies by the origin of tourists, we estimate the main Difference-in-Differences model but separately using the logarithm of overnight stays for domestic and foreign visitors as the dependent variables. Figure 11 presents the linear combination of post-intervention coefficients.

Figure 11: Linear combination of post-UNESCO designation event study Difference-in-Differences coefficients for Italian and Foreign tourists.



Notes: The linear combination is obtained by linearly interpolating the event study coefficients for the post-intervention period (leads $\ell = 0$ to 4). The corresponding Standard Error is derived with the delta method, using the variance–covariance matrix clustered at the municipality level. The total effect is reported for comparison and corresponds to the estimates derived from the main specification whose results are presented in Section 6. The F-test on the pre-intervention coefficients for the split samples yields the following p-values: 0.098 for the italian sample and 0.477 for the foreign sample.

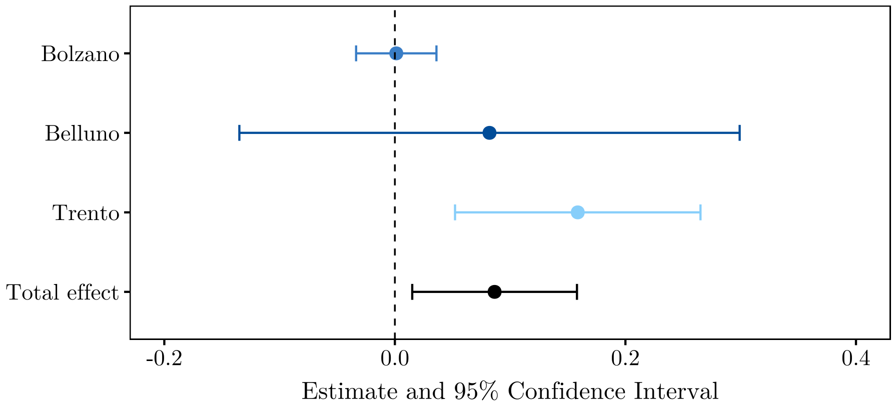
The results reveal a positive and statistically significant effect slightly above +10.3% on domestic tourist arrivals. By contrast, we find negative but statistically insignificant effects on foreign visitors. These findings suggest that the UNESCO listing functioned mainly as an internal information shock, stimulating demand among Italian tourists without generating a comparable response from international markets. One plausible explanation is that foreign tourists may have already internalized the scenic and cultural reputation of the Dolomites prior to 2009, making the UNESCO inscription a source of only marginal information surplus for international markets. Moreover, the announcement likely received greater media coverage and informational relevance within national channels, where news of the certification was more explicitly disseminated. It is also important to note that estimates for foreign overnight stays are less precise, potentially due to the substantial heterogeneity that characterizes international tourist flows in terms of origin, preferences, and travel behavior. This variability may underpin location-specific effects and demand-side asymmetries that can only be detected at a more disaggregated level of analysis.[15]

If this interpretation holds, we would also expect a weaker effect for municipalities located in the province of Bolzano compared to those in Trento and Belluno. This is

[15] This pattern is consistent with Accetturo et al. (2019), who find that cultural proximity—measured by shared language—positively influences tourist flows from German-speaking countries. In the province of Bolzano, the Dolomitic area lies mainly in the southeast, where the share of German speakers is comparatively low (ASTAT, 2024), potentially limiting the impact of UNESCO status on tourism from neighboring countries such as Austria, Germany, and Switzerland.

precisely what emerges when examining heterogeneity at the provincial level. Figure 12 presents the linear combinations of post-treatment effects, estimated separately for treated municipalities in each province. In this respect, the average effect over the period 2009–2013 is close to zero for Bolzano, while it reaches nearly +17.2% for Trento and approximately +8.5% for Belluno. The latter, however, is not statistically significant, likely due to lower estimation precision stemming from the smaller sample size in that subgroup.

Figure 12: Linear combination of post-UNESCO designation event study Difference-in-Differences coefficients by province.



Notes: The linear combination is obtained by linearly interpolating the event study coefficients for the post-intervention period (leads $\ell = 0$ to 4). The corresponding Standard Error is derived with the delta method, using the variance–covariance matrix clustered at the municipality level. The total effect is reported for comparison and corresponds to the estimates derived from the main specification whose results are presented in Section 6. The F-test on the pre-intervention coefficients for the split samples yields the following p-values: 0.729 for the Bolzano sample, 0.868 for the Belluno sample and 0.090 for the Trento sample.

9 Natural heritage preservation

As shown in the previous sections, the recognition of the Dolomites as a UNESCO World Heritage Site, while primarily aimed at safeguarding the natural value of the area, has also contributed to an increase in tourism demand. In this section, we explore whether this increase has led to adverse environmental consequences, focusing on two key dimensions: land consumption and waste production. Our analysis leverages Difference-in-Differences estimators to identify whether these pressures have materially affected the natural environment, or if instead the UNESCO designation may have contributed to improved preservation outcomes.

9.1 Effects on land consumption

Land consumption captures the physical expansion of built-up areas, which may reflect pressures from tourism-related infrastructure development and urbanization, that can fragment natural habitats and alter landscape integrity. To assess whether the increase in tourist flows resulted in higher land use, we employ data from Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA) on consumed soil measured in hectares. This is defined as the surface of land with artificial coverage, encompassing all areas where the landscape has been altered or influenced by construction activities, resulting in the replacement of natural surfaces with artificial structures or materials.

Since annual data are available only from 2015 onward, we compare the only available pre-treatment observation (2006) with the two earliest available post-treatment years (2012 and 2015), allowing us to evaluate both medium and longer-term effects. Specifically, given the impossibility of conducting an event study as in our main analysis, we implement a two-period Difference-in-Differences approach, using repeated cross-sections, estimating the following models:

$$\ln\big(\mathrm{LC}_{it}\big) = \gamma + \tau^{\mathrm{DiD}}_{2012}\left(D_i \times \mathrm{Post}^{2012}_t\right) + \delta_i + \delta_t + \varepsilon_{it} \tag{7}$$

$$\ln\big(\mathrm{LC}_{it}\big) = \gamma' + \tau^{\mathrm{DiD}}_{2015}\left(D_i \times \mathrm{Post}^{2015}_t\right) + \delta_i + \delta_t + \varepsilon_{it} \tag{8}$$

In both specifications, LC_{it} denotes land consumption in municipality i and year t, D_i is the treatment indicator as defined in our main specification, Post^{2012}_t and Post^{2015}_t are post-treatment indicators equal to one for the years 2012 and 2015, respectively. The coefficients $\tau^{\mathrm{DiD}}_{2012}$ and $\tau^{\mathrm{DiD}}_{2015}$ capture the differential percentage change in land consumption between Dolomites municipalities and control municipalities from 2006 to the respective post-designation years. Municipality and year fixed effects are included via δ_i and δ_t, and both models are estimated using the same inverse probability weighting scheme applied in the main analysis.

