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# Swiss Parks of National Importance as model regions of sustainable development – An economic success story for farmers?

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ABSTRACT

Evidence on the socioeconomic effects of the protected area status of affected regions is mixed. While some studies highlight positive outcomes for these regions, others point in the opposite direction. Consequently, this study aimed to add to the discourse on whether protected area status fosters the socioeconomic development of these regions or not. The study focuses on the agricultural sector in protected areas, because this sector is of particular importance for local communes in these regions. Our study aimed to investigate whether the status Swiss Park of National Importance (henceforth park) positively or negatively influenced economic indicators of local farms (i.e., direct payments, income, and revenues). Specifically, the study answers the following question: How would economic farm indicators have developed if the territory had not gained park status? Thus, the study compared the economic indicators of farms located in a park with economic indicators of farms from neighboring regions outside the park. The analyses focused on the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Biosphere Reserve Entlebuch and the Nature Park Gantrisch as case study regions. The empirical findings revealed that gaining the park status had neither positive nor negative significant effects on income of farms inside a park compared to similar farms outside. However, results also showed that gaining the park status had positive rather than negative effects on further economic indicators such as direct payments and revenues.

## 1. Introduction

Protected areas are a cornerstone of international nature protection policies (Wallner et al., 2007). The social, economic, and political effects of protected areas have been investigated for many years (West et al., 2006; Pullin et al., 2013). Two contrasting discourses on the socioeconomic consequences of protected areas have dominated the debate. One discourse argues that protected areas represent barriers to the socioeconomic development of local communities (West et al., 2006; Chaminuka et al., 2012; Farkas and Kovács, 2021; Hinojosa et al., 2018). The other discourse emphasizes protected areas' benefits for the socioeconomic status of local populations within these territories (Adams et al., 2004; Donia et al., 2017). Recent studies exploring the relationship between protected area status and general (regional) economic development have suggested positive rather than negative effects (Knaus et al., 2017; Estifanos et al., 2020; Kauano et al., 2020; Ma et al., 2020). Economic indicators such as gross value added (Knaus et al., 2017) or per capita income (Ma et al., 2020) were used to measure the economic development of local communities within protected areas.

However, empirical studies on the economic impacts of protected area status on agriculture are scarce, although the agricultural sector is vital for local communities in protected areas. Therefore, the main objective of our study was to analyze whether the status Swiss Parks of National Importance (henceforth park) either positively or negatively influenced the economic indicators of local farms. Specifically, we answer the following question: How would economic farm indicators have developed if the territory had not gained park status? For this study, we selected economic indicators, which are used to measure the economic performance of farms (i.e., direct payments, farm income and revenues).

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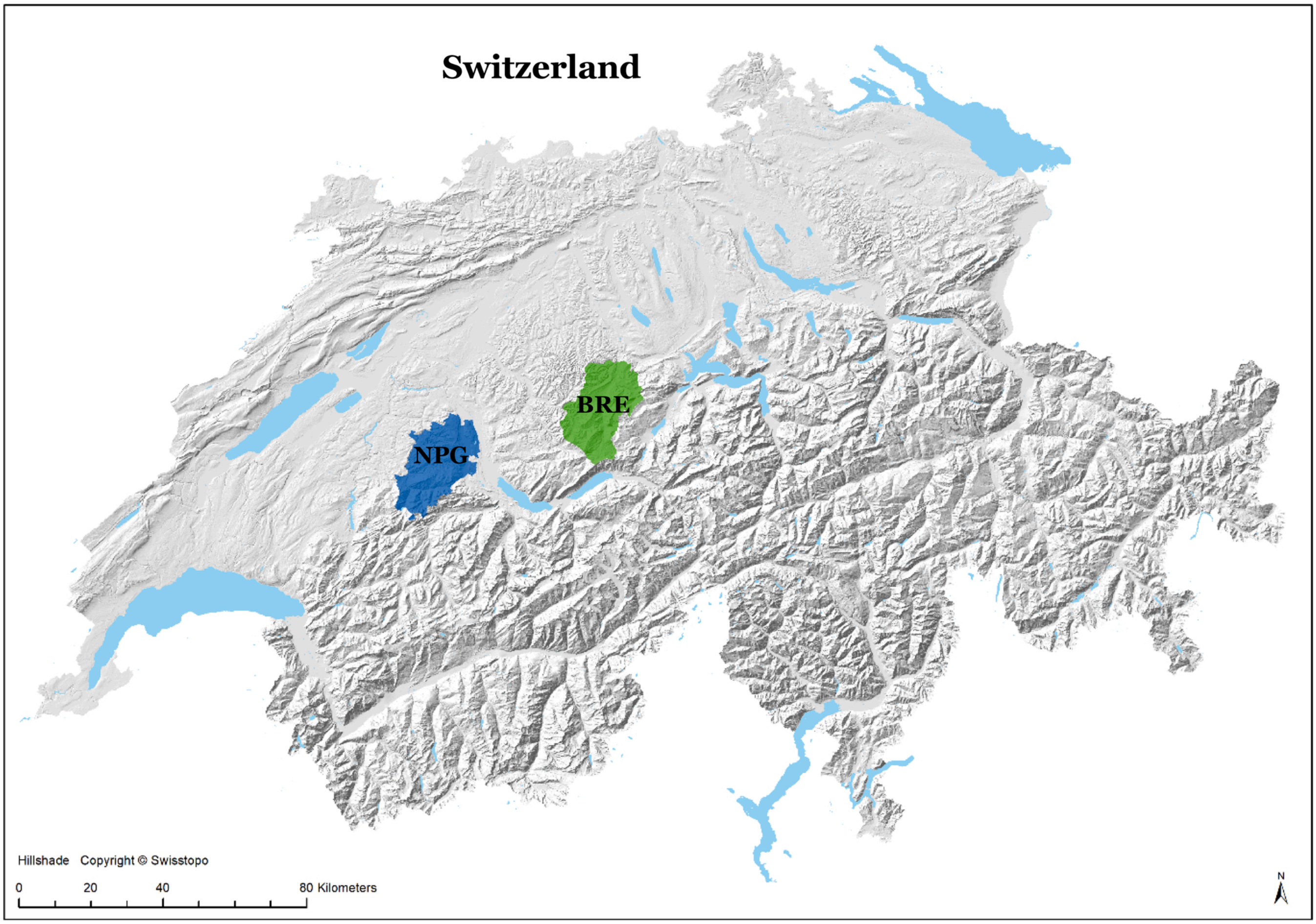


**Fig. 1.** Location of the selected case studies in Switzerland: UNESCO Biosphere Reserve Entlebuch (BRE) in green and Nature Park Gantrisch (NPG) in dark blue.

Consequently, our study investigated what Romano et al. (2021) called "the park effect." In particular, we compared the economic indicators of farms located inside a park with the economic indicators of farms from neighboring regions outside the park. For this purpose, we ensured that farms located in a park and farms from neighboring regions were similar in terms of sociodemographic characteristics of the farm manager, and farm-specific characteristics.

Against this background, we posed the following two contrasting hypotheses based on the two discourses mentioned above on the socioeconomic effects of park status:

**H1.** : Park status negatively affects the economic indicators of farms due to stricter environmental regulations.

**H2.** : Park status creates additional economic benefits for farmers inside the protected area due to improved marketing potential (e.g., higher prices for agricultural products or higher agri-environmental payments from the government).

Even though protected areas additionally provide valuable ecosystem services (He et al., 2018; Schirpke et al., 2021) and social functions (Corrigan et al., 2018; Wallner et al., 2007), an analysis of these aspects was beyond the scope of our study.

For our economic analyses, two parks, namely the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Biosphere Reserve Entlebuch (BRE), a biosphere reserve since 2001 and park since 2008, and the Nature Park Gantrisch (NPG), a park since 2012, were selected as case studies because data for these parks were available. Beyond data availability, both parks have unique characteristics that highlight the diversity of the Swiss Park Network. Our investigation was based on panel data from the Swiss Farm Accountancy Data Network (FADN).

The rest of this article is organized as follows: In Section 2, we describe the two selected case-study regions, namely BRE and NPG. In Section 3, we present our methods and data. In Section 4, we discuss the primary study results and robustness checks. In Section 5, we present the study conclusions.

## 2. Description of the case studies

Switzerland has a concise history of protected areas compared to other countries. Even though the oldest national park in the Alps is in Switzerland (the Swiss National Park, established in 1914), the legal basis for parks was missing for a long time. In 2007, the revised Nature and Cultural Heritage Protection Act (NCHA) was adopted. This revision was necessary to establish clear rules for potential park regions to receive federal support. Today, the fundamental principles that regulate the procedures and prerequisites for parks are set out in the NCHA and the related ordinance (Hammer and Siegrist, 2016).

