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The environmental and socioeconomic impacts of the Italian National Parks: Time and spillover effects across different geographical contexts

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ABSTRACT

Protected Areas such as national parks are increasingly implemented to achieve the long-term conservation of nature and the provision of ecosystem services, hence preventing biodiversity loss. We study the environmental and socioeconomic impacts generated by eight Italian National Parks. We estimate the impacts i) on the short and medium term, ii) on the local population and on the neighboring areas (i.e., their spillovers), and iii) differentiating the analysis by the macro-geographical context in which National Parks are embedded (i.e., north, center, and south of Italy). The analysis is based on the combination of the Propensity Score Matching with the Doubly Robust Difference-in-Differences estimator. We find that the National Parks have a positive and increasing-over-time impact on the share of forested areas. Moreover, from the socioeconomic point of view, their impact has been positive on the number of local units, workers employed (especially in the tourism sector), and the number of incoming work commuters, but negative on the number of agricultural holdings. However, these results depend on the geographical contexts, i.e., most of the positive socioeconomic impacts are in the north. Finally, we find (positive) spillover in terms of forested areas, but non-significant socioeconomic ones.

1. Introduction

Protected Areas (PAs) represent the bedrock for the conservation policy, aiming at preserving the environment and preventing biodiversity loss (Gray et al., 2016). In the last years, PAs have substantially increased worldwide, and their further enlargement has been advocated by both scholars (Visconti et al., 2019) and institutions (UN, 2020). The expansion of PAs has steered an increasing literature on their socioeconomic impact (Jones et al., 2017). The largest part of the literature finds that the socioeconomic impacts of PAs on the local population are non-negative (Kandel et al., 2022; Oldekop et al., 2016), hence dissipating the fears of potential poverty traps. However, with few exceptions (Gurney et al., 2014), in most of the analyses (Andam et al., 2010; Chen et al., 2016; Ferraro and Hanauer, 2014, 2011) only one period of time is taken into account, thus disregarding the time dynamics of the potential effects of PAs establishment. Moreover, while spillover effects of PAs are increasingly the subject of the analyses, most of the literature has focused on environmental leakages (e.g., deforestation in the proximity of PAs) rather than on socioeconomic ones (Pfaff and Robalino, 2017).

The objective of this article is three-fold. First, we aim to investigate the environmental and socioeconomic impact of eight Italian National Parks (NPs) in the short and medium run (respectively, about 10 and 20 years after the implementation).

Second, we investigate the geographical spillover effects, according to the idea that both environmental and socioeconomic impacts of NPs can cross their administrative borders. Third, we analyze to what extent impacts depend on the macro-geographical contexts in which NPs are located, i.e., if the impacts are different across NPs in northern, central, or southern Italy.

The impact of the NPs establishment is assessed at the municipality level. This assessment is carried out by means of a counterfactual approach based on the combination of the Propensity Score Matching (Rosenbaum, 2002) with the Doubly Robust Difference-in-Differences (DR DID) estimator (Sant'Anna and Zhao, 2020). The choice of the NPs to consider in the analysis, as well as the outcome variables to analyze, both respond to the trade-off between the potentially widest set of NPs and the availability of panel data on the Italian municipalities.

For the environmental dimension, we estimate the impact of a NP establishment on two variables related to land use, as it has been

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overwhelmingly regarded among the main determinants of biodiversity conservation (e.g. Newbold et al., 2015). More specifically, we evaluate the effect that NPs have had on the percentage of forested land and the hectares of Utilized Agricultural Area (UAA). Intuitively, NPs would have a non-negative impact on the forested areas and a non-positive impact on the UAA, i.e., NPs should block or highly reduce land use change (Abman, 2018). Note, however, that a proper evaluation of the impact of NPs on biodiversity would require an assessment of the landscape mosaic, and hence would require more detailed data than municipality-level data (Vacchiano et al., 2017).

With respect to the socioeconomic dimension of the impact of NPs, we consider two sets of variables. The first one refers to the overall socioeconomic dynamism of the areas that are 'treated'. As a proxy for this, we estimate the impact of the NPs on i) population density, ii) number of local units, i.e., firms or branches of firms in a geographically identified place, iii) number of workers employed by such local units, iv) number of work commuters (outgoing, ingoing and within the same municipality). These variables are of particular interest, due to the fact that NPs are mostly located in marginal areas (Nobel et al., 2023) with substantial depopulation patterns and stagnating economies (Reynaud et al., 2020).

The second one refers to changes in the composition of the economy and its tertiarization (Busch and Amarjargal, 2022), caused by the additional constraints on the economic activities that are determined by the establishment of NPs. In particular, two economic sectors seem directly affected: tourism and agriculture. On the one hand, NPs might become attractors of tourism (Sinclair et al., 2022). On the other hand, NPs are likely to reduce the profitability of those activities that rely on the use of natural resources (such as agriculture) (Ritzel et al., 2023). Both sectors face challenges in mountain and marginal areas, as those hosting the NPs considered. While tourism represents one of the most important economic sectors of the Italian economy, recently mountain destinations (including natural beauties) only represented 24.5 % of vacations for national tourists (Istat, 2023). However, tourism might be an important driver of socioeconomic change in marginal areas (Salvatore et al., 2018). Agriculture has gone through a sharp transformation over the past decades. Based on the 2010 Italian Census of Agriculture, both the number of farms and the size of UAA have steadily decreased in Italy, since the 1960s (Arzeni and Sotte, 2012; Sardone, 2012). This decline has been much larger in mountainous and remote areas, due to more difficult environmental and socioeconomic conditions. Accordingly, we analyze the impact of NPs on i) number of local units in the tourism sector, ii) number of workers employed by local units in the tourism sector, iii) number of agricultural holdings.

This paper speaks to the increasing literature on the impact assessment of National Parks and Protected Areas. To date, a positive impact of PAs in reducing poverty has been found e.g., in Thailand (Sims, 2010), Tanzania (McNally et al., 2011), Thailand and Costa Rica (Ferraro and Hanauer, 2011), Nepal (den Braber et al., 2018) and Indonesia (Gurney et al., 2014). Evidence on high-income countries is scarcer (Kandel et al., 2022). Weiler and Seidl (2004) find that the re-designation of PAs from 'monuments' to parks in the US massively increased the number of incoming tourists and has positively affected the local economy. Socioeconomic benefits in terms of local business numbers and local revenues are found in southeastern Australia by Heagney et al. (2015). Chen et al. (2016) find a positive impact of the US Northwest Forest Plan on income, population, and property values of the small communities. A small but positive impact on employment levels is estimated by Sims et al. (2019) with respect to the land protection arrangements in New England.

We provide four contributions to this literature.

First, in most of the existing analyses, the impact is assessed considering only one post-treatment instant (Andam et al., 2010; Chen et al., 2016; Ferraro and Hanauer, 2014, 2011). Such a choice potentially neglects time dynamics in the PAs effects, which are important instead (Gurney et al., 2014; Jones et al., 2017). In fact, time dynamics are expected to matter and to interact with location patterns. We confirm this result, and we observe that the impact on the share of forested areas and on the employment in the tourism sector, as well as that on the ingoing work commuters increases with time, while the positive impact on the number of firms dissipates in the medium run.

Second, geographical spillovers or leakages of PAs are increasingly the subject of scrutiny (Pfaff and Robalino, 2017), but most of the focus is on the environmental effects, i.e., the displacement of deforestation (Blackman et al., 2015; Boillat et al., 2022; González-García et al., 2022; Herrera et al., 2019; Mingarro and Lobo, 2023). Our results suggest that it is hard to indicate the presence of socioeconomic spillovers (i.e., none of the estimates are statistically significant) but that there could be environmental ones (positive impact on forested areas).

Third, we analyze whether impacts depend on the macro-geographical context in which the considered NPs are embedded (i.e., northern, central, and southern Italy). Local and regional heterogeneity in PAs impacts has been found elsewhere (Blackman et al., 2015; Kandel et al., 2022). In this prospect, Italy represents an interesting case study, displaying a notable heterogeneity in terms of socioeconomic (Barca et al., 2014) and geographical conditions, as well as structural characteristics of both the agricultural sector (Bozzola et al., 2018; Cubasch et al., 1996) and the tourist sector. In the latter regard, northern regions are the most attractive ones of the country, whereas southern regions seem to be less able to attract tourists, especially foreign ones (Algieri and Álvarez, 2023; Costantino et al., 2021; Istat, 2023). We find that NPs have positive socioeconomic effects mostly in the north, while positive environmental effects are found in any of the three areas considered. Finally, the contribution of this work to the literature also lies in the fact that, from the methodological point of view, this is the first application of the recently proposed DR DID estimator for analyzing the impact of PAs, in the context of counterfactual analysis and impact evaluation (Sant'Anna and Zhao, 2020).

The remainder of the paper is the following. Section 2 presents the methods applied. In section 3, we describe the data, while in section 4, the results are presented. The latter are discussed in section 5, while section 6 hosts the work conclusions.

2. Methods

When a NP is established in the territory of a given set of municipalities, it is not possible to observe what would have happened in that territory (and in the related municipalities) if the area had not been protected. This is a peculiar case of the acknowledged 'fundamental problem of causal inference' (Holland, 1986) and the assessment of the effect(s) generated by the NP represents a specific challenge of the 'observational studies' framework. Comparing in a non-experimental setting the treatment group with an untreated one, thus estimating the causal effect, could lead to biased results due to, e.g., self-selection bias, or systematic differences between treated and untreated units (Dehejia and Wahba, 2002).

To overcome these issues, we adopt the counterfactual estimation approach, similar to other papers focusing on the impact of PAs (Andam et al., 2010; Chen et al., 2023; Ferraro and Hanauer, 2014, 2011; Geldmann et al., 2019; Joppa and Pfaff, 2011; Schleicher, 2018). The intuition is to mimic the experimental design: a sample of 'untreated' units (i.e., municipalities that are not included in a NP) is selected to form the 'counterfactual group' (or 'control group') that is successively compared with the 'treated' one (i.e., the municipalities *in* a NP). Intuitively, the counterfactual group is built by selecting those municipalities that could have hosted a NP, but actually did not. In other words, the aim is to select 'treated' and 'untreated' municipalities that are as much as possible similar in terms of their observable characteristics, but do differ for the treatment status (i.e., *hosting*, or *not*, a NP). The relevant observable characteristics of the municipalities used to identify the most similar observations are commonly defined covariates. Based on the latter, we pair (i.e., we 'match') the municipalities. Such extracted subsample of matched municipalities is then considered for the estimation of the effect(s) generated by the NP establishment. The main goal before estimating the effect of the NP establishment is to extract the 'treated' and 'untreated' (counterfactual) municipalities that are 'the most similar', namely that are balanced in the covariates. Trivially, the best balance in the covariates will allow to avoid the comparison between e. g., a municipality in a marginal area of the Dolomites that is included in a NP with the municipality of Milan.

The method adopted lies in a three-steps process. First, we select the covariates to be used to define the similarity between the treated and the control groups. Second, based on their similarity, out of the total population, we select the observations that will compose the group of counterfactual municipalities and match them with the observations composing the groups of the treated municipalities. In our case, we match the two groups cluster by cluster, i.e., by separately considering the NPs located in northern, central, and southern Italy, according to Fig. 1. Third, we estimate the average treatment effect on the treated (ATT) with the DR DID estimator. More details follow.

