Land Use Policy 87 (2019) 104013

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

The impact of Natura 2000 designation on agricultural land rents in Germany

Dieter Koemle[a,b], Sebastian Lakner[a], Xiaohua Yu[a,*]

[a] University of Goettingen, Department of Agricultural Economics and Rural Development, Platz der Göttinger Sieben 5, 37073 Göttingen, Germany
[b] Department of Biology and Ecology of Fishes, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Müggelseedamm 310, 12587 Berlin, Germany

ARTICLE INFO

Keywords:
Natura 2000
Agricultural land rent
Germany
Generalized propensity score
Zero-inflated beta model

ABSTRACT

Designation of Natura 2000 areas is a major cornerstone in the EU's biodiversity policy. However, it has triggered resistance from land users due to increased regulations on land use and related value change. This study first develops a theoretical model for rent change due to land regulation, and then empirically investigates whether farmland rents in Germany are affected by Natura 2000 designation. We use a matching procedure based on a zero-inflated beta generalized propensity score on German district level agricultural census data. Our results suggest that rental prices of grassland, arable land, and on average are affected negatively by Natura 2000.

1. Introduction

Regulations on land use and farming practice could change the land value. In order to reduce biodiversity loss in modern agro-ecosystems, the EU has introduced regulations to integrate the goals of the Bern Convention on Biodiversity into agricultural policy. Recent policy measures include the cross compliance and greening of Pillar 1 direct payments (Ciaian et al., 2012, 2014; Feichtinger and Salhofer, 2016; Pe'er et al., 2017), voluntary agri-environmental programs (Batáry et al., 2011; Besnard and Secondi, 2014; Keenleyside et al., 2014; Kilian et al., 2012), and the establishment of conservation strategies including financial compensations for extensive farming practices in environmentally sensitive areas (Olmeda et al., 2014). A central instrument for biodiversity protection and enhancement is the Natura 2000 network of protected areas throughout Europe (Lakner and Kleinknecht, 2013). Natura 2000 claims to be the largest international network of protected sites[1] in the world, with 18% of the total EU land area and 6% of the EU's marine territory being set under Natura 2000 designation. Land designated to Natura 2000 plays a key role in ensuring the goals of the habitats and birds directives are met, so that "all habitats of community interest are maintained or restored to Favourable Conservation Status" (Gantioler et al., 2013; Olmeda et al., 2014). Once a site is designated, member states are required to manage and protect it in accordance with the terms of Article 6 of the habitats directive (European Commission, 2014).

Annexes I and II of the Habitats Directive respectively define the habitat types and the species intended for protection. Of the 198 habitat types specified by Annex I of the habitats directive, 63 have been found to depend on or profit from agricultural activities (Halada et al., 2011). Twenty-eight habitat types can be threatened by the abandonment of low intensity agriculture (Ostermann, 1998). With the extension of the Natura 2000 network, policy makers are faced with trading off the interests of conservationists against other types of land users, particularly farmers (Geitzenauer et al., 2016). While some EU countries have designated sufficient areas as Natura 2000 sites, others have been mandated by the European Commission to nominate additional sites.

Besides its ecological impacts, the designation of Natura 2000 sites may also considerably alter economic conditions for land users. Policies related to land use may have a particularly strong impact on land prices due to the low supply elasticity of land (Floyd, 1965). For example, the CAP (Common Agricultural Policy) direct payments consisting of coupled, decoupled, and environmental payments, theoretically may increase land prices considerably (Feichtinger and Salhofer, 2016; Kilian et al., 2012; Klaiber et al., 2017; Michalek et al., 2014), particularly when there is a surplus of entitlements[2] (Ciaian et al., 2014). However, the empirical evidence is mixed, and other authors find little or no

* Corresponding author at: University of Goettingen, Department of Agricultural Economics and Rural Development, Platz der Goettinger Sieben 5, 37073 Göttinger, Germany.

E-mail addresses: koemle@igb-berlin.de (D. Koemle), slakner@gwdg.de (S. Lakner), xyu@gwdg.de (X. Yu).

[1] Natura 2000 sites include Special Protection Areas (SPAs) according to the Birds Directive (79/409/EEC) and Special Areas of Conservation (SACs) according to the Habitats Directive (92/43/EEC).

