The Impact of Wind Turbines Visibility on the Local Economy

Abstract

Tourism in Italy generated an estimated €215 billion in 2023, accounting for 10.5% of national GDP. This study assesses how wind turbine visibility affects tourism across Italian municipalities using a novel, high-resolution measure that combines turbine data with satellite-based elevation models. We find that visibility of wind turbines reduces tourist arrivals by up to 20%, with the effect peaking seven years after installation and gradually fading, suggesting local adaptation. The effect is driven by municipalities where more than 80% of the territory is exposed, particularly in rural, tourism-dependent areas. We uncover a non-linear relationship between the number of visible turbines and the tourism drop, indicating that large wind farms (>65 wind turbines) may be less disruptive than smaller, scattered installations. Tourist spending mirrors these patterns, declining by about 15% (€1.8 million annually), or 1.6% of local GDP. Yet these local costs are outweighed by environmental benefits: 50 turbines generate roughly €5 million annually in CO_2 savings, over three times the tourism-related losses. Our findings call for policies that mitigate local externalities while preserving broader environmental gains, including the strategic siting of large wind farms and attention to environmental justice, as rural communities and small touristic operators bear disproportionate costs.

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1. Introduction

In late summer 2024, a series of arson attacks targeted wind turbine construction sites across Sardinia, a renowned Mediterranean tourist destination (Ansa, 2024). In the village of Orgosolo, located in the island's interior and historically known for its defiance during the "Pratobello Uprising"[1], residents are once again mobilizing in protest, this time against a new wind power project (Locci, 2024). Orgosolo, celebrated for its striking murals and rugged landscapes, has become a symbol of local resistance, with opponents arguing that wind turbines would undermine the area's scenic beauty and reduce its appeal to tourists, a vital source of community income. These demonstrations form part of a broader backlash against the central government's plans to install over 6.2 GW of new wind capacity on the island. Such "Not In My Backyard" (NIMBY) protests against wind energy projects are not unique to Italy; similar movements have emerged worldwide (Boyle et al., 2019; Daniele et al., 2024; Devlin, 2005; Stokes et al., 2023; Töller et al., 2024; Wolsink, 2000). Even high-profile figures have voiced opposition: U.S. President Donald Trump, for instance, famously criticized the visibility of wind turbines from his Turnberry golf course (The Guardian, July 2025).

However, the construction of new wind turbines remains a crucial step toward achieving ambitious climate objectives, including the European Union's commitment to carbon neutrality by 2050 (Wind Europe, 2022). While some local environmental drawbacks are acknowledged, the overall global impact of wind energy is overwhelmingly positive (Meng et al., 2024). Proponents further argue that wind power can stimulate job creation and foster economic growth, although existing evidence suggests that such local economic effects are generally short-lived (Fabra et al., 2024; Costa & Veiga, 2021). Another common argument in favor of wind energy is that the spatial footprint of turbines is relatively limited[2]. Yet Italy's experience offers a compelling counterexample. The country's roughly 7,000 wind turbines occupy just 0.002% of the national territory, concentrated in only 311 municipalities out of nearly 8,000. Nevertheless, as we show in Section 2.1, these turbines are visible

[1] In June 1969, the residents of Orgosolo, a village in Sardinia, organized a peaceful protest against the Italian military's plan to establish a firing range in Pratobello, a common grazing area for local shepherds. Approximately 3,500 people occupied the land, leading to the military's withdrawal and highlighting the community's commitment to nonviolent resistance and territorial autonomy.

[2] For example, with reference to the Sardinian disputes against wind turbines, the local representative of *Legambiente* (the most important environmental association in Italy) claimed that: "*even if we did 10GW, just 1% of the Sardinian territory would be enough. Then of course, the wind turbines will be seen, but this is inevitable for any infrastructure"* (Tecleme, 2024).

from more than 1,950 municipalities, affecting around 25% of Italy's landscape[3]. These figures highlight that the visual footprint of existing and planned wind farms is far from negligible.

In this work we aim to study how the visibility of onshore wind turbines[4] can impact local economies, with a specific focus on tourism, a sector that highly depend on the aesthetic and attractiveness of a pristine landscape. In fact, the visual and acoustic presence of wind turbines may influence tourists' choices (Krekel & Zerrahn, 2017; Schmidt & Klokker, 2014). Our analysis centers on Italy, the fourth most popular touristic destination in the world, where Travel & Tourism sector contributed to €215B in 2023, representing 10.5% of GDP (WTTC, May 2024). The relevance of tourism is not confined to Italy; in the United States for example, the Travel & Tourism market contribute a record-breaking $2.36 TN to the nation's economy in 2023 (WTTC, September 2024).

We assess the impact of wind turbine visibility on tourism using a staggered difference-in-differences approach, applied to a 20-year dataset (1998–2019) on municipal-level tourism. The data are sourced from the Bank of Italy and the Italian National Institute of Statistics (ISTAT). We demonstrate that our estimates are robust to heterogeneous treatment effects by comparing the results from the classic difference-in-differences event study with those obtained using more recent estimators (Callaway and Sant'Anna, 2021; de Chaisemartin & D'Haultfœuille, 2024). To measure exposure, we combine satellite-based digital elevation data with the exact location of turbines installed allowing us to identify areas from which turbines are visible and to construct municipality-level indicators of visual exposure.[5] Wind turbines are not randomly distributed, which can introduce selection biases and challenge the identification of robust and externally valid causal effects. To mitigate this, we restrict our sample to municipalities meeting climate and regulatory criteria, ensuring treatment and control units have a comparable likelihood of hosting wind turbines.

Our results show that, over a ten-year horizon, wind turbine visibility reduces tourist arrivals by 20%, with the effect peaking seven years after turbines first become visible and gradually diminishing thereafter, suggesting local adaptation. The effect is driven primarily by municipalities where between 9 and 65 turbines are visible. We observe a non-linear relationship with the number of visible wind turbines, likely because larger wind farms are typically located in areas with limited tourist

[3] These figures represent municipalities with at least a small part (i.e., >0 per cent) of their territory from which a wind turbine is visible. If we set a minimum threshold of 10% of visibility, the total number of municipalities decreases to 1,530. For more details, refer to Section 2.1.5.

[4] We focus exclusively on onshore wind turbines, as Italy's first offshore wind farm was only commissioned in Taranto in 2022

[5] The approach of using the digital elevation model and the viewshed is similar to what have been done in Guo et al. (2024) and Stegmaier & Krause (2023) to measure respectively the effect of wind turbine visibility on housing prices in US and electoral support for green parties in Germany.

presence. The impact is strongest in municipalities where more than 80% of the territory is exposed, particularly in rural, tourism-dependent areas. Tourist expenditure mirrors this pattern: affected municipalities experience an average annual decline of 15%, approximately €1.8 million per year, or about 1% of local GDP. This contraction extends to broader economic activity, with local income falling by around 1%. On the supply side, B&Bs and private accommodations experience negative effects from wind turbine visibility, while hotels show no decline, reflecting their greater capacity to absorb fluctuations in demand.

On the other hand, wind turbines have been a cornerstone of the green energy transition in Italy. In 2023 alone, they generated a record 23.6 TWh of electricity, accounting for 20% of renewable energy production and 8.8% of total electricity generation (GSE, January 2025). Substituting coal-based electricity with wind energy results in an average reduction of roughly 600 gCO_2 per kWh (Pryor et al., 2020). Given the market price of CO_2 under the EU Emissions Trading System, these reductions can be translated into substantial monetary benefits. We find that 50 wind turbines generate approximately €5 million per year in value from CO_2 savings. In our sample, municipalities are, on average, exposed to 50 turbines, meaning that the environmental benefits are more than three times greater than the estimated annual loss of €1.8 million in tourism expenditure for a municipality facing similar exposure. Given these substantial gains, we discuss policy options aimed at mitigating local negative externalities while still supporting the expansion of renewable energy, and crucially, the strategic selection of locations and quantity of wind turbines. For instance, we find a non-linear relationship between the number of visible turbines, suggesting that constructing large wind farms at once (more than 65 turbines) may be preferable to dispersing smaller numbers of turbines across multiple sites.

This paper contributes to the literature in several ways. First, it provides causal empirical estimates of the impact of wind turbines visibility on tourism activity. Our findings contribute to a relatively extensive body of research examining the relationship between wind turbines and tourists' perceptions (Fooks et al., 2017; Frantál & Kunc, 2011; Landry et al., 2012; Maehr et al., 2015; Parsons & Firestone, 2018; Trandafir et al., 2020; Tverijonaite & Sæþórsdóttir, 2023). This literature generally suggests that tourists tend to prefer unspoiled landscapes and often favor destinations where wind turbines are not visible[6]. Evidence from regions such as Iceland where tourism relies heavily on natural, untouched environments, indicates that tourism providers overwhelmingly perceive wind farms as detrimental, primarily because they "ruin the view" and transform natural areas into

[6] However, there is significant variation depending on individual characteristics, such as being or not a resident, or the individual attitudes toward green issues (Broekel & Alfken, 2015).

"industrial zones" (Sæþórsdóttir et al., 2021). However, most existing studies rely on surveys, field experiments, or qualitative assessments of visitor preferences, which may be influenced by social desirability biases and may not fully capture actual tourist behavior[7]. Complementing this literature, research on tourism in Italy underscores the economic importance of heritage sites and pristine rural landscapes in enhancing tourist appeal and supporting local development (Bertacchini et al., 2024; Nocito et al., 2023). In this context, our study provides robust empirical evidence that municipality characteristics matter, with tourism-oriented and rural municipalities being most affected by visibility of wind turbines.

Second, this paper contributes to the literature documenting a negative relationship between wind turbines visibility and housing values. Previous studies have consistently found that the presence of wind turbines visibility can reduce property values (Dröes & Koster, 2016; Sunak & Madlener, 2016; Guo et al., 2024). Several factors influence the magnitude of this effect. First, the size of the turbines is important, with larger turbines generally associated with greater reductions in property values (Dröes & Koster, 2021). Second, proximity matters: properties located closer to wind turbines typically experience larger declines (Guo et al., 2024; Dröes & Koster, 2021). Finally, the timing of the effect exhibits heterogeneity. For instance, Guo et al. (2024) show that the negative impact on property values may diminish over time or for more recent installations, suggesting that homebuyers may adjust their preferences as they become accustomed to wind turbines. Our results reveal a negative effect of wind turbine visibility on tourism, providing a benchmark for assessing long-term local impacts, while also suggesting adaptation, as the effect diminishes after approximately seven years.

Third, our findings contribute to the literature by highlighting the effects of wind turbines on local economic outcomes, particularly income, in ways that contrast with previous evidence on employment and income impacts from wind energy development. While prior studies generally report modest or short-lived employment gains and limited changes in income (e.g., Brunner & Schwegman, 2022; Costa & Veiga, 2021; Fabra et al., 2024), our results indicate a negative and significant effect on local income. This suggests that the economic spillovers from wind turbine installations may extend beyond temporary job creation, reflecting broader, longer-term impacts on local economies.