The covariates must be selected according to the following rationale. They must be the relevant, observable characteristics that are: 1) statistically significant in terms of treatment adoption, 2) observed *prior* to the treatment or not directly associated with it, 3) predictive of the outcome(s) but not influencing the treatment status. One could just decide to include all such covariates by aiming at reducing the bias that emerges from the mere estimate of the treatment effect obtained by simply comparing treated and untreated municipalities. However, the larger the number of covariates, the stronger the 'dimensionality curse'. The latter lies in the probability of finding the most similar municipalities between the two groups by accounting for *all* the envisaged characteristics. To overcome this issue, we also collapse the information conveyed by each covariate by estimating the Propensity Score (PS). The PS is the conditional probability of hosting a NP (the 'treatment') given the municipalities' observable characteristics (the covariates) that predict the treatment status. Intuitively, the PS is the outcome of a logistic regression model where the binary treatment is predicted given the covariates. Such inclusion is motivated by the proof that being the treated and control groups balanced for the PS, they are also balanced in the covariates (Rosenbaum and Rubin, 1983; Rubin and Thomas, 1996). We include both the covariates and the PS in the balancing of the groups.

To select the useful covariates, the assumption of 'selection on observable' must hold (Heckman and Robb, 1985; Rosenbaum and Rubin, 1985) and, in addition, one should possibly follow the prescriptions of Rosenbaum (2010) and Sauer et al. (2013). Hence, we

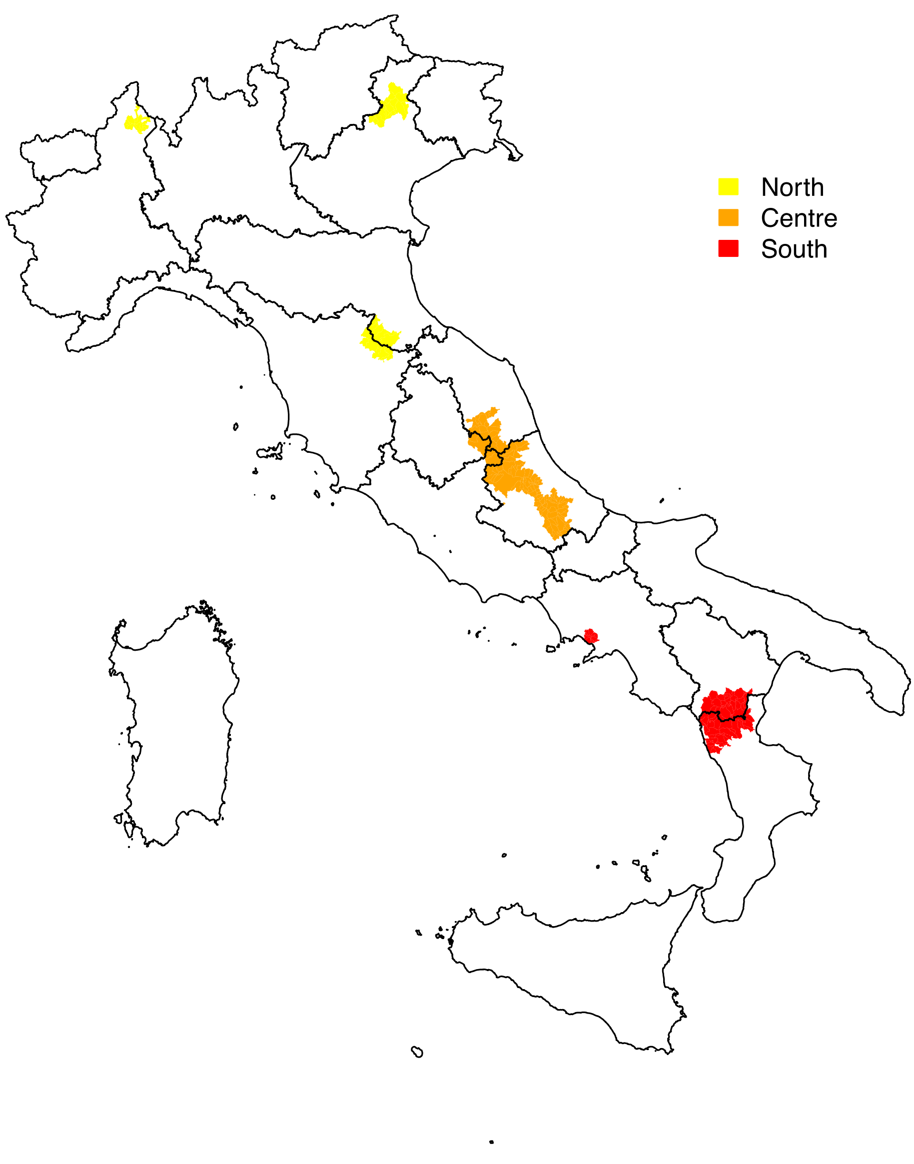

Fig. 1. Map of the National Parks considered in the analyses.

choose the covariates for the matching if they meet the three following criteria. First, we select the covariates that are statistically significant in the logistic regression for the estimation of the PS, i.e., if they show statistically significant coefficients in the estimation model where the binary treatment variable is predicted given the covariates (Ho et al., 2007). Second, we choose the covariates if they peculiarly characterize the treated observations with respect to time-invariant features. Third, we choose those covariates that help in ruling out all the observable differences with respect to the outcome variables, if and only if they can be observed *before* the treatment has taken place. The chosen variables in combination with the estimated PS are used for defining the counterfactual municipalities that must be considered for estimating the ATT, i.e., the effect that the establishment of a NP has on the municipalities being part of it.

There are several matching approaches that can be used for the extraction of the sub-sample on which to estimate the ATT. The selection of the best one to adopt follows the suggestions by Ho et al. (2011, 2007). Namely, we select the matching approach that guarantees the optimal balancing of the covariates and the highest level of reduction of the differences originally observed between the treated and untreated (counterfactual) groups in terms of the covariates. Indeed, the rationale for selecting the optimal matching procedure is the covariates balancing maximization (Imai et al., 2008). In other words, as far the covariates (and the PS) are perfectly balanced between the group of municipalities in NPs and the one not in NPs, the causal comparison of 'treated' and 'untreated' is unconfounded (Rosenbaum, 2002). In line with this, we test several matching procedures and we choose the strategy according to the rule of balancing maximization. Namely, we tested the logistic regression PSM (or its linear Probit specification), the random forests distance matching, the Mahalanobis distance matching (Cochran and Rubin, 1973; Rubin, 1980), the combination of the Mahalanobis nonparametric approach and the PS estimation (Rosenbaum and Rubin, 1983), the constrained caliper matching, the full matching approach with (or without) the discarding of the control/treated municipalities outside the common support (Hansen, 2004), the Nearest Neighbor matching both with and without replication (Abadie and Imbens, 2006), and the Bayesian additive regression trees PSM (Chipman et al., 2010; Ho et al., 2021).

The sub-sample of matched municipalities obtained by means of the matching approach is compared – i.e., the ATT is estimated – by the DR DID estimator (Sant'Anna and Zhao, 2020). Let t be the time: $t = 0$ is the baseline year, $t = 1$ is the follow-up year. Let Y_{mt} be the outcome of interest for the m-th municipality at time t. Whereas the m-th municipality hosts a NP before time t (i.e., it is treated), $P_{mt} = 1$. Otherwise, $P_{mt} = 0$. Easing the notation, because $P_{m0} = 0$ for every municipality, we can write $P_m = P_{m1}$. Following the framework of potential outcomes (Rubin, 2004), let $Y_{mt}(0)$ be the outcome of municipality m at time t if it is not part of a NP, while $Y_{mt}(1)$ indicates the outcome of the same municipality if the NP has been established. The resulting outcome will be: $Y_{mt} = P_m Y_{mt}(1) + (1 - P_m) Y_{mt}(0)$. Let X_m be the observed set of covariates.

The method relies on three assumptions, namely:

A1. The $\{Y_{m0}, Y_{m1}, P_m, X_m\}$ observations (for m = 1, …, n) are independent and identically distributed. Being interested in estimating the ATT, the parameter of interest is $\tau = E[Y_{m1}(1) - Y_{m1}(0)|P_m = 1]$. Hence, the ATT can be re-written as $\tau = E[P_m = 1] - E[P_m = 1] = E[P_m = 1] - E[P_m = 1]$.

A2. $E[P_m = 1, X_m] = E[P_m = 0, X_m]$, i.e., the average conditional outcome of the municipalities within a NP and the municipalities out of a NP would have been the same if the NP were not established, the so-called 'parallel trend assumption'.

A3. For some $\xi > 0$, $P(P_m = 1) > \xi$ and $P(P_m = 1|X_i) \leq 1 - \xi$, i.e., there is at least a small portion of the municipalities that are included in a NP and, for every value of the covariates, there is at least a small probability for the municipality not being part of a NP. This is the so-called 'overlap condition' that guarantees the existence of the range of PS for which it is possible to find a match between a treatment and a control municipality.

We focus on $E[P_m = 1] = E[P_m = 1, X_m] + E[P_m = 0, X_m] - E[P_m = 0, X_m|P_m = 1] = E[P_m = 1] + E[P_m = 0, X_m] - E[P_m = 0, X_m|P_m = 1]$. For estimating the ATT, Abadie et al. (2004) proposed to use $\tau = \frac{1}{E[P]} E\left[\frac{P - ps(X)}{1 - ps(X)}(Y_1 - Y_0)\right]$, where $ps(X) = P(P = 1|X)$. Consequently, the estimator for the ATT is

$$\widehat{\tau}^{ps} = \frac{1}{E_n[P]} - E_n\left[\frac{P - \widehat{\pi}(X)}{1 - \widehat{\pi}(X)}(Y_1 - Y_0)\right]$$

with $\widehat{\pi}(x)$ being the estimator for the true but unknown $ps(x)$.

The DR DID estimator combines the consistency property of the ordinary DID model by Heckman et al. (1997) and the properties of the $\widehat{\pi}(\bullet)$ estimator for $ps(x)$ proposed by Abadie et al. (2004). The result is an estimator that shows robustness even if either the ordinary DID model or the model for the PS are mis-specified. Consequently, let it be that $\Delta Y = Y_1 - Y_0$ and let it be that $\mu^{ps}_{p,\Delta}(X) = \mu^{ps}_{p,1}(X) - \mu^{ps}_{p,0}(X)$, where $\mu^{ps}_{p,t}(x)$ is the model for the true but unknown outcome regression $\gamma^{ps}_{p,t}(x) = E[Y_t|P = p, X = x]$ with $p,t = 0,1$, where the true, but unknown, $\gamma_{p,t}(x) = E[Y_t|P = p, X = x]$. The DR DID estimator for the ATT results to be

$$\widehat{\tau}^{DRDID} = E\left[\left(w^{ps}_1(P) - w^{ps}_0(P, X, \pi)\right)\left(\Delta Y - \mu^{ps}_{0,\Delta}(X)\right)\right],$$

where, for a generic function g, we have that $w^{ps}_1(P) = \frac{P}{E(P)}$ and $w^{ps}_0(P, X; g) = \frac{g(X)(1-P)}{1-g(X)} / E\left[\frac{g(X)(1-P)}{1-g(X)}\right]$. The efficiency bounds and the asymptotic properties holding for the DR DID estimator, as well as the Monte Carlo simulations results which proof its finite sample properties can be found in Sant'Anna and Zhao (2020). The matching procedure and the ATT estimation are performed with the Matching (Sekhon, 2019), MatchIt (Ho et al., 2021) and drdid (Sant'Anna and Zhao, 2020) R packages in addition to user-written R coding.

The same rationale is applied for the analysis of the potential geographical spillover effects. In this regard, the neighboring municipalities of the ones covered by the NPs under analysis (i.e., those sharing a common border with them) are considered as 'treated'. They are matched with the most similar municipalities (in terms of the observed covariates) among those that are not neighbor to municipalities covered by NPs (the municipalities that are considered as treated in the previous analysis framework are previously excluded from the unmatched sample). The DR DID estimator is then applied to the resulting matched sub-sample.

