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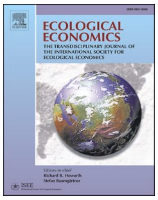

Analysis

Conservation Costs Drive Enrolment in Agglomeration Bonus Scheme

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ABSTRACT

Agglomeration bonus schemes have become important policy tools when the environmental benefit hinges on spatial coordination of conservation sites. We here analyse how spatial factors affect the uptake of an agglomeration payment scheme in a Swiss mountain region, which seeks to establish a network of conservation areas to conserve favourable conditions for biodiversity. We use a combination of spatially explicit farm census (44,279 parcels) and survey data in a spatially lagged explanatory variable model. In addition, we also consider the collaborative process in establishing the eligibility of parcels for receiving the bonus payment. We find that parcels that are more distant from the farm as well as those at steeper slopes are more likely to enter the scheme. This implies that conservation costs are an important driver of the farmers' decisions. The results remain robust when controlling for a wide range of parcel, farm and farmers' characteristics. The analysis also showed that the collaborative process increased the enrolment of parcels cultivated by larger farmers managing their land more intensively. We conclude that the collaborative process increased the weight given to biodiversity from connecting conservation sites in the planning process of the agglomeration bonus scheme.

1. Introduction

Agri-environmental policy schemes usually rely on measures at the farm-level, ranging from regulatory instruments such as input standards to economic instruments including subsidies (DeBoe, 2020). While some biodiversity conservation targets can be addressed locally at farm-levels, others require spatial coordination and cooperation at landscape scales to be effective. Examples for the latter are biospheres, or habitats for seasonally migrating amphibians, or specialist butterflies and birds (Brückmann et al., 2010; Franks, 2011; Goldman et al., 2007; Morelli et al., 2017; Sayer et al., 2013; Zhang et al., 2007; Zingg et al., 2019). When spatial coordination of conservation sites matters, implementing instruments on individual farms in a piece-meal fashion is likely to limit their effectiveness (e.g. Kuhfuss et al., 2019; Manning et al., 2018). In this context, agglomeration bonus payments have been suggested as a useful instrument to support landscape scale biodiversity conservation (Parkhurst and Shogren, 2007; Parkhurst et al., 2002).

We here analyse how spatial factors related to farmers' opportunity costs affect the uptake of an agglomeration payment scheme in a Swiss mountain region. To this end, we combine spatially explicit farm census data and survey data on farmers' environmental awareness in a spatial econometric approach to assess the effect of spatial characteristics and non-spatial factors on the uptake of the scheme.

Previous research has shown that agri-environmental schemes are often ineffective because individual farms implement a specific scheme, while the ecological benefit should emerge on the landscape scale (e.g. Kuhfuss et al., 2019; Manning et al., 2018). Thus, spatially coordinating adoption of agri-environmental schemes could enhance the ecological value on a landscape level (e.g. Mitchell et al., 2013; Tscharntke et al., 2012; Westerink et al., 2017). To achieve this coordination, agglomeration bonus payments are offered to the adopter of an agri-environmental scheme if sufficient spatially proximate land parcels are enrolled in the same scheme (e.g. Parkhurst and Shogren, 2007; Parkhurst et al., 2002; Wätzold and Drechsler, 2014). This allows to reduce the fragmentation of conservation sites and increase the probability of species movement across habitats and thus support landscape-moderated biodiversity patterns and processes (e.g., movement of subpopulations between or species exploitation of resources from different habitat patches; see Tscharntke et al., 2012). Theoretical and experimental research has shown that the success of such schemes in general

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depends on farmers' individual characteristics, on field and farm characteristics, social norms and on the specific design of the instrument (Bell et al., 2016; Chen et al., 2009; Drechsler et al., 2010; Lewis et al., 2011; Parkhurst and Shogren, 2007; Vaissière et al., 2018; Wätzold and Drechsler, 2014; Westerink et al., 2017). While the insights of these studies provide an important background for the design of agglomeration payment schemes, empirical assessments of such schemes are still rare (Krämer and Wätzold, 2018; Shimada, 2020; Toderi et al., 2017). In addition, agglomeration bonus payments are usually implemented via a collaborative process and depend critically on the level of coordination between the farmers and other stakeholders (e.g. Banerjee et al., 2017; Drechsler, 2017; Kuhfuss et al., 2016). Thus, spatial factors influence the uptake of an agglomeration bonus payment on two levels: Firstly, in the collaborative planning process that defines the area eligible in the scheme and, secondly, in the farmers' decision regarding which parcels to actually enrol in the agglomeration bonus scheme. To our knowledge, there is so far no empirical research that addresses this twofold role of spatial factors in the adoption of an agglomeration bonus scheme.

To address this research gap, we analyse an existing agglomeration bonus scheme in Switzerland. In this scheme, farmers receive an additional payment if they enrol land in a biodiversity conservation scheme based on a project plan that spatially coordinates the allocation of parcels to support biodiversity on a landscape scale. We combine parcel characteristics (number of parcels $n = 44{,}279$) such as the parcels' size, steepness and the distance to the farm, with farm characteristics such as farm size, land-use intensity and part-time farming and farmers' characteristics such as age and environmental awareness as well as spatial information of parcel eligibility in agglomeration projects. This broad set of environmental and socio-economic data allows us to account for the twofold role of spatial characteristics in agglomeration bonus schemes (i.e., their influence in the planning process and the actual enrolment on the farm level). We compare different spatially lagged explanatory variable models to assess the robustness of our results to a wide range of specifications. Our results extend existing research by an empirical estimation of the importance of spatial parcel characteristics in the development and adoption of agglomeration bonus payments in a multifunctional and heterogeneous landscape.