[2] To receive Pillar 1 direct payments for one hectare of land, farmers need entitlements for that hectare. Surplus of entitlements means that a farmer has more entitlements than hectares.

https://doi.org/10.1016/j.landusepol.2019.05.032
Received 10 November 2018; Received in revised form 17 February 2019; Accepted 21 May 2019
0264-8377/

direct relationship between land prices and various forms of direct payments (Guastella et al., 2014). Ciaian et al. (2012, 2014) present a conceptual model explaining how cross compliance measures reduce farmers' total benefits from subsidies and therefore the capitalization of the pillar 1 payments into land values. Kilian et al. (2012) confirm findings by Goodwin et al. (2003) that subsidies for agri-environmental programs may not or even negatively affect land rents, as farmers face additional costs to keep up higher environmental standards. Land subject to Natura 2000 designation is automatically subject to the rule of no deterioration (Art. 6(2) of the Habitats Directive), and therefore may decrease farmers' flexibility in input use. A suboptimal input mix will necessarily lead to profit losses if imposed production constraints are not sufficiently compensated. Letort and Temesgen (2014) provide evidence of decreases in land prices in the Bretagne region, France, for water protection policies.

According to Corine Land Cover (CLC) 2012 data, farmland accounts for 34% of total Natura 2000 land area in Germany. While agricultural land has been declining, the percentage of forests inside Natura 2000 sites has increased over the time-frame 1990–2012. Because extensive livestock management and other low-intensity farming practices required by Natura 2000 have become unprofitable, key farmland habitats and species of community interest are under pressure. Germany has therefore picked up the EU's offer to subsidize farmers in designated sites through the rural development fund (pillar 2) of the Common Agricultural Policy.

The land use change under the Natura 2000 regulation might be linked to land value change. It is important to understand how the change impacts the land value, as this is related to the effectiveness of the economic compensation in the policy. By using regional aggregate data and a generalized propensity score matching procedure, we empirically study the link between land rental prices and the share of farmland on Natura 2000 sites. While others have studied the effects of subsidies in general (Feichtinger and Salhofer, 2013), agri-environmental programs (Goodwin et al., 2003; Kilian et al., 2012), or water conservation policies (Letort and Temesgen, 2014) on land prices, we specifically investigate the impact of a European conservation policy on land rental prices at the aggregate level. Knowledge about this relationship is important because Natura 2000 designation could affect many farmers across Europe. We specifically analyze the impact of Natura 2000 on farmland rents for average rent, grassland rent, and arable land rent separately.

2. Background

Germany has a total of 5206 designated Natura 2000 sites, 4557 of which are SACs (Special Areas of Conservation according to the Habitats Directive) and 742 are SPAs (Special Protection Areas according to the Birds Directive). Combined, they cover 15.4% of the terrestrial area and 45% of marine areas. Although EU countries were supposed to report designated sites to the EU Commission three years after the Habitats Directive went into force in 1992, by 1995 Germany had not reported a single site. Following a series of legal claims at the European Court of Justice, Germany reported sufficient Natura 2000 sites by 2005, and the Commission dropped any legal claims that were still pending. Well-known Natura 2000 sites in Germany include the Harz Mountains, the Lüneburg Heath, and the Black Forest in the South.

Problems with delayed implementation of Natura 2000 sites are not specific to Germany. A summary of several implementation difficulties is provided by Geitzenauer et al. (2016), who summarized implementation processes according to (a) institutional capacities, (b) the pressure for institutional change, and (c) the role of actors (authorities, environmental NGOs, and landowners). Implementation was slow not only due to lack of funding and lack of data, but also because farmers and landowners protested designation, as many of them feared losses in land values and production constraints. Local stakeholders were also concerned regarding the lack of involvement of local interest groups in the designation process (Geitzenauer et al., 2016). As Rauschmayer et al. (2009) point out, participation in German site designation was largely restricted to public consultation processes, or to gain information on specific sites. In most cases, however, site designation was based on a top-down technocratic approach. On the other hand, in cases where public participation was encouraged, researchers noticed "participation fatigue" of stakeholders who stopped participating after finding that their expertise was not considered in the designation process (Sauer et al., 2005).

Regulations for Natura 2000 sites enter agricultural policy through both pillars of the Common Agricultural Policy (CAP). First, cross compliance (CC) standards are usually higher in Natura 2000 areas than outside. Second, Article 38 of Council Regulation (EC) No 1698/2005 (European Agricultural Fund for Rural Development, EAFRD) establishes the framework for compensation of farmers directly affected by the Birds Directive and the Habitats Directive. Payments for conservation in sensitive areas may be channeled through voluntary agri-environmental programs (AEPs; EAFRD Code 214). However, these payments may be reduced inside protected areas in case requirements overlap with elevated CC requirements. Third, land that is protected by national and regional protective measures (e.g. "Natuschutzgebietsverordnung") can be additionally funded through the second pillar measure "Natura 2000 payments" (EAFRD Code 213) (Reiter and Sander, 2010). Participating farmers are to refrain from removing landscape elements and breeding sites of bird species, and they need permissions when implementing changes in the terrain or measures that affect the water balance. Further, farmers may be affected by hunting regulations and restrictions in planting non-local plants.