3. Case study description and data

3.1. Case study

The Italian policies and legislations on protected areas have been extensively developed over time – see Mancini (2017) for a detailed description of the evolution of the relevant legislation –. Before the beginning of the 1990s, most of the institutionalization of PAs, especially on National Parks, was due to ad hoc legislations (Mancini, 2017). The turning point was the 1991 law (*Legge Quadro n.394/1991*) that provided a national and comprehensive legislative framework for the implementation of protected areas (Mancini, 2017). Such a law defined the objectives, the typologies (National Parks – *Parchi Nazionali* –, regional and inter-regional natural parks – *Parchi naturali regionali e interregionali* –, Nature reserves – *Riserve naturali* –, Wetlands of International Importance – *Zone umide di interesse internazionale* –, other protected areas – *Altre aree naturali protette* –, and *Aree di reperimento terrestri e marine*) and the institutional set-up of PAs. The law defined some general objectives for PAs. The main idea is to provide a protection regime for those areas that are characterized by relevant environmental and natural values, to (mainly) conserve biodiversity.

National parks are defined as follows: "National parks are made up of terrestrial, river, lake or marine areas that contain one or more intact ecosystems or even partially altered by anthropic interventions, one or more physical, geological, geomorphological, biological formations of international or national importance in terms of values naturalistic, scientific, aesthetic, cultural, educational and recreational such as to require State intervention for the purposes of their conservation for present and future generations." Focusing on the National Parks (IUCN category II), the objective is nature conservation and, as such, economic activities are constrained as specified by the NP regulations that each NP implements. For example, the regulation of the *Parco Nazionale delle Foreste Casentinesi, Monte Falterona e Campigna* constrains the use of synthetic inputs (pesticides and fertilizers) and forbids the creation of new intensive stock farming and stanchion stable systems.[1] New agricultural activities are only allowed at low intensity (organic, integrated pest management and similar farming systems). To date, the Italian NPs are 25, covering an area of 16,000 km^2 and corresponding to the 5.3 % of the country (Italian National Ministry of Ecological Transition, 2022). Boosted by the aforementioned legislation, a relevant number of NPs were established in the 1990s (they are defined as IUCN Management Category II; c.f. https://www.protectedplanet.net). These, due to data-availability issues at the municipality level and other research challenges, are considered here:

- The NPs of the North: the *Parco Nazionale delle Dolomiti Bellunesi* (1990), the *Parco Nazionale della Val Grande* (1992), the *Parco Nazionale delle Foreste Casentinesi, Monte Falterona e Campigna* (1993), for a total number of 39 involved municipalities.
- The central NPs: the *Parco Nazionale dei Monti Sibillini* (1993), the *Parco Nazionale del Gran Sasso e Monti della Laga* (1995), the *Parco Nazionale della Maiella* (1995), with 98 municipalities included.
- The NPs of the South: the *Parco Nazionale del Pollino* (1993) and the *Parco Nazionale del Vesuvio* (1995), with 68 municipalities included.

The NPs are mapped in Fig. 1.

We assume as treated the municipalities whose borders intersect with those of a NP taken into account. These municipalities are 205. Their total surface is equal to 11,148.22 km^2 (i.e., 3.69 % of the country area) and their total population is 947,703 inhabitants (i.e., 1.67 % of the Italian population), considered at the baseline year 1991. They cover mountain areas, both in the Alps (northern Italy) and throughout the Apennines (central and southern Italy).

3.2. Data

We assemble the (balanced) panel data used, covering a two-decade time-period from 1991 up to 2011, resorting to different open access sources of the Official Statistics, mainly from the Istat. The latter was used for retrieving data on: the geographical characteristics of the municipalities, the 1991, 2001, and 2011 *Census of Population and Housing, Census of Industry, Services and Non-profit Institutions* and the *Origin-Destination (O-D) commuting matrices*, as well as the 1990, 2000, and 2010 *Census of Agriculture* (Istat, 2022). We use the CORINE Land Cover source for retrieving information about land use (Copernicus, 2022).

We use two sets of variables: 1) the covariates that are used for pairing the treated and the untreated municipalities (the counterfactual group), and 2) the outcome variables, i.e., the variables on which the NPs impact is estimated.

7,423 municipalities not included in a NP represent the group of untreated units. After data management, these do not include 50 municipalities where the *Parco Nazionale dell'Appennino Tosco-Emiliano*, the *Parco Nazionale dell'Alta Murgia* and the *Parco Nazionale dell'Appennino Lucano Val d'Agri Lagonegrese* have been more recently established (i.e., during the 2000s). The control group is selected by matching the aforementioned municipalities with those in the NPs of interest, by means of the following covariates: the altitude above sea level (in meters), the distance from the coast (in km), the area of the municipality (in km^2), the number of local units at year 1981, the number of workers employed in local units at year 1981, the UAA (in hectares) at year 1982, the population density (inhabitants/km^2) at year 1981, the percentage of urbanized land at year 1990. Table 1 depicts the descriptive statistics of the selected covariates for the unmatched sample of municipalities.

We assess the impact of the NPs from the baseline year 1991 to the follow-up years 2001 and 2011, respectively, in terms of the following outcome variables: population density, number of local units, number of workers employed in these local units, number of local units in the tourism sector, number of workers employed by local units in the tourism sector, number of ingoing, outgoing, and within-municipality work commuters, number of agricultural holdings, UAA, percentage of forested land. Table 2 shows the descriptive statistics of the outcome variables observed at the three time points in the unmatched sample of municipalities.

The analysis of the possible spillover effects generated by the institution of the NPs targets the neighboring municipalities of those directly covered by the NPs under consideration. We identify the neighboring municipalities according to a queen contiguity approach (Anselin, 1988), including those sharing at least one common border with one of the municipalities covered by one NP. The original sample of municipalities has been cleaned out from the 205 municipalities previously considered as 'treated'. There are 206 neighboring municipalities with a total surface of 8,915.16 km^2 (i.e., 2.95 % of the country area) and a total population of 2,356,844 inhabitants (i.e., 4.15 % of the Italian population), considered at the baseline year 1991. Their characteristics in terms of the selected covariates (considering the unmatched sample) are depicted in Table 3.

4. Results

4.1. Covariates selection and matching

From the observable and available information, we choose covariates for the matching procedure based on their statistical significance in the logistic regression model used to estimate the Propensity Score. For further details, please refer to Section 1 of the supplementary materials. These covariates identify the treated municipalities in terms of time-invariant characteristics. However, they are also relevant for the specific characterization of the municipalities in NPs, e.g., the altitude above sea level and the distance from the coast. Also, they contribute to ruling out the pre-treatment differences between the treated and untreated municipalities in terms of some outcome variables, e.g., the number of local units, and the number of workers employed in local units (at year 1981); in relation to the number of agricultural holdings and the UAA (at year 1982); and with respect to the population density (at year 1981). Finally, the municipality area in square km and the percentage of urbanized land (at year 1990) help in ruling out the differences in terms of municipalities' dimension and size.

Tables A1-A3 in the appendix depict the balancing results of the best matching approach. In other words, the matching approach that produces the highest level of similarity between the treated and the untreated municipalities in terms of their characteristics (i.e., the covariates), which is the one adopted. For further details about the balancing results produced by the other matching approaches explored, please refer to Section 2 of the supplementary materials. Therefore, the Bayesian additive regression tree PSM approach is chosen for the extraction of the sub-sample on which to estimate the ATT because it produces the best balance. A detailed description of the balancing results is presented in the appendix while Table 5 depicts a summarized

[1] See https://www.parcoforestecasentinesi.it/sites/default/files/images/bozza_regolamento.pdf.

Table 1
Descriptive statistics of the covariates in the unmatched sample.

Variable	Baseline year 1991 Mean (Standard Deviation)			
	Municipalities in northern NPs (n = 39)	Municipalities in central NPs (n = 98)	Municipalities in southern NPs (n = 68)	Municipalities not in NPs (n = 7,423)
Altitude above sea level	520.231	695.888	466.427	340.893
(meters)	(249.303)	(295.580)	(269.152)	(288.498)
Municipality area	68.202	54.616	46.117	36.210
(km^2)	(48.289)	(57.450)	(33.732)	(49.062)
Distance from the coast	107.293	39.557	13.095	67.168
(meters)	(54.057)	(11.898)	(9.522)	(55.844)
Percentage of urbanized land	0.021	0.008	0.060	0.074
(at year 1990)	(0.022)	(0.011)	(0.108)	(0.116)
Nr. of local units	285.590	147.429	258.309	396.203
(at year 1981)	(436.303)	(305.507)	(427.977)	(2,116.187)
Nr. of workers employed in local units	1,016.256	520.367	727.309	1,739.779
(at year 1981)	(1,765.458)	(1,675.617)	(1,377.763)	(12,850.540)
Nr. of agricultural holdings	242.385	315.378	589.000	385.364
(at year 1982)	(287.930)	(422.234)	(435.004)	(564.497)
UAA	1,723.611	2,461.939	1,859.584	1,931.908
(in hectares, at year 1982)	(1,522.142)	(3,073.355)	(1,471.777)	(3,072.315)
Population density	57.862	49.873	380.983	268.294
(at year 1981)	(57.339)	(58.957)	(775.420)	(636.721)

Source: Istat data for altitude above sea level, municipality area and distance from the coast. CORINE Land Cover for Percentage of urbanized land. 6th (1981) General Censuses of Industry and Services for the nr. of local units and the nr. of workers employed in local units, 3rd (1982) General Censuses of Agriculture for the nr. of agricultural holdings and the UAA. 12th (1981) General Censuses of Population and Housing for population density. Local units are '*unità locali*' in Italian. According to the definition given by the Italian National Institute of Statistics (Istat) and by Eurostat they refer to "an enterprise or part thereof (e.g., a workshop, factory, warehouse, office, mine or depot) situated in a geographically identified place."

simplified version of the results.

The matching approach performs very well in balancing with respect to the covariates and ruling out the systematic differences between the treated and control municipalities. For the northern NPs, 6 out of 10 matching variables are perfectly balanced, while the others present a good level of balance. In relation to the central NPs, 5 matching variables are perfectly balanced, while 5 are well balanced. Finally, considering the southern NPs, 8 matching variables present perfect balance, 1 presents good balance, while the distance from the coast is slightly unbalanced. Fig. A1 in the appendix maps the treated and the control municipalities, distinguishing by groups of NPs (i.e., northern, central, and southern NPs).

We follow the same rationale for the analysis of the spillover effects. After having selected the covariates to be used for the matching (for further details, please refer to Section 1 of the supplementary materials), we investigated different matching approaches. For further details about the balancing results produced by the other matching approaches explored, please refer to Section 2 of the supplementary materials. The balancing results of the best matching strategy, the one selected (i.e., the Bayesian additive regression tree PSM approach) are depicted in Tables A4-A6 of the appendix. However, Table 5 depicts a summarized simplified version of the results shown in tables A4-A6. Considering the neighbor municipalities for the northern NPs, the matching strategy performs well, perfectly balancing 4 out of 10 matching variables, while the others present a good level of balance. With respect to the central NPs, 7 matching variables are perfectly balanced, 2 are well balanced, while 1 (altitude above sea level) is unbalanced. Regarding the southern NPs, 5 matching variables present perfect balance, while 5 are well balanced. Fig. A2 in the appendix maps the municipalities neighboring a NP (i.e., the treated municipalities) and their control, distinguishing by groups of NPs.

4.2. Impact estimation

Table 6 depicts the results of the ATT estimation, i.e., the impact of the NPs on the outcome variables under analysis.

From the environmental point of view, the establishment of a NP does impact, positively, the percentage of forested land in the municipalities being part of a NP. This happens both in the short and in the medium run, in all the three clusters of NPs (but for the central NPs in the short run, for which there is not statistical significance). Conversely, no significant impact is observed for UAA.

From the socioeconomic point of view, the establishment of a NP does not impact the population of the municipalities under treatment, while there is statistical evidence of a positive impact on the number of workers employed in local units of the tourism sector in the northern and central NPs, in the short run. Central NPs are also positively affected in terms of the number of workers employed in such local units in the medium run and in relation to the number of tourism sector establishments in the shorter one. In addition, there is statistical significance of a positive impact on the number of workers employed by local units (considered as a whole) in the northern NPs in the short run. Both the northern NPs and the central ones are positively impacted in terms of the number of ingoing work commuters in the short run, with the former set of NPs being positively impacted also in the medium run. No statistically significant effects are generated with respect to the number of local units (considering the other NPs). Finally, a negative impact of the NPs is found on the number of agricultural holdings, in the short run (central NPs) and in the medium run (southern NPs).