The results for both models, reported in Table 3, show no statistically significant effect on land consumption following the UNESCO recognition. This differential non-change suggests that the increase in tourism flows did not result in substantial new urban development or infrastructure expansion in the Dolomites area relative to comparable non-Dolomite municipalities[16].

[16] The reader could have the concern that the two-period DiD analysis for land consumption, due to its small effective sample size ($N \times 2$) and the inclusion of fixed effects, lacks the statistical power to detect a true effect (Type II error). To mitigate this, we performed a power check by re-estimating our main finding (log overnight stays) in the same low-power setting. The results of this check are reassuring: the core finding of a positive, significant effect on tourism demand is still detected in this constrained sample (coefficient: 0.133, p-value: 0.047, N=680 for 2008–2011). The sustained statistical significance of

Table 3: Difference-in-Differences estimates of the effect of UNESCO World Heritage inscription on the log of land consumption.

	Variation period	
	2006–2012	**2006–2015**
τ^{DiD}_{2012}	0.0002	–
	(0.0020)	
τ^{DiD}_{2015}	–	−0.0118
		(0.0126)
N. of obs.	670	670
R^2	0.999	0.999

Notes: · significant at the 10% level, significant at the 5% level, * significant at the 1% level, *** significant at the 0.1% level. Standard errors clustered at the municipality level in parentheses. All models include municipality and year fixed effects. Variations are computed relative to the baseline year 2006. Coefficients are rounded to four decimal places to provide greater precision.

9.2 Effects on Waste production

We next examine whether higher tourist inflows are associated with the quantity and composition of waste produced in the Dolomites municipalities. This is a relevant dimension, as increases in visitors often put pressure on local waste management systems and can serve as a proxy for the environmental footprint of tourism. Tourists tend to generate more mixed and disposable waste—such as food packaging, single-use items, and containers—while staying in accommodations or using public facilities, where sorting rules may be less rigorously followed than in households. As a result, tourism-driven waste typically includes a higher share of unsorted (residual) waste, which is more costly and environmentally damaging to process.

As in the previous section, municipal-level waste data are sourced from ISPRA. The dataset includes quantities in tonnes of waste in total and across different categories. Our analysis focuses on the most relevant fractions: organic waste, plastic, glass, paper, and green waste among the sorted categories, and unsorted waste as the main undifferentiated residual component, as well as total waste production. Together, these account for approximately 80% of total waste production[17]. Moreover, to account for demographic evolution over time, we normalize each waste category by the municipal resident population to obtain

the tourism effect in this demanding framework validates the model's ability to identify impacts, lending credibility to the neutral finding for land consumption.

[17]For this reason, note that, in our analysis, the sum of the chosen fractions does not equal total sorted or total waste, as ISPRA reports additional minor categories that we omit for parsimony.

per capita waste production (tonnes per person).

Due to the unavailability of pre-treatment data (prior to 2010), our analysis is restricted to the 2010–2015 period, immediately after the Dolomites' UNESCO inscription. We estimate separate event study DiD models for each waste category to trace the evolution of output levels in Dolomite municipalities relative to non-Dolomite municipalities.

While the use of fixed effects helps control for time-invariant differences, the lack of pre-treatment data means we cannot formally validate the parallel trends assumption. Therefore, our results should be interpreted as strong correlational evidence of differential trends, as we cannot fully exclude that unobserved factors, correlated with the UNESCO designation, may have influenced the observed change.

Formally, we estimate the following specification:

$$\ln\big(W_{it}^{c}\big) = \alpha + \sum_{k \neq 2010} \tau_k^{c} \left(D_i \times \mathbf{1}\{t = k\}\right) + \delta_i + \delta_t + \varepsilon_{it}^{c} \tag{9}$$

Where W_{it}^{c} is the per-capita waste of category c in municipality i and year t, and D_i is the treated indicator. As before δ_i and δ_t denote municipality and year fixed effects and the equations are estimated using the re-weighted sample. By omitting the term for $k = 2010$, each coefficient τ_k^{c} measures the percentage change in waste generation in year k for treated versus control municipalities relative to this baseline year.

The resulting coefficients indicate a reduction in total waste production driven by a decline in unsorted waste in the treated municipalities (see Table 4). This finding is highly suggestive of improvements in waste sorting and environmental management practices, a positive differential trend possibly catalyzed by the enhanced awareness and regulation linked to UNESCO status. Despite the limitations imposed by the data availability, this evidence points toward a beneficial environmental co-effect.

Table 4: Event study Difference-in-Differences estimates of the effect of UNESCO World Heritage inscription on the log of per capita waste production variables.

Dependent Variable	**Year**					**N. obs.**	R^2
	2011	**2012**	**2013**	**2014**	**2015**		
Organic waste	0.066	0.130 ·	0.137 ·	0.127 ·	0.108	1,893	0.897
	(0.065)	(0.074)	(0.075)	(0.073)	(0.073)		
Plastic	0.034	0.204 ·	0.177	0.150	0.132	1,951	0.841
	(0.107)	(0.105)	(0.131)	(0.104)	(0.116)		
Glass	0.033	−0.022	−0.111	−0.023	−0.190	1,941	0.569
	(0.106)	(0.088)	(0.076)	(0.061)	(0.126)		
Paper	−0.027	0.010	0.013	0.003	0.018	1,977	0.777
	(0.043)	(0.033)	(0.034)	(0.039)	(0.040)		
Green waste	−0.007	−0.057	−0.125	0.040	−0.043	1,638	0.800
	(0.179)	(0.194)	(0.206)	(0.168)	(0.199)		
Total sorted waste	−0.027	−0.001	−0.013	0.023	0.005	1,977	0.887
	(0.035)	(0.031)	(0.034)	(0.035)	(0.033)		
Unsorted waste	−0.172**	−0.208**	−0.192*	−0.218*	−0.230**	1,977	0.835
	(0.061)	(0.076)	(0.088)	(0.085)	(0.083)		
Total municipal waste	−0.080**	−0.066*	−0.073*	−0.052	−0.063**	1,977	0.894
	(0.031)	(0.028)	(0.034)	(0.033)	(0.024)		

Notes: · significant at the 10% level, * significant at the 5% level, ** significant at the 1% level, *** significant at the 0.1% level. Standard errors clustered at the municipality level in parentheses. All models include municipality and year fixed effects. Reference year = 2010.