Natura 2000 designation and its integration into rural development programs are handled by the German states ("Bundesländer"). Therefore, it is up to the states whether they grant subsidies to farmers in Natura 2000 areas or not. For the programming period of 2007–2013, six states chose not to pay any subsidies for EAFRD Code 213. One of these six states, Saxony, did provide additional payments for Natura 2000 farming via the agri-environmental program Code 214. Also, participation in subsidized Natura 2000 farming was voluntary in the states of Saxony and Bavaria, while it was mandatory in all other states whether subsidies were paid or not. An additional complication of Bavaria was the substantial overlap between 213 and 214 measures, making it difficult to identify which farms or regions received money for farming in Natura 2000 areas. The remaining ten states paid a total of 119 million € in subsidies via Code 213, with the maximum amount of 31.2€ million paid by Brandenburg and Berlin combined, and the lowest amount by Hesse (2.1 million €) (Table 1). Payments were primarily focused on grasslands, but some states also subsidized extensively managed arable land. In the state of Lower Saxony, payments were only granted if the farmed land was protected according to state legislation in addition to Natura 2000 (Reiter and Sander, 2010; Tietz et al., 2007). In the state of Schleswig-Holstein, all Natura 2000 agricultural areas were subsidized with 80€ per hectare per year, while most other states had differentiated payments depending on the severity of the production impairment. Fig. 1 shows where farms receiving payments in Natura 2000 are concentrated in Germany. Of particular notice is the Schwarzwald (black forest) in the South-West, the Lüneburg Heath and wetlands along the river Elbe to the south of Hamburg, protected areas in the Ruhrpott region, as well as protected areas to the east of Berlin.

3. Theoretical framework

3.1. Basic model

In the classical economic literature, without regulation, land is assumed to be freely used to maximize its profit. Land market values therefore reflect the marginal revenue of production. Regulating the use

Table 1
Summary of EAFRD Code 213 payments in the German States for farming in Natura 2000 areas for the 2007–2013 programming period (Sources: State Rural Development Programs and their evaluation reports).

State[a]	Budget[b]	Area	Farms	Details	Premium
Baden-Württemberg	€ 7.91 Mio	8,385 ha	3043	• Extensive use of semi-natural dry grasslands (Code 6210), species-rich Nardus grasslands (Code 6230) and milinia meadows on calcareous, peaty and clayey-silt-laden soils (Code 6410) • Extensive use (grazing) of European dry heaths (Code 4030), Juniperus communis formations on heaths or calcareous grasslands (Code 5130), Xeric sand calcareous grasslands (Code 6120), of semi-natural dry grasslands (Code 6210), and species-rich Nardus grasslands (Code 6230)	50–200 €/ha
Bavaria	€ 2.60 Mio	883 ha	338	• Voluntary participation • Restrictions in the application of mineral fertilizers and chemical pesticides on arable land • Grassland – Extensive mowing – Restriction on mineral fertilizers and chemical pesticides – Restriction on organic fertilizers excluding solid dung • ponds	85–470 €/ha
Brandenburg/ Berlin	€ 31.20 Mio	38,819 ha	594	• Grassland – Extensive use of grassland – Late and constrained use of grassland – Conservation of wetlands • Extensive production methods on arable land	30–200 €/ha
Hesse	€ 2.10 Mio	3,904 ha	509	• Only on grassland • No chemical-synthetic pesticides and fertilizers • No irrigation and land development • Conduct agricultural use at least once a year • Other regulations regarding time of mowing etc.	200 €/ha
Lower Saxony and Bremen	€ 17.57 Mio	21,056 ha	1826	• Payment levels are based on the production handicap • Constraints – No machine tillage from March 1 to June 15 – No conversion of grassland to arable land – no fertilization – 2.5 m grassy margins	33–874.5 €/ha
Northrhine-Westphalia	€ 21.20 Mio	35,349 ha	5316	• Payments for permanent grasslands inside SACs and SPAs • Payment level and constraints depending on protection level (high, medium, low) • Constraints – No conversion of grasslands to arable land – No drainage – No removing of biotopes and other habitat features – Protection of relief features	36–98 €/ha
Saxony-Anhalt	€ 23.29 Mio	27,217 ha	444	• No fertilization on grassland • Constraints on the use of fertilizers, pesticides, and tillage methods • Hamster protection	8–199 €/ha
Schleswig-Holstein	€ 13.3 Mio	18,277 ha	1196	• No deep tillage on grasslands • No drainage • No removal of traditional “Beet-Graben-Systems”	80 or 150 €/ha