Table 7 depicts the estimation results of the NPs spillover effects, i.e., the potential impact generated by the institution of the NPs on the municipalities that are adjacent to those directly covered by the National Parks.

The most relevant effects are those generated by the environment-related outcome variable, with a positive impact on the percentage of forested land in the medium run, but only when considering NPs in central Italy and in the south and, also, in the short run in the case of the southern NPs. Conversely, there is no evidence of potential spillover effects generated by the northern NPs in this perspective. Also, the results show a positive impact on the number of ingoing work commuters in the short run, when considering the neighboring municipalities of the northern NPs. This is the solely statistically significant spillover effect from the socioeconomic perspective.

Table 2
Descriptive statistics of the outcome variables in the unmatched sample.

Variable	Municipalities in northern NPs (n = 39) Mean (Standard Deviation)			Municipalities in central NPs (n = 98) Mean (Standard Deviation)			Municipalities in southern NPs (n = 68) Mean (Standard Deviation)			Municipalities not in NPs (n = 7,423) Mean (Standard Deviation)		
	1991	2001	2011	1991	2001	2011	1991	2001	2011	1991	2001	2011
Population density	56.164	56.728	58.138	47.848	45.572	44.098	412.059	407.210	398.410	281.120	292.101	312.039
	(57.057)	(57.811)	(60.796)	(61.778)	(61.194)	(60.581)	(829.311)	(815.421)	(790.443)	(641.967)	(638.519)	(650.298)
Nr. of local units	281.513	270.487	322.231	154.571	156.347	201.837	290.000	334.588	415.897	421.050	482.427	618.884
	(426.615)	(420.678)	(565.995)	(358.795)	(437.984)	(680.735)	(452.480)	(581.173)	(738.993)	(2,203.069)	(2,971.325)	(4,284.808)
Nr. of workers employed in local units	1,061.769	1,180.872	1,259.897	530.765	523.102	594.612	747.985	789.779	950.941	1,785.720	1,884.601	2,131.865
	(1,765.016)	(1,940.341)	(2,211.793)	(1,773.463)	(1,858.299)	(2,282.565)	(1,285.332)	(1,468.269)	(1,833.244)	(12,251.87)	(12,835.26)	(16,150.990)
Nr. of tourism sector units	31.846	27.256	29.179	14.378	15.439	19.316	18.809	20.250	28.382	29.672	33.160	42.962
	(41.982)	(38.697)	(43.759)	(27.860)	(33.195)	(47.749)	(24.429)	(26.978)	(42.708)	(153.424)	(186.850)	(249.249)
Nr. of workers employed in tourism sector units	80.897	81.385	109.256	34.918	35.704	60.020	41.912	45.794	66.382	93.404	109.809	157.210
	(131.166)	(124.588)	(186.122)	(90.854)	(97.115)	(177.369)	(68.114)	(81.339)	(112.747)	(705.104)	(883.595)	(1,218.805)
Nr. of ingoing work commuters	1,187.231	1,383.308	1,489.949	663.786	698.806	729.367	1,241.176	1,121.529	1,259.574	3,278.011	3,288.723	3,642.136
	(2,455.489)	(2,640.758)	(2,859.729)	(2,849.527)	(2,858.054)	(2,957.807)	(2,060.748)	(2,001.918)	(2,246.208)	(22,053.860)	(19,723.270)	(20,553.921)
Nr. of outgoing work commuters	1,353.940	1,428.897	1,522.949	745.643	727.867	747.112	1,514.632	1,356.529	1,541.147	3,301.705	3,313.072	3,649.832
	(2,252.358)	(2,299.026)	(2,457.184)	(2,410.528)	(2,385.706)	(2,317.406)	(2,539.983)	(2,333.664)	(2,690.685)	(27,026.000)	(24,481.590)	(26,175.390)
Nr. of within-municipality work commuters	824.872	778.872	804.744	521.786	488.510	472.990	879.441	735.088	789.460	2,248.458	2,102.845	2,193.336
	(1,710.700)	(1,563.164)	(1,632.340)	(2,150.822)	(2,143.476)	(2,024.240)	(1,454.318)	(1,318.783)	(1,448.276)	(20,571.871)	(18,176.610)	(18,803.090)
Nr. of agricultural holdings	192.205	140.436	65.897	260.112	155.082	125.449	568.544	507.456	223.941	348.984	292.659	197.346
	(246.247)	(191.285)	(71.561)	(333.257)	(201.137)	(150.121)	(447.614)	(469.955)	(254.300)	(531.782)	(485.468)	(350.371)
UAA (in hectares)	1,538.068	1,338.762	1,255.910	2,224.746	1,817.482	1,820.920	1,793.653	1,519.410	1,202.441	1,835.524	1,616.310	1,574.561
	(1,472.821)	(1,789.576)	(1,664.513)	(2,775.085)	(2,123.582)	(2,176.468)	(1,538.043)	(1,438.156)	(1,349.271)	(2,952.305)	(2,590.982)	(2,686.009)
Percentage of forested land	0.819	0.821	0.824	0.669	0.670	0.679	0.574	0.577	0.586	0.360	0.362	0.355
	(0.156)	(0.156)	(0.156)	(0.210)	(0.210)	(0.215)	(0.244)	(0.244)	(0.246)	(0.328)	(0.329)	(0.327)

Source: 13th (1991), 14th (2001), and 15th (2011) General Censuses of Population and Housing for population density. 7th (1991), 8th (2001), and 9th (2011) General Censuses of Industry and Services for the nr. of local units, nr. of workers employed in local units, nr. of tourism sector units, nr. of workers employed in tourism sector units. 1991, 2001, and 2011 Origin-Destination (O-D) commuting matrices for the nr. of ingoing work commuters, nr. of outgoing work commuters, nr. of within-municipality work commuters. 4th (1990), 5th (2000) and 6th (2010) General Censuses of Agriculture for the nr. of agricultural holdings and the UAA. CORINE Land Cover for Percentage of forested land.

Table 3
Descriptive statistics of the covariates in the unmatched sample (neighboring municipalities).

Variable	Baseline year 1991 Mean (Standard Deviation)			
	Neighbor municipalities, northern NPs (n = 70)	Neighbor municipalities, central NPs (n = 89)	Neighbor municipalities, southern NPs (n = 47)	Not neighbor municipalities (n = 7,217)
Altitude above sea level (meters)	509.143 (308.111)	568.618 (258.518)	232.064 (248.092)	337.161 (287.205)
Municipality area (km^2)	49.097 (40.097)	43.022 (44.122)	35.094 (33.732)	36.008 (49.269)
Distance from the coast (meters)	110.105 (55.306)	39.359 (19.476)	7.967 (7.496)	67.480 (55.884)
Percentage of urbanized land (at year 1990)	0.032 (0.044)	0.019 (0.029)	0.190 (0.220)	0.075 (0.115)
Nr. of local units (at year 1981)	243.629 (342.248)	248.787 (538.690)	1,328.043 (6,165.212)	393.432 (2,086.378)
Nr. of workers employed in local units (at year 1981)	967.971 (1,636.769)	988.966 (2,688.748)	6,580.872 (3,2116.060)	1,724.996 (12,766.990)
Nr. of agricultural holdings (at year 1982)	193.729 (226.627)	378.966 (411.041)	759.787 (667.649)	384.863 (566.648)
UAA (in hectares, at year 1982)	1,342.033 (1,464.189)	2,194.740 (2,237.756)	1,906.900 (2,082.411)	1,934.551 (3,097.601)
Population density (at year 1981)	94.841 (138.297)	97.308 (128.639)	1,684.502 (3,672.115)	262.862 (562.937)

The spillover effects are assessed from the baseline year 1991 to the follow-up years 2001 and 2011 in terms of the same (aforementioned) outcome variables. Table 4 depicts the descriptive statistics of such variables of interest observed at the three time points with respect to the unmatched sample of municipalities.

5. Discussion

The evidence from the data at hand hints at the fact that the NPs achieve both environmental and socioeconomic impacts, albeit to a different degree. In line with most of the international literature on this topic (e.g. Oldekop et al., 2016; Zhang et al., 2020), there is a positive impact on forested land in the municipalities being part of a NP, if compared with control municipalities. However, our results confirm the existence of a specific time dynamic in the effects generated by NPs. The fact that in the medium run this positive impact is even larger than in the short run seems to suggest that time widens the gap between what has happened under the protective role of NPs and what would have happened without their implementation (Mingarro and Lobo, 2023). Unlike forested areas, no significant effect is observed for agricultural areas. While a more detailed analysis would be required to understand this non-statistically significant result, one explanation might lay in the recognition of the importance of preserving grassland and pastures for the conservation of biodiversity (Haller and Bender, 2018).

When turning to the socioeconomic impacts of the NPs, results are more nuanced. The establishment of a NP fosters the economic activities, and – unlike the case of the environmental impacts – this impact is more prominent in the short run rather than in the medium run. When considering the socioeconomic impacts, there are two main and contrasting effects. On the one hand, we detect a positive effect on the overall number of workers in local units, on those employed in the tourism sector and on the number of ingoing work commuters. On the other hand, the number of agricultural holdings in the municipalities included into a NP is negatively affected, in comparison with the municipalities in the control groups, although this effect does not couple with the previously mentioned effect on UAA.

These impacts imply a significant change, and a generalized tertiarization (Busch and Amarjargal, 2022) in the local economy of the municipalities affected by the introduction of a new NP, as already confirmed by previous studies on a different set of Italian NPs (D'Alberto et al., 2023). The increase in touristic flows after that is not new in the literature (for the US, see Fredman et al., 2007; Loomis, 1999; Weiler and Seidl, 2004). More in general, the positive effect on the number of workers in total local units (i.e., touristic, and non-touristic ones) might be the result of an economy-wide impact of NPs, involving other economic sectors existing in the area. Similarly, the number of ingoing work commuters is positively impacted by the establishment of a NP, not only in the short run, but also in the medium one (as it is in the case of the northern NPs). This hints at the increased socioeconomic dynamism of the area covered by the NP. These dynamics are particularly important given the mountain characteristics of the municipalities directly involved by the establishment of new NPs in the 1990s. As in the case of the improvement of multifunctionality for agricultural activities, it seems that introducing additional 'side' activities can act as 'glue' keeping local households and local people in the area covered by NPs, hence counterbalancing socioeconomic decline and depopulation processes (Cois and Barbieri, 2020, p. 81). Moreover, the limited statistical significance in relation to the number of local units (and those specifically operating in the tourism sector) as well as to the declining number of agricultural holdings could be due to the restrictions imposed on both land uses and building new infrastructures, when a new NP is established, as indicated by previous literature results (Mayer et al., 2010; Oldekop et al., 2016). Note that ambiguous results on farm performance has been found in, e.g., Switzerland (Ritzel et al., 2023). Hence, further attention to the dynamics of the agricultural sector should be paid, especially due to the ongoing difficulties of mountain agriculture over the decades (Arzeni and Sotte, 2012; Fanfani, 2008; Sardone, 2012). Indeed, these restrictions could prevent the growth in the number of establishments newly built in the municipalities being part of a NP.

The most innovative result of this analysis is that we find that NPs' socioeconomic impacts display a substantial heterogeneity across macro-geographical contexts of Italy. This result confirms the cross-countries results from a meta-analysis by Kandel et al. (2022) but, in contrast to them, we find that most of the positive results are in the wealthiest areas of the country. Southern NPs, located in the economically weakest regions of Italy – with higher unemployment rates, lower levels of GDP per capita and exports (Istat, 2021) – seem to show no statistically significant effects in these regards, especially in the short run. Conversely, those regions with higher levels of per-capita income, larger endowment of material infrastructures and greater capacity of solving collective action problems (see e.g. Putnam et al., 1994) seem to benefit the most from the establishment of a new NP, being capable to

Table 4
Descriptive statistics of the outcome variables in the unmatched sample (neighboring municipalities).