10 Conclusions

This paper has examined the effects of the Dolomites' inscription as a UNESCO World Heritage Site on local tourism demand and environmental outcomes. Exploiting the institutional discontinuity generated by the 2009 designation and combining Difference-in-Differences techniques with inverse probability weighting and LASSO-based covariate selection, we find robust evidence that the recognition significantly increased tourism demand in the Dolomitic municipalities. The average rise in overnight stays amounts to about 9.1% in the four years following the inscription, with the effect gradually intensifying and becoming statistically significant soon after the designation. Heterogeneity analyses indicate that the increase was mainly driven by domestic tourism and was stronger in Trento than in the other provinces. In terms of market response, the supply side exhibited a restrained and non-expansionary pattern: we found no increase in the number of tourism facilities, and notably, a comparative reduction in available bed capacity. This suggests that the demand shock was absorbed not through quantitative expansion, but likely through pricing, capacity management, or a subtle transition toward higher-value, smaller-scale accommodations. These results collectively suggest a positive trajectory for the overall sustainability of the UNESCO inscription.

Consistent with this non-expansionary supply response, we next explore whether the UNESCO recognition was accompanied by changes in environmental outcomes. We observe no apparent increase in land consumption in treated municipalities despite higher visitor flows. At the same time, total municipal waste displays a statistically significant decline, mainly driven by a reduction in unsorted waste—suggestive of improved sorting practices or the influence of local environmental policies.

Overall, the results suggest that the UNESCO designation acted as a catalyst for both reputational and economic gains while fostering better environmental stewardship. The evidence points to the potential of cultural certification to deliver local economic benefits without compromising environmental quality, provided that effective institutional coordination and robust regulatory safeguards are in place.

However, the external validity of these findings is limited by the distinctive geographical, institutional, and social context of the Dolomites, characterized by strong regional autonomy, advanced administrative coordination, and a long-standing environmental consciousness. Future research could assess whether similar dynamics emerge in different governance settings or in other categories of heritage sites, and explore the longer-term economic and ecological consequences of heritage-driven tourism, including its effects on land markets, housing, public services, and local development. A complementary strand of future work could deepen the environmental dimension by incorporating high-frequency indicators,such as air quality, noise, and traffic, to capture overtourism externalities, and by linking waste dynamics to seasonal visitor flows to sharpen causal identification of UNESCO's impact on local public goods.

Additional material

Variable description and Summary statistics

A complete list of the variables used in this analysis, including those obtained directly from primary sources and those derived through subsequent processing, together with their units of measurement and data sources, is provided in Table A.1.

Summary statistics for the main variables employed in the paper are reported in Table A.2. In particular, the table provides descriptive information on the distribution of the outcome variables and of the covariates selected by the LASSO algorithm, as described in Section 5.1. This is intended to offer a clear overview of the heterogeneity and variability associated with each characteristic.

Calibration and quality of the Propensity Score

Figure A.1 presents the calibration curves used to evaluate the accuracy of our propensity score estimates. The 45-degree red line represents perfect calibration, where predicted probabilities exactly match the observed treatment frequencies. The dashed line shows the logistic calibration curve, obtained by regressing the treatment indicator on the logit of the estimated propensity scores. The solid black curve provides a more flexible representation of calibration based on a non-parametric Loess smoother of the treatment indicator on the predicted probabilities, and highlights any potential local miscalibration. The grey shaded area around the Loess curve denotes the pointwise 95% bootstrap confidence band based on 2,000 resamples.

The logistic calibration intercept is approximately zero, indicating that on average there is no systematic shift between predicted and observed treatment probabilities. In other words, the model does not consistently over or under-estimate the propensity scores across the distribution. Additionally, the calibration slope of 1.266 suggests a mild degree of miscalibration but these discrepancies remain minimal and are unlikely to introduce significant bias into the IPW estimates. Similarly, the Loess curve and its confidence band display only minor and sporadic deviations from the ideal line, providing further evidence that miscalibration is not severe.

Further confirmation of the model's probabilistic accuracy is given by the low Brier score of 0.079. This is calculated as the mean squared difference between the predicted probabilities and the actual treatment assignments, offering a global measure of model performance (Brier, 1950; Gerds et al., 2008; Steyerberg et al., 2010). Complementing this result, the Integrated Calibration Index (ICI) proposed by Austin and Steyerberg (2019) reports an average absolute deviation of 0.026 between predicted and observed probabilities across the full support of the score. This implies that, on average, predicted probabilities differ from true outcome frequencies by only 2.6 percentage points.

Table A.1: Variables, measurement units and data sources.