Parks are characterized by beautiful landscapes, rich biodiversity, and high-quality cultural assets; economic activities, including agricultural production, are permitted (Federal Office for the Environment, 2019). The establishment of a park requires the approval of the local population. The federal government does not support a park until it meets the legal requirements for nature and landscape values, demonstrates democratic legitimacy, sets out its goals in a charter, and guarantees its spatial integrity and financial security in the long term. The NCHA defines parks as areas with high natural and landscape values and establishes the following three park categories: 1) National Park, 2)

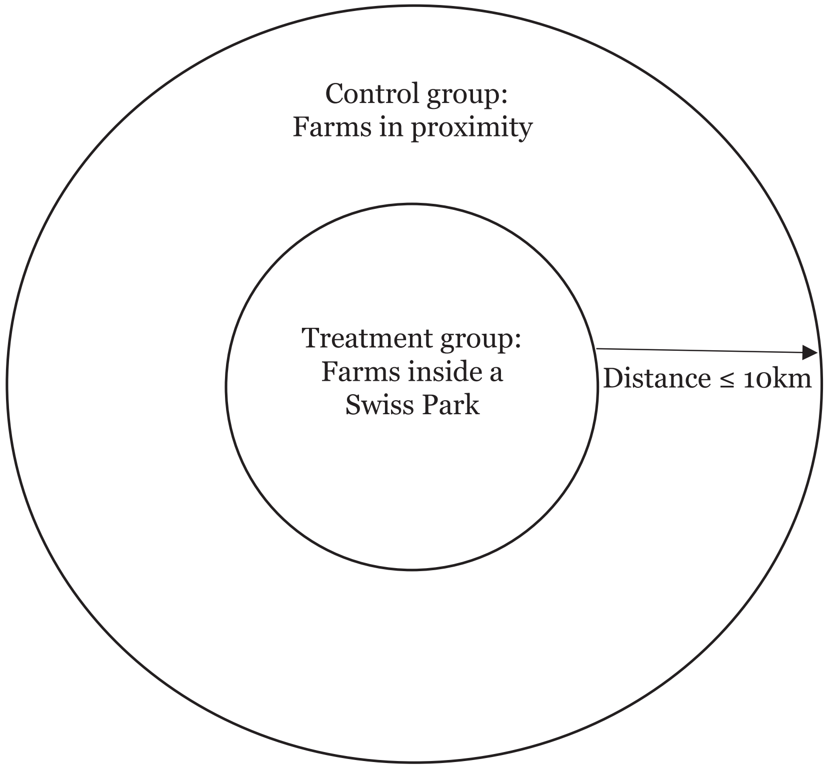


**Fig. 2.** Overview of the quasi-experimental study design: Treatment group and the control group "narrow radius".

Regional Nature Park, and 3) Nature Discovery Park. Regional Nature Parks are partially populated rural areas characterized by high natural, landscape, and cultural values. They promote the quality of nature and landscape and the sustainable development of the regional economy. By definition, parks serve as model regions for sustainable development. However, it is essential to note that park authorities have no legislative power and cannot change the existing legal requirements for nature and landscape values. Nevertheless, the park management can create incentives by offering new product ideas and lucrative distribution opportunities for local products through the Swiss Parks product label (Swiss Parks Network, 2022a, 2022b).

To investigate the effects of parks on farm economic indicators, we selected the two parks, BRE and NPG. Fig. 1 shows the locations of the two case study regions in Switzerland (BRE in green and NPG in blue). Both case study regions are in the hill and mountain zones, with dairy farming as the primary agricultural activity. The two study regions are described in detail below.

### *2.1. Biosphere Reserve Entlebuch*

In 2001, this region received the designation of UNESCO Biosphere Reserve and applied for designation as Park of National Importance as soon as the legal basis for parks came into force. In 2008, BRE was recognized by the Swiss Federal Government as the first Regional Nature Park of National Importance and a pioneer in the Swiss Parks Network. Moreover, BRE is considered the flagship region by UNESCO (Swiss Parks Network, 2022c).

Entlebuch is home to some of Switzerland's most extensive moorlands. The moorlands are the reason why the area applied for the status of UNESCO Biosphere Reserve; new legislation in 1990 restricted agricultural activities in moorlands. These restrictions marked the beginning of the biosphere idea, which envisioned the restrictions as a means of converting specific natural areas into tourist attractions.

The BRE territory covers 394 square kilometers and is home to approximately 17,000 inhabitants living in seven communities. The altitude ranges from 589 m to 2348 m asl and is a typical rural pre-alpine region in the heart of Switzerland. About 22% of the region's 6000 employees (full-time equivalents) work in agriculture on 850 farms, with tourism being another important employment sector (Gemeindeverband UNESCO Biosphäre Entlebuch, 2021). Compared to the Swiss average, the primary sector (i.e., the forestry, agricultural, and fishery sectors) is heavily overrepresented. As a predominantly rural region, Entlebuch is under severe economic pressure because of its strong focus on agriculture. However, due to regional designations, such as UNESCO Biosphere Entlebuch and Echt Entlebuch, producers have an ideal platform and distribution system that increases the region's overall value creation.

### *2.2. Nature Park Gantrisch*

Since 2012, this 400-square-kilometer area has been certified as a Regional Nature Park. The altitude ranges from 510 m to 2229 m asl and comprises 19 communities. Approximately 46,700 inhabitants live in the region.

In addition to agriculture and forestry, health, social services, construction, and retail trade are the largest economic sectors in the area. Approximately 17.6% of the region's 18,200 employees work in agriculture. According to the Gantrisch Agricultural Association, about 1000 farmers work in the park (Biedermann, 2018). NPG management supports the marketing of regional products through agricultural activities. NPG contains many valuable cultural-historic sites, such as castles, old baths, a pilgrim route, and locally adapted farms. Furthermore, eight museums, some with international significance, are in the NPG (Swiss Parks Network, 2022d).

## 3. Methods and databases

This study employed a quasi-experimental study design, which allowed us to estimate, with certain preconditions, causal effects outside of the laboratory by comparing treated and untreated groups. In our

**Table 1**
Difference-in-differences setup.

| | Treatment group | Control group |
|---|---|---|
| Pretreatment period | $Y^T_{pre} = \lambda_{pre} + \gamma^T$ | $Y^C_{pre} = \lambda_{pre} + \gamma^C$ |
| Post-treatment period | $Y^T_{post} = \lambda_{post} + \gamma^T + \beta$ | $Y^C_{post} = \lambda_{post} + \gamma^C$ |
| First difference | $\Delta Y^T = (\lambda_{post} - \lambda_{pre}) + \beta$ | $\Delta Y^C = (\lambda_{post} - \lambda_{pre})$ |

study design, farms inside a park served as the treatment group, whereas farms near a park served as the control group. More specifically, we established two control groups based on the following two (sub-) samples of farms in proximity to a park, as follows: First, we established a control group "narrow radius" based on a pool of farms located within 10 km of the park border. Second, we established a control group "wide radius" based on a pool of farms located within 20 km of the park border. Based on this study design, we used the synthetic control method (SCM) in combination with a difference-in-differences (DiD) analysis. We used SCM to ensure that the control and the treatment groups were similar regarding sociodemographic characteristics of the farm manager and farm characteristics. The SCM further ensures that the economic performance of farms of the control and treatment groups were similar before gaining the park status. The use of a DiD analysis to estimate the causal effects of an exogenously given treatment in the framework of a quasi-experiment is a commonly used empirical strategy (see, e.g., An, 2012; Nguyen, 2013; Ritzel and Kohler, 2017). The primary aim of the DiD analysis was to estimate the differences in mean outcomes between the treatment group and the control group after the treatment and to subtract outcome differences before park status began to affect economic indicators (Lechner, 2011). Consequently, a DiD estimator allowed us to estimate the average causal effect of the park on the economic indicators of farms inside the park.

In Subsection 3.1, we provide an overview of our quasi-experimental study design. In Subsection 3.2, we introduce the SCM. In Subsection 3.3, we provide an overview of the DiD estimator and then describe the data in Subsection 3.4.

### 3.1. Description of the quasi-experimental study design

To empirically test the two proposed contrasting hypotheses, we compared economic farm outcomes before and after gaining park status. Our approach was based on counterfactual causality analysis (Roy, 1951; Rubin, 1974). To determine the causal effects on farms in a park, we needed to answer the following question: How would economic farm indicators have developed if the territory had not gained park status (counterfactual state)? The difference between factual and counterfactual states was the causal effect of the treatment (gaining park status). A counterfactual state can never be observed. Therefore, we derived the causal effect from the differences in economic indicators between farms located in a park and farms near a park. Farms inside a park constituted the treatment group, whereas farms located near a park border served as the control group.

For each of the two parks analyzed, we constructed the following two control groups: 1) a group "narrow radius" consisting of farms within 10 km of a park border (Fig. 2); and 2) a group "wide radius", consisting of farms within 20 km of a park border (see Fig. 4 in Appendix A). In the NPG case, farms in the two neighboring parks were removed from the control groups.

In contrast to a randomized control trial, our setting involved a selection bias (assignment to the treatment and control groups was nonrandom) because the regions had applied for park status (see Table 8 in Appendix A). We argue that, based on the defined criteria, park status is given exogenously by the FOEN (see Table 8 in Appendix A). Even though regions apply for park status, owing to the exogeneity of park status, our setting could be considered a quasi-experiment, which allowed us to estimate the causal effects of park status on farms' economic outcomes. By constructing synthetic control units (synthetic parks), we could answer the following counterfactual question: How would farms' economic outcomes have developed if BRE and NPG had not gained park status? Against this background, SCM provided a systematic approach to estimating this counterfactual outcome.