Variable	Neighbor municipalities, northern NPs (n = 70) Mean (Standard Deviation)			Neighbor municipalities, central NPs (n = 89) Mean (Standard Deviation)			Neighbor municipalities, southern NPs (n = 47) Mean (Standard Deviation)			Not neighbor municipalities (n = 7,217) Mean (Standard Deviation)		
	1991	2001	2011	1991	2001	2011	1991	2001	2011	1991	2001	2011
Population density	92.476	92.618	93.612	100.113	99.715	100.985	1,731.340	1,697.905	1,660.391	275.737	287.254	307.979
	(132.458)	(131.385)	(133.011)	(138.810)	(137.902)	(140.535)	(3,385.180)	(3,005.268)	(2,797.333)	(579.617)	(589.607)	(609.752)
Nr. of local units	237.657	238.286	276.714	268.371	291.326	385.551	1,405.277	1,702.809	2,320.021	418.302	479.204	614.002
	(360.767)	(389.691)	(481.918)	(580.175)	(694.817)	(983.772)	(6,142.238)	(7,450.441)	(10,262.940)	(2,176.991)	(2,951.081)	(4,263.515)
Nr. of workers employed in local units	931.186	981.657	1,029.886	1,094.461	1,118.989	1,246.326	6,175.362	6,002.702	7,331.021	1,773.945	1,875.981	2,119.615
		(1,669.973)		(2,894.626)	(2,964.899)	(3,439.818)	(29,557.490)	(28,150.360)	(34,153.310)	(12,188.52)	(12,811.55)	(16,139.830)
	(1,560.831)		(1,753.070)									
Nr. of tourism sector units	24.729	24.000	26.400	16.989	19.865	26.472	80.702	91.851	133.404	29.544	33.030	42.737
	(37.510)	(38.589)	(42.783)	(34.383)	(41.966)	(57.987)	(316.829)	(375.700)	(544.037)	(153.376)	(186.946)	(248.785)
Nr. of workers employed in tourism sector units	62.700	67.914	98.700	46.438	49.315	89.326	252.319	300.723	439.362	93.246	109.718	156.777
	(105.320)	(112.374)	(193.786)	(107.000)	(116.395)	(227.052)	(1,174.201)	(1,474.965)	(2,092.985)	(708.611)	(888.017)	(1,224.08)
Nr. of ingoing work commuters	1,038.375	1,087.586	1,167.243	1,490.056	1,444.944	1,575.146	9,256.702	8,353.661	9,271.702	3,234.449	3,256.619	3,559.505
	(1,929.997)	(2,035.605)	(2,226.495)	(4,311.880)	(4,142.931)	(4,551.357)	(45,520.110)	(39,847.270)	(42,824.060)	(26,391.200)	(24,007.740)	(25,766.54)
Nr. of outgoing work commuters	1,116.471	1,164.157	1,245.186	1,391.034	1,376.213	1,492.382	7,529.319	6,858.489	7,604.553	3,232.523	3,251.281	3,612.447
	(1,778.136)	(1,769.463)	(1,870.889)	(3,511.342)	(3,341.415)	(3,586.296)	(31,751.820)	(27,978.170)	(30,201.320)	(21,719.650)	(19,469.551)	(20,342.630)
Nr. of within-municipality work commuters	621.971	585.543	583.200	1,002.056	911.449	924.764	5,567.574	4,802.660	5,115.447	2,202.996	2,065.634	2,161.350
		(1,136.980)		(2,944.690)	(2,652.628)	(2,728.732)	(27,940.900)	(23,977.393)	(25,313.600)	(20,269.200)	(17,962.051)	(18,634.690)
	(1,214.171)		(1,137.717)									
Nr. of agricultural holdings	159.900	107.014	67.957	345.326	273.978	214.753	666.702	559.830	327.192	348.794	292.950	197.540
	(190.652)	(127.685)	(83.012)	(400.502)	(394.174)	(308.556)	(543.635)	(473.480)	(364.483)	(534.484)	(487.979)	(352.015)
UAA	1,240.289	1,074.167	903.839	2,052.188	1,799.080	1,807.252	1,700.056	1,395.901	1,431.659	1,839.507	1,620.750	1,579.128
(in hectares)	(1,473.857)	(1,212.471)	(1,030.456)	(2,198.011)	(2,016.704)	(1,873.623)	(1,971.06)	(1,747.188)	(2,268.250)	(2,975.957)	(2,611.153)	(2,707.335)
Percentage of forested land	0.763	0.764	0.765	0.421	0.421	0.419	0.204	0.205	0.212	0.357	0.358	0.351
	(0.185)	(0.183)	(0.183)	(0.285)	(0.285)	(0.282)	(0.246)	(0.247)	(0.256)	(0.328)	(0.328)	(0.325)

Table 5
Simplified and summarized balancing results of Tables A1-A3 and A4-A6.

Variable	Northern NPs	CentralNPs	Southern NPs	Neighbor, northern NPs	Neighbor, central NPs	Neighbor, southern NPs
Score	+++	+++	+++	+++	+++	+
Altitude above sea level (meters)	+	+++	+++	+	—	+++
Municipality area (km^2)	+++	+	+++	+++	+++	+++
Distance from the coast (meters)	+++	+	—	+	+	+++
Percentage of urbanized land (at year 1990)	+	+++	+++	+	+++	+
Nr. of local units (at year 1981)	+	+	+++	+	+++	+
Nr. of workers employed in local units (at year 1981)	+	+	+	+++	+++	+
Nr. of agricultural holdings (at year 1982)	+++	+++	+++	+	+++	+++
UAA (in hectares, at year 1982)	+++	+	+++	+++	+++	+
Population density (at year 1981)	+++	+++	+++	+	+	+++

'+++': Standardized Mean Difference (SMD) $<$ 0.1; '+': SMD between 0.1 and 0.2; '—': SMD $>$ 0.2.

Table 6
Estimation of the Average Treatment Effect on the Treated (ATT).

Outcome variable	1991–2001			1991–2011		
	Northern NPs	Central NPs	Southern NPs	Northern NPs	Central NPs	Southern NPs
Population density	0.312	−1.117	−23.552	0.372	−1.852	−50.416
	(0.783)	(0.763)	(16.181)	(1.611)	(1.396)	(25.982)
	[−1.249, 1.872]	[−2.683, 0.450]	[−58.109, 11.004]	[−2.971, 3.715]	[−4.748, 1.044]	[−108.636, 7.803]
Nr. of local units	−1.795	9.786	8.309	24.667	34.276	−49.412
	(6.424)	(7.656)	(27.061)	(21.543)	(28.871)	(65.538)
	[−14.713, 11.123]	[−8.032, 27.603]	[−46.925, 63.543]	[−23.134, 72.468]	[−33.223, 101.774]	[−180.884, 82.060]
Nr. of workers employed in local units	**104.718***	9.041	7.765	132.487	38.541	−123.103
	(42.931)	(16.697)	(45.808)	(93.349)	(48.260)	(130.918)
	[25.350, 224.786]	[−25.447, 43.529]	[−86.381, 101.910]	[−58.403, 323.378]	[−79.706, 156.787]	[−382.158, 135.952]
Nr. of tourism sectorunits	0.667	**1.286***	−2.191	−4.692	3.173	−3.279
	(6.148)	**(0.477)**	(1.630)	(2.885)	(1.958)	(4.331)
	[−12.402, 13.735]	**[0.430, 3.001]**	[−5.567, 1.185]	[−10.726, 1.342]	[−1.178, 7.525]	[−12.233, 5.674]
Nr. of workers employedin tourism sector units	**4.077***	**3.082****	−1.044	−8.462	**14.459***	−16.426
	(2.052)	**(1.219)**	(5.055)	(17.782)	**(5.663)**	(14.012)
	[1.445, 9.865]	**[0.461, 6.624]**	[−12.041, 9.953]	[−48.713, 31.790]	**[4.628, 33.546]**	[−46.351, 13.498]
Nr. of ingoing work commuters	**219.051*****	**60.735*****	−70.412	**325.897*****	47.490	−202.177
	(66.853)	**(20.663)**	(64.253)	**(106.293)**	(34.299)	(106.804)
	[79.285, 358.819]	**[15.859, 105.610]**	[−209.712, 68.888]	**[105.970, 545.825]**	[−28.347, 123.327]	[−421.063, 16.710]
Nr. of outgoing work commuters	32.872	−10.398	−101.221	56.462	−47.643	−209.338
	(35.354)	(14.286)	(75.3332)	(56.817)	(32.559)	(101.116)
	[−42.104, 107.847]	[−42.196, 21.400]	[−269.766, 67.325]	[−64.420, 177.343]	[−121.462, 26.177]	[−427.548, 8.872]
Nr. of within-municipality work commuters	−51.897	−2.939	15.647	−28.923	−32.500	−9.059
	(35.632)	(11.847)	(56.196)	(37.849)	(27.957)	(54.940)
	[−127.707, 23.912]	[−27.871, 21.994]	[−102.798, 134.093]	[−109.595, 51.749]	[−98.629, 33.629]	[−122.013, 103.895]
Nr. of agricultural holdings	2.333	**−45.194****	7.765	−38.205	6.306	**−106.456****
	(13.573)	**(18.441)**	(23.672)	(33.532)	(27.666)	**(48.942)**
	[−26.145, 30.812]	**[−84.216, −6.171]**	[−41.077, 56.607]	[−106.483, 30.073]	[−56.207, 68.819]	**[−202.227, −10.684]**
UAA (in hectares)	81.038	−146.845	96.028	134.418	76.536	−258.517
	(200.248)	(101.285)	(123.473)	(223.156)	(133.943)	(152.260)
	[−356.304, 518.380]	[−352.219, 58.530]	[−147.531, 339.587]	[−346.343, 615.179]	[−194.542, 347.614]	[−580.930, 63.896]
Percentage of forested land	**0.002***	0.001	**0.002*****	**0.010*****	**0.015*****	**0.020*****
	(0.000)	(0.001)	**(0.000)**	**(0.002)**	**(0.006)**	**(0.006)**
	[0.000, 0.004]	[−0.002, 0.011]	**[0.000, 0.004]**	**[0.004, 0.0015]**	**[0.004, 0.027]**	**[0.008, 0.032]**

Standard errors in parenthesis. 95 % confidence intervals in brackets. Significance levels: '*': 0.1; '**': 0.05; '***': 0.01.

Table 7
Estimation of the spillover effects.