Variable	Unit	Source
Total overnight stays	Count	ISPAT, ASPAT, SISTAR
Italian overnight stays	Count	ISPAT, ASPAT, SISTAR
Foreign overnight stays	Count	ISPAT, ASPAT, SISTAR
Total arrivals	Count	ISPAT, ASPAT, SISTAR
Tot. nr. of facilities	Count	ISPAT, ASPAT, SISTAR
Tot. nr. of beds	Count	ISPAT, ASPAT, SISTAR
UNESCO fraction	Share	Authors' elaborations from UNESCO data
UNESCO dummy	Binary	Authors' elaborations from UNESCO data
TRI (Mean)	m	Authors' elaborations from Tarquini et al. (2023)
TRI (Riley)	m	Authors' elaborations from Tarquini et al. (2023)
TRI (RMSD)	m	Authors' elaborations from Tarquini et al. (2023)
Elevation	m	Tarquini et al. (2023)
Latitude	degrees	ISTAT Municipal centroids
Longitude	degrees	ISTAT Municipal centroids
Discontinuous urban fabric	ha	European Union, Copernicus Land Monitoring Service (2006)
Continuous urban fabric	ha	European Union, Copernicus Land Monitoring Service (2006)
Industrial areas	ha	European Union, Copernicus Land Monitoring Service (2006)
Road networks	ha	European Union, Copernicus Land Monitoring Service (2006)
Airports	ha	European Union, Copernicus Land Monitoring Service (2006)
Port areas	ha	European Union, Copernicus Land Monitoring Service (2006)
Sport recreational areas	ha	European Union, Copernicus Land Monitoring Service (2006)
Urban green areas	ha	European Union, Copernicus Land Monitoring Service (2006)
Construction sites	ha	European Union, Copernicus Land Monitoring Service (2006)
Landfills	ha	European Union, Copernicus Land Monitoring Service (2006)
Mining areas	ha	European Union, Copernicus Land Monitoring Service (2006)
Permanent grasslands	ha	European Union, Copernicus Land Monitoring Service (2006)
Rainfed arable land	ha	European Union, Copernicus Land Monitoring Service (2006)
Former cultivated land	ha	European Union, Copernicus Land Monitoring Service (2006)
Mixed crops	ha	European Union, Copernicus Land Monitoring Service (2006)
Rice fields	ha	European Union, Copernicus Land Monitoring Service (2006)
Olive groves	ha	European Union, Copernicus Land Monitoring Service (2006)
Vineyards	ha	European Union, Copernicus Land Monitoring Service (2006)
Orchards	ha	European Union, Copernicus Land Monitoring Service (2006)
Heterogeneous agricultural areas	ha	European Union, Copernicus Land Monitoring Service (2006)
Broadleaf forests	ha	European Union, Copernicus Land Monitoring Service (2006)
Coniferous forests	ha	European Union, Copernicus Land Monitoring Service (2006)
Mixed forests	ha	European Union, Copernicus Land Monitoring Service (2006)
Transitional woodland scrub	ha	European Union, Copernicus Land Monitoring Service (2006)
Sparse vegetation	ha	European Union, Copernicus Land Monitoring Service (2006)
Heathlands	ha	European Union, Copernicus Land Monitoring Service (2006)
Pasture areas	ha	European Union, Copernicus Land Monitoring Service (2006)
Bare rock and cliffs	ha	European Union, Copernicus Land Monitoring Service (2006)
Watercourses	ha	European Union, Copernicus Land Monitoring Service (2006)
Water bodies	ha	European Union, Copernicus Land Monitoring Service (2006)
Glaciers and perennial snow	ha	European Union, Copernicus Land Monitoring Service (2006)
Inland wetlands	ha	European Union, Copernicus Land Monitoring Service (2006)
Brackish marshes	ha	European Union, Copernicus Land Monitoring Service (2006)
Lagoons	ha	European Union, Copernicus Land Monitoring Service (2006)
Beaches	ha	European Union, Copernicus Land Monitoring Service (2006)
Peatbogs	ha	European Union, Copernicus Land Monitoring Service (2006)
Salt pans	ha	European Union, Copernicus Land Monitoring Service (2006)
Sclerophyllous vegetation	ha	European Union, Copernicus Land Monitoring Service (2006)
Agroforestry areas	ha	European Union, Copernicus Land Monitoring Service (2006)
Burnt areas	ha	European Union, Copernicus Land Monitoring Service (2006)
Estuaries	ha	European Union, Copernicus Land Monitoring Service (2006)
Irrigated arable land	ha	European Union, Copernicus Land Monitoring Service (2006)
Seas and oceans	ha	European Union, Copernicus Land Monitoring Service (2006)
Land consumption	ha	ISPRA
Total municipal waste	t	ISPRA
Total sorted waste	t	ISPRA
Organic waste	t	ISPRA
Plastic	t	ISPRA
Glass	t	ISPRA
Paper	t	ISPRA
Green waste	t	ISPRA
Unsorted waste	t	ISPRA

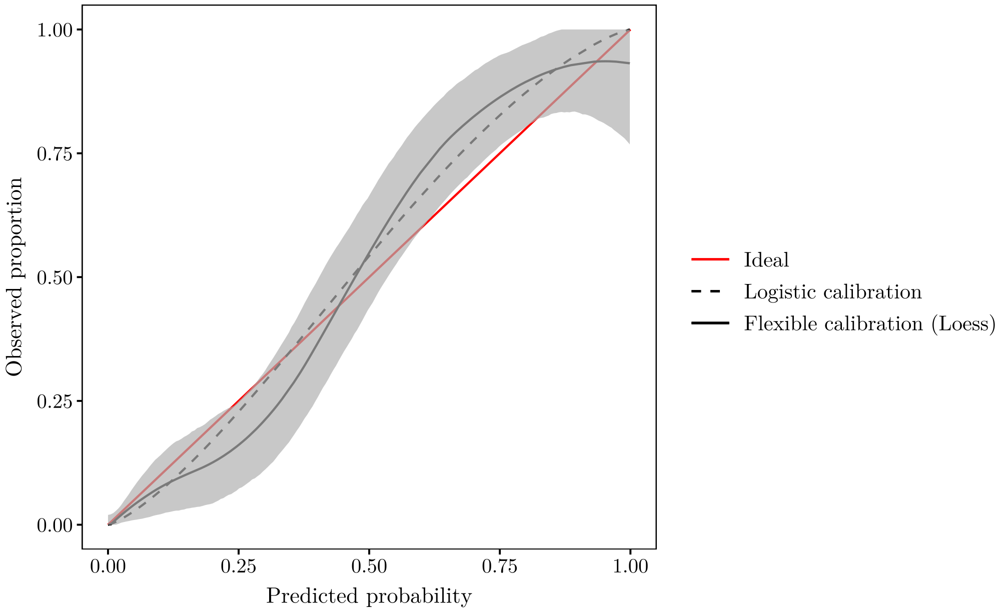
Notes: UNESCO fraction measures the fraction of the Dolomites World Heritage Site serial property's core zones relative to the municipality's total area. UNESCO dummy identifies all municipalities with a positive core zone fraction.