### 3.2. Synthetic control method

We individually applied the SCM to the two case study parks (BRE and NPG). For each of the two parks, we analyzed $j \in (1, J+1)$ (pseudo) units, whereby unit 1 is affected by the treatment (gaining park status). In our case, unit 1 consists of all the farms located in the park and $J$ of individual farms located in proximity. Therefore, using SCM, we constructed a synthetic park, whereby $j = 2, \ldots, J+1$ represents a pool of untreated farms (farms in proximity). For each unit $j$ and year $t$, we observed $Y^N_{jt}$ as the counterfactual outcome (outcome without the treatment) and $Y^I_{jt}$ as the factual outcome (outcome with the treatment). Consequently, we estimated the outcome of the treated unit $j = 1$ (all farms located in a park) in the absence of the treatment (the counterfactual state). The treatment effect $\tau_{1t}$ for the treated unit $j = 1$ for $T_1$ could be stated as follows (Eq. 1):

$$\tau_{1t} = Y^I_{jt} - Y^N_{jt} \tag{1}$$

To obtain $Y^N_{jt}$, a synthetic park was estimated as a convex combination of farms located near a park. A synthetic park would replicate the outcome variables and the matching variables of the treated unit (all farms located inside a park) during the pretreatment period. Therefore, a synthetic park was defined as the weighted average of the farms near the park. Given the weights $W = (w_2, \ldots, w_J + 1)$, a synthetic park estimate of $Y^N_{jt}$ was formalized as follows (Eq. 2):

$$Y^N_{jt} = \sum_{j=2}^{J+1} w_j Y_{jt} \tag{2}$$

To control for potential unobserved determinants of the outcome variable, Abadie et al., (2010, 2015) suggested including the outcome variable in the matching procedure.

### 3.3. Difference-in-differences analysis

The SCM produced a time series dataset comprising the annual average values of the outcome variables for the farms located in a park and for the synthetic farms. This dataset was used to perform a DiD analysis. We conducted a DiD analysis of each of the two parks. According to Imbens and Wooldridge (2009), a DiD analysis can be formalized using the set of equations shown in Table 1.

The DiD then yields the following equation (Eq. 3):

$$\Delta Y^T - \Delta Y^C = \beta \tag{3}$$

where $Y$ denotes the outcome variables for the treatment group $T$ (all farms located inside a park) or the control group $C$ (a synthetic park). The subscript *pre* identifies the period before gaining park status, $\gamma$ refers to location-specific effects that are constant over time (e.g., sharing a common border), and $\lambda$ represents a common time trend (e.g., capturing changes in agricultural policy). The coefficient $\beta$ allows quantification of the treatment or the park effect.

The first difference $\Delta Y^T$ eliminates location-specific effects $\gamma$, whereas the DiD $\Delta Y^T - \Delta Y^C$ eliminates the common time trend $\lambda$. As a result, we get the estimator $\beta$ identifying the park effect.

The DiD analysis can be implemented econometrically as follows (Eq. 4):

$$Y_{it} = \beta_0 + \beta_1 D^T_i + \beta_2 D^{post}_t + \beta_3 \left(D^T_i \times D^{post}_t\right) + \epsilon_{it} \tag{4}$$

where $Y_{it}$ denotes an economic farm outcome of group $i \in$ {farms in a park; synthetic park} in year $t$. The superscript *post* identifies the period

**Table 2**
Description of the outcome and matching variables.

| Variable | Description | Scale |
|---|---|---|
| **Outcome variable** | | |
| (a) Direct payments | Direct payments per hectare from the government to all farms (located inside or outside a park) | Continuous: CHF/hectare |
| (b) Income | Total farm income (total revenues – total costs) divided by family work units (FWUs) | Continuous: CHF/FWU |
| (c) Revenues | Total revenues (market revenues + direct payments) per hectare | Continuous: CHF/hectare |
| **Matching variable** | | |
| *Sociodemographic characteristics* | | |
| (a) Age | Age of the farm manager | Continuous: years |
| (b) Education | Educational level of the farm manager | Ordinal: 1 = without education; 2 = apprenticeship; 3 = master's degree in agriculture or higher |
| *Farm-specific characteristics* | | |
| (c) Organic | Share of organic production | Binary: 1 = organic; 0 = conventional |
| (d) Farm size | Total utilized agricultural area | Continuous: hectares |
| (e) Livestock | Total livestock units | Continuous: units |
| (f) Labor | Total FWUs | Continuous: units |

CHF: Swiss francs

after gaining park status, and the superscript $T$ identifies the treatment group (all farms in a park). Accordingly, $D^{post}$ is a dummy variable that takes the value of 1 for the years after gaining park status and 0 for the years before gaining park status. $D^T$ is a dummy variable taking the value of 1 if the observation comes from farms in a park and 0 if the observation comes from a synthetic park. The coefficient $\beta_3$ identifies the park effect while $\epsilon_{it}$ denotes the error term for unobserved characteristics of group $i$ at time $t$, which is assumed to fulfill the zero conditional mean assumption.

To estimate an unbiased average treatment effect on the treated (ATT) using an SCM in combination with a DiD analysis, two assumptions need to hold. First, a common trend between the economic outcomes of the farms located in a park and those of the control group must exist before gaining park status (common trend assumption [CTA]). Second, the treatment group should not be affected by park status (stable unit treatment value assumption [SUTVA]). The SCM should at least ensure that the CTA is not violated. Whether the CTA and the SUTVA hold can be checked visually.

Eq. (4) was estimated using ordinary least squares (OLS) regression with robust standard errors. When autocorrelation was present at lag 1, we estimated a Prais–Winsten AR(1) regression model with robust standard errors (the alternative model). Testing for an AR(1) process, we used the Arellano-Bond test for autocorrelation (Arellano and Bond, 1991). The empirical analysis was conducted using Stata 16.

### 3.4. Definitions of the variables, description of the database, and construction of balanced pseudo-panels

#### 3.4.1. Definitions of the variables

The empirical analysis was performed for the following three outcome variables describing the economic indicators of farms: (a) direct payments per hectare, (b) income per family work unit, and (c) total revenues per hectare (Table 2). These variables are described below.

*Direct payments per hectare* are payments from the government to all farmers inside and outside a park. We considered these payments because they constitute a large proportion of farm income. For instance, in Switzerland, direct payments account for almost 100% of farm income in 2019 (Jan et al., 2020). Direct payments can be interpreted as a reward from the government for the provision of public goods. They include the following two types of payments: (a) payments that all farmers receive for the cultivation of land and the maintenance of livestock (e.g., general direct payments or food security payments, etc.) and (b) payments for participation in voluntary agri-environmental schemes,[1] which compensate farmers for their associated forgone income (Mack et al., 2017, 2020). Note that farms, both inside and outside a park, can participate in the same voluntary agri-environmental programs. The first type of direct payment should not differ between treated farms and synthetic parks when land use and livestock are similar. However, regarding direct payments for participation in agri-environmental programs, we hypothesized that payments might increase after farms gain park status. In contrast, in the control group, they would remain the same. Thus, we hypothesized that farmers' participation in voluntary agri-environmental programs inside a park might increase significantly after gaining park status compared to farms outside a park.

*Income per family work unit* was derived from net farm income (total farm income[2]) divided by the number of family units working on a farm. Income per family work unit can be interpreted as remuneration for labor on family farms (Zorn et al., 2018). This variable represents the standard ratio in the FADN system.

*Total revenues per hectare* consist of market revenues from sold products and direct payments for the provision of public goods. When direct payments per hectare increase due to agri-environmental programs, the forgone farm income associated with adopting agri-environmental schemes often leads to reduced market revenues. Therefore, we hypothesized that farms inside a park could generate higher total revenues per hectare after gaining park status by one of the following means:

a. Receiving better prices for their products through direct marketing or food labels.
b. Increasing agriculture-related activities, such as agrotourism, to increase their revenue after receiving the park status.
c. Providing more public goods.

To construct a synthetic park, we used the six matching variables presented in Table 2. For sociodemographic matching variables, we considered age and education. We also considered the following four farm-specific characteristics: organic production, farm size, livestock units and labor units (Table 2).

#### 3.4.2. Database

We used an unbalanced panel data set from the Swiss FADN (Renner et al., 2019) to estimate causal effects. For each of the parks analyzed, we considered 11 years, with five years before and five years after the treatment. To estimate the impacts of park status on BRE since 2008, we used FADN data from 2003 to 2013. The period from 2003 to 2007 represented pretreatment, and the period from 2009 to 2013 represented post-treatment. The park effect for NPG in 2012 was estimated using data from 2007 to 2017 (pretreatment period: 2007–2011; post-treatment period: 2013–2017).

During 2015–2016, the Swiss FADN changed its data collection system. For this reason, the database uses two different samples: the dataset from 2005 to 2015 is based on the sample of the reference farms, whereas the dataset from 2016 to 2017 is based primarily on the sample

[1] An overview of direct payments in Switzerland and how they changed from 2003 to 2017 is provided by Federal Office For Agricultural at the following URL: https://www.agrarbericht.ch/de.