[a] The states of Hamburg, Mecklenburg-Vorpommern, Rheinland-Pfalz, and Thuringia did not participate in EAFRD Code 213. The state of Saxony paid Natura 2000 subsidies for voluntary farmer participation via the agri-environmental programs EAFRD Code 214.
[b] Budget for the entire programming period 2007–2013 according to ex-post evaluation reports.

of land through policies such as environmental zoning (e.g. Natura 2000), however, would change the rent due to less choice, even though there is some compensation. Farmland rent r enters a farmer's profit function π as an input cost on land L:

$$\pi = f(L, N(L)) + v(N(L)) - \sum_i w_i x_i(N(L)) - \mathrm{rL} \tag{1}$$

where $f(L, N(L))$ is the total revenue from production and non-Natura 2000 related subsidies, v is the subsidy for Natura 2000 land and N is an indicator of Natura 2000 farmland, x_i are other inputs and w_i is the marginal cost of x_i. We assume that input costs are exogenous, but input use is related to Natura 2000 farmland. The farmer maximizes profit by setting the marginal profit of each input to zero. Partially differentiating the profit function with respect to land and setting zero yields

$$r = \frac{\partial f(L, N)}{\partial L} + \frac{\partial f(L, N)}{\partial N}\frac{\partial N}{\partial L} + \frac{\partial v}{\partial N}\frac{\partial N}{\partial L} - \sum_i w_i\left(\frac{\partial x_i}{\partial N}\frac{\partial N}{\partial L}\right)$$

or

$$r = \frac{\partial f(L, N)}{\partial L} + \left[\frac{\partial f(L, N)}{\partial N} + \frac{\partial v}{\partial N} - \sum_i \frac{\partial x_i}{\partial N} w_i\right]\frac{\partial N}{\partial L} \tag{2}$$

Rent is therefore described by two components, the marginal revenue of land $\frac{\partial f(L,N)}{\partial L} > 0$, and the effect of Natura 2000, $\left[\frac{\partial f(L,N)}{\partial N} + \frac{\partial v}{\partial N} - \sum_i \frac{\partial x_i}{\partial N} w_i\right]\frac{\partial N}{\partial L}$.

$\frac{\partial f(L,N)}{\partial N} < 0$: it is plausible that Natura 2000 designation reduces the marginal productivity and therefore marginal revenue of land, given unchanged output prices. We name this effect the revenue effect of Natura 2000.

$\frac{\partial v}{\partial N}$ could be positive or negative. We name this the subsidy effect of Natura 2000. As v is the total payment per farm, a positive sign would mean that the per-farm payment increases as designated farmland increases. A negative sign would suggest the opposite.

The sign of $\frac{\partial x_i}{\partial N}$ will depend on the specific input. For example, it could be negative regarding the use of synthetic fertilizers, while it may be positive for labor. We call this term the input effect.

Finally, the sign of $\frac{\partial N}{\partial L}$ is likely to be positive. This means that a larger farm size is associated with a higher share of Natura 2000 farmland. Intuitively, if a farmer owns more land, the chance of owning

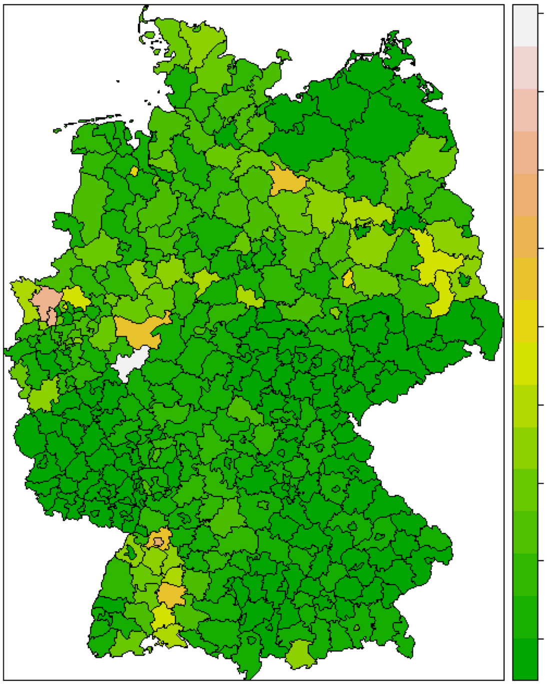

Fig. 1. Share of farms receiving funding for Natura 2000 farming in German districts in 2010.

some land on protected land should also be higher.