Table A.2: Descriptive statistics for the main variables

Variable	**Min**	**Q1**	**Median**	**Q3**	**Max**	**Mean**	**Std. Dev.**	**N. of Obs.**
Total overnight stays	0.00	15,915.25	64,328.00	209,853.00	1,781,471.00	181,499.02	278,796.82	3,060
Italian overnight stays	0.00	9,814.75	29,550.00	101,781.75	1,601,952.00	109,054.63	198,327.02	3,000
Foreign overnight stays	0.00	1,368.00	14,213.50	80,733.25	1,215,834.00	76,084.96	143,220.83	2,998
Total arrivals	0.00	2,732.50	10,999.50	37,519.25	357,699.00	32,576.99	51,500.28	3,060
Tot. nr. of facilities	0	6	21	66	2,158	62.58	133.59	2,906
Tot. nr. of beds	0	135	532	1,574	17,790	1,299.81	1,915.33	2,906
UNESCO fraction	0.00	0.00	0.00	0.00	0.69	0.05	0.12	3,141
UNESCO dummy	0.00	0.00	0.00	0.00	1.00	0.23	0.42	3,141
TRI (RMSD)	0.09	3.67	4.62	5.32	8.23	4.50	1.28	3,141
TRI (Riley)	0.25	10.37	13.07	15.06	23.28	12.71	3.61	3,141
Elevation	201.73	930.52	1,316.52	1,657.79	2,494.81	1,300.80	494.23	3,141
Industrial areas	0.00	0.00	0.00	0.00	513.95	11.56	43.09	3,141
Coniferous forests	0.00	327.19	957.94	2,352.64	13,448.87	1,631.60	1,881.71	3,141
Mixed forests	0.00	12.41	201.77	640.20	7,223.95	476.62	743.94	3,141
Heathlands	0.00	0.00	36.06	199.36	2,756.25	158.80	294.59	3,141
Construction sites	0.00	0.00	0.00	0.00	43.43	0.21	2.85	3,141
Agricultural crops	0.00	16.36	99.44	210.53	1,676.00	154.81	194.33	3,141
Crops	0.00	0.00	0.00	0.00	324.30	8.31	35.59	3,141
Watercourses	0.00	0.00	0.00	0.00	122.14	1.15	8.75	3,141
Orchards	0.00	0.00	0.00	11.92	1,219.30	83.97	214.28	3,141
Glaciers	0.00	0.00	0.00	0.00	1,546.03	43.78	189.22	3,141
Permanent grasslands	0.00	0.00	82.93	308.85	4,071.32	242.92	423.49	3,141
Road networks	0.00	0.00	0.00	0.00	130.38	1.00	9.60	3,141
Rocks cliffs	0.00	0.00	14.21	374.56	6,611.62	446.84	976.13	3,141
Arable land	0.00	0.00	0.00	0.00	649.88	20.44	77.16	3,141
Cultural systems	0.00	0.00	0.00	96.14	3,500.48	111.19	294.45	3,141
Disc. urban fabric	0.00	25.16	50.68	98.65	1,909.62	80.65	134.96	3,141
Peatbogs	0.00	0.00	0.00	0.00	37.90	0.11	2.03	3,141
Woodland vegetation	0.00	5.46	109.20	318.24	2,329.32	240.01	358.60	3,141
Sparse vegetation	0.00	0.00	76.06	348.85	4,124.83	345.58	671.30	3,141
Vineyards	0.00	0.00	0.00	0.00	1,313.42	26.90	116.41	3,141

Notes: The table reports descriptive statistics for all outcome variables and the covariates selected by the LASSO among those listed in Table A.1.

Figure A.1: Calibration plot (Reliability curve) of estimated propensity scores for UNESCO World Heritage Site Inscription.



Notes: The 45-degree red line indicates perfect calibration. The dashed line shows the logistic calibration curve, obtained by regressing the treatment indicator on the logit of the estimated propensity scores. The solid black curve is a non-parametric Loess smoother of the treatment indicator on the predicted probabilities. The grey shaded area represents the pointwise 95% bootstrap confidence band based on 2,000 resamples. The logistic regression yields an intercept close to zero and a calibration slope of 1.266, suggesting limited miscalibration.

Table A.3: Standardized Mean Difference of covariates before (Unadjusted sample) and after (Adjusted sample) Inverse Probability Weighting.

Variable	**Difference Unadjusted**	**Difference Adjusted**
Permanent grasslands	0.2014	0.0029
Urban green areas	0.0127	0.0042
Peatbogs	0.0127	0.0045
Heterogeneous agricultural areas	0.0767	0.0073
Broadleaf forests	0.1217	0.0073
Sport recreational areas	0.0962	0.0100
Construction sites	0.1175	0.0225
Watercourses	0.0276	0.0245
Mixed forests	0.0200	0.0409
Longitude	1.3261	0.0606
Rainfed arable land	0.2866	0.0618
Mixed crops	0.2443	0.0645
Bare rock and cliffs	0.3785	0.0825
Heathlands	0.556	0.0883
Sparse vegetation	0.2468	0.1019
Inland wetlands	0.1404	0.1082
TRI (Mean)	0.9448	0.1103
Former cultivated land	0.0555	0.1111
Continuous urban fabric	0.1131	0.1121
Coniferous forests	0.5400	0.1126
Airports	0.1474	0.1142
TRI (RMSD)	0.9517	0.1196
TRI (Riley)	0.9517	0.1196
Transitional woodland scrub	0.0079	0.1215
Road networks	0.1665	0.1308
Water bodies	0.0985	0.1361
Discontinuous urban fabric	0.0643	0.1445
Mining areas	0.1611	0.1509
Industrial areas	0.0958	0.1646
Orchards	0.4071	0.1835
Pasture areas	0.1876	0.1864
Elevation	0.7176	0.2121
Beaches	0.3854	0.2272
Latitude	0.2121	0.2670
Glaciers and perennial snow	0.3444	0.2757
Vineyards	0.3664	0.2838
Average SMD	0.3077	0.1132

Notes: Standardized Mean Differences (SMDs) are reported in absolute value. Land-cover covariates that exhibited zero values in both treated and control groups, and thus yielded a null SMD, were excluded to ensure greater clarity and conciseness. "Average SMD" is the average absolute SMD across all covariates.