[2] Total farm income = Total revenues (per farm) – total costs (per farm).

**Table 3**
Summary statistics (mean values of economic outcomes and matching variables) for the treated farms and the control groups “narrow radius” and “wide radius” for Biosphere Reserve Entlebuch, 2003–2013.

| Variable | Treatment group Mean | Control group “narrow radius” | | | | Control group ”wide radius” | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean Unbalanced panel | Mean Balanced pseudo-panel | Difference Unbalanced − balanced panel | p-value | Mean Unbalanced panel | Mean Balanced pseudo-panel | Difference Unbalanced − balanced panel | p-value |
| Direct payments | 3065 | 2930 | 3066 | − 136 | 0.344 | 2800 | 3101 | − 301 | 0.000 |
| Income | 32769 | 39154 | 36880 | 2274 | 0.429 | 42645 | 35964 | 6681 | 0.005 |
| Revenues | 9892 | 13156 | 10795 | 2361 | 0.529 | 14580 | 10882 | 3698 | 0.000 |
| Age | 46.0 | 46.2 | 45.9 | 0.3 | 0.711 | 46.2 | 45.5 | 0.7 | 0.288 |
| Education | 2.2 | 2.2 | 2.2 | 0.0 | 0.316 | 2.4 | 2.2 | 0.2 | 0.000 |
| Organic | 26.4 | 13.0 | 14.4 | − 1.4 | 0.652 | 8.2 | 17.2 | − 9.0 | 0.000 |
| Farm size | 19.2 | 19.1 | 19.2 | − 0.1 | 0.939 | 17.6 | 17.9 | − 0.3 | 0.442 |
| Livestock | 24.6 | 29.8 | 26.2 | 3.6 | 0.020 | 33.8 | 25.5 | 8.3 | 0.000 |
| Labor | 1.4 | 1.6 | 1.5 | 0.1 | 0.039 | 1.6 | 1.5 | 0.1 | 0.000 |
| Observation number | 1725 | 3203 | 121 | | | 5082 | 231 | | |

The *p*-values were derived using an equality test (*t*-test) of variable means for the unbalanced panel and the balanced pseudo-panel.
Treatment group: Farms located in a park.
Control group “narrow radius”: Farms located within 10 km of a park ($\leq$ 10 km).
Control group “wide radius”: Farms located within 20 km of a park ($\leq$ 20 km).

**Table 4**
Summary statistics (mean values of economic outcomes and matching variables) for the treated farms and the control groups “narrow radius” and “wide radius” for Nature Park Gantrisch, 2007–2017.

| Variable | Treatment group Mean | Control group “narrow radius” | | | | Control group “wide radius” | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean Unbalanced panel | Mean Balanced pseudo-panel | Difference Unbalanced − balanced panel | p-value | Mean Unbalanced panel | Mean Balanced pseudo-panel | Difference Unbalanced − balanced panel | p-value |
| Direct payments | 2942 | 2684 | 2665 | 19 | 0.754 | 2819 | 2661 | 157 | 0.022 |
| Income | 40708 | 50334 | 53396 | − 3062 | 0.460 | 47316 | 53286 | − 5969 | 0.026 |
| Revenues | 11661 | 12000 | 12630 | − 630 | 0.324 | 11640 | 12534 | − 894 | 0.073 |
| Age | 48.5 | 46.0 | 46.2 | − 0.2 | 0.887 | 47.8 | 47.1 | 0.7 | 0.273 |
| Education | 2.4 | 2.4 | 2.5 | − 0.1 | 0.365 | 2.3 | 2.4 | − 0.1 | 0.016 |
| Organic | 11.3 | 5.9 | 4.5 | 1.4 | 0.559 | 12.2 | 7.0 | 5.2 | 0.034 |
| Farm size | 20.9 | 24.7 | 26.0 | − 1.3 | 0.353 | 22.5 | 25.6 | − 3.1 | 0.000 |
| Livestock | 29.0 | 35.2 | 39.5 | − 4.3 | 0.069 | 31.7 | 39.1 | − 7.4 | 0.000 |
| Labor | 1.8 | 1.7 | 1.8 | − 0.1 | 0.170 | 1.7 | 1.8 | − 0.1 | 0.007 |
| Observation number | 1141 | 2025 | 88 | | | 2448 | 176 | | |

The *p*-values were derived using an equality test (*t*-test) of variable means for the unbalanced panel and the balanced pseudo-panel.
Treatment group: Farms located in a park.
Control group “narrow radius”: Farms located within 10 km of the park ($\leq$ 10 km).
Control group “wide radius”: Farms located within 20 km of a park ($\leq$ 20 km).

**Table 5**
Pretreatment mean values of economic indicators and matching variables before gaining park status (2003–2007) for the treatment group, the synthetic parks, and the unmatched pool of farms (basis for synthetic parks) for the Biosphere Reserve Entlebuch based on the control group “narrow radius”.

| Variable | (a) Direct payments | | | (b) Income | | | (c) Revenues | | |
|---|---|---|---|---|---|---|---|---|---|
| | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) |
| Economic indicators | 3090 | 3086 | 3072 | 29620 | 29928 | 36170 | 9810 | 9775 | 10825 |
| Age | 45.2 | 45.1 | 45.5 | 45.2 | 43.7 | 45.5 | 45.2 | 45.1 | 45.5 |
| Education | 2.2 | 2.2 | 2.2 | 2.2 | 2.0 | 2.2 | 2.2 | 2.1 | 2.2 |
| Organic | 31.3 | 23.2 | 18.1 | 31.3 | 27.3 | 18.1 | 31.3 | 24.6 | 18.1 |
| Farm size | 19.1 | 19.8 | 17.9 | 19.1 | 17.6 | 17.9 | 19.1 | 18.6 | 17.9 |
| Livestock | 23.1 | 23.1 | 24.5 | 23.1 | 20.9 | 24.5 | 23.1 | 23.1 | 24.5 |
| Labor | 1.5 | 1.5 | 1.5 | 1.5 | 1.4 | 1.5 | 1.5 | 1.5 | 1.5 |

Treatment group: Farms in a park.
Synthetic parks: Matched farms based on a SCM located within 10 km of the park.
Unmatched pool of farms (basis for synthetic parks): Unmatched farms located within 10 km of the park.

**Table 6**
Pretreatment mean values of economic indicators and matching variables before gaining park status (2007–2011) for the treatment group, the synthetic parks, and the unmatched pool of farms (basis for synthetic parks) for Nature Park Gantrisch based on the control group "narrow radius".

| Variable | (a) Direct payments | | | (b) Income | | | (c) Revenues | | |
|---|---|---|---|---|---|---|---|---|---|
| | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) |
| Economic indicators | 2767 | 2767 | 2594 | 40572 | 40356 | 49175 | 12075 | 12076 | 12485 |
| Age | 47.5 | 47.1 | 45.7 | 47.5 | 46.4 | 45.7 | 47.5 | 47.3 | 45.7 |
| Education | 2.5 | 2.5 | 2.5 | 2.5 | 2.4 | 2.5 | 2.5 | 2.5 | 2.5 |
| Organic | 9.8 | 4.1 | 3.4 | 9.8 | 5.7 | 3.4 | 9.8 | 2.1 | 3.4 |
| Farm size | 20.0 | 22.5 | 24.8 | 20.0 | 21.7 | 24.8 | 20.0 | 22.4 | 24.8 |
| Livestock | 28.2 | 42.3 | 37.7 | 28.2 | 37.4 | 37.7 | 28.2 | 32.0 | 37.7 |
| Labor | 1.7 | 1.8 | 1.8 | 1.7 | 1.7 | 1.8 | 1.7 | 1.8 | 1.8 |

Treatment group: Farms inside the park.
Synthetic parks: Matched farms based on a SCM located within 10 km of the park.
Unmatched pool of farms (basis for synthetic farms): Unmatched farms located 10 km of the park.