[7] The only notable exception is the work from Broekel & Alfken (2015) who study actual touristic flows in Germany in relation with distance from wind turbines, finding a negative effect. Although the authors themselves recognize that their approach cannot be defined as causal, their work can be considered the most robust among existing ones regarding wind turbines and tourism. Compared to them, at least as far as identification is concerned, we make considerable progress thanks to the use of an econometric model and approach that reflects the current state of the art, the details of which are described later in Section 2.2.

Crucially, these income effects align with our tourism findings, implying that wind turbines influence local economic activity not only through labor market channels but also via tourism-related pathways, such as reductions in visitor expenditure and diminished attractiveness of municipalities to tourists.

Finally, this study contributes to the literature on the cost-benefit analysis of wind power generation, aligning with the consensus that the overall global environmental impact of wind energy is decisively positive, despite the recognized presence of localized environmental externalities (Meng et al., 2024). Substantial prior literature has focused on quantifying these benefits, primarily through the estimation of CO2 emissions savings achieved by deploying wind turbines (Pryor et al., 2020; O'Mahoney & Denny, 2011; Beltrami et al., 2021). Utilizing these previous findings as a foundational methodology, this study reports the calculated CO2 savings specific to Italy over the considered time frame and compares them against the cost on the local economies. This analysis consolidates the fact that the global environmental benefits significantly outweigh the overall costs. We extend the discussion by proposing specific policy interventions designed to compensate for negative local externalities, ensuring the sustained realization of net environmental gains.

The remainder of the paper is structured as follows. Section 2 describes the data, and Section 3 outlines the empirical strategy. Section 4 presents the results, while Section 5 compares the costs associated with tourism to the environmental benefits arising from CO_2 savings. Section 6 concludes with a discussion of policy implications and potential directions for future research. Finally, Section 7 provides the acknowledgments.

2. Data

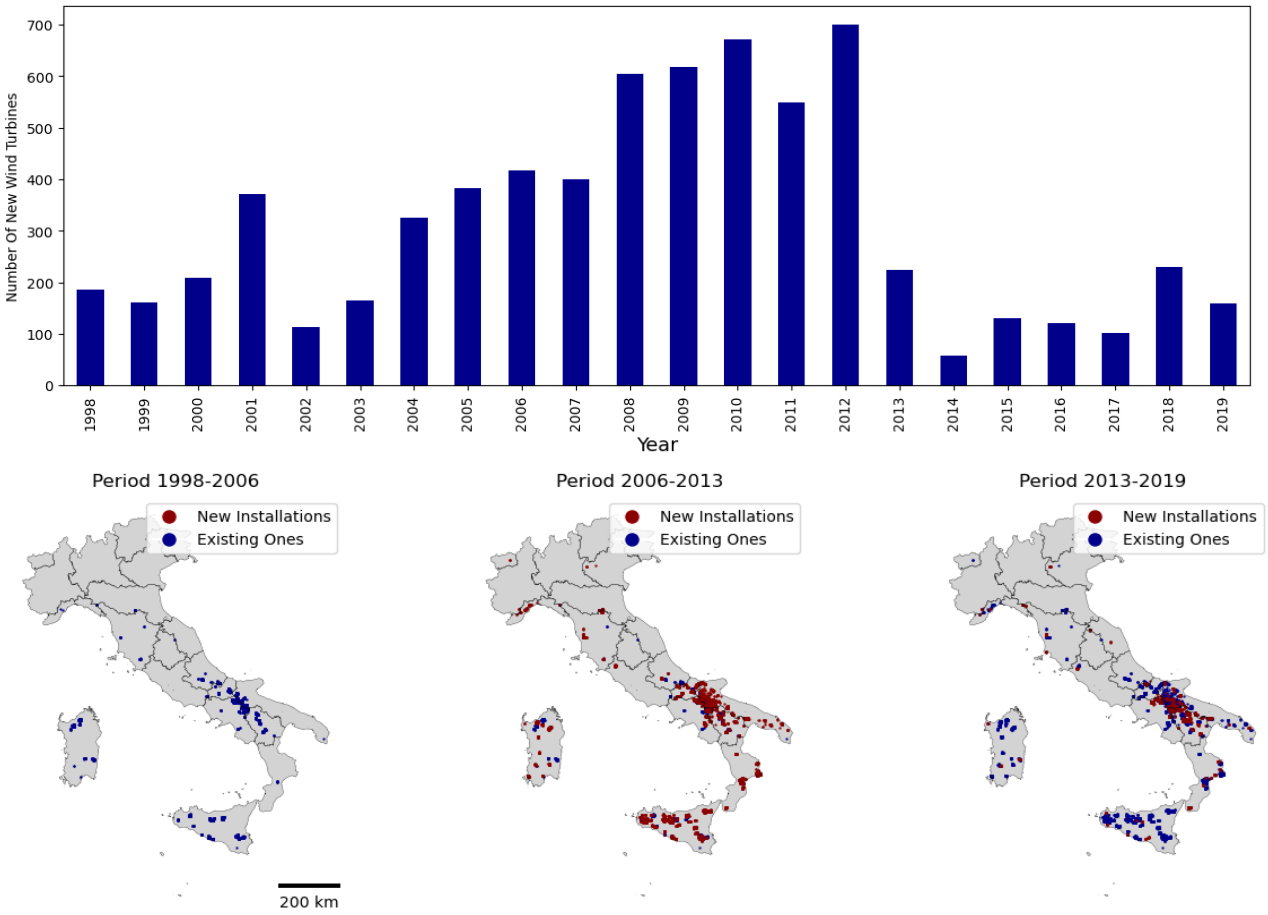
2.1 Wind Turbines Data

Data on wind turbines, producibility, and eligible areas are provided by the research unit of the Authority for the Management of Energy Services – GSE - (*Gestore dei Servizi Energetici*). Specifically, we use the latest (i.e. 2019) full database of all wind turbines in Italy, that reports for each turbine, the energy class, the geocoded location, and the year in which the turbine was linked to the national grid.[8] In Figure 1, we show the location and timing of construction of wind turbines over years. As we can see, the period between 2008 and 2012 was undoubtedly the booming years for new wind turbines installations, that suddenly dropped after 2013. In terms of territorial distribution, most

[8] All the dataset provided by the GSE are publicly and freely available, with the exception of the information regarding the year in which the wind turbine was linked to the grid that has been kindly provided by the GSE under a non-disclosure-agreement.

of new installations are concentrated in the same area of existing ones, tough we can observe a significant expansion in the southern part of the Puglia region (e.g. on the heel of Italy) as well in Sicily in the 2006-2013 period.

Figure 1: Wind Turbines Installations

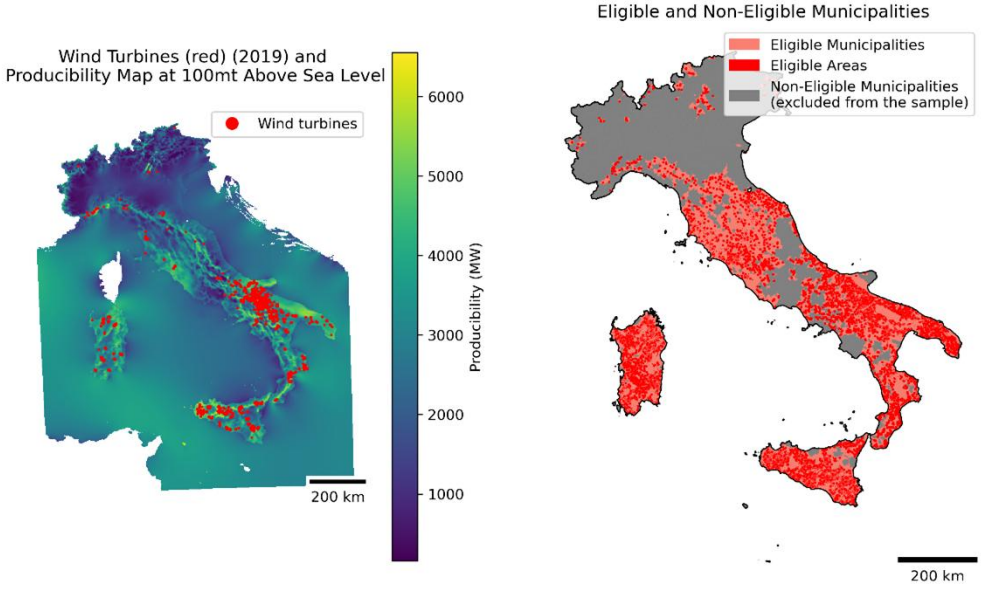


Note: The figure shows on the top-panel the distribution of the year of installations of wind turbines. Please note that year 1998 also include Pre-1998 installations. On the bottom panel we show the same data on the map, where the red markers highlight the turbines built in the period reported in the title.

From the GSE, we also collect the producibility grid that estimates how much wind energy can be produced by a wind turbine in a certain location (according to historical climate data). In addition, we also use another precious information provided by the GSE, that is a collection of geo-polygons that identify eligible areas (*Aree Idonee*) over the Italian territory, that are areas suitable for new onshore wind power installations, calculated starting from the areas with wind power production at a height of 100m above 2250 MWh/MW and excluding urbanized areas and areas subject to environmental and cultural restrictions.

The left-hand panel of Figure 2 shows the spatial distribution of wind turbines across Italy alongside the country's wind potential. In a natural experiment, the treatment should approximate random assignment, meaning that both the treatment and control groups should have a similar likelihood of receiving the treatment. To approach this ideal, we ensure that municipalities not exposed to wind turbines (the control group) and those within the turbines' viewshed (the treatment group) are comparable in terms of factors influencing turbine construction. To this end, we focus on eligible municipalities. The right-hand panel of Figure 2 highlights the municipalities included in our sample in pink, while the grey areas indicate municipalities excluded from the analysis.

Figure 2: Producibility and Eligible Areas



Note: On the left-panel of the figure we show the producibility grid at 100mt above the sea level expressed in MWh/MW and the existing wind turbines (red markers). On the right-panel we highlight eligible areas ("aree idonee") in red, and eligible municipalities in pink (e.g. municipalities which include a portion of eligible area).

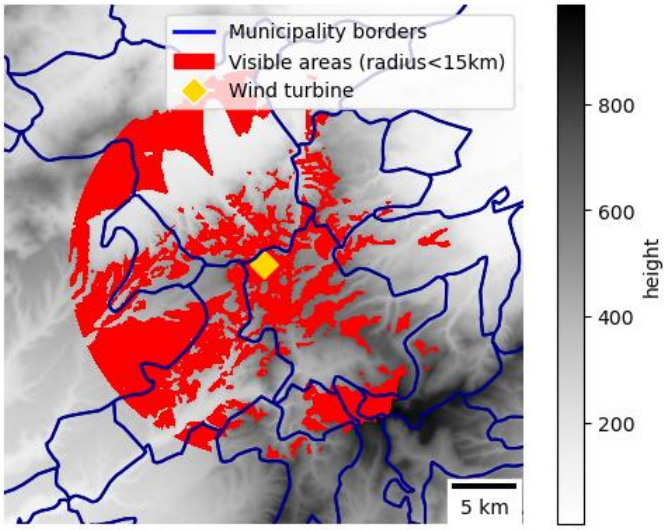
We also use Digital Elevation Data from the European Digital Elevation Model (EU-DEM) ("Copernicus DEM," 2022). These data provide the elevation of each 30-meter pixel across Italy, representing the first surface captured by the sensors (i.e., a digital surface model). Using this information, we calculate wind turbine visibility exposure for each location.