Outcome variable	1991–2001			1991–2011		
	Neighbor municipalities, northern NPs	Neighbor municipalities, central NPs	Neighbor municipalities, southern NPs	Neighbor municipalities, northern NPs	Neighbor municipalities, central NPs	Neighbor municipalities, southern NPs
Population density	1.183 (2.011) [−3.347, 5.712]	1.865 (1.463) [−1.174, 4.904]	−71.954 (85.713) [−260.939, 117.031]	−2.795 (2.934) [−9.074, 3.485]	3.108 (3.061) [−3.941, 10.156]	−63.729 (135.040) [−337.945, 210.486]
Nr. of local units	−16.657 (11.121) [−43.221, 9.906]	4.348 (16.848) [−31.967, 40.664]	199.702 (155.490) [−184.694, 584.099]	−17.243 (25.304) [−77.303, 42.817]	32.438 (52.880) [−84.562, 149.438]	579.149 (482.582) [−628.644, 1,786.942]
Nr. of workers employed in local units	70.671 (41.394) [−12.069, 153.412]	22.213 (32.175) [−43.194, 87.621]	−282.872 (213.226) [−742.936, 177.191]	90.186 (52.371) [−13.656, 194.027]	78.281 (73.698) [−77.012, 233.574]	475.745 (584.472) [−893.388, 1,844.877]
Nr. of tourism sector units	−1.129 (0.987) [−3.187, 0.930]	1.584 (1.103) [−0.712, 3.880]	4.830 (6.952) [−12.156, 21.816]	−2.357 (2.072) [−6.830, 2.116]	2.730 (3.150) [−4.009, 9.470]	27.979 (26.549) [−35.726, 91.683]
Nr. of workers employed in tourism sector units	−1.629 (4.921) [−12.929, 9.672]	0.854 (2.972) [−5.567, 7.275]	27.617 (35.440) [−57.852, 113.086]	10.886 (13.112) [−21.576, 43.347]	15.663 (15.131) [−17.234, 48.559]	88.872 (109.288) [−177.986, 355.730]
Nr. of ingoing work commuters	**75.986*** **(32.708)** **[4.398, 156.369]**	15.596 (30.354) [−46.716, 77.907]	−857.553 (669.929) [−2,483.513, 768.407]	52.286 (60.143) [−69.724, 174.295]	51.124 (50.342) [−57.694, 159.942]	1,134.745 (1,440.213) [−2,399.539, 4,669.029]
Nr. of outgoing work commuters	89.586 (50.438) [−28.225, 207.396]	17.618 (34.029) [−59.682, 94.918]	−527.106 (450.570) [−1,611.612, 557.399]	76.429 (56.026) [−45.757, 198.614]	35.584 (58.974) [−90.849, 162.018]	673.809 (936.597) [−1,623.824, 2,971.441]
Nr. of within-municipality work commuters	4.829 (23.817) [−45.997, 55.654]	−14.449 (37.757) [−95.508, 66.609]	−440.787 (459.383) [−1,579.095, 697.521]	−2.700 (31.082) [−69.736, 64.336]	−15.865 (51.332) [−125.629, 93.899]	596.447 (860.101) [−1,650.524, 2,843.418]
Nr. of agricultural holdings	−0.829 (12.826) [−27.519, 25.862]	−15.427 (14.788) [−45.270, 14.416]	−25.340 (31.581) [−87.736, 37.055]	−14.129 (16.765) [−48.503, 20.245]	51.933 (31.367) [−14.873, 118.738]	−67.149 (67.564) [−205.557, 71.259]
UAA (in hectares)	−59.002 (112.248) [−290.480, 172.475]	−31.343 (83.854) [−211.946, 149.260]	−94.536 (77.689) [−250.195, 61.123]	−67.815 (135.781) [−353.328, 217.697]	107.004 (105.212) [−106.857, 320.866]	−63.729 (135.040) [−337.945, 210.486]
Percentage of forested land	0.000 (0.001) [−0.002, 0.002]	0.001 (0.001) [−0.003, 0.000]	**0.002***** **(0.000)** **[0.000, 0.004]**	0.001 (0.005) [−0.011, 0.008]	**0.014**** **(0.002)** **[0.001, 0.028]**	**0.017***** **(0.006)** **[0.005, 0.030]**

Standard errors in parenthesis. 95 % confidence intervals in brackets. Significance levels: '*': 0.1; '**': 0.05; '***': 0.01.

capitalize on it, as an additional source of economic activity. In this regard, differences across Italy are wide. To have a glimpse of the Italian North-South divide, note for example that in 2021 the *Lombardia* region (North) had a purchasing power standard per inhabitant of 41,400, while *Calabria* (South) of 18,100. Similarly, the unemployment rate in 2022 in *Lombardia* was 4.9 % while 14.6 % in *Calabria*.[2] In particular, these ongoing territorial divides largely matter and, for lagging behind regions, not even the decision of establishing a new NP will deliver the promised results, breaking the vicious cycle of underdevelopment there (OECD, 2006).

However, besides structural differences, looking at the general patterns of tourism in Italy might offer some further explanations. The country is the tenth most competitive destination in the world (WEF, 2022), given the vast set of natural, cultural, and gastronomic resources (Costantino et al., 2021). In 2022, seaside destinations were the most popular ones for national tourists (52.5 % of total vacations), followed by those in mountain areas (24.5 % of the total) and in the countryside (14.1 %) (Istat, 2023). However, not all Italian regions are equally able to exploit tourism as growth potential factors (Costantino et al., 2021). In 2022, the three most visited regions in Italy were all central and northern regions (i.e., Veneto, Lombardy, and Tuscany), which accounted for 38.7 % of the total number of arrivals (this share increases at 46.1 % if one considers international tourists only). On the contrary, the whole group of the Italian southern regions, including Sicily and Sardinia too, only account for 18.4 % of the total arrivals (according to Istat data, available at: dati.istat.it). Southern regions of Italy face many challenges stemming from inadequate essential infrastructure (e.g., airports, ports, and high-speed rail). Additional issues hinder their capacity to attract tourists, such as: insufficient maintenance of the territory, hydro-geological instability, perceived high crime rates, low-quality of public services at local level, and insufficient digital infrastructure collectively (CDP, 2016). Moreover, one additional issue pertains to the specific characteristics of the nexus between NPs and touristic flows. Indeed, tourists mostly perceive Italian southern regions as seaside destinations rather than as naturalistic ones (Istat, 2023). Therefore, the effectiveness of establishing a NP in those regions may be compromised without adequate support from a suitable communication strategy. In Italy, where regional governments are responsible for promoting tourism, it is evident that promoting NPs to a broad national and international audience, poses significant challenges in the South, whereas it is much easier for those regions being located across the Alps (D'Arco et al., 2021; Montaguti and Mingotto, 2015; Saviano et al., 2018). While specific and structural data on protected areas are not available, anectodical evidence suggests that these North-South

[2] Eurostat data, available at https://ec.europa.eu/eurostat/databrowser/bookmark/35db0702-bb09-4302-8c2b-0e8f81bd8c6a?lang=en (GDP per capita), and at https://ec.europa.eu/eurostat/databrowser/bookmark/8165189b-9733-4557-88fd-0620b59321fe?lang=en (unemployment rate). Accessed on 10/02/2024.

differences apply to touristic flows to NPs too (Montaguti and Mingotto, 2015). Probably the number of tourists visiting southern Italy, and choosing a NP as their destination, is so small that it does not reach the critical mass that is necessary for the development of a touristic sector in the NPs and for guaranteeing its profitability.

Moreover, the scrutiny of the role of geographical spillovers also represents one of the novelties of this work. In fact, this has not highlighted any significant socioeconomic leakages to the surrounding municipalities. This finding seems suggesting that the establishment of a new NP is not expected to have neither positive nor negative economic effects beyond its own boundaries. In particular, the local economy of the neighboring municipalities seems not changing after the establishment of a new NP in the surroundings. On the opposite, NPs environmental effects move beyond their borders, with positive impacts on the forested areas in the NPs neighboring municipalities. The topic has been only recently investigated (Pfaff and Robalino, 2017) and no clear findings emerge from the literature. For example, Mingarro and Lobo (2023) share our results, while e.g. Robalino et al. (2017) find that spillovers might be negative.

According to the main findings of this work, no real trade-off between environmental and socioeconomic impacts is observed after the establishment of a new NP. Rather, a sort of win–win outcome seems to be achieved in the municipalities affected by it, albeit different impacts show very different extents. Surely, after their introduction, the NPs display their different impacts over different time span, and they eventually produce a dramatic change in the local economy structure and characteristics, hence creating winners and losers among the local economic agents. Therefore, despite such an expected win–win outcome, for new NPs in the future, it is important to involve local communities in a participatory approach, also well before their establishment. It is essential that citizens are explained the main expected impacts of the introduction of a new NP.

Among other, here are some of the most relevant take-home messages for local communities and local stakeholders:

- *Rome was not built in a day. Neither was a forest*! Impact on forested areas are greater in the medium run, so, be patient. And have an appropriate discount rate for the environmental benefits.
- *A small village will remain a small village*! Your birthplace will not be invaded by new residents from the outside, so do not expect (too much of) new apartments or new buildings to be built, because of the NP. However, expect a larger number of ingoing work commuters, driving there every morning.
- *Be ready to change your business*! The fact that more and more tourists will come and visit the NP will be good for the local economy, provided the original business model is changed. New job opportunities are expected to originate in the service and in the tourist sector, despite a drop in the number of agricultural holdings. Such a tertiarization of the local economy – despite its positive effects – might eventually widen inequalities divides, with some economic agents benefitting from the NPs, while others being harmed.
- *You (*i.e.*, the socioeconomic impacts of NPs) shall not pass*! When a new NP is established, no socioeconomic impacts are likely to leak beyond its boundaries. This seems suggesting that the local economy of the neighboring municipalities is not expected to significantly change, as in the case of the municipalities directly covered by a NP.
- *Breaking news! A new NP has born*! It is important that local stakeholders communicate properly the establishment of a new NP, especially in those regions where tourists are not particularly used to nature-based destinations. Only by properly promoting it, the economic benefits of the establishment of a new NP can be obtained.

The abovementioned messages are somehow generalized impacts that emerge from the analysis of the NPs established in the 1990s.

6. Conclusions

In the last decades there has been a great increase in the number and size of Protected Areas worldwide. An increasing literature has focused on the assessment of the socioeconomic impact of PAs, mostly finding no major trade-offs between conservation goals and support to the local economy. In this article we analyze the environmental and socioeconomic impacts of three National Parks clusters in Italy, including a total of 205 municipalities, using a counterfactual approach based on the combination of the Propensity Score Matching method and the Doubly Robust Difference-in-Differences estimator very recently proposed in the literature.

The results indicate that there are no major trade-offs between the protection of forested areas and the socioeconomic impacts of NPs. The impact on the share of forested areas is positive while the one on the UAA is non-significant. From the socioeconomic perspective, the results, when significant, generally indicate a positive impact, albeit with a restructuring of the local economy, from agriculture toward the touristic sector, which suggests the existence of possible winners and losers after the establishment of a NP. However, time and the macro-geographical context matter and interact with each other. The environmental impact increases with time and moving South. On the contrary, the results suggest that only the NPs in northern and central Italy (i.e., the wealthier and more attractive regions for touristic flows) can take advantage of the opportunities offered by the establishment of NPs, displaying positive impacts on the local employment (overall, and in touristic establishments) and on the incoming work commuters. Moreover, incoming commuters increase with time in the northern NPs, while the impact on the other variables dissipate. Finally, we find that the socioeconomic effects of NPs are spatially limited to the municipalities hosting them.

About the limitations that characterize this study, first, it should be noticed that the estimated socioeconomic impacts of the establishment of new NPs are grounded on the use of proxies only. This choice comes from the availability of the data necessary for having comparable results across Italy and across different NPs. For example, data at the municipality level on income is available only since the early 2000s (D'Alberto et al., 2023), and hence is not possible to estimate the impact at the baseline years for the NPs established in the 1990s. Similarly, with the currently available data we are not able to further dig into the mechanisms behind the positive impacts and tertiarization of the local economy. Further studies should then deepen the touristic flows and their impact at the micro-level, below the municipality one in selected case studies. This alternative empirical strategy might be much more useful in order to disentangle specific economic mechanisms, lying behind the establishment of a new NP. Micro-level data would also allow to estimate the distributional effects that NPs, through the tertiarization of the economy, might cause.

The environmental dimension is even more difficult to estimate, especially when going back to past decades. For this reason, only forested land and UAA have been considered, disregarding other and more detailed indicators that might only be available in limited case studies (see e.g. Agnoletti, 2007). A proper evaluation of the environmental effects of the NPs would certainly require more granular and spatially explicit data, below the municipality level, that would allow to detect the land use mosaic that is crucial for the conservation of biodiversity (Haller and Bender, 2018; Vacchiano et al., 2017).