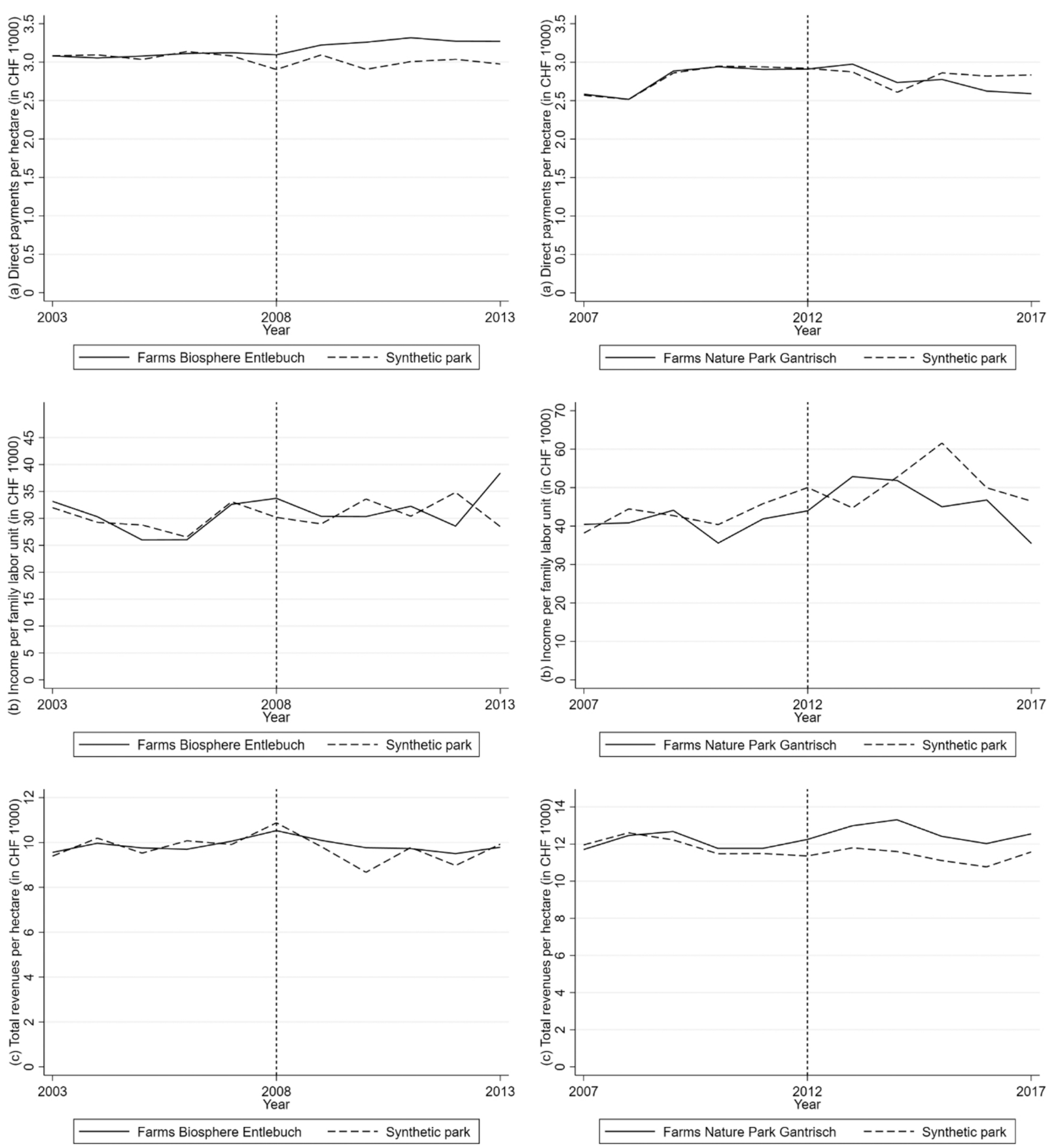


**Fig. 3.** Trends in farms' economic indicators in terms of (a) direct payments, (b) income, and (c) revenues for the treated farms and the synthetic parks for control group "narrow radius.".

 

**Table 7**
Results from the difference-in-differences analysis based on the SCM time series dataset (the control group “narrow radius”).

| Statistic | Biosphere Reserve Entlebuch | | | Nature Park Gantrisch | | |
|---|---|---|---|---|---|---|
| | (a) Direct payments | (b) Income | (c) Revenues | (a) Direct payments | (b) Income | (c) Revenues |
| ATT | 0.249 * ** | 1.513 | 0.096 | – 0.149 | – 5.255 | 0.672 * |
| | (0.049) | (2.625) | (0.389) | (0.049) | (4.996) | (0.362) |
| $N$ | 22 | 22 | 22 | 22 | 22 | 22 |
| $R^2$ | 0.748 | 0.126 | 0.055 | 0.722 | 0.381 | 0.317 |
| Alternative model | No | No | No | No | Yes | Yes |

ATT: Average treatment effect on the treated.
* $p \leq 0.1$; * * $p \leq 0.05$; * ** $p \leq 0.01$.
Robust standard errors are in parentheses.

of the "farm income situation" (Schmid et al., 2017). FADN farms inside the two parks, BRE and NPG, and the pools of farms located near the parks were identified through a geographic information system (GIS) that used officially available park perimeter data (FOEN, 2020) linked with geographic coordinates reported in the FADN data.

Based on the unbalanced FADN dataset, we constructed pseudo-panels because the application of the SCM required balanced panel data. Table 9 in Appendix B shows a fictitious example of constructing a balanced pseudo panel dataset.

Summary statistics (mean values of the outcome and matching variables) for the treatment group, the control group “narrow radius”, and control group “wide radius” can be found in Table 3 (BRE; 2003–2013) and Table 4 (NPG; 2007–2017). For the control groups, the table shows the mean values for both the unbalanced data panel derived from the FADN and the constructed balanced pseudo-panel. Furthermore, we tested for significant differences in mean values between the unbalanced panel and the balanced pseudo-panel using a *t*-test.

For the control group “wide radius”, the mean values for the variables of the unbalanced panel and the balanced pseudo-panel differed significantly. This was true for both the BRE and NPG. Therefore, we focused on the results for the control group “narrow radius”. The results for the control group “wide radius” could be considered as a robustness check.

We defined three criteria for the robustness of our results. First, the results (the magnitudes of the DiD estimators) based on the control group with a narrow radius and the results based on the control group with a wide radius should not differ substantially from each other. Second, it should be possible to identify a consistent pattern in the results. Third, the mean values of the outcome and matching variables should not substantially differ between the treatment and the control groups in the pretreatment period.

Regarding the empirical analysis, two limitations must be taken into consideration. First, our empirical strategy was based on unbalanced panel data. By constructing balanced pseudo-panels, we lost observations and variation within the data. However, the construction of balanced pseudo-panels was necessary because the application of a SCM requires strongly balanced panel data. Second, the mean values of the variables of the unbalanced panel and the balanced pseudo-panel for the control group with a wide radius differed significantly. Nevertheless, we believe that the analyses based on the control group with a wide radius represent a valuable robustness check.

## 4. Results and discussion

In Subsection 4.1, we present and discuss the results for both parks, BRE and NPG, based on the control group with a narrow radius. We first present and discuss the matching results for the synthetic parks and describe their composition (Subsection 4.1.1). Second, subsection 4.1.2 provides the results for the main research questions. We visualize the time trends of the outcome variables and present the estimates of the ATT based on the DiD analysis. Based on the control group “wide radius” in Subsection 4.2, we provide deviations from the results presented in Subsection 4.1. The corresponding tables and figures for the results based on the control group “wide radius” can be found in Appendix C.

### 4.1. Park effects based on the control group “narrow radius”

#### 4.1.1. Results of the matching procedure based on the synthetic control method

A synthetic park was constructed as a convex combination of farm types in proximity to a park that imitated the farms inside a park as closely as possible. In this subsection, we assess the quality of the matching procedure by comparing the pretreatment mean values of the outcome and matching the variables of the farms located in a park with those of the synthetic parks and with those of the unmatched pool of farms (Table 5 for BRE and Table 6 for NPG). The pretreatment mean values are presented separately for the three outcome variables of (a) direct payments, (b) income, and (c) revenues. Note that the unmatched pool of farms was the basis for constructing the synthetic park. We present the variable values of the unmatched pool of farms to highlight the need for the construction of synthetic parks. Therefore, we did not use the unmatched pool of farms to estimate the causal park effect on farms’ economic indicators using a DiD analysis.

We can see that pretreatment mean values of the outcome variables differ only slightly between the treated farms and the synthetic parks. In contrast, the same values vary considerably between the treated and the unmatched pool of farms outside a park. Thus, for both parks, regarding the outcome variables, the unmatched samples of farms outside a park did not constitute appropriate control groups for our statistical analysis. For both parks, for the economic indicator "direct payments per hectare," the pretreatment mean values of the unmatched pools of farms were lower than those of the synthetic parks. By contrast, for the economic indicators "income" and "revenues," the pretreatment mean values of the unmatched pools of farms were considerably higher than those of the synthetic parks. For instance, for the economic indicator "income," the pretreatment mean value of the unmatched pool of farms was approximately CHF 9000 higher than the mean value of the synthetic park.

Regarding matching variables, we can observe more significant differences between the mean values of the unmatched pool of farms and the treated farms than between the synthetic parks and the treated farms. For instance, in BRE, the average share of farms with organic production in the unmatched sample was only 18.1%, compared to 31.3% in the treatment group. However, although the matching through the SCM reproduced the share of organic production in the synthetic parks imperfectly, the share of organic production was much better than that of the unmatched pool of farms. For some of the matching variables, we observed the opposite trend. For instance, in NPG, for the outcome variable "direct payments," livestock units at 37.7 for the unmatched sample were much closer to the treated values (28.2 units) compared to the synthetic parks (42.3 units). Even though the matching was not always perfect, especially regarding farms’ economic outcomes, the SCM prevented "extreme counterparts" and ensured that the CTA was not violated.

Weights of each farm type in the synthetic parks for BRE and NPG are provided in Table 12 in Appendix C.

#### 4.1.2. Effects of park status on economic indicators of farms

Fig. 3 shows the trends in the economic farm indicators: (a) direct payments per hectare, (b) income per family work unit, and (c) total revenues per hectare for the treated farms (all farms located in a park) and the synthetic parks. For both BRE and NPG, we can observe that the CTA and the SUTVA are not violated for all economic farm outcome variables.