The overall effect of Natura 2000 at the farm level will therefore depend on whether the sign of the aggregate components in the brackets of Eq. (2) is positive or negative. According to the arguments outlined above, it will be negative as long as reductions in input costs do not outweigh the (negative) productivity and subsidy effects. It will be zero, if the effects compensate each other exactly.

3.2. The effect of Natura 2000 designation on average rent

In the empirical part of this paper, we study the effect of Natura 2000 designation on district average rent. From our derivation above, the average rent within a district is

$$\frac{1}{F}\sum_j r_j = \frac{1}{F}\sum_j\left[\frac{\partial f_j(L,N)}{\partial L} + \left(\frac{\partial f_j(L,N)}{\partial N} + \frac{\partial v_j}{\partial N} - \sum_i \frac{\partial x_{ij}}{\partial N} w_{ij}\right)\frac{\partial N}{\partial L}\right] \tag{3}$$

where *j* indexes the individual farms and *F* is the total number of farms. We can now decompose (4) (3)explicitly into Natura 2000 farms (*FN*) and non-Natura 2000 farms (*FO*).

$$\frac{1}{F}\sum_j r_j = \frac{FN}{F}\left\{\frac{1}{FN}\sum_j\left[\frac{\partial f_j^N(L,N)}{\partial L} + \left(\frac{\partial f_j^N(L,N)}{\partial N} + \frac{\partial v_j^N}{\partial N} - \sum_i \frac{\partial x_{ij}^N}{\partial N} w_{ij}\right)\frac{\partial N}{\partial L}\right]\right\} + \frac{FO}{F}\left\{\frac{1}{FN}\sum_j \frac{1}{FO}\left[\frac{\partial f_j^O(L,N)}{\partial L} + \frac{\partial f_j^O(L,N)}{\partial N}\frac{\partial N}{\partial L}\right]\right\}$$

where $\frac{\partial f_j^O(L,N)}{\partial N}\frac{\partial N}{\partial L}$ is the revenue spillover effect of Natura 2000 designation on those farms that are not in any designated site. For example, it could be the increased competition for non-designated land, which could lead to an increase in farmland rents. It would be negative if other components of revenue, e.g. other second pillar payments, are reduced due to more funding going to Natura 2000 farmers. We assume that other input costs for non-Natura 2000 farms remain unchanged.

To sum up, Natura 2000 farming could have a positive, as well as a negative effect on average land rental prices, and the sign depends on (1) the relationship between revenues, subsidies, and input adjustment of Natura 2000 farmers, as well as (2) possible spillover effects of Natura 2000 designation to non-Natura 2000 farmers.

To make the above descriptions more tractable, the mechanism is explained more clearly in Fig. 2. Similar to Michalek et al. (2014), the horizontal axis shows the total amount of farmland. From the left to X^N is farmland under Natura 2000, and from the right side to X^N is the amount of farmland without Natura 2000. On the vertical axes we show land rental price and subsidy. D_0^N and D_0^{other} respectively represent the demand curves for Natura 2000 and non-Natura 2000 (other) farmland *before* designation, and the rental price is R^*. After designation, the demand curve for Natura 2000 farmland could shift down to D_1^N, given the revenue effect E^{Rev}. If a subsidy for Natura 2000 farming is granted, the demand curve will shift up to D_1^{N+S}, the corresponding effect being E^{Sub} in Fig. 2. Non-Natura 2000 farmland now becomes more scarce, which could lead to an upward shift in its demand function (D_1^{other}). The