To assess municipal-level exposure, we generate a viewshed for each individual turbine, determining the areas from which it is visible. This analysis uses each turbine's location along with all 30-meter resolution pixels from the EU-DEM covering the surrounding municipalities as input.[9] This approach

[9] We take a square of 60X60 km centered around each wind turbine.

allows us to estimate, for each municipality, the proportion of its territory from which a wind turbine is visible. The viewshed analysis accounts for the terrain's morphology as well as artificial structures such as buildings, walls, and similar obstacles. For instance, if a wind turbine is obscured by a forest, mountain, or other impediment, this will be reflected in the analysis. We implement this procedure using the GDAL package, following the methodology proposed by Wang et al. (2000). Figure 3 illustrates the computed viewshed (in red) for the wind turbines (gold markers), highlighting the areas within each municipality where the turbines are visible. The viewshed is calculated with a maximum visibility distance of 15 km[10], an observer height (i.e., the wind turbine) of 90 meters and a target height of 10 meters. After computing the viewshed for each individual turbine, we aggregate the viewsheds within each municipality for each year (Figure 4). This allows us to calculate both the proportion of each municipality's area from which at least one wind turbine is visible and the expected number of visible turbines per municipality.

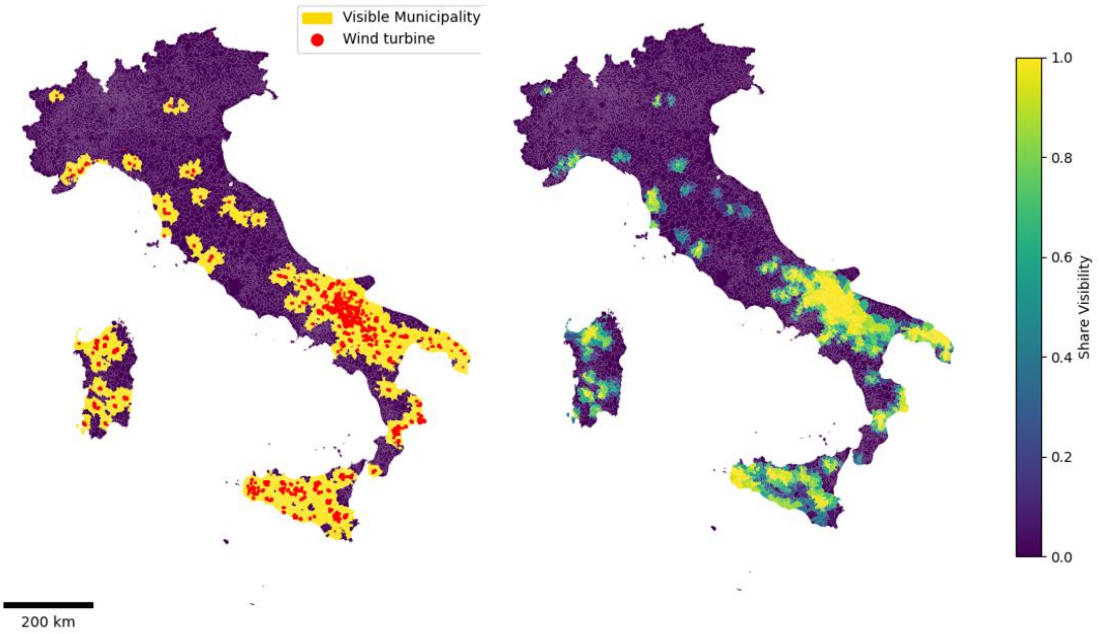
Figure 3: Viewshed Example



Note: The figure shows an example of the viewshed for one wind turbine. The red areas highlight the portion of territory from which the wind turbine (yellow polygon) is visible. The blue lines highlight municipal borders. The grey colormap reports the values of the digital elevation model (in meters).

[10] The maximum visible distance clearly depends on the weather and light conditions (e.g. time of day). These can obviously vary from period to period and within a day. The value we used (15 km), can be defined as a conservative value, in the sense that it is possible that visibility is lower in many cases with the consequence that the intensity of our treatment could be overestimated. We also made this choice taking into account any problems of treatment spillover to the closest areas. 15 km is also the default value used in the ARCGIS viewshed tool (ARCGIS, 2024).

Figure 4: Wind Turbines Visibility



Note: On the left panel we have wind turbines (in red), and municipality that have at least a portion of their territory where the wind turbines are visible. On the Right panel we show the share of visibility for each municipality (share of the territory from which at least one turbine is visible).

To conduct a heterogeneous analysis based on proportion of each municipality's area from which at least one wind turbine is visible and the expected number of visible turbines per municipality, we refer to the boxplots in Figure 5.

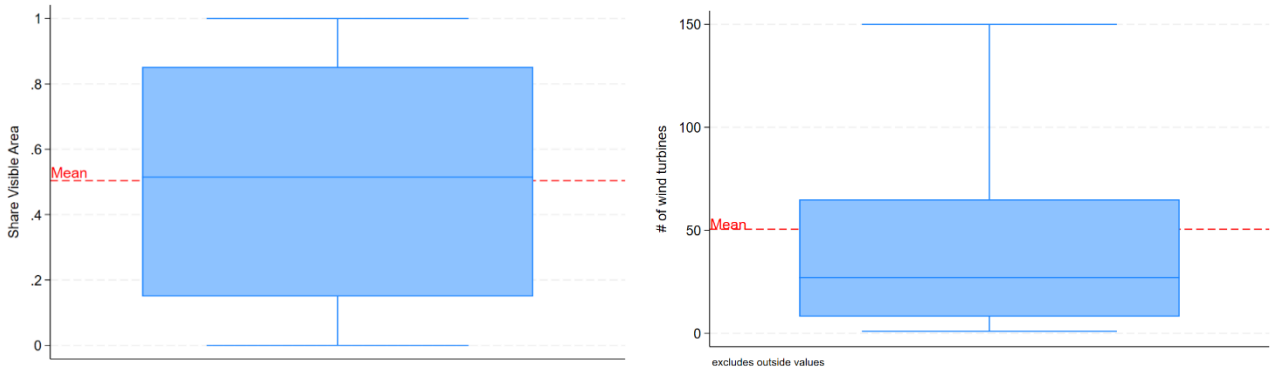


Figure 5: Boxplots of share of visible area and numbers of wind turbines

Note: In the right-hand side panel, the median and mean value are close to 0.5,while the first quartile is 0.15 and third quartile is 0.85. For the number of visible turbines per municipality the median=27 and mean=50, while the first quartile is 8 and third quartile is 65.

Observing a symmetric distribution of visible areas, we divide the sample into three bins for the analysis. This approach allows us to preserve statistical power while avoiding excessive subsampling.

Moreover, the Italian National Institute of Statistics (ISTAT) classifies municipalities according to their level of tourism and key characteristics, such touristic versus non-touristic[11] status. Touristic municipalities are further categorized based on tourism type, including maritime, mountain, historic, cultural, and lake destinations. Later, we leverage this classification to conduct heterogeneous analyses and identify which types of municipalities are most affected by wind turbine visibility. In particular we exploit as urban versus rural status. Table 1 presents descriptive statistics summarizing the characteristics of municipalities where wind turbines are visible.

Table 1. Number of municipalities by type and wind turbine visibility

Wind Turnine Visibility	Urban	Rural	Touristic	Non-Touristic	Total
With Wind Turbine	577	482	763	296	1,059
Without Wind Turbine	412	284	566	130	696
Total	989	766	1,329	426	1,755

The distribution shows that both rural and touristic municipalities represent a notable share of areas where wind turbines are visible, providing context for subsequent analyses of their potential local impacts.

2.2 Tourism Data

Tourism data in Italy come from two main sources. The Bank of Italy conducts an annual survey on international tourism, collecting information through interviews and traveler counts at border crossings—including roads, railways, ports, and airports—supplemented with administrative records and, since late 2020, mobile phone data. The second source is the Italian National Institute of Statistics (ISTAT), which carries out a monthly survey tracking tourist flows and hospitality infrastructure, including the number of beds and types of available accommodations. For tourist flows, we rely on data from the Bank of Italy, which offer a longer time coverage (available since 1998), whereas ISTAT data at the municipal level are only available from 2014 onward. For hospitality infrastructure, we use data provided by ISTAT. In addition, we draw on ISTAT's classification of municipalities by tourism characteristics (see Table 1 for further details).

[11] Municipalities where accommodation facilities are absent and/or which are characterized by negligible tourist flows. These comprise 1,704 municipalities (21.5% of the total), where 6% of the population resides.

The Bank of Italy provides the raw data of the interviews, together with the expansion factors that can be used to recover the total estimated number of tourists passing through each municipality. Clearly, the weakness of the Bank of Italy's data is that being a survey, although numerically important[12], it does not include all the municipalities every year. Following what was done also in Nocito et al. 2023, we impute to those municipalities for which not even one interview is present a value of zero tourists, but we exclude from the sample all those municipalities that never appear in the sample in any year of the survey (13 per cent of the total).

In Appendix 9.1, we present the distribution of average tourist flows according to the two data sources, along with the overall changes between the first and second periods of our study. This confirms substantial heterogeneity at both the national and regional levels. We also report the distribution of tourist accommodations (i.e., the supply side of tourism), which closely corresponds to the observed patterns of tourist demand.

2.3 Other variables

To compare our findings with other socioeconomic outcomes, we also consider house prices, income, and population. Data on house prices come from the Osservatorio del Mercato Immobiliare (OMI), managed by the Italian Revenue Agency (Agenzia delle Entrate), and are available from 2004 onward. The dataset reports minimum and maximum prices per square meter across different property categories (e.g., economic, luxury). We use these figures to compute the annual average housing price at the municipal level. Income data are obtained from the Italian Ministry of Economy and Finance (MEF), providing municipal-level estimates. Population figures are sourced from ISTAT, the Italian National Institute of Statistics.

Table 2 presents the mean values and sample sizes for the outcomes analyzed, restricted to the 'Eligible Areas' outlined in Section 2.1.

Table 2. Descriptive Statistics Table for Eligible Areas

	Observations	Mean
Tourist arrivals	67,938	6,987.535
Tourist expenditure	23,236	10,500,000
Average income	54,473	12,397.97

[12] Approximately 130,000 interviews are carried out annually, equal to approximately 1 per thousand of Italian and foreign travelers crossing the country's borders, and over 1.5 million qualified traveler counts.

Population	46,980	9,025.044
# of B&B	52,192	14.43
# of hotels	52,192	3.37
# of visible wind turbines	14,648	50
% territory with viewshed	14,648	0.5

Note: The number of visible wind turbines and the percentage of territory within the viewshed (i.e., exposed to wind turbine visibility) are reported only for municipalities in the treatment group'.