Within the scope of this article, we are mainly interested in the effect of park status—in particular, in the difference in economic farm outcomes between all farms located in a park and their synthetic counterfactuals. For the BRE economic outcome "direct payments," a visual inspection of Fig. 3 suggests a clear positive treatment effect of park status. For the economic outcome "income," the ATT should be close to zero and statistically nonsignificant, whereas for "revenues," the treatment effect should be statistically nonsignificant positive. In the case of NPG, a positive effect of gaining park status on the economic farm outcome "revenues" can be assumed. For the other two economic indicators, "direct payments" and "income," the visual inspection indicates treatment effects that are marginal, negative, and statistically nonsignificant.

Table 7 presents the results of the DiD analysis based on the SCM time series dataset. In the case of BRE, all model variants were estimated using OLS regression with robust standard errors. In the case of NPG, the model variant with the dependent variable "direct payments" was estimated using an OLS regression. In contrast, for the other model variants, we detected autocorrelation at lag 1. Therefore, we chose the Prais–Winsten AR(1) regression as the alternative model. In particular, we were interested in the ATT.

As previously suggested upon visual inspection of Fig. 3, in the case of BRE, the positive treatment effect for the economic indicators "direct payments" is confirmed by the results of the DiD analysis. We can identify positive but statistically nonsignificant effects for the other two economic outcomes. In the case of the economic indicator "direct payments," the ATT was CHF 249 per year. In other words, if the FOEN had not granted park status to BRE, direct payments per hectare would have been, on average, CHF 249 lower every year.

In the case of NPG, the positive treatment effect for the economic indicator "revenues" suggested by the visual inspection of Fig. 3 was confirmed by the results of the DiD analysis. We identified adverse but statistically nonsignificant effects for the other two economic outcomes. For the economic indicator "revenues," the ATT amounts to CHF 672 per year. In other words, if the FOEN had not granted park status to NPG, total revenues per hectare would have been, on average, CHF 672 lower yearly.

### 4.2. Robustness check: Results for the control group “wide radius”

The extension of the control group via further control units led to a better fit of the SCM’s matching procedure (see Tables 10 and 11 for the matching results and Table 13 for farm type weights in Appendix C). For example, in two out of three economic indicators ("direct payments" and "revenues") for BRE farms, the share of farms with organic production (31.3%) in the synthetic park matched precisely with the treatment group (Table 10). In contrast, regarding the economic indicator "direct payments," the matching based on the control group “”narrow radius” indicated an 8.1% lower share of organic production for the synthetic park than for the farms located in BRE (Table 5). In the case of NPG, for the matching variable "livestock," the synthetic park constructed based on the control group “wide radius” reproduced the treated group much better (Table 11 in Appendix C) than the synthetic park based on the control group “narrow radius” (Table 6). The same is true for the matching variable "farm size."

In the case of BRE, the visual inspection of the trends in economic farm indicators (Fig. 5 in Appendix C) and the results of the DiD analysis (Table 14 in Appendix C) indicate that regarding "direct payments," the statistically significant positive treatment effect (detected with the control group “narrow radius”, see Table 7) is nonexistent anymore when the control group includes farms with a wide radius. In the case of NPG, the statistically significant positive treatment effect regarding the indicators "revenues" remains robust. The ATT was CHF 1097. This result implies that if the FOEN had not granted park status to NPG, total revenues per hectare would have been, on average, CHF 1097 lower every year.

## 5. Conclusions

Two contrasting opinions on the socioeconomic consequences of protected areas have dominated the current debate. One opinion argues that protected areas negatively influence local inhabitants’ socioeconomic development; the other opinion emphasizes the potential of protected areas to improve local socioeconomic development. The agricultural sector is particularly important for protected areas and their local communes. Therefore, this article contributes to this debate by analyzing whether gaining the park status influenced (either positively or negatively) local farms’ economic indicators. Accordingly, two parks were selected: the BRE (designated a biosphere reserve in 2001 and a park in 2008) and the NPG (established as a park in 2008). Specifically, the study answers the following question: How would economic farm indicators have developed if the territories had not gained park status? Therefore, a quasi-experimental study design was carried out and economic indicators of farms located inside a park were compared with farms located in neighboring regions outside the park. Regarding the sociodemographic characteristics of the farm manager and farm-specific characteristics, the use of the SCM ensured that farms inside a park were similar to those farms outside the park. To estimate the effects of park status on farms’ economic indicators, a DiD analysis was carried out.

The empirical findings revealed that gaining the park status had no significantly negative effect on economic performance of farms inside a park. However, the results also revealed that protected area status did not lead to a significantly higher farm income inside the park compared to similar farms outside. Evidence revealed that farms inside the BRE received significantly more direct payments from the government than similar farms in the narrow radius outside the park. For the NPG, significantly higher revenues were verified for farms inside the park compared to farms outside. Thus, previous studies were confirmed which suggested positive rather than negative effects of park status on socioeconomic development. Therefore, H1 (park status negatively affects the economic indicators of farms due to stricter environmental regulations) can be rejected, while at least for some economic indicators, H2 (park status causes additional financial benefits for farmers inside the protected area due to improved marketing potential) cannot be rejected. Even though, protected areas additionally provide valuable ecosystem services and social functions, an analysis of these aspects was beyond the scope of our study. Nevertheless, especially regarding the trade-offs between the ecological and economic pillars of sustainability, our results can be considered good news for the public, policymakers, and those responsible for the management of parks. The study found that further ecological restrictions and, therefore, further ecological expansion do not necessarily cause adverse effects on farms’ economic indicators in protected areas.

In general, quantitative evaluations of the impacts of gaining park status, focusing on a comparison between parks and neighboring regions, are currently missing in Switzerland. Therefore, similar to our empirical approach, future research should focus on comparative impact evaluations by considering other vital sectors, such as tourism and forestry.

## Data Availability

The data that has been used is confidential.

## Appendix A

(See here Appendix Fig. 4 and Table 8).

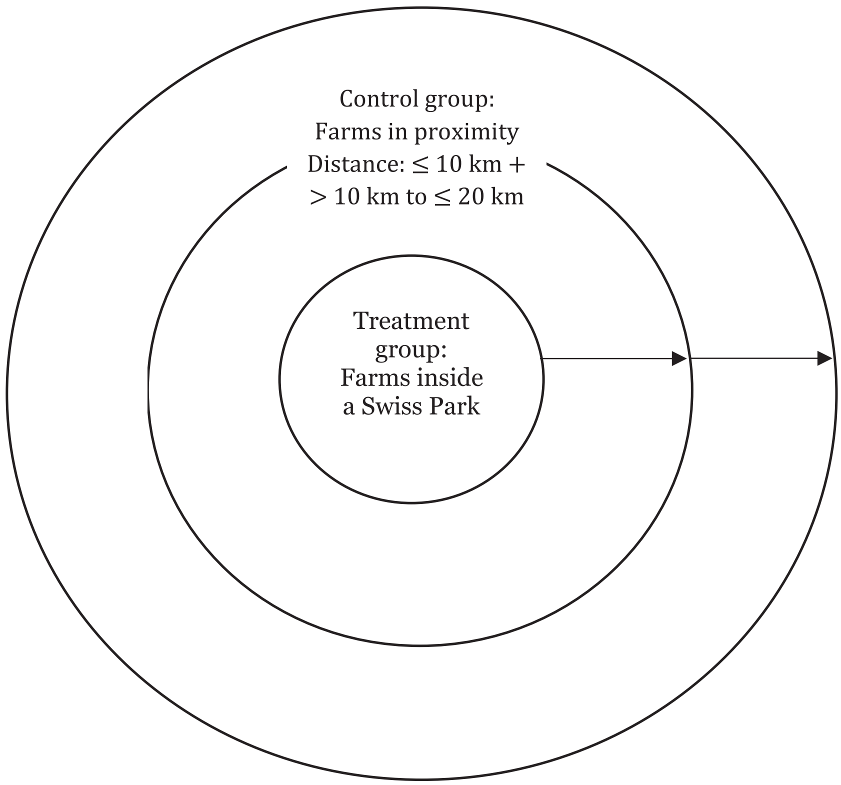


**Fig. 4.** Overview of the quasi-experimental study design: The treatment group and the control group "wide radius".

**Table 8**
Steps for gaining the status of Park of National Importance (Federal Office for the Environment, 2019; Swiss Parks Network, 2022e).

| Step | Description |
|---|---|
| (1) **Feasibility study** | The region where a park project is planned prepares a feasibility study and a management plan that includes detailed planning and contents for the park's construction. A region must meet the following two prerequisites:<br>• High natural and scenic values<br>• The inhabitants' and local authorities' total commitment to the project<br>The FOEN determines the feasibility. If the FOEN confirms the feasibility, a provisional supervisory board is formed with the full participation of the local authorities and the inhabitants. |
| (2) **Establishment** | Implementation of the project's planned measures and the park charter's development is the basis for the park label. The development of the park charter is a collaborative process involving the inhabitants, the economic stakeholders, and further groups of interest. The park charter comprises the following three elements:<br>• A 10-year park contract<br>• A 10-year management plan<br>• A four-year plan<br>The "establishment" step takes up to four years for Regional Nature Parks and Nature Discovery Parks and eight years for national parks. Within these respective periods, the park project can apply for the Candidate label from the FOEN. To receive the Candidate label, the park project must provide a management plan and a request for financial support. If the project meets the requirements, it is granted the Candidate label and financial support for the establishment phase. |
| (3) **Operation** | Finally, the inhabitants vote on the project. If a majority of the inhabitants vote "Yes," the FOEN verifies whether the park charter meets the requirements and grants the Park of National Importance label. Consequently, the operating phase begins.<br>The park must implement many ecological, sociocultural, and economic projects to meet the park charter's targets. These activities are reviewed every 10 years. If the review is positive, the park can apply for an additional 10-year operating phase based on a revised park charter. The inhabitants again vote on the new park charter. |

## Appendix B

(See here Appendix Table 9).