Alternative Event Study Difference-in-Differences specifications

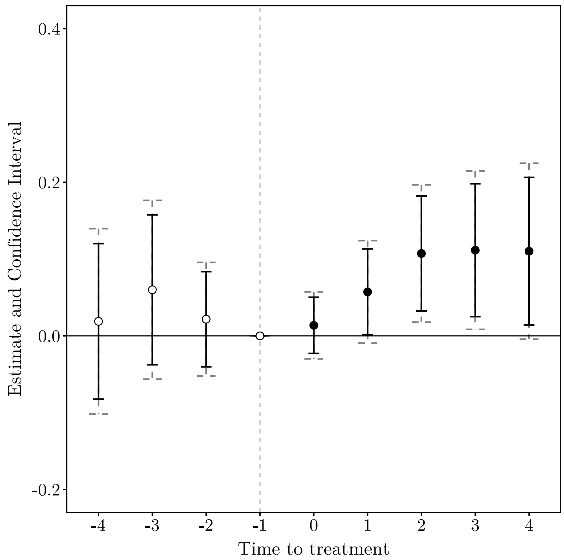
Table A.4 presents the results from alternative specifications of the event-study Difference-in-Differences model for the impact of Dolomites' UNESCO World Heritage Site designation, alongside our main specification. In particular, column (1) corresponds to the raw model without any fixed effects or re-weighting, column (2) shows estimates for the model without inter-municipal-group-by-year fixed effects and thus does not account for confounding factors in tourism supply, column (3) refers to our main specification estimated on the original sample, without applying re-weighting, while column (4) shows the results from the main specification as described in Equation 1.

Table A.4: Event-study Difference-in-Differences estimates of the effect of UNESCO World Heritage inscription on log overnight stays.

	Model			
	(1)	**(2)**	**(3)**	**(4)**
τ_{-4}^{DiD}	0.917***	0.055	0.051	0.068
	(0.223)	(0.057)	(0.063)	(0.096)
τ_{-3}^{DiD}	0.943***	0.115 ·	0.069	0.120
	(0.225)	(0.063)	(0.060)	(0.102)
τ_{-2}^{DiD}	0.860***	0.012	0.032	0.059
	(0.222)	(0.037)	(0.039)	(0.062)
τ_{0}^{DiD}	0.609**	0.087*	0.019	0.018
	(0.215)	(0.043)	(0.021)	(0.020)
τ_{+1}^{DiD}	0.630**	0.097*	0.048	0.071*
	(0.215)	(0.044)	(0.032)	(0.033)
τ_{+2}^{DiD}	0.642**	0.133*	0.087*	0.131**
	(0.215)	(0.067)	(0.042)	(0.047)
τ_{+3}^{DiD}	0.636**	0.076	0.093 ·	0.106*
	(0.215)	(0.054)	(0.052)	(0.053)
τ_{+4}^{DiD}	0.492**	0.071	0.109 ·	0.106 ·
	(0.213)	(0.062)	(0.064)	(0.058)
Weighted	No	Yes	No	Yes
δ_i	No	Yes	Yes	Yes
δ_t	No	Yes	No	No
δ_{ct}	No	No	Yes	Yes
N. of Obs.	3,044	3,044	3,044	3,044
R^2	0.021	0.985	0.984	0.987

Notes: The subscripts i, t, and c denote municipality, year, and inter-municipal group, respectively. · significant at the 10% level, * significant at the 5% level, ** significant at the 1% level, *** significant at the 0.1% level. Weighted indicates that observations are weighted according to inverse probability weights computed as in Equation 5. In all the models the reference period is −1.

Figure A.2: Event-study Difference-in-Differences estimates of the effect of UNESCO World Heritage inscription on log arrivals with Standard Logit IPW.



Notes: White dots correspond to all pre-intervention periods, while black dots represent all post-intervention periods. Solid black bars depict 90% confidence intervals, grey dashed bars depict 95% confidence intervals. Standard errors are clustered at the municipality level. Inverse Probability Weights are calculated using a Standard Logit over the entire set of covariates.

References

Ababneh, A. (2021). Heritage management and accessibility to world heritage sites in jordan: A field work analysis study of petra. *Heritage & Society*, 14(2-3):160–183.

Accetturo, A., Cascarano, M., Degasperi, P., and Modena, F. (2019). The effects of common culture and language on economic exchanges: evidence from tourist flows. *Regional Studies*.

Agnew, N. and Demas, M. (2013). Visitor management and carrying capacity at World Heritage sites in china. In *Extended Abstracts of the International Colloquium*, pages 17–19.

Almeida, T. S. B. (2023). *The attractiveness of the UNESCO cultural heritage: from the perspective of tour operators*. PhD thesis, Universidad de Sevilla.

Andergassen, R. and Guerra, A. (2025). The UNESCO effect on property values: A synthetic control study on the dolomites. *Available at SSRN 5588130*.

Angrist, J. D., Imbens, G. W., and Rubin, D. B. (1996). Identification of causal effects using instrumental variables. *Journal of the American statistical Association*, 91(434):444–455.

Ashenfelter, O. C. and Card, D. (1984). Using the longitudinal structure of earnings to estimate the effect of training programs. *National Bureau of Economic Research Cambridge, Mass., USA*.

ASTAT (2024). ASTAT Info 56/2024: Ergebnisse der Sprachgruppenzählung – 2024 Risultati Censimento linguistico – 2024. Technical Report Info 56, ASTAT, Bozen. Pressnote ASTAT.

Austin, P. C. and Steyerberg, E. W. (2019). The integrated calibration index (ici) and related metrics for quantifying the calibration of logistic regression models. *Statistics in medicine*, 38(21):4051–4065.

Ballinari, D. and Bearth, N. (2024). Improving the finite sample performance of double/debiased machine learning with propensity score calibration. *arXiv preprint arXiv:2409.04874*.

Bertacchini, E., Revelli, F., and Zotti, R. (2024). The economic impact of UNESCO world heritage: Evidence from italy. *Regional Science and urban economics*, 105:103996.

Bertocchi, D., Van der Borg, J., and Camatti, N. (2021). Tourism peaks on the three peaks: Using big data to monitor where, when and how many visitors impact the dolomites UNESCO World Heritage site. *Rivista geografica italiana: CXXVIII, 3, 2021*, pages 59–81.

Bonzanigo, L., Giupponi, C., and Balbi, S. (2016). Sustainable tourism planning and climate change adaptation in the alps: A case study of winter tourism in mountain communities in the dolomites. *Journal of Sustainable Tourism*, 24(4):637–652.

Brier, G. W. (1950). Verification of forecasts expressed in terms of probability. *Monthly Weather Review*, 78(1):1–3.

Buckley, R. (2018). Tourism and natural World Heritage: A complicated relationship. *Journal of Travel Research*, 57(5):563–578.

Butts, K. (2021). Difference-in-differences estimation with spatial spillovers. *arXiv preprint arXiv:2105.03737*.