Further studies might tackle these limitations. For example, by introducing additional and more refined biodiversity indicators, eventually covering a shorter time span. Additionally, some studies based on case studies can be developed as well. Accordingly, it would be possible to integrate both quantitative and qualitative analyses over a single NP. This alternative empirical strategy might be useful not only to disentangle specific economic mechanisms, lying behind the establishment of a new NP, but also to better appreciate the different effects perceived by different types of economic agents within each NP. Also, our results call for future analyses based on firm level data that would allow to further disentangle the mechanisms through which PAs impact the territories from the socioeconomic point of view. For example, to what extent residents modify their occupation, the touristic activities (e.g., number of overnight stays) expand, or farming activities increase added values.

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CRediT authorship contribution statement

Riccardo D'Alberto: Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Formal analysis, Conceptualization. **Matteo Zavalloni:** Writing – review & editing, Writing – original draft, Resources, Data curation, Conceptualization. **Francesco Pagliacci:** Writing – review & editing, Writing – original draft, Visualization, Resources, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix

The balancing of the covariates is depicted in terms of several statistics, namely: the covariates' mean, the Standardized Mean Difference (SMD), the variance ratio, the mean and maximum of the empirical cumulative density function (eCDF), both for the municipalities in NPs and those not in NPs. The same statistics, in addition to the percent balance improvement in SMD, variance ratio, mean eCDF, and maximum eCDF are depicted for the municipalities being matched.

The SMD is the difference in the means of each covariate between the groups, standardized by the standard deviation of the covariate in the treated group. Standardization prevents the mean difference from being confounded by changes in the standard deviation of the covariate, hence achieving the same scale for all the covariates. The variance ratio represents the ratio of the variance of a covariate in one group to that in the other (Austin, 2009; Ho et al., 2020), while the eCDF considers the whole covariate distribution (rather than just the mean or variance), offering supplementary insights about the overall imbalance (note that the maximum eCDF is also known as the Kolmogorov-Smirnov statistics) (Diamond and Sekhon, 2013).

Since there is high correlation between the mean or maximum absolute SMD and the level of bias in the ATT, SMDs close to zero are assumed to indicate optimal balance between the groups (Austin, 2009; Stuart et al., 2013). For assessing the optimality of balance, we consider the rule of thumb suggesting that SMD values < 0.1 indicate perfect balance, values between 0.1 and 0.2 indicate good balance, while SMD > 0.2 hints at concerns about covariates imbalance (see, for example, Stuart et al., 2014 and the references therein).

Table A1
Balancing results of the Bayesian additive regression tree PSM approach – Northern NPs.

Matching variable	Mean		Standardized Mean Difference	Variance Ratio eCDF Mean eCDF Max	Mean	Standardized Mean Difference [% Balance Improvement in Std. Mean Diff.]	Variance Ratio eCDF Mean eCDF Max	% Balance Improvement in Variance Ratioe CDF Meane CDF Max
	Treated (n = 39)	Unmatched controls (n = 7,423)			Matched controls (n = 39)			
Score	−1.644	−3.560	5.565	0.163 0.480 0.898	−1.647	0.003 [99.9]	1.012 0.000 0.051	99.3 100.0 94.3
Altitude above sea level (meters)	520.231	340.893	0.719	0.747 0.159 0.416	495.231	0.100 [86.1]	0.991 0.031 0.128	96.9 80.7 69.2
Municipality area (km^2)	68.202	36.210	0.663	0.969 0.262 0.435	66.672	0.032 [95.2]	1.011 0.019 0.077	66.6 92.6 82.3
Distance from the coast (meters)	107.293	67.168	0.742	0.937 0.223 0.457	105.469	0.034 [95.5]	0.905 0.023 0.103	−54.1 89.8 77.5
Percentage of urbanized land (at year 1990)	0.021	0.075	−2.383	0.037 0.188 0.304	0.016	0.154 [93.6]	0.952 0.041 0.205	98.5 77.9 32.6
Nr. of local units (at year 1981)	285.590	396.203	−0.254	0.043 0.018 0.064	232.744	0.121 [52.2]	1.684 0.040 0.180	83.5 −122.3 −178.7
Nr. of workers employed in local units (at year 1981)	1,016.256	1,739.779	−0.410	0.019 0.021 0.078	762.795	0.145 [65.0]	1.591 0.063 0.205	88.3 −196.5 −162.4

(continued on next page)

Table A1 (*continued*)

Matching variable	Mean		Standardized Mean Difference	Variance Ratio eCDF Mean eCDF Max	Mean	Standardized Mean Difference [% Balance Improvement in Std. Mean Diff.]	Variance Ratio eCDF Mean eCDF Max	% Balance Improvement in Variance Ratioe CDF Meane CDF Max
	Treated (n = 39)	Unmatched controls (n = 7,423)			Matched controls (n = 39)			
Nr. of agricultural holdings (at year 1982)	242.385	385.364	−0.497	0.260	248.513	−0.021	1.170	88.3
				0.069		[95.7]	0.019	72.7
				0.241			0.128	46.8
UAA (in hectares, at year 1982)	1,723.611	1,931.908	−0.137	0.246	1,729.920	−0.004	0.899	92.5
				0.046		[97.0]	0.037	18.2
				0.127			0.154	–20.9
Population density (at year 1981)	57.862	268.294	−3.670	0.008	54.302	0.062	0.887	97.5
				0.271		[98.3]	0.032	88.2
				0.460			0.128	72.1

Table A2
Balancing results of the Bayesian additive regression tree PSM approach – Central NPs.

Matching variable	Mean		Standardized Mean Difference	Variance Ratio eCDF Mean eCDF Max	Mean	Standardized Mean Difference [% Balance Improvement in Std. Mean Diff.]	Variance Ratio eCDF Mean eCDF Max	% Balance Improvement in Variance Ratio eCDF Mean eCDF Max
	Treated (n = 98)	Unmatched controls (n = 7,423)			Matched controls (n = 98)			
Score	−1.283	−3.723	4.589	0.171	−1.311	0.052	1.163	91.5
				0.461		[98.9]	0.000	99.9
				0.831			0.061	92.6
Altitude above sea level (meters)	695.887	340.893	1.201	1.050	711.255	−0.052	1.083	−64.8
				0.291		[95.7]	0.023	92.0
				0.540			0.112	79.2
Municipality area (km^2)	54.616	36.210	0.320	1.371	44.089	0.183	3.859	−327.8
				0.204		[42.8]	0.039	80.9
				0.333			0.112	66.3
Distance from the coast (meters)	39.557	67.168	−2.321	0.045	40.849	−0.109	1.083	97.4
				0.207		[95.3]	0.013	94.0
				0.421			0.143	66.0
Percentage of urbanized land (at year 1990)	0.008	0.075	−5.860	0.009	0.007	0.040	0.972	99.4
				0.326		[99.3]	0.015	95.3
				0.522			0.092	82.4
Nr. of local units (at year 1981)	147.429	396.203	−0.814	0.021	102.837	0.146	5.655	55.2
				0.094		[82.1]	0.022	76.1
				0.292			0.092	68.6
Nr. of workers employed in local units (at year 1981)	520.367	1,739.779	−0.728	0.017	261.133	0.155	20.279	26.1
				0.140		[78.7]	0.033	76.7
				0.309			0.092	70.3
Nr. of agricultural holdings (at year 1982)	315.378	385.364	−0.166	0.560	328.194	−0.030	0.884	78.8
				0.044		[81.7]	0.016	64.7
				0.122			0.082	33.1
UAA (in hectares, at year 1982)	2,461.939	1,931.908	0.173	1.001	2,065.839	0.129	4.254	22.3
				0.138		[25.3]	0.022	84.0
				0.251			0.071	71.6
Population density (at year 1981)	49.873	268.294	−3.705	0.009	50.229	−0.006	1.203	96.1
				0.308		[99.8]	0.031	89.8
				0.511			0.153	70.1

Table A3
Balancing results of the Bayesian additive regression tree PSM approach – Southern NPs.

Matching variable	Mean		Standardized Mean Difference	Variance Ratio eCDF Mean eCDF Max	Mean	Standardized Mean Difference [% Balance Improvement in Std. Mean Diff.]	Variance Ratio eCDF Mean eCDF Max	% Balance Improvement in Variance Ratio eCDF Mean eCDF Max
	Treated (n = 68)	Unmatched controls (n = 7,423)			Matched control (n = 68)			
Score	−1.578	−3.723	4.842	0.150	−1.579	0.003	1.010	99.5
				0.460		[99.9]	0.000	100.0
				0.825			0.029	96.4

(*continued on next page*)

Table A3 (*continued*)

Matching variable	Mean: Treated (n = 68)	Mean: Unmatched controls (n = 7,423)	Standardized Mean Difference	Variance Ratio / eCDF Mean / eCDF Max	Mean: Matched control (n = 68)	Standardized Mean Difference [% Balance Improvement in Std. Mean Diff.]	Variance Ratio / eCDF Mean / eCDF Max	% Balance Improvement in Variance Ratio / eCDF Mean / eCDF Max
Altitude above sea level (meters)	466.427	340.893	0.466	0.870	454.324	0.045	0.953	65.6
				0.121		[90.4]	0.022	81.7
				0.265			0.074	72.2
Municipality area (km^2)	46.117	36.210	0.294	0.473	43.619	0.074	1.304	64.6
				0.168		[74.8]	0.021	87.4
				0.343			0.088	74.3
Distance from the coast (meters)	13.095	67.168	−5.679	0.029	15.020	−0.202	0.773	92.7
				0.329		[96.4]	0.018	94.6
				0.614			0.147	76.1
Percentage of urbanized land (at year 1990)	0.060	0.075	−0.132	0.863	0.068	−0.067	0.760	−86.2
				0.133		[49.2]	0.034	74.5
				0.294			0.103	65.0
Nr. of local units (at year 1981)	258.309	396.203	−0.322	0.041	290.206	−0.075	0.811	93.5
				0.029		[76.9]	0.021	28.5
				0.133			0.132	0.60
Nr. of workers employed in local units (at year 1981)	727.309	1,739.779	−0.735	0.012	960.809	−0.170	0.456	82.4
				0.075		[76.9]	0.021	71.8
				0.194			0.088	54.5
Nr. of agricultural holdings (at year 1982)	589.000	385.364	0.468	0.594	546.750	0.097	1.276	53.2
				0.149		[79.3]	0.022	85.0
				0.373			0.118	68.5
UAA (in hectares, at year 1982)	1,859.584	1,931.908	0.173	1.001	1,805.483	0.037	1.347	79.8
				0.138		[25.2]	0.028	70.0
				0.251			0.103	50.8
Population density (at year 1981)	380.983	268.294	0.145	1.483	382.674	−0.002	1.011	97.2
				0.127		[98.5]	0.037	70.6
				0.288			0.147	48.9

Table A4
Balancing results of the Bayesian additive regression tree PSM approach – Neighbor municipalities, northern NPs.