Our results show that the agglomeration bonus scheme increased the connectivity between biodiversity conservation areas in our case study region and thus effectively created a network of conservation areas. We also find that parcels that are more distant from the farm (i.e., the farmstead) as well as those at steeper slopes are more likely to enter the scheme. This implies that farmers' management costs are an important driver of the farmers' decision on which parcel to enrol in an agglomeration scheme. This result remains robust independent of whether we consider the collaborative process or not. With respect to the process, our analysis also showed that the collaborative planning increased the enrolment of parcels cultivated by larger farmers managing their land more intensively. This provides an important basis for the further development and implementation of agglomeration bonus schemes.

The remainder of the paper is structured as follows. In the next section, we introduce the agglomeration bonus scheme in Switzerland. In Section 3, we first outline our conceptual model and then present our empirical estimation strategy. We present the case study region and data in Section 4. The results of our regression analysis are presented in Section 5. We discuss our results in the last section and conclude with policy implications of our study.

2. Policy Background

Agglomeration bonus payments are a policy option for agri-environmental programs that aim to create a spatially contiguous network of conservation sites. Farmers receive a bonus payment on top of the regular area payment if they designate land for conservation that is in close proximity to neighbours' conservation areas. In Switzerland, the government supports biodiversity conservation via a policy program called biodiversity promotion areas[1] that combines a payment for conservation habitats with an agglomeration bonus scheme (Mack et al., 2020). The underlying payment is an input-oriented agri-environmental scheme (i.e., farmers get a payment for managing land according to a specified practice that promotes biodiversity conservation). For example, a farmer gets a payment for a low intensive use of hay meadows. This means that a farmer is not allowed to cut the grass before June 15th (after date of flowering) nor to use fertilization on his grassland. On top of this payment, farmers get a bonus payment if they spatially coordinate the allocation of these biodiversity conservation area enrolled in the input-oriented scheme. The overall goal of the Swiss agglomeration bonus payment is to establish a network of conservation areas to conserve and foster favourable conditions for the distribution of flora and fauna species (BLW, 2015). Within the perimeter of an agglomeration project, farmers can sign a contract in which they commit to integrate their biodiversity promotion areas into a spatial conservation network. In exchange, they receive an agglomeration bonus. Since 2001, the total area included in the spatial conservation networks in Switzerland has steadily increased and covers almost 80% of the biodiversity promotion areas in 2018 (BLW, 2020).

To receive agglomeration bonus payments, farmers need to collaborate in a so-called agglomeration project that defines parcels' eligibility. Who is involved in defining the project can vary. Some projects are rather farmer driven while others were developed through collaborative planning involving farmers, members of the local communities, farm advisors and usually members of ecological planning firms (Jenny et al., 2018; Krämer and Wätzold, 2018). In either case, the project perimeter, its goals (e.g., a sufficiently large target area and the eligible measures funded in the project) need to be defined. The Federal Office for Agriculture has to approve all projects according to minimal standards for a set of objective indicators. Farmers must sign a contract in which they ensure the corresponding management for at least eight years.

While the project perimeter and the eligible measures are defined in the description of the agglomeration project, farmers are free to decide which parcels they actually enrol in the agglomeration bonus scheme. To enrol land for the agglomeration bonus, it is not necessary that parcel borders of biodiversity promotion areas are adjacent. It is rather key that a parcel is located in a surrounding with other suited parcels and or natural elements (forests, water bodies, etc.). This means that the general characteristics of proximate parcels are more important than the enrolment of a single, neighbouring parcel.

3. Method

3.1. Conceptual Model

We build on a model developed by Wätzold and Drechsler (2014) as conceptual background and to derive our hypotheses. A farmer will enrol a parcel, i, into a conservation network if the utility of doing so, π_i, is positive. Assume conservation cost is a function, $\alpha_i(X)$, that depends on a vector of farmer, farm and parcel characteristics, X, with elements $x_1, \ldots, x_n$. In a first stage, the farmer receives an input-oriented payment p, for enrolling the parcel in a conservation scheme. The additional agglomeration bonus is q. The utility function is then given by:

$$\pi_i = p - \alpha_i(X) + q\varphi_i(\beta(b_i, d_i, \alpha_i(X))) \tag{1}$$

The farmer receives the agglomeration bonus payment if the parcel is eligible for and enrolled in an agglomeration project (i.e., when the indicator function $\varphi_i(\cdot) = 1$). The eligibility function is given by $\beta(\cdot)$, which depends on specific biodiversity levels, b_i, the proximity to other

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[1] In Switzerland these schemes are called Biodiversitätsbeiträge (in German), Contributions à la biodiversité (in French), Contributi per la biodiversita (in Italian), contribuziuns da biodiversitad (Rumantsch).

conservation parcels, d_i, and conservation costs, $\alpha_i(X)$. For further specification of the eligibility function, an additive multi-attribute value function approach could be used, that assigns value functions and weights to each of the attributes biodiversity, distance and cost (Eisenführ et al., 2009). (More detail on this specification approach is provided in Appendix A.) The conceptual model reflects the twofold role of spatial characteristics in the uptake of the agglomeration bonus scheme. On the one hand, spatial characteristics directly affect the farmers' conservations costs $\alpha_i(X)$. While on the other hand, the spatial characteristics affect the eligibility function $\varphi_i(\cdot)$.

To develop hypotheses on our key question, the effect of farm and parcel characteristics on uptake, we investigate their marginal effect on utility:

$$\frac{\partial \pi_i}{\partial x_n} = -\frac{\partial \alpha_i}{\partial x_n} + q\frac{\partial \varphi_i}{\partial \beta}\frac{\partial \beta}{\partial \alpha_i}\frac{\partial \alpha_i}{\partial x_n} \tag{2}$$

Eq. (2) reveals that the marginal effect of a characteristic on conservation cost is reinforced by the marginal effect of the characteristic on the eligibility function. For example, take slope as parcel characteristic. The first term on the right-hand side (i.e., the marginal change of conservation costs) becomes negative if conservation cost decreases with increasing slope of terrain. By intuition this is due to lower opportunity cost in steep terrain. Considering the negative sign of the marginal cost changes, the effect on total utility becomes positive when slope increases. The second term reinforces this effect because eligibility will decrease with increasing marginal conservation cost. This is plausible because conservation efforts need to consider cost-effectiveness and, ceteris paribus, will target the least-cost selection of parcels.