3. Empirical Strategy

The main challenge we face in terms of identification concerns the non-random timing and location of wind turbine construction. Turbines are rarely built arbitrarily; their placement often reflects a combination of economic, social, political, and environmental considerations. Importantly, many of these factors may be correlated with the very outcomes we aim to study, such as tourist flows or broader local economic indicators. For instance, in areas with a strong tourism industry, municipalities or tourist operators' association might actively oppose wind turbine projects to preserve the attractiveness of the landscape. Beyond socio-economic factors, regulatory constraints also play a role: certain territories, due to landscape, cultural, or heritage protection, are subject to restrictions that can prohibit or complicate turbine construction. These considerations illustrate that simply comparing municipalities with and without wind turbines can lead to significant biases, as the placement of turbines is influenced by factors that also affect economic outcomes. To mitigate these potential distortions, we take several steps to make the sample as homogeneous as possible and to construct a measure of treatment that is less dependent on local economic conditions. Once these steps are applied, we exploit the staggered timing of treatment to implement a difference-in-differences design, as wind turbines are built in different years.

A key point is that our measure of treatment, the visibility exposure to wind turbines, means that the group of treated municipalities may include some that do not actually host wind turbines within their territory. While these exposed municipalities may have some influence, formal or informal, over decisions in neighboring areas regarding turbine construction, it is reasonable to assume that their decision-making power is limited. Including municipalities that did not actively seek or have strong control over treatment helps attenuate selection-into-treatment bias.

To further enhance sample homogeneity, we first exclude municipalities that are ineligible for wind turbine construction. We define eligible territory using the criteria provided by GSE (as discussed in Section 2.1.3), ensuring that no municipality in the control group could have hosted a turbine even if willing. By removing municipalities with a very low probability of treatment, we avoid including "bad controls" and improve the comparability between treated and control groups.[13]

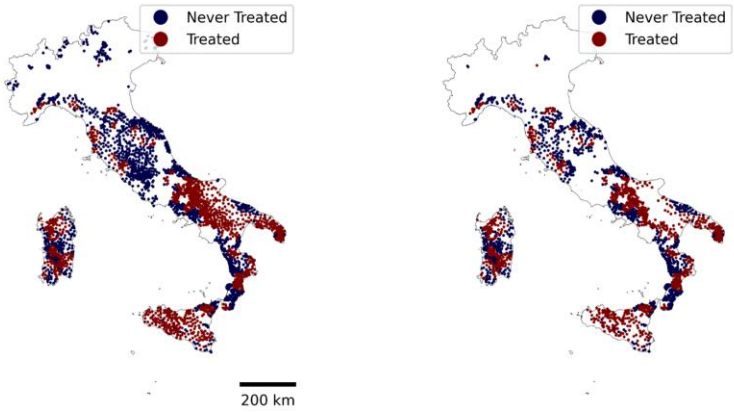
After having excluded non-eligible municipalities, we employ the following sub-sampling procedure: for each Treated Municipality (TM) that has ever been treated, we search all the Non-Treated municipalities (NTMs), that have never been treated and that match the following conditions:

1. Falls in the same region of TM
2. Falls in the same population bracket of TM [14]
3. Is closer than 30km from TM[15]

We keep all the NTMs that are matched at least once, and all TM that have at least one matched control. We drop all other municipalities.

Figure 8 shows the location of Treated and Non-Treated municipalities before and after the matching procedure. Clearly, we lose some observations especially in the North and Center of Italy, tough, our final clean sample still looks representative with respect to eligible territories and potential territories where wind turbines could be constructed (i.e. see Figure 5).

Figure 6: Sample Before and After the



Note: The two maps show the centroids of Never Treated (blue) and Ever Treated municipalities (red), before and after the matching procedure described above. Thus, the observations shown in the right-panel comprise the subsample that we will use in the analysis. Clearly, the visible consequence of the procedure is to have treated and control municipalities that are much closer.

[13] We also exclude a small number of municipalities (N=32) which are not eligible according to the GSE measures but do have wind turbines in their territory or are exposed to wind turbines of nearby municipalities.

[14] We use the following population brackets: [0,3000,5000,15000,30000,100000,250000,3000000]

[15] We compute distance using the aerial distance between the centroids of the two municipalities

After further restricting the sample, we begin by examining the dynamic Two-Way Fixed Effects (TWFE) model, considered the "traditional event study approach."

Equation 1

$$Y_{i,t} = \alpha_i + \alpha_t + \sum_{k=-K}^{-2} \gamma^{lead}{}_k D^k{}_{i.t} + \sum_{k=0}^{L} \gamma^{lags}{}_k D^k{}_{i.t} + X_{i,t} + \epsilon_{i,t} \quad (eq.1)$$

where $Y_{i,t}$ is the outcome variable (e.g. number of tourists, housing prices), α_i is the municipality fixed effect, α_t is the year fixed effect, $D^k{}_{i.t}$ is a dummy=1 if a municipality *i* is under the viewshed of wind turbines in year *t*; γ_k is the effect of being exposed to wind turbines *k* years before (leads) and after (lags) the wind turbine has been implemented and the contemporaneous effect (when *k*=0), $X_{i,t}$ is a set of covariates that are varying across municipalities, such as population, and finally $\epsilon_{i,t}$ is the error terms that we clustered at municipality level. We avoid normalizing tourist arrivals by population, as population itself may respond to wind turbine installation, potentially biasing per capita measures[16]. Instead, we use log tourism outcomes and include population as a control only in robustness checks to account for demographic differences across municipalities.

However, Sun & Abraham (2021) showed that coefficients from dynamic Two-Way Fixed Effects (TWFE) models can generate negative weights, potentially leading to misleading interpretations, as the estimated effects may combine treatment effects from different periods. To address this issue, we compare the classic event-study estimates with the Callaway & Sant'Anna, 2021 and de Chaisemartin & D'Haultfœuille, 2024 estimators, finding that in our case there are no statistically significant differences between the approaches.

For the number of tourists and tourist expenditure, we use Poisson regressions to account for the large number of zero observations and to obtain a consistent relative measure of the effects (Chen & Roth, 2024). Indeed, municipalities exhibit substantial variation in their baseline levels of tourist arrivals, implying that the interpretation of the event-study coefficients γ_k in absolute terms would not be scale-invariant. As a robustness check, we therefore re-estimate the models using the dependent variable in absolute levels and compare these estimates to the mean outcome of the treatment group, focusing only on changes along the extensive margin. Population is expressed in logarithmic form, while for other outcome (income and housing prices), we use the change in logarithm.

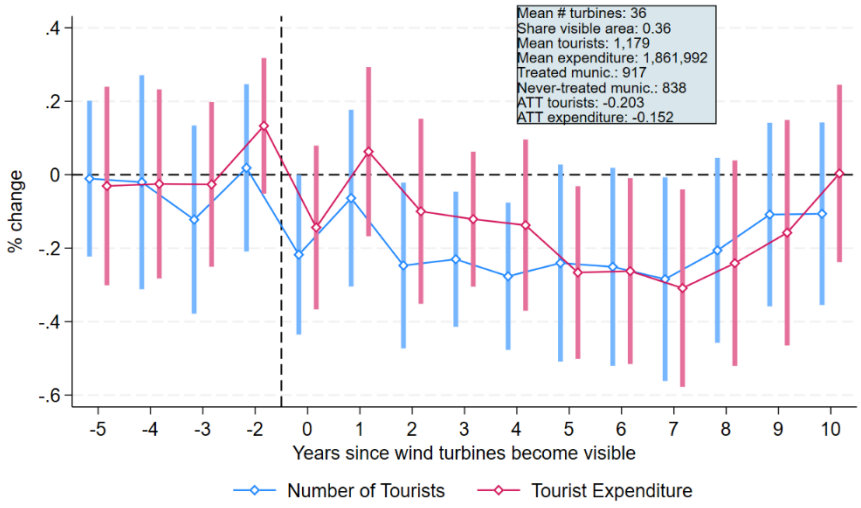
[16] Normalizing by a variable that is endogenous to the treatment can introduce post-treatment bias (see Angrist & Pischke, 2009; Montgomery et al., 2018), leading to misleading inferences about causal effects.

4. Results

4.1 Main result: effect of wind turbines visibility on tourism

We begin by examining the impact of wind turbine installations on the number of tourists and tourist expenditure. We compare municipalities that experience the installation with those that are not yet treated or never treated, using a classic staggered difference-in-differences event-study design. We restrict the analysis to the matched units, as outlined in Section 3 and relying on Poisson regressions to address potential biases introduced by zero values (Chen & Roth, 2024).

Figure 7: Impact of wind turbines visibility on tourist arrivals and expenditure



Note: Standard errors are clustered at municipality level; we keep only municipality that have balanced observations; The average number of tourists and tourist expenditure refer to the treatment group, since the ATT refers to the Average Treatment effect of Treated units,

The blue event-study shows that municipalities exposed to wind turbines visibility experience an average decline in tourist arrivals of approximately 20% relative to comparable matched controls. This effect grows over time, reaching a peak reduction of 28% around seven years after turbines become visible. From roughly the eighth year onward, the decline starts to moderate, suggesting that tourists may gradually adapt to the presence of visible wind turbines, rather than the effect being entirely permanent. The years before wind turbines become visible serve as placebo tests, confirming that there are no systematic differences in tourism trends prior to turbine installation. Appendix 9.2 presents a series of robustness checks to assess the sensitivity of our findings. First, re-estimating the model in absolute terms rather than using the Poisson specification yields consistent results, confirming the presence of negative effects after wind turbines become visible. Next, we show that the traditional TWFE event-study estimates are statistically different from those

obtained using more recent estimators (Callaway and Sant'Anna, 2020; de Chaisemartin and D'Haultfœuille, 2024), suggesting that our results are not driven by bias arising from the staggered timing of wind turbine implementation. We further extend the analysis to include a wider set of pre- and post-installation periods, again finding consistent negative effects. Expanding the sample to include all municipalities in Italy also confirms the robustness of the negative impact. Finally, a randomization test demonstrates that the estimated effects are not the result of spurious correlations.

When examining tourist expenditure (red line), we observe a pattern like that for tourist numbers after wind turbines become visible. On average, municipalities experience a 15% decline in tourist expenditure in the years after installation. Given that tourism accounts for approximately 10.5% of local GDP in Italy (WTTC, May 2024), this estimated 15% reduction in tourist expenditure corresponds to roughly 1.6% of municipal GDP. In Appendix 9.2, we further examine the local economic effects by analyzing income growth, measured as the change in log income to account for differences in baseline levels. We find a negative impact of around 1% in the six to seven years following wind turbine installation, confirming that turbine visibility has an adverse effect on the local economy. Both population and housing market indicators also decline after installation. Consistent with evidence from other countries, we observe pre-existing downward trends in income and population even before the turbines are built. This pattern suggests that residents may begin relocating in anticipation of construction, leading to a gradual reduction in local income. Alternatively, it may indicate that wind turbines are more likely to be sited in areas already experiencing demographic and economic decline. Interestingly, the housing market also shows a negative effect at the municipal level, with prices beginning to fall in the year prior to turbine visibility, consistent with the anticipation effects documented by Dröes and Koster (2016) for the Netherlands.