Matching variable	Mean: Treated (n = 70)	Mean: Unmatched controls (n = 7,217)	Standardized Mean Difference	Variance Ratio / eCDF Mean / eCDF Max	Mean: Matched controls (n = 70)	Standardized Mean Difference [% Balance Improvement in Std. Mean Diff.]	Variance Ratio / eCDF Mean / eCDF Max	% Balance Improvement in Variance Ratio / eCDF Mean / eCDF Max
Score	−1.525	−3.223	3.799	0.286	−1.538	0.028	1.130	90.2
				0.461		[99.2]	0.000	100.0
				0.850			0.057	93.3
Altitude above sea level (meters)	509.143	337.161	0.558	1.151	546.057	−0.120	0.775	−81.1
				0.148		[78.5]	0.035	76.5
				0.301			0.114	62.0
Municipality area (km^2)	49.097	36.008	0.326	0.662	49.594	−0.012	1.173	61.2
				0.153		[96.2]	0.023	85.1
				0.286			0.057	80.0
Distance from the coast (meters)	110.105	67.480	0.771	0.979	120.092	−0.181	1.056	−162.8
				0.234		[76.6]	0.046	80.2
				0.414			0.157	62.0
Percentage of urbanized land (at year 1990)	0.032	0.075	−0.985	0.145	0.027	0.112	1.108	94.7
				0.141		[88.6]	0.048	66.0
				0.262			0.229	12.7
Nr. of local units (at year 1981)	243.629	393.432	−0.438	0.027	178.500	0.190	0.832	94.9
				0.035		[56.6]	0.054	−53.9
				0.097			0.214	−121.1
Nr. of workers employed in local units (at year 1981)	967.971	1,724.996	−0.463	0.016	822.800	0.089	0.494	82.9
				0.032		[80.8]	0.071	−124.1
				0.082			0.214	−160.1
Nr. of agricultural holdings (at year 1982)	193.729	384.863	−0.843	0.160	165.029	0.127	2.351	53.4
				0.100		[85.0]	0.024	76.1
				0.298			0.114	61.7
UAA (in hectares, at year 1982)	1,342.033	1,934.551	−0.405	0.223	1,458.970	−0.080	0.781	83.5
				0.069		[80.3]	0.035	49.7
				0.170			0.129	24.3
Population density (at year 1981)	94.841	262.862	−1.215	0.060	80.619	0.103	0.657	85.0
				0.200		[91.5]	0.059	70.9
				0.334			0.200	40.0

Table A5
Balancing results of the Bayesian additive regression tree PSM approach – Neighbor municipalities, central NPs.

Matching variable	Mean: Treated (n = 89)	Mean: Unmatched controls (n = 7,217)	Standardized Mean Difference	Variance Ratio eCDF Mean eCDF Max	Mean: Matched controls (n = 89)	Standardized Mean Difference [% Balance Improvement in Std. Mean Diff.]	Variance Ratio eCDF Mean eCDF Max	% Balance Improvement in Variance Ratio eCDF MeaneCDF Max
Score	−1.727	−3.040	4.426	0.104	−1.728	0.004	1.016	99.3
				0.414		[99.9]	0.000	100.09
				0.692			0.022	96.8
Altitude above sea level (meters)	568.618	337.161	0.895	0.810	638.022	−0.268	1.456	−78.4
				0.205		[70.0]	0.066	67.7
				0.409			0.191	53.3
Municipality area (km^2)	43.022	36.008	0.159	0.802	41.493	0.035	0.790	−7.0
				0.089		[78.2]	0.019	79.2
				0.180			0.090	51.1
Distance from the coast (meters)	39.359	67.480	−1.444	0.121	41.513	−0.111	1.045	97.9
				0.174		[92.3]	0.023	86.5
				0.376			0.124	67.2
Percentage of urbanized land (at year 1990)	0.019	0.075	−1.933	0.063	0.016	0.010	1.156	94.8
				0.226		[94.8]	0.030	86.7
				0.351			0.112	68.0
Nr. of local units (at year 1981)	248.787	393.432	−0.269	0.067	205.854	0.080	0.993	99.7
				0.059		[70.3]	0.030	49.4
				0.187			0.169	9.8
Nr. of workers employed in local units (at year 1981)	988.966	1,724.996	−0.274	0.044	736.404	0.094	1.160	95.2
				0.093		[65.7]	0.050	46.2
				0.211			0.180	15.0
Nr. of agricultural holdings (at year 1982)	378.966	384.863	−0.014	0.526	417.213	−0.093	0.800	65.3
				0.025		[−548.6]	0.027	−11.2
				0.123			0.090	27.1
UAA (in hectares, at year 1982)	2,194.740	1,934.551	0.116	0.522	2,371.279	−0.079	0.790	63.8
				0.096		[32.1]	0.025	74.2
				0.212			0.067	68.2
Population density (at year 1981)	97.308	262.862	−1.287	0.052	82.415	0.116	1.387	88.9
				0.170		[91.0]	0.041	75.8
				0.287			0.146	49.1

Table A6
Balancing results of the Bayesian additive regression tree PSM approach – Neighbor municipalities, southern NPs.

Matching variable	Mean: Treated (n = 47)	Mean: Unmatched controls (n = 7,217)	Standardized Mean Difference	Variance Ratio eCDF Mean eCDF Max	Mean: Matched controls (n = 47)	Standardized Mean Difference [% Balance Improvement in Std. Mean Diff.]	Variance Ratio eCDF Mean eCDF Max	% Balance Improvement in Variance Ratio eCDF Mean eCDF Max
Score	−1.641	−3.463	2.615	0.150	−1.726	0.122	1.010	−131.4
				0.460		[95.3]	0.000	100.0
				0.825			0.029	92.2
Altitude above sea level (meters)	232.064	337.161	−0.424	0.870	245.149	−0.053	1.079	73.9
				0.121		[87.5]	0.025	72.3
				0.265			0.170	42.2
Municipality area (km^2)	35.094	36.008	−0.028	0.473	34.099	0.030	0.866	82.0
				0.168		[−8.9]	0.039	14.2
				0.343			0.127	1.2
Distance from the coast (meters)	7.967	67.480	−7.939	0.029	7.264	0.094	0.773	91.4
				0.329		[98.8]	0.018	96.1
				0.614			0.147	78.4
Percentage of urbanized land (at year 1990)	0.190	0.075	0.526	0.863	0.215	−0.113	0.628	63.8
				0.133		[43.8]	0.050	69.7
				0.294			0.128	62.0
Nr. of local units (at year 1981)	1,328.043	393.432	0.152	0.041	639.596	0.112	0.811	−93.4
				0.029		[26.3]	0.021	43.1
				0.133			0.132	39.2
Nr. of workers employed in local units (at year 1981)	6,580.872	1,724.996	0.151	0.012	2,170.511	0.138	0.456	−172.0
				0.075		[9.2]	0.021	36.9
				0.194			0.088	26.3

(*continued on next page*)

Table A6 (*continued*)

Matching variable	Mean		Standardized Mean Difference	Variance Ratio eCDF Mean eCDF Max	Mean	Standardized Mean Difference [% Balance Improvement in Std. Mean Diff.]	Variance Ratio eCDF Mean eCDF Max	% Balance Improvement in Variance Ratio eCDF Mean eCDF Max
	Treated (n = 47)	Unmatched controls (n = 7,217)			Matched controls (n = 47)			
Nr. of agricultural holdings (at year 1982)	759.787	384.863	0.562	0.594 0.149 0.373	735.957	0.036 [93.6]	1.276 0.022 0.118	17.2 81.4 68.8
UAA (in hectares, at year 1982)	1,906.900	1,934.551	−0.013	1.001 0.138 0.251	1,502.039	0.194 [−364.2]	1.347 0.028 0.103	6.7 −55.1 −12.1
Population density (at year 1981)	1,684.502	262.862	0.387	1.483 0.127 0.288	1,608.674	0.021 [94.7]	1.011 0.037 0.147	80.7 44.8 42.8

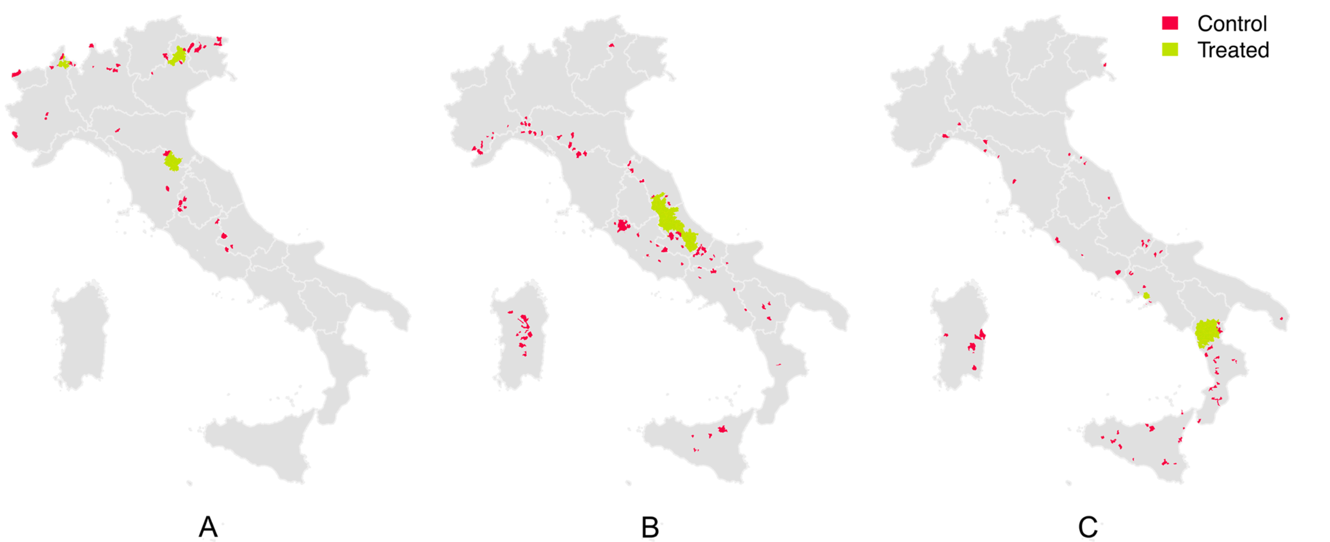

Fig. A1. Municipalities covered by a NP (treated municipalities) and control municipalities, per group of NPs: A) northern NPs; B) central NPs; C) southern NPs.

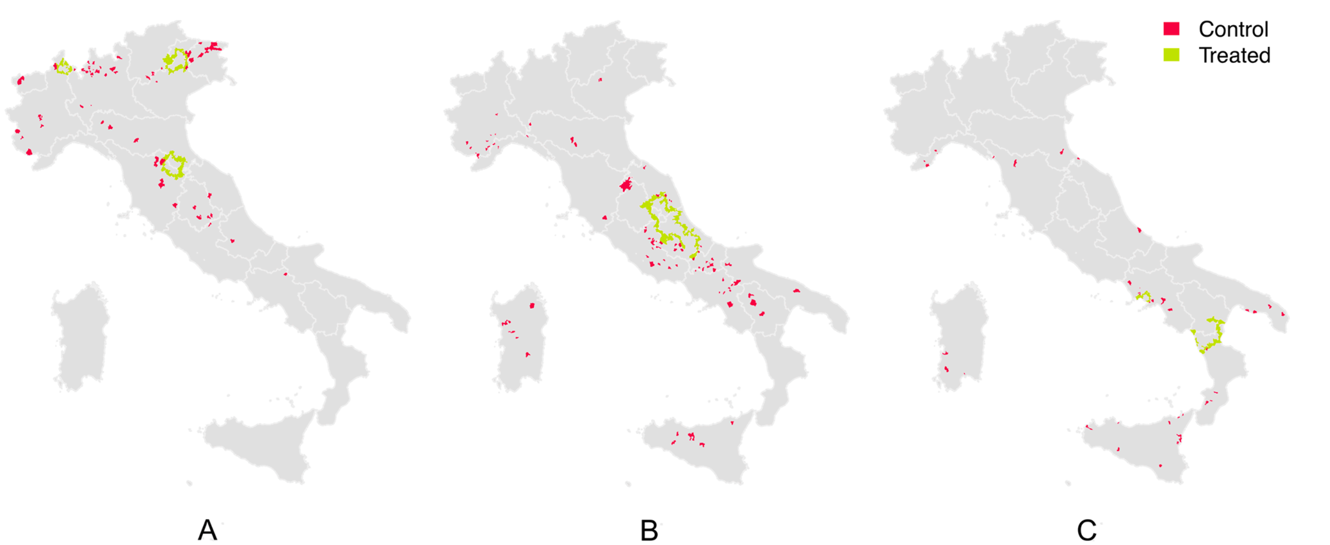

Fig. A2. Neighboring municipalities of a NP (treated municipalities) and control municipalities, per group of NPs: A) northern NPs; B) central NPs; C) southern NPs.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gloenvcha.2024.102838.

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