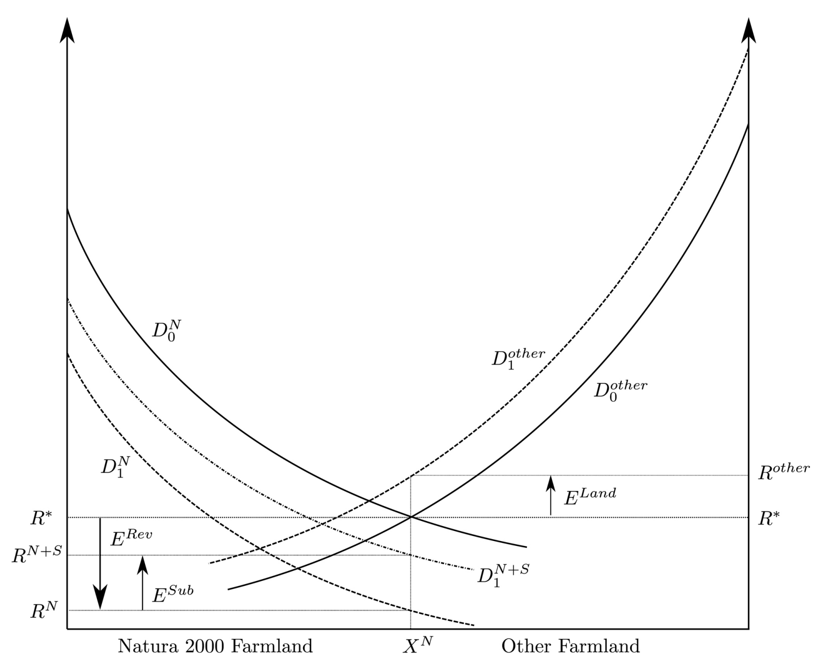

Fig. 2. The impact of Natura 2000 designation on farmland rental prices inside and outside Natura 2000 sites.

new average price is then a weighted average between R^N, R^{N+S}, and R^{other}. Depending on the ratio of Natura 2000 farmers and other farmers, it may be lower or higher than the original equilibrium price R^*.

4. Econometric models

Depending on the nature of the data, researchers have used several econometric methods to estimate the incidence of policy on land values. While standard OLS models often suffer from endogeneity problems (Goodwin et al., 2003), scholars have applied instrumental variable (IV) methods (e.g. Poudyal et al., 2009) or spatial regression techniques that may or may not include IVs (Letort and Temesgen, 2014; Feichtinger and Salhofer, 2016). While IVs can be used to correct for endogeneity, the identification relies on finding appropriate instruments (Michalek et al., 2014). In addition, in order to reduce the bias the researcher needs large quantities of data; in the face of weak instruments and small datasets, using IV can severely bias the estimated parameters (Wooldridge, 2010). An alternative approach used by Michalek et al. (2014) in the context of land values is based on treatment evaluation methods, namely the generalized propensity score method.

Similarly to other measures in agricultural policy, Natura 2000 farmland designation may not be random. As described above, the designation process follows several steps including local, national and EU levels of policy making. Nevertheless, the first step in Natura 2000 designation is the environmental quality of a potential site which houses habitats and species of community interest. Natural conditions will also shape the agricultural and political environment of a region, which in turn influences site designation. The decision whether to subsidize Natura 2000 farming through 2nd pillar payments is made at the state level. It is therefore likely that the effect of Natura 2000 farmland on land rental prices is confounded with the effect of natural, agricultural and political factors as is shown in Fig. 3. The analysis of the impact of Natura 2000 farming policy must therefore account for (1) the higher level political process of the Natura 2000 implementation strategy (i.e. the outcome of the rural development strategy), and (2) the actual outcome of the policy implementation (i.e. the number of Natura 2000 farms), and (3) the impact of designation on land rental prices. Therefore, if the impact of Natura 2000 farming on land prices is confounded with natural conditions and political and agricultural factors, standard regression analysis is not applicable and will produce biased results. A common method of controlling for confounding effects (i.e. to block the back-door paths shown in Fig. 3) is to use the propensity score.

With binary treatments, the model of choice for the propensity score is usually a probit or logit. For continuous treatments, Hirano and Imbens (2004) provide an estimation procedure based on the *generalized propensity score*. The Hirano and Imbens estimator requires weak unconfoundedness between the treatment and the outcome variable, given all observed explanatory variables. The generalized propensity score is defined as $r(t, x) = f_{T|X}(t|x)$, which describes the conditional density of treatment t given covariates x.

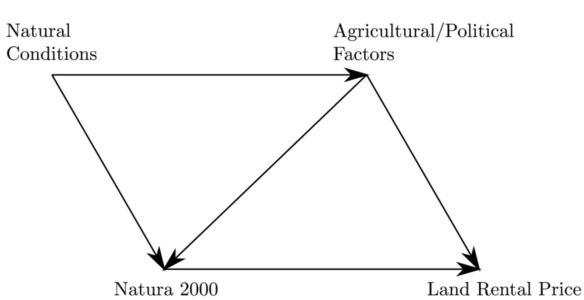

Fig. 3. Graph of the confounding relationships between natural conditions, agricultural factors, and Natura 2000 designation and their impact on land price.