In Appendix 9.2, we show the impact of wind turbine installations on tourism supply metrics, specifically the number of hotels, bed and breakfasts (B&Bs), and private apartments. For analytical clarity, we group these into two categories: hotels and other accommodations. This distinction is crucial for capturing differences in their capacity to adapt to fluctuations in demand. Larger establishments, such as hotels, benefit from economies of scale, enabling them to absorb demand shocks by adjusting prices. In contrast, smaller establishments, such as B&Bs, may face greater challenges, often opting for closure when faced with sustained drops in demand. Private accommodations, such as bed and breakfasts and short-term rentals, decline following wind turbine installation, while the number of hotels remains stable or slightly increases, suggesting some degree of substitution effect. These patterns indicate that the negative impact on tourism is primarily demand-

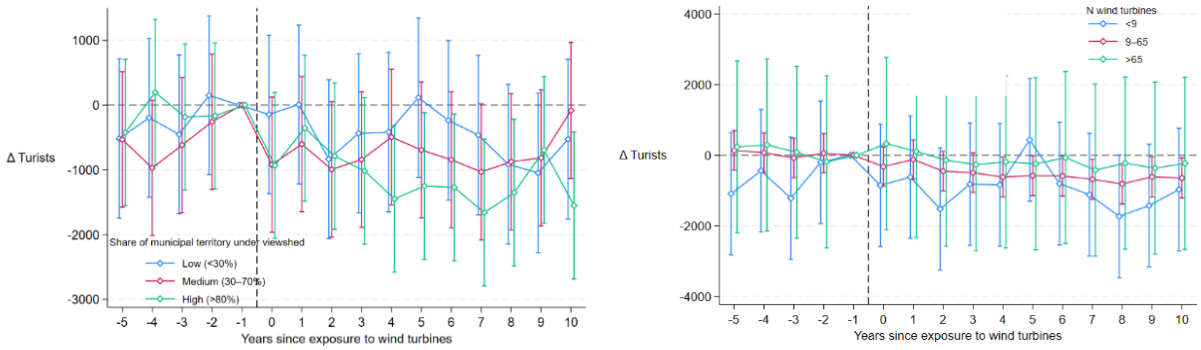
driven, with supply adjustments occurring gradually, six to seven years after installation, in line with declines in overall tourist expenditure (red line in Figure 7).

4.2 Heterogeneity analyses

While the main results in Figure 7 report average effects, municipalities differ in both the share of territory exposed to wind turbine visibility and the number of turbines visible. On average, treated municipalities have 0.36% of their territory exposed, with 36 turbines visible. In this section, we explore how the impact of wind turbines varies across municipalities along these two dimensions, examining whether larger exposure or a higher number of visible turbines amplifies the observed effects.

To examine heterogeneous effects, we first decompose the impact of wind turbine installation by the share of each municipality exposed to turbine visibility, and second, by the number of turbines visible from the municipality (see Section 2 for summary statistics). For the first categorization, we split municipalities into three groups: low exposure (<30% of territory), medium exposure (30–70%), and high exposure (>80%).

Figure 8: Impact of wind turbines visibility on tourist arrivals by intensity of treatment



Our findings in Figure 8 show that the negative effect of wind turbines on the number of tourists, as reported in Figure 7, is primarily driven by municipalities with high exposure. In this group (green line), the effect is the only one statistically different from zero between four and seven years after the turbines become visible. Moreover, municipalities with medium and high exposure levels experience a more immediate impact, with a significant decline in tourism (at the 10% level) already observable in the year of exposure. On the right-hand panel of Figure 8, we examine the heterogeneous effects associated with different numbers of wind turbines visible from each municipality. The results indicate that when more than 65 turbines are visible, the effect on tourist numbers is never statistically significant, likely because large wind farms are typically located in remote areas with limited tourist presence. In contrast, we find significant effects for municipalities

where between 9 and 65 turbines are visible, consistent with main result in Figure 1. For municipalities with fewer than 9 visible turbines, the estimated effects are even more negative, but are not statistically different from zero. This pattern suggests that the relationship between the number of visible wind turbines and tourist activity is likely non-linear.

In addition to the intensity of exposure, the visual characteristics of the territory may also play a crucial role. The visual impact of wind energy infrastructure varies considerably depending on the characteristics of the surrounding landscape and its perceived appropriateness for such developments (Johansson & Laike, 2007). This means that the type of landscape plays a central role in shaping both public perception and acceptance of wind turbines. For instance, Wolsink (2007a), in a study around the Wadden Sea, found that industrial and military zones were generally regarded as suitable locations for wind farms, whereas natural reserves, scenic landscapes, and recreational areas were considered far less appropriate. Here, to understand which kind of municipalities are most affected, we use the ISTAT classification (see section 2 for more detail). First, we find that the negative effect is largely driven by touristic municipalities[17]. Among these, rural municipalities, especially those located in mountain or maritime areas, experience the strongest negative effects on tourism from visibility of wind turbines (see Appendix 9.3 for further details). This finding contributes to the literature by showing that not only turbine height and proximity matter (Guo et al., 2024; Dröes & Koster, 2021), but also the type of surrounding landscape. In doing so, our analysis provides empirical evidence for a relationship that had previously been suggested only at a theoretical level.

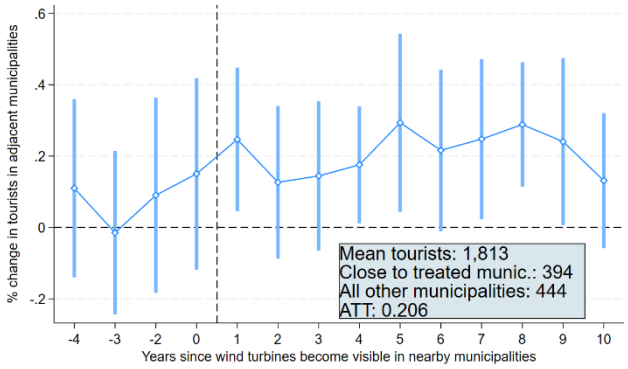
4.3 Potential spillover

To better understand the dynamics in bordering control municipalities, we conduct a separate analysis with two objectives. First, we assess whether bordering control municipalities serve as valid controls by ensuring they are not significantly influenced by wind turbine installations in adjacent treated municipalities ("no spillover effects"). Second, we examine the potential for displacement effects, hypothesizing that tourists might shift their preferences to nearby municipalities where wind turbines are not visible. If such displacement occurs, we would expect an increase in tourist numbers in bordering municipalities as they offer proximity to the treated areas without the perceived visual disamenities of wind turbines. So, we conduct an analysis in which the treatment group includes

[17] "Non-tourist municipalities" are municipalities where no accommodation facilities are present and/or tourist flows are negligible. These include 1,704 municipalities (21.5% of the total), which together account for 6.2% of the population.

municipalities adjacent to, but not directly affected by, wind turbine visibility, while the control group is restricted to municipalities without wind turbine visibility and located farther away.

Figure9: Impact of wind turbines visibility on tourist arrivals in adjacent municipalities



Our analysis shows that, in the years after a new wind turbine installation, tourist numbers increase in nearby municipalities that are not exposed to turbine visibility. This suggests that tourists may prefer nearby areas without visible wind turbines.

5 Cost-Benefit analysis and compensation

A comprehensive cost-benefit analysis of wind turbine implementation requires careful estimation of both the associated costs and the potential benefits. While data on the negative impact of wind turbines on tourism help quantify certain costs, they do not provide insights into the corresponding benefits. Although conducting a full cost-benefit analysis is beyond the scope of this paper, this section explores a key factor involved in estimating the benefits. Specifically, we estimate the amount of CO_2 emissions avoided through wind turbine installations at the municipal level, based on varying wind energy potentials. We then assign a monetary value to these emission reductions and compare this figure to the estimated negative impacts. Finally, we propose a theoretical compensation model for local externalities, incorporating the global environmental benefits into the analysis.

To calculate how much CO2 is saved by wind turbines, we start by understanding how much 'clean energy' (energy that is produced with 0 emissions) is produced by wind turbines in Italy. We are not considering the cost of producing wind turbines in terms of carbon emissions because are so low compared to other energy sources that they are irrelevant (cite some papers). To understand how much energy is produced by each wind turbine, we use the producibility at 100mt above the sea level (map on the left hand side of figure 5, section 1) expressed in MWh/MW. Producibility is the measure of how much electricity a wind turbine can produce on average in one year, given the wind resource at the site. We took the producibility grid is formed by 5km by 5km squares , and so for each wind

turbine we associate the producibility of the closest centroid. We then compute the annual production of each turbine by taking into consideration the power class (provided by Gestore dei Servizi Energetici S.p.A) in the following way:

Annual production (MWh) = producibility (MWh/MW)*Power class (MW)

There are four power classes in the dataset '200-1000 kW', '1000-2000 kW, '2000-3000 kW', >3000 kW' and we took the midpoint for each classes to calculate the annual production (for the last class we consider 3500) for each wind turbine.

The average annual production for a wind turbine in Italy in the considered time period (1998-2019) is around 7.000 MWh[18].

One challenge from engineering perspective is to calculate how much gCO_2 per kWh is saved using wind turbines. Researchers often estimate the climate benefits of renewable energy by comparing the life-cycle emissions intensity of different electricity sources. According to the IPCC Sixth Assessment Report (AR6 WGIII) (Skea et al., 2022), electricity generated from wind emits approximately 9.3 g CO_2-eq per kWh, whereas coal-based generation releases about 965 g CO_2-eq per kWh, and natural gas around 465 g CO_2-eq per kWh. These findings are consistent with prior analyses that examine emission reductions from replacing fossil fuel–based electricity with renewables (O'Mahoney & Denny, 2011; Beltrami et al., 2021). Building on these sources and following the approach of Pryor et al. (2020), we assume that substituting coal-fired power with wind energy results in an average reduction of roughly 600 g CO_2 per kWh.

We then consider the value in monetary terms of the CO_2 saved. We take the price of CO2 in SendeCO2, which publicly report the average yearly CO_2 price following EU ETS (emission trading system) market price. The average CO_2 price from 2008 to 2023 has been 23.90 €/t.

Converting everything in kg, we have $0.6\,\text{kg/kwh} * 0.0239\,€/\text{kg} = 0.01434\,€/\text{kwh}$ saved for every kwh. Considering that for our sample the average annual production is 7,000,000 kwh for a wind turbine, we found that on average a wind turbine saved 100,380€ in one year. For example, considering that wind turbines in Italy in 2019 were around 6000, this means savings of 602 million € in 2019.