Canale, R. R., De Simone, E., Di Maio, A., and Parenti, B. (2019). UNESCO World Heritage sites and tourism attractiveness: The case of italian provinces. *Land use policy*, 85:114–120.

Card, D. and Krueger, A. B. (1993). Minimum wages and employment: A case study of the fast food industry in new jersey and pennsylvania. *National Bureau of Economic Research Cambridge, Mass., USA*.

Conley, T. G. (1999). Gmm estimation with cross sectional dependence. *Journal of econometrics*, 92(1):1–45.

Çorbacıoğlu, Ş. K. and Aksel, G. (2023). Receiver operating characteristic curve analysis in diagnostic accuracy studies: A guide to interpreting the area under the curve value. *Turkish journal of emergency medicine*, 23(4):195–198.

Cuccia, T., Guccio, C., and Rizzo, I. (2016). The effects of UNESCO World Heritage list inscription on tourism destinations performance in italian regions. *Economic Modelling*, 53:494–508.

Cui, S., Gao, Y., Huang, Y., Shen, L., Zhao, Q., Pan, Y., and Zhuang, S. (2023). Advances and applications of machine learning and deep learning in environmental ecology and health. *Environmental Pollution*, 335:122358.

De Simone, E., Giua, M., and Vaquero-Piñeiro, C. (2024). Eat, visit, love. world heritage list and geographical indications: Joint acknowledgement and consistency as drivers of tourism attractiveness in italy. *Tourism Economics*, 30(6):1531–1556.

Deshpande, S. and Kuleshov, V. (2023). Calibrated and conformal propensity scores for causal effect estimation. *arXiv preprint arXiv:2306.00382*.

Duvivier, C., Bussière, C., and Polge, E. (2025). Protected areas and local economic development. *Regional Studies*, 59(1):2430346.

Elmi, M. and Wagner, M. (2013). Turismo sostenibile nelle dolomiti. *Una strategia per il bene patrimonio mondiale UNESCO*, page 209.

European Commission and Directorate-General for Environment (1997). *Natura 2000 – Managing our heritage*. Publications Office.

European Union, Copernicus Land Monitoring Service (2006). CORINE Land Cover 2006 (vector, 100 m resolution). European Union's Copernicus Land Monitoring Service information, `https://land.copernicus.eu/en/products/corine-land-cover/clc-2006`. Accessed: May 2025.

Falk, M. T. and Hagsten, E. (2021). Visitor flows to World Heritage sites in the era of instagram. *Journal of Sustainable Tourism*, 29(10):1547–1564.

Falk, M. T. and Hagsten, E. (2023). Threat perception and adaptive capacity of natural world heritage site management. *Environmental management*, 71(2):285–303.

Fischer, J. E., Bachmann, L. M., and Jaeschke, R. (2003). A readers' guide to the interpretation of diagnostic test properties: clinical example of sepsis. *Intensive care medicine*, 29:1043–1051.

Fondazione Dolomiti UNESCO (2008). *Nomination of the Dolomites for inscription on the World Natural Heritage List UNESCO*. Italy. Nomination dossier submitted for World Heritage inscription by the Italian State Party (Provinces of Belluno, Bolzano-Alto Adige, Pordenone, Trento, Udine and Regione Autonoma Friuli Venezia Giulia).

Fondazione Dolomiti UNESCO (2014). Statuto della Fondazione "Dolomiti – Dolomiten – Dolomites – Dolomitis UNESCO". `https://www.dolomitiunesco.info/fondazione-dolomiti-unesco/statuto`. Accessed: May 2025.

Fondazione Dolomiti UNESCO (2015). World Heritage Site The Dolomites: Overall Management Strategy [+ Tourism Strategy]. Accessed: May 2025.

Franch, M., Martini, U., and Della Lucia, M. (2011). La sostenibilità dello sviluppo turistico: il caso delle dolomiti patrimonio naturale dell'UNESCO. *Impresa Progetto-Electronic Journal of Management*, (2).

Franch, M., Martini, U., Luigi Novi Inverardi, P., and Buffa, F. (2006). From reconstruction and analysis of tourist profiles to some suggestions to destination management—an empirical research in the dolomites area. *Tourism Review*, 61(2):30–37.

Frey, B. S., Pamini, P., and Steiner, L. (2013). Explaining the World Heritage list: an empirical study. *International Review of Economics*, 60:1–19.

Gerds, T. A., Cai, T., and Schumacher, M. (2008). The performance of risk prediction models. *Biometrical Journal: Journal of Mathematical Methods in Biosciences*, 50(4):457–479.

Goller, D., Lechner, M., Moczall, A., and Wolff, J. (2020). Does the estimation of the propensity score by machine learning improve matching estimation? the case of germany's programmes for long term unemployed. *Labour Economics*, 65:101855.

Gong, H., Zheng, Y., Shi, J., Wang, J., Yang, H., Sibalo, S. P. A., Mwamlima, A., Li, J., Xu, S., Xu, D., et al. (2023). An examination of the spatial spillover effects of tourism transportation on sustainable development from a multiple-indicator cross-perspective. *Sustainability*, 15(5):4522.

Gutman, R., Karavani, E., and Shimoni, Y. (2024). Improving inverse probability weighting by post-calibrating its propensity scores. *Epidemiology*, 35(4):473–480.

Handorf, E., Yin, Y., Slifker, M., and Lynch, S. (2020). Variable selection in social-environmental data: sparse regression and tree ensemble machine learning approaches. *BMC medical research methodology*, 20:1–10.

Hardiman, N. and Burgin, S. (2013). World Heritage area listing of the greater blue mountains—did it make a difference to visitation? *Tourism Management Perspectives*, 6:63–64.

Hirano, K., Imbens, G. W., and Ridder, G. (2003). Efficient estimation of average treatment effects using the estimated propensity score. *Econometrica*, 71(4):1161–1189.

Holland, P. W. (1986). Statistics and causal inference. *Journal of the American statistical Association*, 81(396):945–960.

Huang, C.-H., Tsaur, J.-R., and Yang, C.-H. (2012). Does world heritage list really induce more tourists? evidence from macau. *Tourism management*, 33(6):1450–1457.

Hyland, E. B. and Quinn, J. E. (2023). Conservation spillover effect of UNESCO World Heritage sites into surrounding landscapes. *PeerJ*, 11:e15858.