The marginal effects of distance (Eq. (3)) and biodiversity values (Eq. (4)) on utility are:

$$\frac{\partial \pi_i}{\partial d_i} = q\frac{\partial \varphi_i}{\partial \beta}\frac{\partial \beta}{\partial d_i} \tag{3}$$

$$\frac{\partial \pi_i}{\partial b_i} = q\frac{\partial \varphi_i}{\partial \beta}\frac{\partial \beta}{\partial b_i} \tag{4}$$

Given that spatial connectivity is key in an agglomeration bonus scheme, we expect that the eligibility function prioritizes parcels with small distance to other conservation parcels, so that $\frac{\partial \beta}{\partial d_i} < 0$ and hence the overall marginal effect of distance between parcels on utility is negative. For biodiversity values we expect the opposite (i.e., a prioritization of high biodiversity values in the eligibility function), so that $\frac{\partial \beta}{\partial b_i} > 0$, and thus an overall positive marginal effect of biodiversity values on utility.

In a further specification of the eligibility function, e.g., as an additive multi-attribute value function, weights can be assigned to the different attributes (i.e., biodiversity, distance, and the conservation costs). We expect that if farmers specify and assign the weights on their own, they will give conservation costs comparatively more weight than biodiversity and distance. In the case in which it is done in a collaborative manner by farmers and conservation experts, we expect that biodiversity and proximity of conservation areas receive more, or at least equal, weight as conservation costs.

3.2. Econometric Framework

In our empirical analysis, we aim to identify factors determining whether the parcel is in the agglomeration project ($y = 1$) or not ($y = 0$). To this end, we estimate variations of the following core model:

$$\boldsymbol{y} = \boldsymbol{X_p}\boldsymbol{\beta_p} + \boldsymbol{X_n}\boldsymbol{\beta_n} + \boldsymbol{W}\boldsymbol{X_i}\boldsymbol{\theta} + \boldsymbol{\varepsilon} \tag{5}$$

where the parcel's characteristics $\mathbf{X_p}$, farm and farmer characteristics $\mathbf{X_n}$ as well as the participation of proximate parcels with $\mathbf{WX_i}$ are considered and $\boldsymbol{\varepsilon}$ is an error term. Parcel characteristics and farm level fixed effects represent conservation costs $\alpha_i(X)$. For the representation of the collaborative development of the agglomeration project, we use different specifications of the core model. The key challenge in our analysis is that the weightings in the eligibility function are not observable in our data. This means that we do not have information about the collective negotiations when defining the project perimeter. Parcels could be attributed to the agglomeration project only considering their suitability for enhancing biodiversity or considering only conservation costs or a mixture of both. This might create a selection bias in the agglomeration project. For example, the eligibility of parcels to be included in the agglomeration project could rely on conservation costs if only farmers are involved in this process. Such a selection bias would imply that only parcels with low opportunity costs enter the eligibility function. Moreover, other observables and unobservables may bias inference on enrolment determinants, e.g. characteristics of the decision maker.

To address this potential endogeneity of the parcel characteristics and the conservation reserve, we estimate different variations of the above model. We show the robustness of our key results to a wide range of specifications. In the first model, we assume that all parcels in the case study area are eligible for the agglomeration bonus payment but are more likely to be enrolled in the program with higher shares of proximate parcels that had already been enrolled in the input-oriented payment for biodiversity promotion areas p (Model 1). For this, we use a spatially lagged form of the conservation practice as explanatory variable (SLX model). This counterfactual approach implies that the weights in the eligibility function are solely put on conservation costs, constrained only by the proximity of already existing conservation areas. To account for the different parcel densities in the study region, we specify W as a binary k-nearest neighbour matrix. Here we chose $k = 5$ proximate parcels reflecting an average number of neighbouring parcels. Sensitivity results from relaxing this assumption are presented in Appendix B. We use WX_i as a control variable and expect the model to be robust to other numbers of k (LeSage and Pace, 2010; LeSage and Pace, 2014). We did not weight the neighbourhood matrix with the physical distance between parcels and only considered adjacent parcels. The reason is that larger parcels or natural elements between parcels (such as a mountain creek) would have influenced the weight of these parcels in the matrix even though there would be no relevant impact from a biodiversity perspective.

We extend our base specification (Model 1) by adding dummies for each individual agglomeration project developed in our case study region (Model 2). This accounts for the shared environment of these parcels, which increases the likelihood that the observations are not independent in space and that the error term is thus spatially correlated (e.g. Cliff and Ord, 1970). Therefore, we aim to reduce potential bias for omitted spatially correlated variables. We follow Storm and Heckelei (2018) and control not only for the participation of proximate parcels in a conservation program WX_i but also for spatially correlated errors on a higher spatial level (i.e., we control for the agglomeration projects associated with a parcel). Next, we also account for socio-economic variables, such as age and environmental awareness that might influence the utility from enrolling parcels into the agglomeration bonus scheme (Model 3). The sample size is however reduced for this specification because of missing data.

Finally, we chose a project centred approach (Model 4) and use only parcels that are effectively part of the agglomeration project. This means that we use the maps resulting from the collaboration between the farmers and the conservation experts which defined a conservation network plan specifying the actual eligibility of parcels (i.e., that belong to $\beta(\cdot)$). We do not have to control for spatial lags in this model since the plan defines the range of parcels that a farmer can choose to enrol in the agglomeration bonus scheme. Please note that more parcels are eligible than actually enrolled. Due to data limitations, this second approach focuses on one agglomeration project in our case study region and thus represents only a sub-set of the full data.