According to Bank of Italy data, the average annual tourist expenditure in a municipality is around €12 million. As reported in Section 2.3, municipalities exposed to wind turbine visibility are, on average, exposed to about 50 wind turbines. Given the estimated 15% decrease in tourism spending

[18] We exploit the classes given by GSE for each wind turbine in Italy to calculate the mean value

presented in the results section, this corresponds to an annual loss of roughly €1.8 million. However, this loss remains lower than the estimated €5 million in revenue generated through CO_2 savings associated with wind energy production. While this is substantial, it remains well below the total environmental benefits generated by 50 turbines, which amount to roughly €1.8 million. To reconcile local losses with global gains, municipalities could be compensated through a dedicated "Renewable Energy Tourism Fund," financed by a small levy on wind energy revenues proportional to the CO_2 savings achieved. Additional funding could come from EU green funds, national climate subsidies, or direct contributions from wind farm developers via a "local impact fee," with government top-ups ensuring full compensation if revenues are insufficient. Rather than relying solely on compensation mechanisms, policymakers should prioritize the optimal siting of wind turbines to minimize local costs while maintaining overall energy and environmental benefits. Careful planning can take into account factors such as landscape characteristics, tourism intensity, and population density to reduce negative local externalities. By strategically locating turbines in areas where their visibility and impact on economic and social activities are limited, it is possible to reconcile the expansion of wind energy with the protection of local communities and their economic well-being.

6 Conclusions

Our results contribute to the often heated and polarized debate surrounding the "green–green" dilemma posed by the construction of wind turbines. Globally, wind energy clearly delivers environmental benefits, and at the national level, similar advantages arise in terms of energy independence and system resilience. In particular, wind energy represents an effective strategy to mitigate the volatility of energy prices and to strengthen resilience against disruptions in traditional fossil fuel supply chains, which are increasingly exposed to international tensions. However, while the benefits of wind energy tend to be widely shared, the environmental and visual costs are highly concentrated, falling primarily on the communities that host wind farms. This imbalance is partly due to technological and geographical constraints, which make wind energy development viable and profitable only in specific locations. Moreover, the direct local economic benefits of wind turbines are minimal (Fabra et al., 2024), as these projects require little ongoing labor and are largely limited to the construction phase, offering limited spillover effects for local economies. In this context, the emergence of NIMBY-type conflicts is almost inevitable.

Our findings provide compelling evidence that wind turbine visibility has substantial local economic effects. We show that tourist arrivals decline by up to 20%, peaking seven years after installation and

gradually diminishing thereafter, suggesting that communities may adapt over time. The effect is particularly pronounced in municipalities with 9 to 65 visible turbines and in areas where more than 80% of the territory is exposed, highlighting the importance of both the scale of exposure and the spatial distribution of turbines. Rural, tourism-dependent municipalities are disproportionately affected, underscoring the vulnerability of areas that rely heavily on natural and cultural amenities for their economic activity. This is also consistent with Daniele et al. (2024) who find that more touristic municipalities tend to have a greater political reaction to wind turbine projects.

Tourist expenditure reflects this pattern, with affected municipalities experiencing an average annual decline of 15%, equivalent to approximately €1.8 million or 1.6% of local GDP. The negative impacts extend to broader economic activity, with local income falling by around 1%. These results emphasize that, while wind energy generates substantial environmental benefits, careful policy design is essential to mitigate local economic costs, particularly in tourism-dependent and rural areas. In this context, our findings highlight the potential value of strategic turbine placement and compensatory measures to balance local economic outcomes with the broader environmental gains from renewable energy development. %.

However, these losses are outweighed by substantial environmental benefits: on average, 50 wind turbines generate €5 million per year in value from CO_2 emission savings, more than three times greater than the costs associated with wind turbine visibility for a municipality. Compensation mechanisms could take various forms, including dedicated funds, contributions from developers, or EU and national green subsidies. One promising policy direction is to develop complementary direct local benefits, such as enhanced electrification infrastructure, public charging stations, or improved grid access, to offset perceived landscape costs.

Overall, our results offer important guidance for the design and implementation of wind energy policies. They underscore the need for careful consideration of compensatory mechanisms and, crucially, the strategic selection of locations and quantity of wind turbines. For instance, we find a non-linear relationship between the number of visible turbines, suggesting that constructing large wind farms at once (more than 65 turbines) may be preferable to dispersing smaller numbers of turbines across multiple sites[19].

Beyond compensation and optimal allocation, our findings highlight the importance of minimizing the landscape impact of wind turbines and addressing the socio-economic heterogeneity of their

[19] At the same time, a careful assessment must also consider ecological impacts, since large wind farms may potentially degrade biodiversity and natural habitats over a broader area than smaller installations, highlighting the need to balance environmental benefits with potential local ecological costs.

effects. In Italy, potential wind farm locations frequently coincide with peripheral or ultra-peripheral municipalities, areas that are often economically disadvantaged, experiencing depopulation, and facing limited access to public services. This raises important environmental justice concerns: while the benefits of renewable energy are broadly shared, the costs are disproportionately borne by vulnerable communities. Our results reveal heterogeneity in impacts on the tourism sector. While we find no significant effect on traditional accommodations such as hotels, smaller operators, including B&Bs and private accommodation, experience notable declines, likely because they operate at smaller scales and target different tourist segments. Future research could further examine how renewable resources affects different demographic and socioeconomic groups, explore disparities in economic and social outcomes, and assess the effectiveness of compensation mechanisms in alleviating local burdens. Such work would provide valuable guidance for policies aiming to balance the environmental benefits of wind energy with equitable local outcomes.

Finally, our study underscores the need to consider how public perceptions evolve over time. While wind turbines are often initially seen as intrusive, awareness campaigns emphasizing their role in global environmental sustainability may gradually increase acceptance. Future work could also examine how technological and design innovations can minimize landscape degradation, providing actionable guidance to balance global environmental gains with localized social, economic, and aesthetic impacts.

7 Acknowledgements

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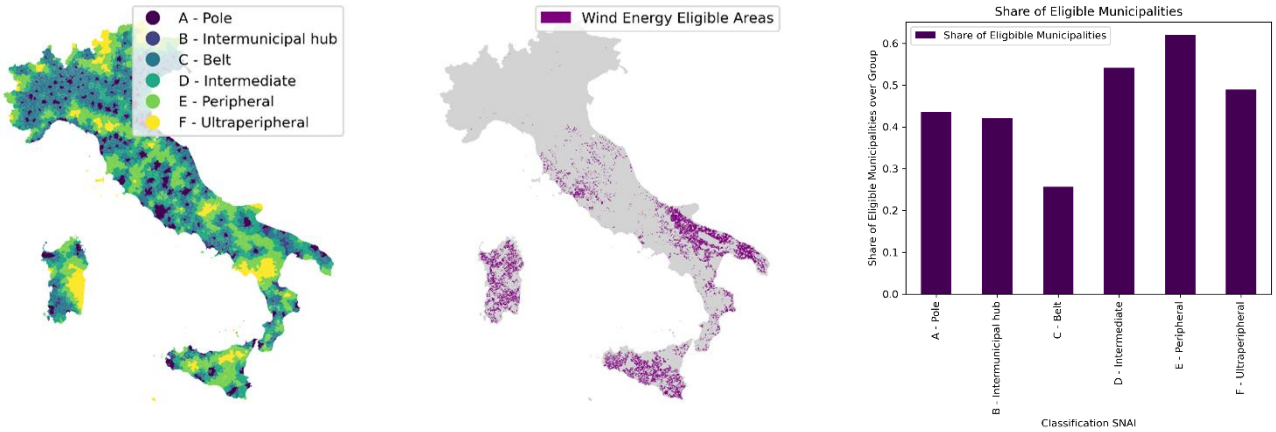
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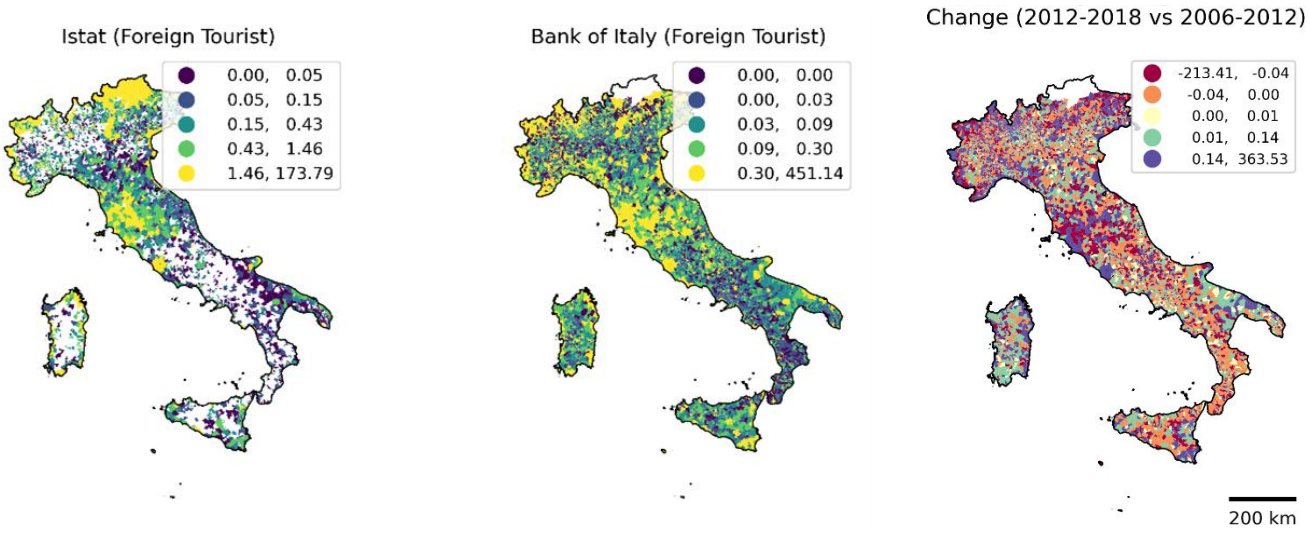
9 Appendix

9.2 Additional Descriptive Statistics

Figure A SEQ Figure_A * ARABIC 1: Classification of Aree Interne



Note: The figure shows on the left-panel the classification of Italian Municipalities according to the "Aree Interne Strategy", where municipalities are differentiated based on the level of accessibility of public services such as public transports and schools. Municipalities classified as Intermediated. Peripheral or Ultraperipheral are the "Internal Areas", territories that tend to be more economically disadvantaged and subject to depopulation, and for these reasons are designatory of specific public policies. For more details see https://www.agenziacoesione.gov.it/strategia-nazionale-aree-interne/. On the central panel we show eligible ("idonee") areas for wind turbines according to GSE (see more in Section 2.1.3 in the main text), on the right panel we show the share of municipalities which have eligible parcels in their territory according to each classification. Clearly, the "Internal Areas" appear to be more eligible compared to the other areas.