Given our district-level data, there is a choice among several indicators that could be used to describe the intensity of Natura 2000 farming. In principle, data could be obtained from (1) the agricultural census, (b) the FADN (Farm Accountancy Data Network) dataset, or by combining CORINE land cover data with GIS maps from Natura 2000 sites. We experimented with indicators from all of these sources, and decided to use the share of farms receiving Natura 2000 related subsidies from the agricultural census at the district level. This is a relatively precise measure of the share of farmers that are actually affected by the policy. In contrast, the FADN data are not representative, although the results were similar. Finally, indicators based on CORINE land cover maps did not show enough precision to produce reliable estimates.

Our treatment variable has two complications compared to a standard continuous treatment, in that (1) is a proportion (i.e. between zero and one), and that (2) about one third of the observations is zero due to the reasons described above. A less-elegant method would be to use a binary model to estimate the propensity score based on the presence of absence of Natura 2000 farming. More elegantly, the zero-inflated beta model (Ospina and Ferrari, 2010, 2012b,a) can work with the properties of our data directly. The density function of the Beta distribution is a function of two parameters, μ with $0 < \mu < 1$, and $\phi > 0$:

$$f(N; \mu, \phi) = \frac{\Gamma(\phi)}{\Gamma(\mu\phi)\Gamma((1-\mu)\phi)} N^{\mu\phi-1}(1-N)^{(1-\mu)\phi-1}, \quad N \in (0, 1) \tag{4}$$

which is defined on the open interval (0, 1). μ denotes the expected value of the distribution N is the share of Natura 2000 farms, and ϕ is the precision parameter of the Beta distribution. Because the Beta distribution cannot be used to model proportional data that include zeros, Ospina and Ferrari propose a mixture of two models, in particular

$$\text{bi}_0(N; \alpha, \mu, \phi) = \begin{cases} \alpha & \text{if } N = 0 \\ (1-\alpha) f(N; \mu, \phi) & \text{if } N \in (0, 1) \end{cases} \tag{5}$$

where α is the probability density in case $N = 0$. Therefore, bi_0 models the conditional distribution of Natura 2000 farming in a district, given any covariates. The zero inflated Beta model has three parameters that can be modeled separately. First, α is modeled as a binary model, e.g. a logit. Similarly, μ is also modeled using a logit specification. Finally, ϕ is modeled using a log transformation of a linear model, which ensures positivity. Each partial model in the zero inflated Beta model can be defined separately, however, for consistency, we use the same covariates in the logit models and assume that the precision parameter is constant.

Imbens and Hirano (2004) stress that the overlap conditions given the covariates have to be maintained in order to produce reliable estimates. Schafer (2015) implements a procedure in `R` named `overlap_fun()` that balances the covariate overlap within the dataset based on the generalized propensity score. We adapted this procedure to work with the zero inflated Beta estimation function written by Ospina (Ospina and Ferrari, 2010) and included in the `gamlss` package (Stasinopoulos et al., 2017; Rigby and Stasinopoulos, 2005). To check for covariate balance after matching, we adopted the procedure of Imbens and Hirano (2004) by discretizing on three treatment groups and five GPS groups, to see whether there were significant differences between three classes of treatment. Table 2 presents the t-statistics of comparisons among three treatment groups after applying the matching procedure. In particular, each t-statistic tests whether the mean difference of the variable in question in one treatment group vs. the combination of the two other treatment groups is significantly different from zero. Only four t-statistics are significant at the 5% level (share of agricultural GDP in 1999, average altitude, and average farm size), which makes us optimistic that the matching procedure based on the generalized propensity score has worked reasonably well.

Table 2
t-Statistics comparing three treatment level groups after matching.

	Group 1	Group 2	Group 3
Median Share of Natura 2000 farming	0.000	0.009	0.072
Covariates		*t*-Statistics	
Average Rent 1999	0.069	1.007	−1.755
Grassland Rent 1999	−0.282	0.867	−0.897
Arable Land Rent 1999	−0.224	1.217	−1.576
% Green Party	−1.755	2.952	−1.877
Share Grassland 1999	0.307	0.022	−0.276
Share Arable Land 1999	−0.539	0.047	0.583
Share Agr. GDP 1999	−2.69	2.744	−0.164
Average Altitude	0.033	1.965	−1.476
Share Rented Ag. Land 1999	−0.887	−0.344	1.133
Pigs per ha 1999	−0.828	−0.523	0.711
Cows per ha 1999	0.731	0.639	−0.705
Average Farmsize 1999	−1.624	1.221	1.930

The two separate parts of the zero inflated beta model also have an economic meaning related to the three stages outlined above. The binary logit model α describes the higher-level decision of a state of how to implement Natura 2000 farming policy (e.g. whether it should be subsidized or not). The second stage then models the actual outcome (i.e. the proportion of affected farmers), given the first stage.