IUCN (2009). Iucn evaluation of nominations of natural and mixed properties to the World Heritage list: The dolomites (italy). Technical Report WHC-09/33.COM/INF.8B2, IUCN World Heritage Programme, Gland, Switzerland. Report prepared for the 33rd Session of the World Heritage Committee, Sevilla, June 2009.

Kallus, N. (2020). Deepmatch: Balancing deep covariate representations for causal inference using adversarial training. In *International Conference on Machine Learning*, pages 5067–5077. PMLR.

Kutlu, D., Zanbak, M., Soycan, S., Kasalak, M. A., and Aktaş Çimen, Z. (2024). The influence of World Heritage sites on tourism dynamics in the eu 27 nations. *Sustainability*, 16(20):9090.

Lazzarotti, O. (2000). Patrimoine et tourisme: un couple de la mondialisation. *Mappemonde*, 57(1):12–16.

Niculescu-Mizil, A. and Caruana, R. (2005). Predicting good probabilities with supervised learning. In *Proceedings of the 22nd international conference on Machine learning*, pages 625–632.

Pak, A., Rad, A. K., Nematollahi, M. J., and Mahmoudi, M. (2025). Application of the lasso regularisation technique in mitigating overfitting in air quality prediction models. *Scientific Reports*, 15(1):547.

Panzera, E., de Graaff, T., and de Groot, H. L. (2021). European cultural heritage and tourism flows: The magnetic role of superstar World Heritage sites. *Papers in Regional Science*, 100(1):101–123.

Patuelli, R., Mussoni, M., and Candela, G. (2016). *The effects of World Heritage Sites on domestic tourism: a spatial interaction model for Italy*. Springer.

Peira, G., Pasino, G., Bonadonna, A., and Beltramo, R. (2022). A UNESCO site as a tool to promote local attractiveness: Investigating stakeholders' opinions. *Land*, 12(1):11.

Rabenseifner, J., Klaassen, S., Kueck, J., and Bach, P. (2025). Calibration strategies for robust causal estimation: Theoretical and empirical insights on propensity score based estimators. *arXiv preprint arXiv:2503.17290*.

Riley, S. J., DeGloria, S. D., and Elliot, R. (1999). Index that quantifies topographic heterogeneity. *intermountain Journal of sciences*, 5(1-4):23–27.

Robins, J. M., Rotnitzky, A., and Zhao, L. P. (1994). Estimation of regression coefficients when some regressors are not always observed. *Journal of the American statistical Association*, 89(427):846–866.

Rogerson, C. M. and Van der Merwe, C. D. (2016). Heritage tourism in the global south: Development impacts of the cradle of humankind world heritage site, south africa. *Local Economy*, 31(1-2):234–248.

Rosenbaum, P. R. and Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70(1):41–55.

Rubin, D. B. (1974). Estimating causal effects of treatments in randomized and nonrandomized studies. *Journal of educational Psychology*, 66(5):688.

Rubin, D. B. (1978). Bayesian inference for causal effects: The role of randomization. *The Annals of statistics*, pages 34–58.

Rubin, D. B. (1990). Comment: Neyman (1923) and causal inference in experiments and observational studies. *Statistical Science*, 5(4):472–480.

Rubin, D. B. (2005). Causal inference using potential outcomes: Design, modeling, decisions. *Journal of the American statistical Association*, 100(469):322–331.

Scuttari, A., Isetti, G., and Habicher, D. (2019a). Visitor management in world heritage sites: Does overtourism-driven traffic management affect tourist targets, behaviour and satisfaction?: The case of the dolomites UNESCO World Heritage site, italy. In *Overtourism*, pages 187–205. Routledge.

Scuttari, A., Orsi, F., and Bassani, R. (2019b). Assessing the tourism-traffic paradox in mountain destinations. a stated preference survey on the dolomites' passes (italy). *Journal of Sustainable Tourism*, 27(2):241–257.

Steyerberg, E. W., Vickers, A. J., Cook, N. R., Gerds, T., Gonen, M., Obuchowski, N., Pencina, M. J., and Kattan, M. W. (2010). Assessing the performance of prediction models: a framework for traditional and novel measures. *Epidemiology*, 21(1):128–138.

Streifeneder, T. and Omizzolo, A. (2017). The dolomites UNESCO World Heritage: visitors' mobility behaviour and acceptance of regulatory measures. *Eco Mont-J Protect Mt Areas Res*, 9(special issue):93–97.

Szabó, A. and Ujhelyi, G. (2024). National parks and economic development. *Journal of public economics*, 232:105073.

Tarquini, S., Isola, I., Favalli, M., Battistini, A., and Dotta, G. (2023). Tinitaly, a digital elevation model of italy with a 10 meters cell size (version 1.1). *Istituto Nazionale di Geofisica e Vulcanologia (INGV)*, 10.

Tibshirani, R. (1996). Regression shrinkage and selection via the lasso. *Journal of the Royal Statistical Society Series B: Statistical Methodology*, 58(1):267–288.

UNESCO World Heritage Centre (2009). Nomination file 1237rev: The Dolomites. Nomination dossier, UNESCO World Heritage Centre. Accessed May 2025.

UNESCO World Heritage Centre (2025). *Operational Guidelines for the Implementation of the World Heritage Convention.* Paris.

UNESCO World Heritage Committee (2007). Decisions adopted at the 31st session of the World Heritage committee (christchurch, 2007).

UNESCO World Heritage Committee (2009). Decision 33 com 8b.6: The dolomites (italy). Natural properties - Properties deferred or referred back by previous sessions.

Wilson, M. F., O'Connell, B., Brown, C., Guinan, J. C., and Grehan, A. J. (2007). Multiscale terrain analysis of multibeam bathymetry data for habitat mapping on the continental slope. *Marine Geodesy*, 30(1-2):3–35.

Yang, C.-H. and Lin, H.-Y. (2014). Revisiting the relationship between World Heritage sites and tourism. *Tourism Economics*, 20(1):73–86.

Yang, Y., Xue, L., and Jones, T. E. (2019). Tourism-enhancing effect of World Heritage sites: Panacea or placebo? a meta-analysis. *Annals of Tourism Research*, 75:29–41.

Zhang, J., Xiong, K., Liu, Z., and He, L. (2022). Research progress and knowledge system of world heritage tourism: a bibliometric analysis. *Heritage Science*, 10(1):42.

Zunjic, I. (2023). Committee decisions impact on the World Heritage list: breaking the balance. *Protection of Cultural Heritage*, (17):115–128.