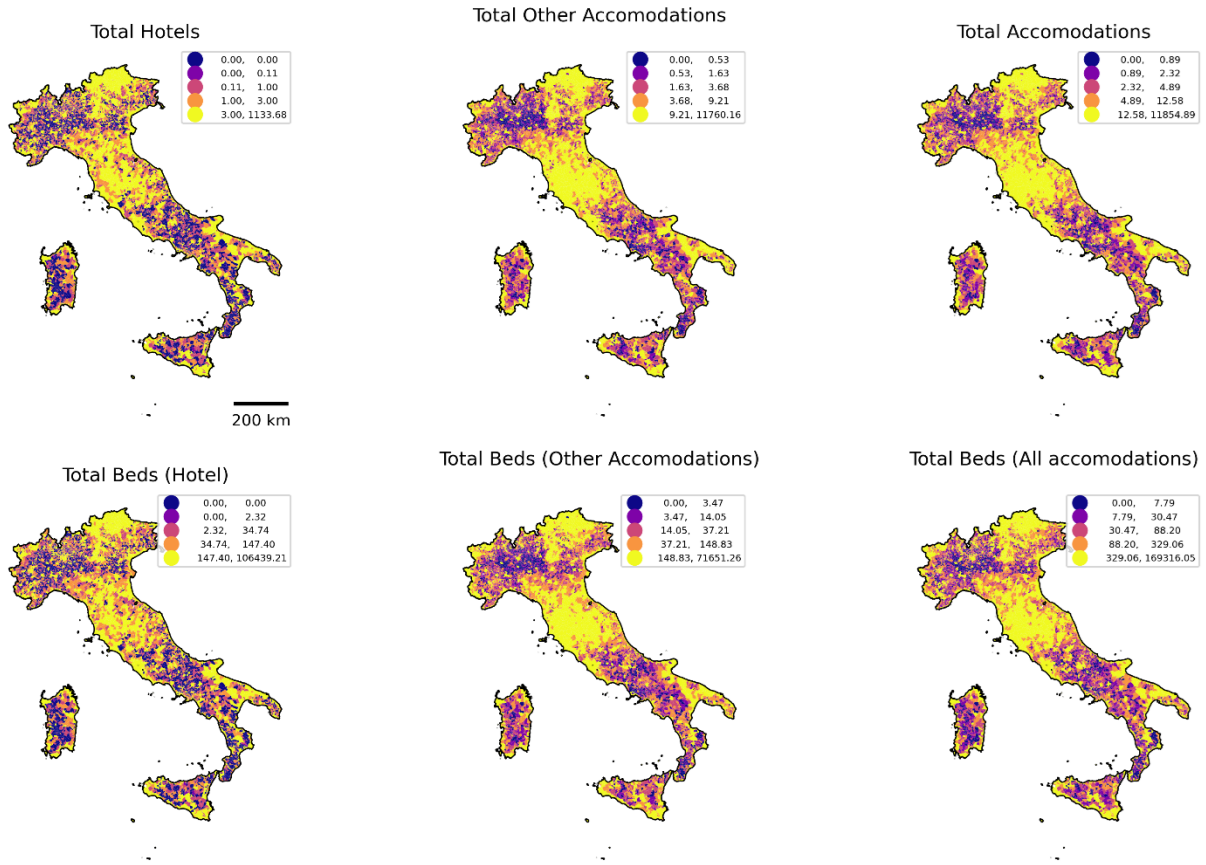


Note: The figure shows average (over all years) touristic flows per capita in all Italian Municipalities according to ISTAT and Bank of Italy data. Note that ISTAT data ranges between 2014 and 2019, while

Bank of Italy data between 1998 and 2019. White areas are missing data. Detailed descriptive statistics are provided in Table A 1 *in the appendix*

The figure shows average number of Touristic accommodations per capita in all Italian Municipalities according to ISTAT. Detailed descriptive statistics are provided in Table A 2 *in the appendix*

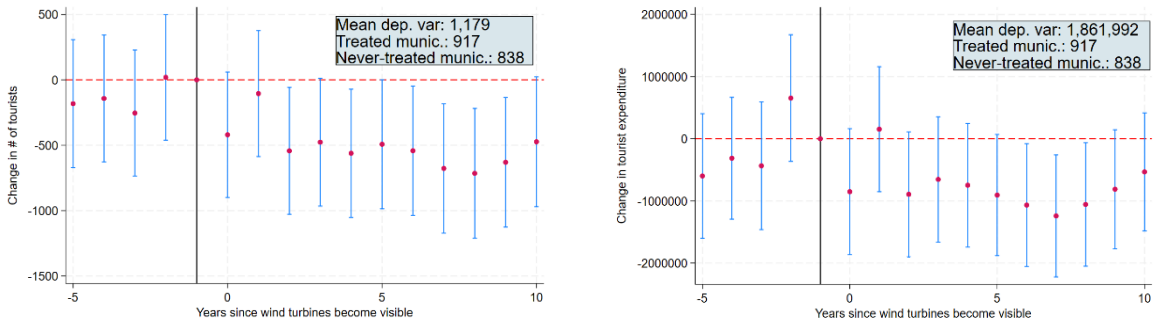
Figure SEQ Figure * ARABIC : Touristic Accomodations



9.3 Additional Results

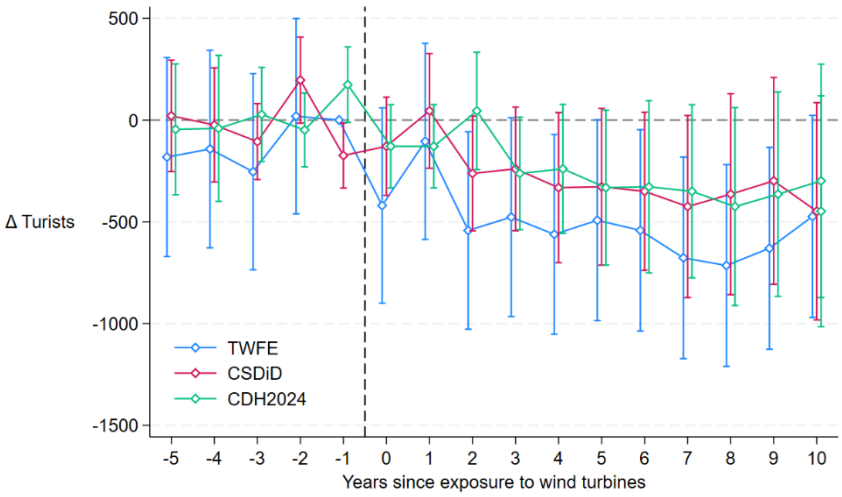
Rubustness on the main result

To assess the robustness of our main finding, we conduct a series of robustness checks. We begin by estimating the event study using the dependent variable in absolute terms, rather than relying on the Poisson specification.



Here, we observe a pattern very similar to the main results shown in Figure 7. In the left-hand panel, the visibility of wind turbines is associated with an average reduction of approximately 500 tourists per treated municipality relative to comparable matched controls. Given that the average number of tourists in our restricted sample is 1,400, this corresponds to a decline of roughly 35%. Nevertheless, the Poisson estimates provide a more reliable measure when considering relative effects (Chen & Roth, 2024). In right-hand side, toursits expenditure follow a similar patter.

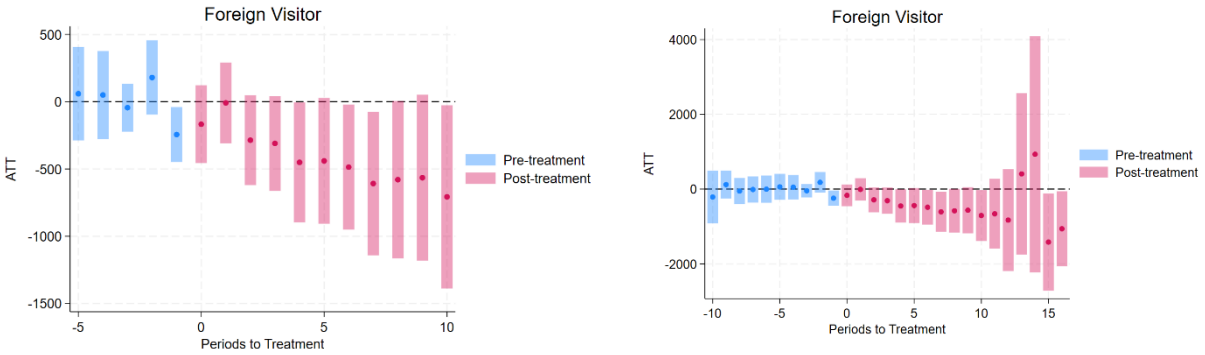
Then, we compare the traditional Two Way Fixed effect (TWFE) event study approach, with more recent estimator in literature (Callaway and Sant'Anna (2020); de Chaisemartin and D'Haultfœuille (2024), respectively called here CSDiD and CDH2024).



We show that the traditional TWFE event-study estimates are not statistically different from those obtained using the Callaway and Sant'Anna (2020, CSDiD) and de Chaisemartin and D'Haultfœuille (2024, CDH2024) estimators. This suggests that our results are not substantially affected by biases associated with the staggered timing of wind turbine implementation. Both the CSDiD and CDH2024 estimators produce slightly higher point estimates than the traditional event-

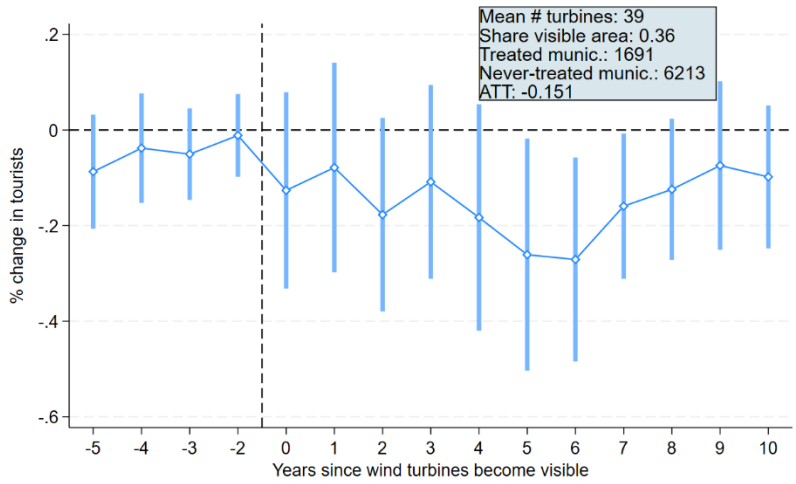
study approach, but they still capture the pronounced negative trend in tourist arrivals following turbine installation relative to the pre-treatment period. The relatively large standard errors reflect the limited sample size, so the point estimates are generally significant at the 10% level rather than at 5%.

Moreover, when controlling for log population and region fixed effects in the Callaway and Sant'Anna (2020) framework, the results closely align with the TWFE estimates:



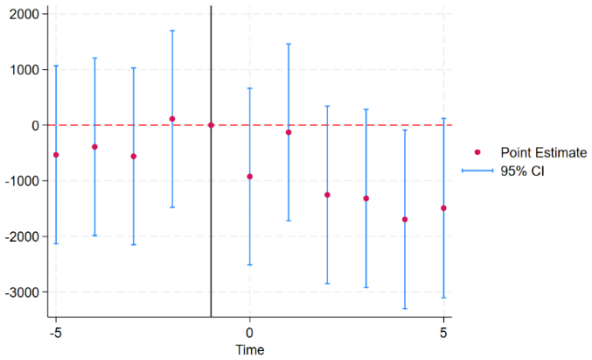
The estimated average treatment effect on the treated (ATT) is −419, statistically significant at the 5% level. Extending the analysis to include all possible pre- and post-treatment periods, right hand figure, confirms the robustness of these findings.