The comparison of these two approaches allows for a robust and meaningful assessment of the role of $\alpha_i(X)$ even if the true weightings for biodiversity from connecting conservation sites, distance and conservation costs in the eligibility function $\beta(\cdot)$ are unobservable. The R code used in our study is presented in the online Appendix C.

4. Case Study Region, Control Variables and Data

4.1. Case Study Region

This study focuses on the Saas and Matter valleys in the Canton of Valais, Switzerland. These steep V-shaped valleys are surrounded by a series of peaks higher than 4000 m elevation, isolating them east-west, as well as towards the south from Italy (Fig. 1). This typical European mountain region is characterized by a continental, inner-Alpine climate with moderate temperatures and comparably low precipitation (Brändle, 2019). The case study region can be seen as an exemplary case for small-scaled and diverse farming practices in a heterogeneous and multifunctional landscape of high biodiversity conservation potential (Huber et al., 2013).

According to the census data in 2016, there were 464 farms registered in the area, of which 73% participate in an agglomeration project. On average, farmers in the region currently cultivate less than 10 ha of agricultural land and house around seven livestock units. The main farming activity is the production of livestock based on grassland. There are only a few hectares of crops at the bottom of the valley. Part-time farming based on small livestock has become a widespread activity and regional tradition. The census dataset contains information about land use of each of the 44,279 parcels of farms in the case study region. 27% of the parcels are part of an agglomeration project. Fig. 1 gives an overview of the location of the parcels in the dataset, the parcels included in the scheme and the associated agglomeration projects as designed by the canton of Valais.

4.2. Variables

We use a set of farmer, farm and parcel characteristics to assess the role of conservation costs in agglomeration payment schemes. In line with our conceptual model, we present these factors in three groups: factors affecting profits, additional factors affecting farmers' participation decisions, and suitability for biodiversity conservation.

Plots' productivity is a key variable affecting profits. Low productivity has been associated to higher program uptake in France (Calvet et al., 2019). This is consistent with results of a pan-European analysis that show that location in less favourable farming areas increases the probability for program participation (Zimmermann and Britz, 2016). For the specific case of Switzerland, this association has been made with certain mountain zones that are defined by factors including slope and vegetation period (Mack et al., 2020). Apart from productivity, farm size and working time spent on the farm affect profits. Farm size is often measured in terms of area or gross margin. The pan-European study using gross margin as indicator for size finds a positive effect of size on the likelihood of participation in an agri-environmental policy (Zimmermann and Britz, 2016). Studies using area as indicator have revealed mixed results. Some, inter alia from Switzerland, find a positive effect (Cullen et al., 2020; Mack et al., 2020; Pavlis et al., 2016; Ruto and Garrod, 2009) while others have found a negative effect (Defrancesco et al., 2008). However, it is important to keep in mind that there is substantial variation across European countries in what is considered large which can limit the transferability of results. Farmers working part-time on their farms have often been found to be more likely to participate in agri-environmental programs (Lastra-Bravo et al., 2015; Mack et al., 2020). Explanations provided in the literature are that due to income diversification, they are less dependent on maximizing revenue on all of their agricultural area and they may be more capable of coping with the risks of uncertain environmental outcomes.

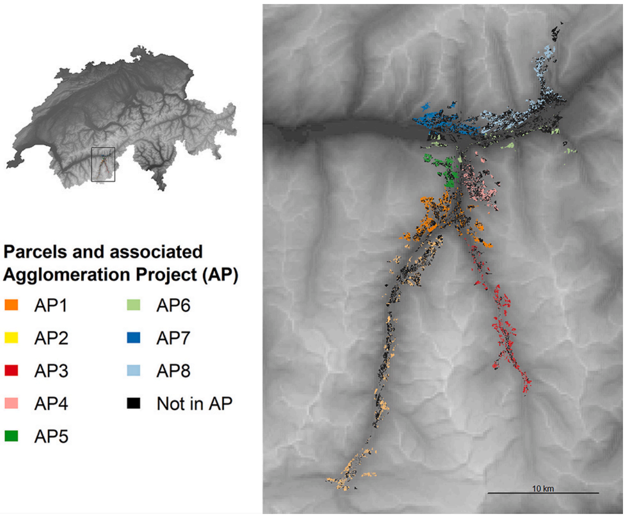

Fig. 1. Overview of the study region including eight agglomeration projects (AP) and the associated parcels. Black parcels are not enrolled in the Swiss biodiversity conservation program BFF (Data sources: Brändle, 2019 and Swisstopo).

Next to profits, many other socio-economic factors, such as farmers' age and environmental awareness can impact participation decisions. While age is often found to be negatively associated with agri-environmental program participation (Zimmermann and Britz, 2016; Lastra-Bravo et al., 2015), there are also contrary examples (Defrancesco et al., 2008). In some studies, environmental awareness has proven to increase the likelihood of program uptake, while in others there was no significant effect (Cullen et al., 2020; Defrancesco et al., 2008; Mettepenningen et al., 2013). Related to parcels, Calvet et al. (2019) find that pre-program conformity with program requirements and ease of implementation of required measures positively affected program uptake.