According to Guillerm (2017), pseudo-panels consist of stable groups of individuals rather than individuals over time. Individual variables were replaced by their intragroup means. Table 10 shows a fictitious example of constructing a balanced pseudo-panel dataset.

**Table 9**
Fictitious example of the construction of a balanced pseudo-panel dataset.

| ID | Year | Farm type | Direct payments per hectare | Agricultural area | Livestock units | Labor units | Agricultural zones |
|---|---|---|---|---|---|---|---|
| Panel 1: Unbalanced panel dataset | | | | | | | |
| 1 | 2003 | dairy cows | 2800 | 20.0 | 15.0 | 1.4 | hill |
| 1 | 2004 | dairy cows | 2850 | 20.0 | 16.0 | 1.4 | hill |
| 1 | 2006 | dairy cows | 2870 | 20.0 | 16.0 | 1.4 | hill |
| 2 | 2003 | dairy cows | 2650 | 27.0 | 20.0 | 1.6 | hill |
| 2 | 2005 | dairy cows | 2700 | 27.0 | 22.0 | 1.6 | hill |
| 2 | 2006 | dairy cows | 2600 | 27.0 | 22.0 | 1.6 | hill |
| Panel 2: Balanced pseudo-panel dataset | | | | | | | |
| | Year | Farm type | Direct payments per hectare | Agricultural area | Livestock units | Labor units | Agricultural zones |
| | 2003 | dairy cows | 2725 | 23.5 | 17.5 | 1.5 | hill |
| | 2004 | dairy cows | 2850 | 20.0 | 16.0 | 1.4 | hill |
| | 2005 | dairy cows | 2700 | 27.0 | 22.0 | 1.6 | hill |
| | 2006 | dairy cows | 2735 | 23.5 | 19.0 | 1.5 | hill |

In Panel 1, the observation for the year 2005 is missing for Farm #1, and the observation for the year 2004 is missing for Farm #2. To achieve a balanced panel, the data were aggregated by computing the mean values for the variables dependent on year, farm type, and agricultural zones. Accordingly, Panel 2 shows the (balanced) pseudo-panel dataset comprising the (aggregated) mean values of the considered variables. For some farm types, constructing a balanced pseudo-panel was not feasible due to missing annual observations in the unbalanced panel dataset. Consequently, the number of observations in the balanced pseudo-panel was reduced.

**Table 10**
Pretreatment mean values of economic indicators and matching variables before gaining park status (2003–2007) for the treatment group, the synthetic parks, and the unmatched pool of farms for the Biosphere Reserve Entlebuch based on the control group "wide radius".

| Variable | (a) Direct payments | | | (b) Income | | | (c) Total revenues | | |
|---|---|---|---|---|---|---|---|---|---|
| | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) |
| Economic indicator | 3090 | 3090 | 3047 | 29620 | 29739 | 35748 | 9810 | 9790 | 10748 |
| Age | 45.2 | 45.2 | 45.0 | 45.2 | 45.2 | 45.0 | 45.2 | 45.1 | 45.0 |
| Education | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| Organic | 31.3 | 31.3 | 20.3 | 31.3 | 25.5 | 20.3 | 31.3 | 31.3 | 20.3 |
| Farm size | 19.1 | 19.1 | 16.8 | 19.1 | 18.2 | 16.8 | 19.1 | 19.0 | 16.8 |
| Livestock | 23.1 | 23.1 | 23.4 | 23.1 | 22.2 | 23.4 | 23.1 | 23.3 | 23.4 |
| Labor | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |

Treatment group: Farms inside a park.
Synthetic parks: Matched farms based on a SCM located within 20 km of the park.
Unmatched pool of farms (basis for synthetic parks): Unmatched farms located within 20 km of the park.

## Appendix C

(See here Appendix Fig. 5 and Tables 10–14).

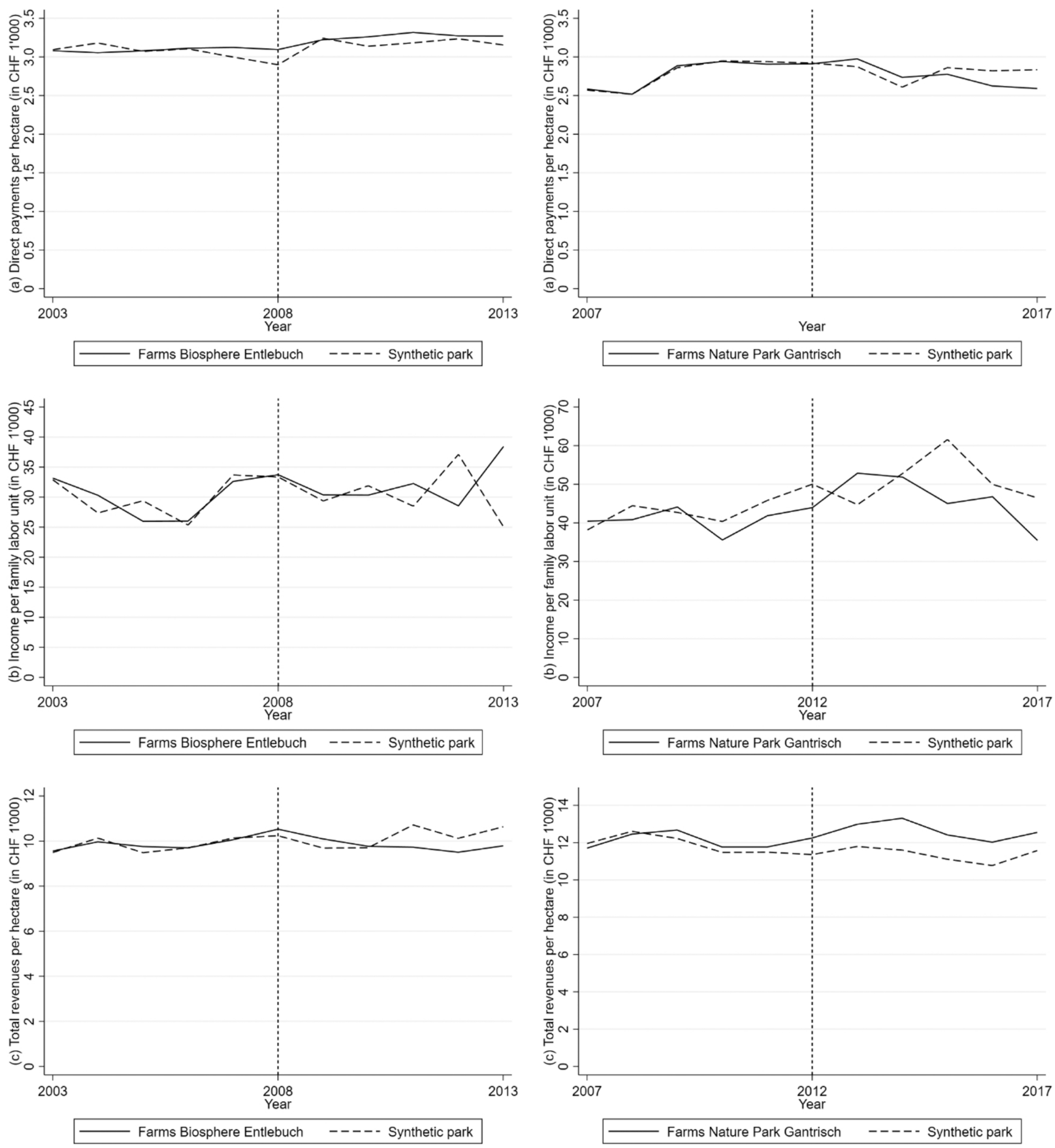


**Fig. 5.** Trends in economic farm indicators for (a) direct payments per hectare (in CHF 1000), (b) income per family work unit (in CHF 1000), and (c) total revenues per hectare (in CHF 1000) for the treated farms and the synthetic parks of control group “wide radius.”.