Here, we consider all municipalities in Italy to maximize statistical power, resulting in 1,691 treated municipalities and 6,213 never-treated municipalities.



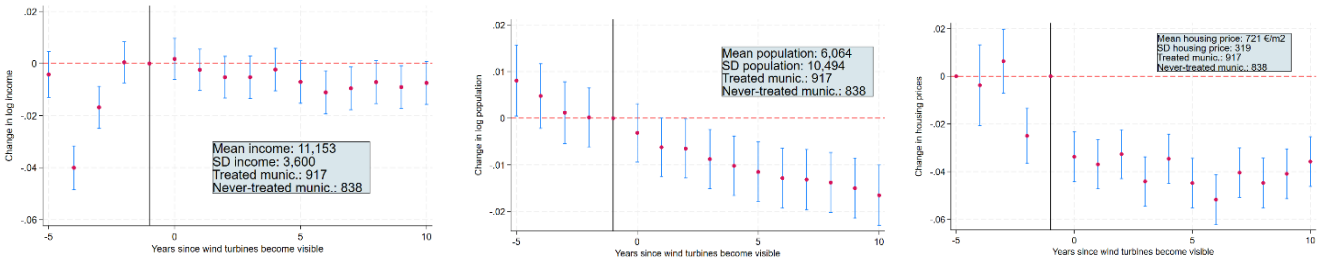
The negative effect of wind turbine visibility seems stronger in this broader sample. This likely reflects the fact that substantial differences remain between treated and never-treated municipalities, and the probability of receiving wind turbines varies across locations.

We also restrict the sample by considering only municipality with a stronger recoridng data about toursit, selecting only those municiplaity with at maxium 13 zeros (in the main analysis we select those with maximum 26 zeros).



As expected, our estimates are larger because we exclude many observations with zero values. However, in relative terms, the effect the same and the overall trajectory of the effect is unchanged. This indicates that our results are not driven by the presence of many zeros in certain municipalities.

Other outcomes: income, population, housing

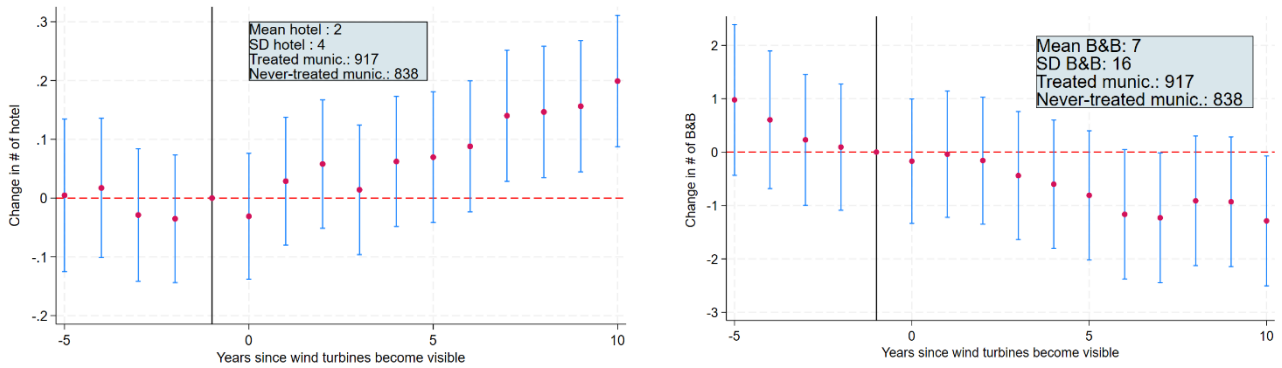


Figures illustrate the dynamic effects of wind turbine visibility on local economic outcomes. Panel (a) reports the event-study estimates for income growth, measured as the change in log income relative to 2010. The results indicate a decline of about 1% in the years following installation. Panel (b) shows similar dynamics for population, with a gradual decrease beginning even before turbine visibility, suggesting possible anticipatory migration or pre-existing demographic decline. Panel (c) presents the results for housing market outcomes, where a clear anticipation effect is observed: housing prices start to fall roughly one year prior to visibility, consistent with evidence from Dröes and Koster (2016). Overall, these figures support the main finding that wind turbine visibility is associated with localized economic and demographic contraction.

The effects of wind turbines on tourism supply

Here we show the impact of wind turbine installations on tourism supply metrics, specifically the number of hotels, bed and breakfasts (B&Bs), and private apartments. For analytical clarity, we group these into two categories: hotels and other accommodations. This distinction is crucial for capturing differences in their capacity to adapt to fluctuations in demand. Larger establishments, such as hotels,

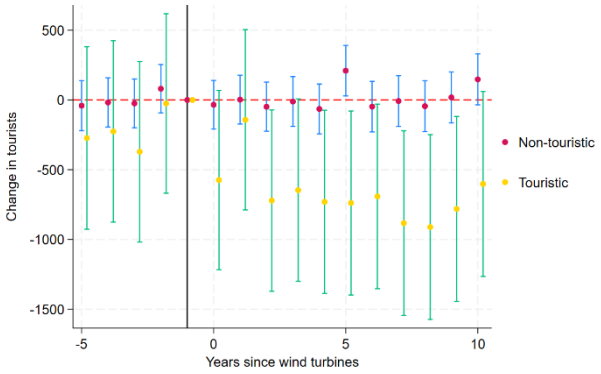
benefit from economies of scale, enabling them to absorb demand shocks by adjusting prices. In contrast, smaller establishments, such as B&Bs, may face greater challenges, often opting for closure when faced with sustained drops in demand.

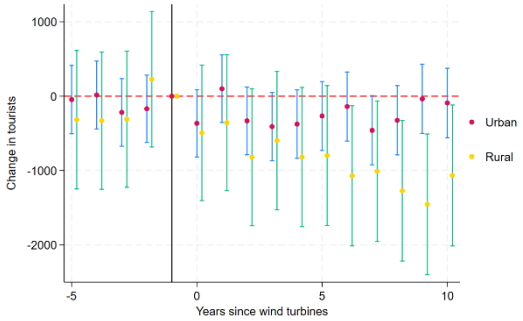


The findings reveal a decline in private accommodations, such as bed and breakfasts and short-term rentals. In contrast, we find no evidence of a negative effect on the number of hotels; if anything, their numbers slightly increase over time. This pattern may reflect a substitution effect, where the contraction in smaller, family-run accommodations is partially offset by the expansion of larger hotel establishments. Overall, these results suggest that the negative effects of wind turbines on tourism are primarily demand-driven, as the decline in tourist demand occurs more immediately after installation, while the supply side adjusts more slowly, with small decreases emerging only about 6 or 7 years after (when the overall tourist expenditure start to decrease in the main finding in figure 7).

Heterogeneous analysis by category

We begin by examining whether the impact of wind turbines differs between touristic and non-touristic municipalities (left-hand side graph). Our results show that the overall negative effect is largely driven by touristic areas, where the presence of wind turbines appears to have a stronger and more persistent impact on local economic outcomes. Next, we classify municipalities as either rural or urban (right-hand side graph). The rural category includes areas characterized by natural features such as mountains, coastlines, or lakes, while all others are classified as urban. Out of 1,755 municipalities in our sample, 766 fall into the rural category, which explains the relatively large standard errors observed in estimates for this subgroup (see Section 2 for additional descriptive statistics). Despite this, the evidence consistently points to rural municipalities as the primary drivers of the overall effect, suggesting that wind turbine visibility is particularly consequential in areas where natural landscapes are central to economic activity and local identity.





We find that main effect is driven by touristic municipality.

Next, we classify municipalities as either rural or urban. The rural category includes municipalities characterized by natural features such as mountain, maritime, or lake environments, while all others are classified as urban. Among the 1,755 municipalities in our sample, only 766 are categorized as rural, which contributes to relatively large standard errors in estimates for this subgroup (See section 2 for more descriptive statistics). Nevertheless, the point estimates indicate that the observed effects are primarily driven by rural municipalities.

Other potential mechanism

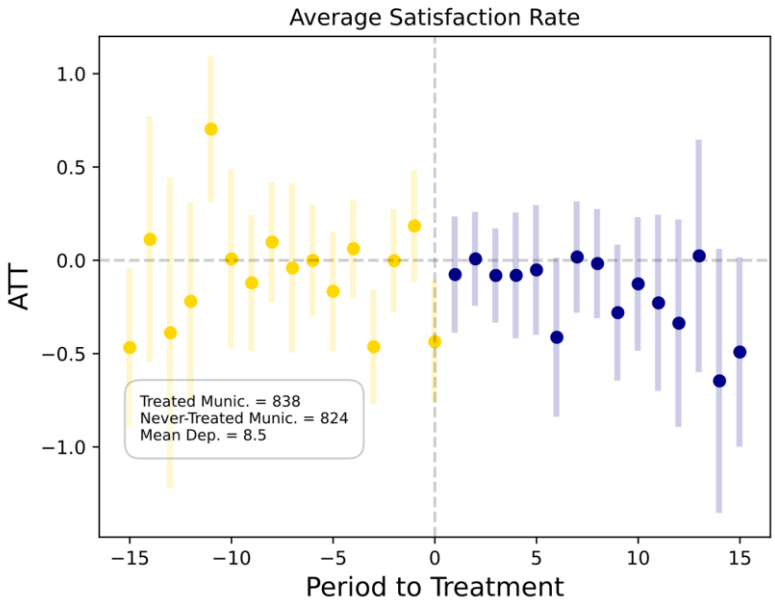
Satisfaction

To begin with, we tried to exploit the data relating to satisfaction contained in the survey of the Bank of Italy, i.e. an item that goes on a scale from 1 to 10, in which tourists are asked about their overall level of satisfaction with the holiday.[20] Results are reported in Figure 12, and appear clearly null and unsignificant, suggesting that satisfaction is not a mechanism driving the decline in the tourism demand. Tough, it is important to acknowledge that there can be some bias in this measure of reported satisfaction, in fact there is not even correlation between touristic flows and average touristic satisfactions. These results also raise important doubts regarding the interpretation and implications

[20] Specifically, the question asked is: On a scale from 1 (bad) to 10 (excellent), how much did you enjoy your visit to Italy?

of qualitative or survey-based results suggesting that tourists decisions might not be affected by the presence of wind turbines.

Figure SEQ Figure * ARABIC 12: ATT of Wind Turbine Visibility on Tourists Satisfaction



Note: The figure shows the estimates of the ATT using the Callaway and Sant'Anna (2021) estimator. The average satisfaction rate is computed at the municipality level using the survey item contained in the Bank of Italy questionnaire.

Heterogeneous based on timing of implementation