When farmers can individually decide which parcels to enrol in an agri-environmental program, their own assessment of biodiversity conservation suitability indeed plays a role (Cullen et al. 2020). Farmers naturally have in-depth knowledge of their parcels but identifying biodiversity at a regional scale can be intricate. Biodiversity levels typically are the result of complex relationships between various biotic, abiotic and land management factors. Relating to land management, management intensity has been found to be associated with species composition in Swiss sub-alpine regions. For example, meadows in agri-environmental schemes, which are subject to a late first cut and no or limited fertilising contribute to species richness (Kampmann et al., 2008). In contrast, more intensively managed grasslands (i.e., fertilized grassland with multiple cuts or a high stocking density) tend to have fewer species (Le Clec'h et al., 2019; Peter et al., 2008). For Swiss alpine summer pastures, livestock density was found to be negatively associated with biodiversity levels (Zabel, 2019). At the European scale, stocking density was found to negatively impact farmers' decisions to participate in agri-environmental programs (Zimmermann and Britz, 2016).

4.3. Data

We here combine data from three sources (see also Table 1): 1) farm census data from all farms in the case study region in 2011 and 2016[2] including information on spatially explicit parcel characteristics and

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[2] Please note that the agglomeration projects in our case study region were established before 2016.

Table 1
Description of variables.

	Description	Used in model*				Unit	Min	Max	Mean
		1	2	3	4				
Dependent variable									
	Parcel is enrolled in agglomeration project (=1) or not (=0)					0/1	0	1	0.27
Independent variable									
Parcel level: opportunity cost	Parcel size: Log parcel area	x	x	x	x	10 m^2 (ha)	1.79 (0.01)	12.56 (2.8)	6.66 (0.1)
	Distance Farm –Parcel: Log distance between parcel and farm	x	x	x	x	m (km)	0 (0.4)	10.17 (26.12)	6.89 (1.78)
	Parcel slope: Square root of the mean parcel slope	x	x	x	x	degree	0 (1.5)	8.33 (38.5)	4.45 (20.8)
Area: control for participation of other parcels in the area	Biodiversity promotion areas in the neighbourhood: Share of proximate parcels ($N = 5$) enrolled in an agri-environmental scheme	x	x	x		0/1	0	5	2.16
	Associated agglomeration project		x			Dummy variable (1–8)			
Farm control variables	Farm size: Log effective agricultural area of farm	x	x	x	x	ha	0.1 (0.3)	4.31 (74.7)	2.45 (15.5)
	Intensity: Factor for intensity of cattle farming	x	x	x	x	Factor (Livestock units)	0 (0)	11.9 (181)	0.44 (14.57)
	Part-time farming: Full time (=0) or part time (=1) farmer	x	x	x	x	0/1			1: 28,657 / 0: 18,563
	Environmental Awareness: Farmers' environmental awareness			x		Factor (1–5)	2.6	5	3.97
	Age of the farmer in 2016			x		years	25	64	47.11

* Model 1: Econometric model with spatially lagged form of the conservation practice as explanatory variable using all parcel data; Model 2: Spatially lagged econometric model (as Model 1) including spatially correlated errors on a higher spatial level (i.e., the project level) using all parcel data; Model 3: Model 1 including survey data (i.e., subset of parcel data for all farms that responded to the survey); Model 4: Econometric model with only eligible parcels but without spatially lagged explanatory variable (i.e., subset of parcel data for the agglomeration project 2). Full summary statistics is presented in the online Appendix C.

land-use type of 44,279 parcels (Brändle, 2019); 2) Spatially explicit information on effective parcel eligibility for the payment in one of the agglomeration bonus schemes in the perimeter for the agglomeration project AP 2 in the region Mattertal (Landplan 2016); 3) Survey data from before the launch of the agglomeration bonus program to consider farmers' individual characteristics such as age and environmental awareness (Brändle et al., 2015).

The survey data were collected between October 2011 to January 2012. We conducted both a mail survey ($n = 111$ i.e., 25% of all farms in the region) and 15 semi-structured interviews to collect data on farming objectives and farmer attitudes, for example on extensive land-uses. Data on attitudes was collected on five-point Likert scales. The environmental awareness variable used in this study results from the mean of five survey questions related to environmental awareness. 1) The importance of promoting and protecting biodiversity with agricultural activities, 2) the perception of biodiversity loss, 3) the satisfaction with the level of biodiversity on own fields, 4) their perceived impact on biodiversity and 5) whether they would promote biodiversity also without legal obligation (see Brändle et al., 2015 for details). The benefit of this variable is that it was collected before the implementation of the agglomeration bonus scheme. Thus, it is not affected by the collaborative planning process that might have influenced famers' environmental awareness.

The survey data were subsequently linked to agricultural farm census data. This resulted in a sub-set of the data that extended the available farm individual census data with farmer specific variables. We used information on the size of the parcel, the distance between parcel and farm as well as the mean parcel slope as characteristics of the parcels that affect farmers' conservation costs. For each farm, the data provided information about farm size in hectares, the type and number of animals, whether it was a full- or part-time farm enterprise and farmers' age. To meet the assumption of normally distributed error terms, we log- or square root transformed some of the variables. The variable *Intensity* results from a factor analysis of variables related to animal husbandry including the type of animals such as the number of cows, goats or sheep. The variable distinguishes between intensive cattle farms, extensive sheep farms and mixed cattle and sheep farms. *Distance Farm-Parcel* is the line between the parcel and the farm, calculated from their respective coordinates. Finally, we calculated a variable (Biodiversity promotion areas in neighbourhood) that reflects the distance between the parcels enrolled in an agri-environmental scheme before the creation of the agglomeration project plans. This variable is the weighted average of parcels in the agglomeration project among the k = 5 neighbours of each parcel.

5. Results

We find that the proximity to parcels already enrolled in a biodiversity conservation scheme is positively associated with enrolment in the agglomeration scheme. This implies that the agglomeration project in fact created a network between existing conservation areas. Controlling for spatially correlated errors on a higher spatial level in Model 2 did not affect magnitude and significance of coefficient estimates.