**Table 11**
Pretreatment mean values of economic indicators and matching variables before gaining park status (2007–2011) for the treatment group, the synthetic parks, and the unmatched pool of farms for Nature Park Gantrisch based on the control group “wide radius”.

| Variable | (a) Direct payments | | | (b) Income | | | (c) Total revenues | | |
|---|---|---|---|---|---|---|---|---|---|
| | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) |
| Economic indicator | 2767 | 2767 | 2609 | 40572 | 42311 | 47707 | 12075 | 11952 | 12636 |
| Age | 47.5 | 48.0 | 46.8 | 47.5 | 48.4 | 46.8 | 47.5 | 47.9 | 46.8 |
| Education | 2.5 | 2.4 | 2.4 | 2.5 | 2.3 | 2.4 | 2.5 | 2.4 | 2.4 |
| Organic | 9.8 | 9.5 | 5.5 | 9.8 | 9.8 | 5.5 | 9.8 | 9.0 | 5.5 |

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**Table 11** (*continued*)

| Variable | (a) Direct payments | | | (b) Income | | | (c) Total revenues | | |
|---|---|---|---|---|---|---|---|---|---|
| | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) | Treatment group | Synthetic park | Unmatched pool of farms (basis for synthetic parks) |
| Farm size | 20.0 | 20.8 | 23.6 | 20.0 | 20.0 | 23.6 | 20.0 | 20.7 | 23.6 |
| Livestock | 28.2 | 28.3 | 36.1 | 28.2 | 28.2 | 36.1 | 28.2 | 29.2 | 36.1 |
| Labor | 1.7 | 1.7 | 1.8 | 1.7 | 1.6 | 1.8 | 1.7 | 1.8 | 1.8 |

Treatment group: Farms inside a park.
Synthetic parks:
Matched farms based on a SCM located within 20 km of the park.
Unmatched pool of farms (basis for synthetic parks): Unmatched farms located within 20 km of the park.

**Table 12**
Farm type weights for the synthetic parks of control group “narrow radius” (≤ 10 km from a park border).

| Farm type | Biosphere Reserve Entlebuch | | | Nature Park Gantrisch | | |
|---|---|---|---|---|---|---|
| | (a) Direct payments | (b) Income | (c) Revenues | (a) Direct payments | (b) Income | (c) Revenues |
| **Plain zone** | | | | | | |
| Dairy cows | 0.247 | 0.000 | 0.000 | 0.193 | 0.000 | 0.009 |
| Suckler cows | 0.330 | 0.000 | 0.170 | NA | NA | NA |
| Mixed cattle | – | – | – | NA | NA | NA |
| Combined dairy cows and arable crops | NA | NA | NA | 0.000 | 0.000 | 0.007 |
| Combined pigs and poultry | 0.000 | 0.000 | 0.091 | NA | NA | NA |
| Combined others | NA | NA | NA | 0.068 | 0.024 | 0.626 |
| **Hill zone** | | | | | | |
| Dairy cows | 0.000 | 0.000 | 0.382 | 0.115 | 0.503 | 0.147 |
| Suckler cows | 0.151 | 0.000 | 0.000 | NA | NA | NA |
| Mixed cattle | 0.017 | 0.000 | 0.124 | NA | NA | NA |
| Combined dairy cows and arable crops | NA | NA | NA | – | – | – |
| Combined pigs and poultry | 0.000 | 0.000 | 0.000 | NA | NA | NA |
| Combined others | NA | NA | NA | 0.000 | 0.000 | 0.134 |
| **Mountain zones** | | | | | | |
| Dairy cows | 0.132 | 0.453 | 0.000 | 0.000 | 0.000 | 0.002 |
| Suckler cows | 0.123 | 0.257 | 0.233 | NA | NA | NA |
| Mixed cattle | 0.000 | 0.000 | 0.000 | NA | NA | NA |
| Combined dairy cows and arable crops | NA | NA | NA | – | – | – |
| Combined pigs and poultry | 0.000 | 0.290 | 0.000 | NA | NA | NA |
| Combined others | NA | NA | NA | – | – | – |

NA: Farm type was unavailable as a control unit in the unbalanced panel dataset.
The dash (–) indicates that the farm type could not be considered using a SCM due to missing observations.

**Table 13**
Farm type weights for the synthetic parks (the control group “wide radius”).

| Farm type | Biosphere Reserve Entlebuch | | | Nature Park Gantrisch | | |
|---|---|---|---|---|---|---|
| Radius: ≤ 10 km | (a) Direct payments | (b) Income | (c) Revenues | (a) Direct payments | (b) Income | (c) Revenues |
| **Plain zone** | | | | | | |
| Dairy cows | 0.083 | 0.085 | 0.037 | 0.000 | 0.000 | 0.000 |
| Suckler cows | 0.218 | 0.087 | 0.255 | NA | NA | NA |
| Mixed cattle | – | – | – | NA | NA | NA |
| Combined dairy cows and arable crops | NA | NA | NA | – | – | – |
| Combined pigs and poultry | 0.014 | 0.000 | 0.000 | NA | NA | NA |
| Combined others | NA | NA | NA | 0.293 | 0.000 | 0.574 |
| **Hill zone** | | | | | | |
| Dairy cows | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Suckler cows | 0.001 | 0.000 | 0.007 | NA | NA | NA |
| Mixed cattle | 0.001 | 0.000 | 0.022 | NA | NA | NA |
| Combined dairy cows and arable crops | NA | NA | NA | – | – | – |
| Combined pigs and poultry | 0.050 | 0.000 | 0.000 | NA | NA | NA |
| Combined others | NA | NA | NA | 0.000 | 0.083 | 0.000 |
| **Mountain zones** | | | | | | |
| Dairy cows | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Suckler cows | 0.191 | 0.130 | 0.165 | NA | NA | NA |
| Mixed cattle | 0.001 | 0.000 | 0.000 | NA | NA | NA |
| Combined dairy cows and arable crops | NA | NA | NA | 0.000 | 0.000 | 0.000 |
| Combined pigs and poultry | 0.002 | 0.340 | 0.000 | NA | NA | NA |
| Combined others | NA | NA | NA | – | – | – |
| **Radius: > 10 km to ≤ 20 km** | **(a) Direct payments** | **(b) Income** | **(c) Revenues** | **(a) Direct payments** | **(b) Income** | **(c) Revenues** |

(*continued on next page*)

**Table 13** (*continued*)

| Farm type | Biosphere Reserve Entlebuch | | | Nature Park Gantrisch | | |
|---|---|---|---|---|---|---|
| Radius: ≤ 10 km | (a) Direct payments | (b) Income | (c) Revenues | (a) Direct payments | (b) Income | (c) Revenues |
| | | | **Plain zone** | | | |
| Dairy cows | 0.147 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Suckler cows | 0.001 | 0.000 | 0.000 | NA | NA | NA |
| Mixed cattle | – | – | – | NA | NA | NA |
| Combined dairy cows and arable crops | NA | NA | NA | 0.000 | 0.000 | 0.160 |
| Combined pigs and poultry | 0.006 | 0.000 | 0.150 | NA | NA | NA |
| Combined others | NA | NA | NA | 0.000 | 0.000 | 0.000 |
| | | | **Hill zone** | | | |
| Dairy cows | 0.002 | 0.000 | 0.000 | 0.097 | 0.661 | 0.000 |
| Suckler cows | 0.129 | 0.173 | 0.203 | NA | NA | NA |
| Mixed cattle | 0.001 | 0.000 | 0.000 | NA | NA | NA |
| Combined dairy cows and arable crops | NA | NA | NA | – | – | – |
| Combined pigs and poultry | 0.002 | 0.000 | 0.000 | NA | NA | NA |
| Combined others | NA | NA | NA | 0.283 | 0.145 | 0.000 |
| | | | **Mountain zones** | | | |
| Dairy cows | 0.002 | 0.109 | 0.000 | 0.327 | 0.087 | 0.266 |
| Suckler cows | 0.003 | 0.000 | 0.000 | NA | NA | NA |
| Mixed cattle | 0.140 | 0.077 | 0.159 | NA | NA | NA |
| Combined dairy cows and arable crops | NA | NA | NA | – | – | – |
| Combined pigs and poultry | – | – | – | NA | NA | NA |
| Combined others | NA | NA | NA | – | – | – |

NA: Farm type was unavailable as a control unit within the unbalanced panel dataset.
The dash (–) indicates that the farm type could not be considered in the SCM due to missing observations.

**Table 14**
Results from the difference-in-differences analysis based on the SCM time series dataset (the control group "wide radius").

| Statistic | Biosphere Reserve Entlebuch | | | Nature Park Gantrisch | | |
|---|---|---|---|---|---|---|
| | (a) Direct payments | (b) Income | (c) Total revenues | (a) Direct payments | (b) Income | (c) Total revenues |
| ATT | 0.097 | 0.739 | − 0.301 | − 0.044 | − 3.196 | 1.097 * * |
| | (0.069) | (1.880) | (0.289) | (0.163) | (4.063) | (0.386) |
| $N$ | 22 | 22 | 22 | 22 | 22 | 22 |
| $R^2$ | 0.395 | 0.796 | 0.204 | 0.783 | 0.436 | 0.555 |
| Alternative model | No | Yes | No | Yes | No | No |

ATT: Average treatment effect on the treated.
* $p \leq 0.1$; * * $p \leq 0.05$; * ** $p \leq 0.01$.
Robust standard errors are in parentheses.

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