We also find a positive association between parcel characteristics and enrolment in the agglomeration project program in all four estimated models (Table 2). This implies that parcels that are more distant from the farm and parcels in steeper terrain are more likely to be enrolled in the agglomeration payment scheme. More distant and steeper parcels usually have higher cultivation and thus lower conservation costs. This suggest that farmers' opportunity costs are an important driver in the decision which parcels to enrol in such a program. In addition, parcels belonging to a larger farm are also more likely to be enrolled in the program in all four models.

The key finding of our analysis is that the importance of conservation costs remains stable across all model specifications. This suggests that our estimation of the effect of spatial parcel characteristics on the uptake of an agglomeration scheme is robust independent of whether we considered the distance between parcels already enrolled in an agri-environmental scheme as eligibility criteria (models 1–3) or whether we considered the actual eligibility in the project (model 4). The effect of

Table 2
Estimation results and comparison of models.

	Model 1		Model 2		Model 3		Model 4	
Intercept	−9.124	***	−8.880	***	−9.467	***	−11.034	***
	(0.383)		(0.401)		(1.403)		(1.014)	
Farm size	1.067	***	1.002	***	0.864	**	1.993	***
	(0.162)		(0.160)		(0.291)		(0.412)	
Intensity	−0.364	***	−0.328	**	−0.174		−0.427	
	(0.111)		(0.110)		(0.171)		(0.542)	
Part-time farming	−0.158		−0.140		−0.524		−1.035	
	(0.224)		(0.223)		(0.382)		(0.662)	
Parcel size	0.067	***	0.068	***	−0.021		−0.067	.
	(0.015)		(0.015)		(0.026)		(0.041)	
Distance farm - parcel	0.166	***	0.165	***	0.181	***	0.223	***
	(0.021)		(0.021)		(0.037)		(0.048)	
Parcel slope	0.251	***	0.254	***	0.248	***	0.971	***
	(0.018)		(0.018)		(0.031)		(0.044)	
Biodiversity promotion area in neighbourhood	0.870	***	0.868	***	0.884	***		
	(0.012)		(0.012)		(0.021)			
Environmental awareness					0.324	.		
					(0.238)			
Age					0.010			
					(0.015)			
Associated agglomeration project			Yes					

Signif. codes: '***' 0.001; '**' 0.01; '*' 0.05; '.' 0.1. Standard Errors in brackets. Estimates of dummy variables in Model 2 are shown in the online Appendix (C).

the parcels' mean slope even increases when considering only parcels that are actually eligible in the agglomeration project (Fig. 2). Thus, the weight of the conservation costs in the choice which parcel to enrol becomes even more important.

With respect to the role of the collaborative process in the agglomeration project, we find two opposite effects. On the one hand, we find that in our models 1 and 2, the size of the parcel is positively associated with enrolment in the agglomeration scheme. In the fourth model, the coefficient for the size of the parcel is negative and insignificant, implying that through the negotiation of the agglomeration project, larger parcels are not given particular preference in determining the project perimeter. On the other hand, the comparison between models that consider all parcels to be eligible (i.e., models 1–3) with the model that considers the actual project perimeter (model 4) also reveals that the negotiations of the agglomeration project might have increased the weight given to biodiversity from connecting conservation sites in the definition of the perimeter. This is implied by the result that the farms' intensity is negatively associated with the parcels membership in the agglomeration scheme when assuming all parcels would be eligible. This association is no longer significant in model 4. Thus, our results suggest that the negotiation process might have increased the pressure on farms with high cattle intensity to enrol parcels into the agglomeration scheme. In addition, the weight of the farm size also increased in the case that we only considered the eligible parcels (Model 4). This implies that larger farms became even more likely to enrol land into the agglomeration bonus scheme.

The consideration of regional dummy variables in Model 2 showed that there might be omitted spatially correlated variables that differentiate the agglomeration projects (see online Appendix). However, they had no influence on our main estimates. Including the socio-economic control variables part-time farming, age and environmental awareness in our Model 3 did not impact the estimates of the parcel

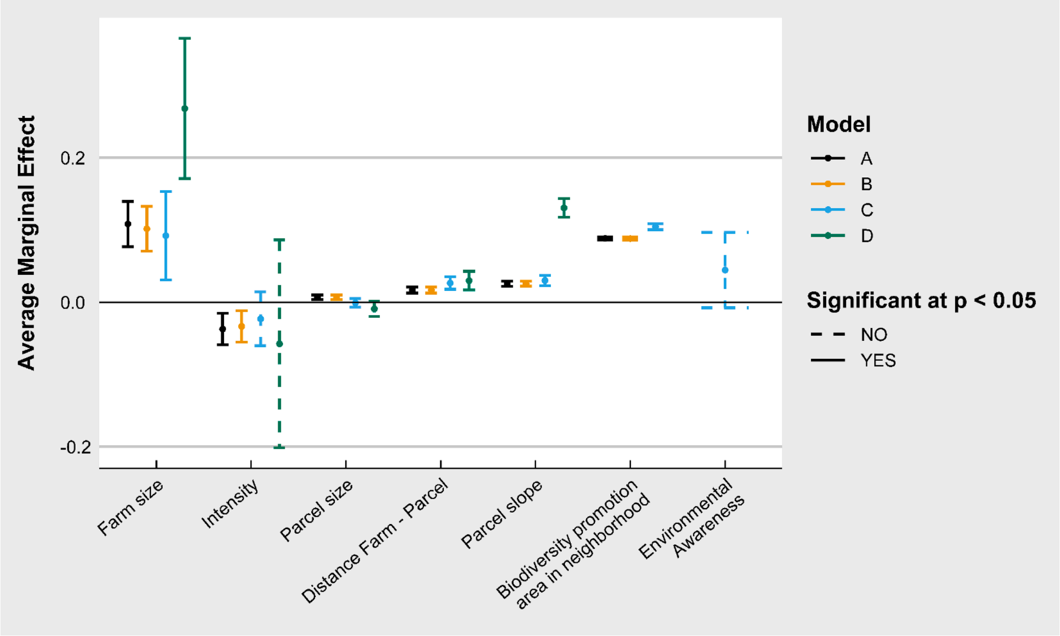

Fig. 2. Average marginal effects (AME) of parcel, neighbourhood and farm factors in models (BFF = Biodiversity promotion area in neighbourhood).

characteristics. Our results suggest that farmers with a more environmentally friendly attitude are more likely to enrol their parcels in the agglomeration scheme. This effect, however, is not significant at the 5% level which implies that also farmers that stated to be less concerned about the environment enrolled their parcels in the scheme. We found no association between enrolment and part-time farming as well as age.

6. Discussion and Conclusion

Agri-environmental schemes are key instruments for biodiversity conservation. These schemes are usually implemented at the farm level whereas the environmental benefit e.g. of biodiversity, emerges on the landscape scale (Tscharntke et al., 2012). Thus, a growing body of literature is dealing with novel instrument designs that incorporate spatial coordination and landscape scale cooperation (e.g. Engel, 2016).

We here assessed the role of spatial characteristics related to farmers' opportunity costs to the uptake of an agglomeration payment scheme in Switzerland. This scheme is based on a collaborative development of an agglomeration project involving farmers, members of the local communities, farm advisors and usually members of ecological planning firms. Based on the collaboratively developed plan, farmers can choose to enrol land in the scheme and receive a payment for low intensive management and an additional bonus for the contribution to a network of conservation areas.

Our results show that the collaborative agglomeration projects lead to a higher connectivity between the biodiversity conservation areas in our case study region and we find that parcels that are more distant from the farm as well as those at steeper slopes are more likely to enter the agglomeration scheme. Such a network of conservation areas is supposed to foster favourable conditions for the distribution of flora and fauna species (e.g., to increase the movement of subpopulation between habitat patches or to allow species to exploit resources from different habitats).

Our result holds independent of our estimation approach and implies that farmers' opportunity costs are an important driver of the farmers' decision which parcel to enrol in an agglomeration scheme. This is also in line with research on farmers motivation to enter agri-environmental schemes in general (e.g., Van Herzele et al., 2013). However, we are aware that also other behavioural factors such as cultural identity affect farmers decision to enrol a certain parcel into an agri-environmental scheme (Burton et al., 2020).

The differences between our counterfactual approach in which all parcels are potentially eligible and the approach in which only parcels in the network plan are eligible suggests that the collaborative process increased the likelihood that also larger farms with higher cattle intensity enrol land in the scheme. In contrast, the probability that larger parcels enter the scheme decreased. This proposes that the collaborative process had a corrective role towards more weight for the expected biodiversity from connecting biodiversity promotion areas compared to conservation costs. In this context, Krämer and Wätzold (2018) who qualitatively assessed three case studies of the agglomeration bonus in Switzerland concluded that the involvement of farmers in the management of agglomeration projects is a crucial component in increasing the quality of conservation areas. At the same time, another qualitative evaluation of the agglomeration bonus payment in Switzerland revealed that farmers often dominate the development of project perimeters and eligible measures (Jenny et al., 2018). Our empirical analysis confirms this ambivalent impact of the collaborative process on the successful implementation of agglomeration bonus payments in Switzerland.

Regarding policy, our results suggest that the collaborative development of agglomeration projects is beneficial to increase the weight given to biodiversity from connecting conservation sites in the planning process of bonus payment schemes. Without the input of local communities, farm advisors and usually members of ecological planning firms, farmers' conservation costs are the dominant factor in the choice of enrolling a parcel in the scheme. Thus, policy makers should try to increase the weight of biodiversity aspects in the collaborative spatial planning processes of agglomeration bonus payments. In addition, tailoring the bonus payment to the effective conservation costs in space (i.e., differentiate the bonus depending on the spatial characteristics of the parcel) could increase the efficiency of the scheme (e.g. Banerjee, 2018).

Further research could combine our analysis with more information about the negotiation process such as power relations in the negotiations, changes in environmental awareness, and the role of social norms (e.g., Chen et al., 2009; Toderi et al., 2017; Westerink et al., 2017). This would help to assess the external validity of our conceptual model and approach. In addition, the inclusion of data on the effective change of flora and fauna species would be an important next step to be able to assess also the additional effectiveness and efficiency of the scheme compared to other instruments supporting biodiversity in agricultural landscapes. Using more recent data could also help to identify mid and long-term effects of the agglomeration bonus scheme including spillover and leakage effects. Finally, we also acknowledge that our cases study region is specific to inner Alpine mountain regions. The region is a biodiversity hotspot and exhibits a large environmental heterogeneity creating also a high variability in conservation costs. The generalization of our results to regions with lower heterogeneity and different socio-economic environments is not straightforward. Thus, the application of the conceptual model and our empirical approach should be extended also to other regions to scale the knowledge about underlying factors that drive the enrolment of land into the agglomeration bonus scheme. This could provide important insights on how agri-environmental schemes can create environmental benefits on a landscape scale.

Source of Support

None.

Declaration of Competing Interest

The work described in the above-mentioned manuscript has not been published previously and is not under consideration for publication elsewhere. The manuscript is approved by all authors and by the responsible authorities. If accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

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Appendix A. Appendix

The eligibility function can be specified as an additive multi-attribute value function (Eisenführ et al., 2009):

$$\beta(X) = w_b\beta_b(b_i) + w_d\beta_d(d_i) + w_\alpha\beta_\alpha(\alpha(x_i))$$

which assigns a value to each parcel, X, in the project perimeter. Each parcel is characterized by a vector b_i, d_i, x_1, …, x_n indicating the levels of the relevant attributes, b_i, for biodiversity, d_i, for distance and x_1, …, $x_n$for cost. A normalized value function is assigned to each attribute: for biodiversity $\beta_b()$, for distance $\beta_d()$, and for cost $\beta_\alpha()$. In the model, the value function is determined either by the farmers in the project perimeter or in the more collaborative approach by the farmers together with other stakeholders. They also assign the weights which are given by w_b, w_d, w_α, with $w_b + w_d + w_\alpha = 1$.

We argue that the mutual preferential independence and difference independence conditions for this type of model are likely to hold. Subsets of the attributes are preferentially independent of the complementary subsets and the attribute value functions can be determined independently from one another. By intuition, this is because the objectives of cost efficiency, distance to structural elements and biodiversity levels are well-defined and independent and it is not plausible that e.g. the preference for a low cost plot changes with variation in the level of biodiversity. Note that preference independence does not call for statistical independence. The indicator function, φ_i, can then determine that all parcels, e.g., above a given threshold are eligible.

Appendix B. Appendix

Sensitivity analysis of regression results with increasing number of considered neighbours. A) Intensity; B) Farm size; C) Distance Farm –Parcel; D) Parcel slope; E) Parcel Size and F) Biodiversity promotion areas in the neighbourhood. y-axes show the average marginal effect and the standard error of the corresponding factor on the likelihood of being enrolled in the agglomeration bonus scheme. x-axes represent a k-nearest neighbour matrix with k = 1,2,…20. k = 1 implies that each parcel needs to be adjacent to a parcel that is already enrolled in an agri-environmental scheme. This, however, is neither prescribed in the scheme nor a useful specification of the neighbourhood matrix. The estimates remain robust with increasing values for k.

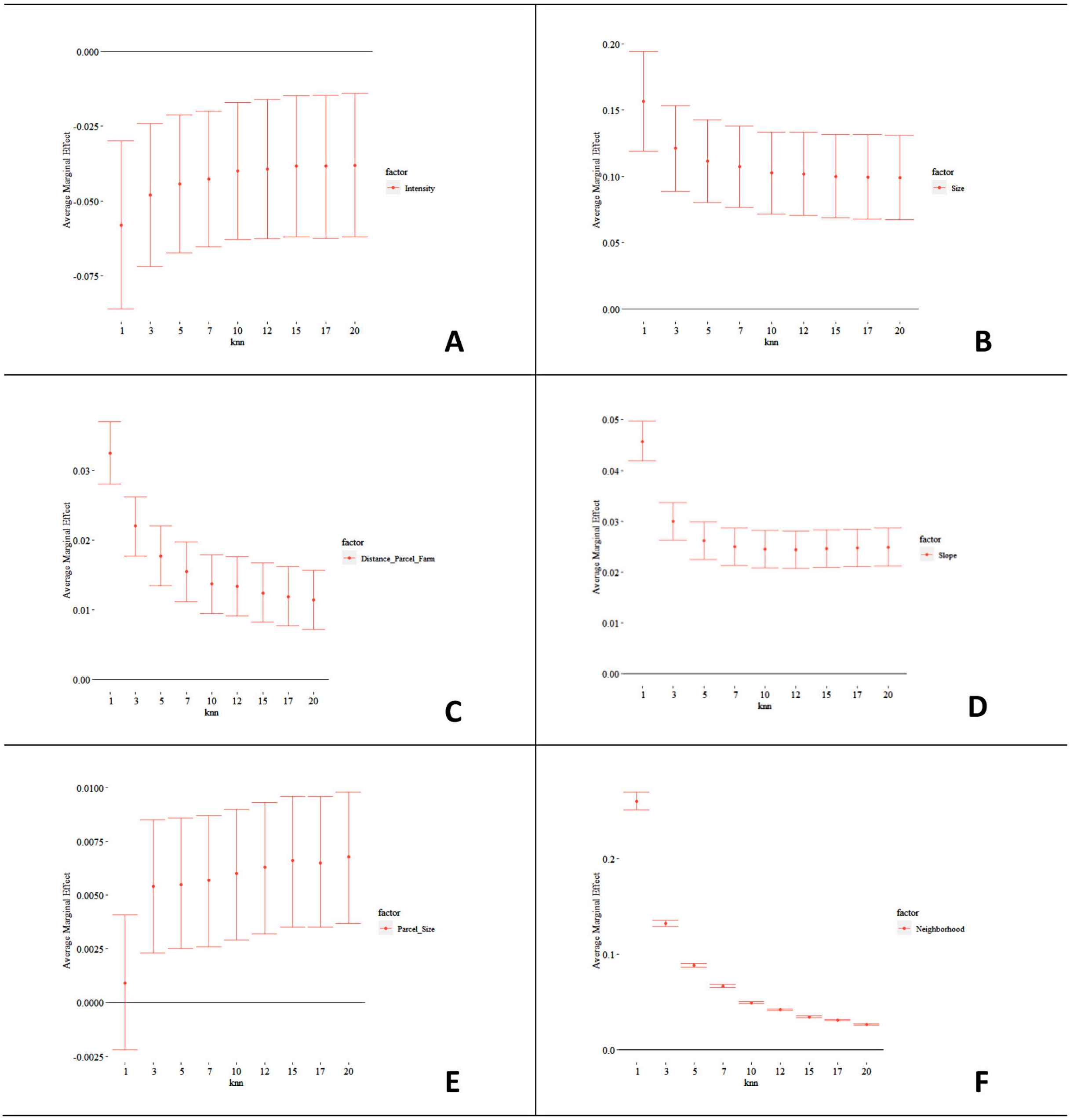

Fig. B.1. Average marginal effect of independent variables with increasing number of neighbours.

Appendix C. Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecolecon.2021.107064.

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