The third stage is estimated after estimating the GPS and confirming its balancing property, which is the estimation of the impact of Natura 2000 farming on land rental prices. In addition to a function of Natura 2000 and the GPS, we account for further unobserved differences between the German states by adding state dummies. These differences could reflect macroeconomic conditions as well as local specificities from the implementation of agricultural policy. Morgan and Winship (2015) describe the approach of controlling for additional covariates after matching as “doubly robust”, although in the context of binary treatment variables. We estimate the equation

$$ln\ R = f(N, \mathrm{GPS}, S) \quad (6)$$

where R is district level rent, N is an indicator of Natura 2000 farming, *GPS* is the generalized propensity score, and S is a set of state dummies, by OLS. As a further robustness check, we estimated a second set of models using control variables that may have likely influenced land prices between the pre-treatment (1999) and the post-treatment era (2010).

5. Data

5.1. Data sources and variable choice

In 2010, according to the agricultural census (Farm Structure Survey – FSS), 59.8% of the utilized agricultural area (UAA) was rented. Therefore, we can assume that rental prices are a strong indicator for the value of agricultural land. Our analysis is cross-sectional in nature, but it uses results from two different agricultural censuses, namely 1999 and 2010. In particular, 1999 observations represent “pre-treatment” characteristics, i.e. district level agricultural characteristics before Natura 2000 farming policies were implemented (see also the discussion above). Similar to Michalek et al. (2014), we chose variables we believed affected the outcome (land rental price in 2010) as well as the treatment (Natura 2000 farming). Productivity is usually seen as a main driver of land prices, and therefore we control for 1999 district level productivity characteristics to model the generalized propensity score. Agricultural factors include the livestock densities of cows and pigs, as well as general land use variables such as arable land and grassland as a share of total agricultural land. Other productivity related characteristics may be captured by the pre-treatment (i.e. 1999) land rental prices. Farm size has also been an important driver of land rental prices by being able to exploit scale effects (Ciaian et al., 2012; Lence and Mishra, 2003; Michalek et al., 2014), as well as be an indicator for farmer lobbying power (larger farmers may also be better organized). The structure of the rental market, expressed as the share of rented land, has been argued to influence land sale prices by Feichtinger and Salhofer (2013), and the same argument could hold for rental prices as well. Finally, natural conditions such as the altitude above sea level are likely to affect land prices (higher altitudes are associated with rough terrain and less favorable climate conditions for many crops, thereby increasing production costs and decreasing productivity). Finally, in the FSS of 2010, Natura 2000 farming has been collected as an indicator variable equal to 1 if the farm received payments for Natura 2000 farming and 0 otherwise.

It is important to note that some of the sampling definitions changed between the FSS of 1999 and 2010, therefore direct comparisons cannot be made between the two datasets (for example by using a difference in difference approach). The following data sources were accessed for the analysis:

- District level data on average, grassland and arable land rents were acquired from the FSS 2010 and 1999 were collected from the state statistical offices of Germany. The regional statistics database (www.regionalstatistik.de) provided data on the amount of arable land, grassland, total agricultural land, livestock, and the amount of rented land in a district.
- The number of farms receiving Natura 2000 payments corresponding to the FSS 2010 was provided by the state statistical bureaus. On average, 6% of farms received payments for farming on Natura 2000 sites.
- Environmental protection policies are often associated with NGO activities and the green party. We use the district level results of the green party in the last state-level election as an indicator of how environmental protection is perceived by the general public.
- Data of regional GDP were accessed through the federal accounts database of the German Statistical Agency (http://www.vgrdl.de/).
- A digital elevation model (DEM) of Germany in 200 m resolution, a shape-file showing the German districts, and Corine Land Cover data for Germany were downloaded from the German Geodata Center (http://www.geodatenzentrum.de). From the DEM, average altitude was calculated using QGIS (QGIS Development Team, 2015) for each district.

The summary statistics of our data are shown in Table 3.

5.2. Treatment of district restructuring in the data

The German states of Saxony and Saxony-Anhalt underwent a restructuring of their districts between 1999 and 2010, and Mecklenburg-Vorpommern in 2011. To improve the comparability of the two datasets, we applied the following procedure: Where two districts were merged, we took the average weighted by rented area (in case of rental price) or sum (e.g. hectares of farmland) of the two districts. If one district (a) was split into two and then merged with another district (b), we added a weighted average to of (a) to (b) and so on, based on the amount of land that was allocated to each district. We double-checked these results by comparing them to the 2010 data and found them to be similar.

6. Results and discussion

Agriculture in Germany is quite diverse, and so are rental prices as is shown in Fig. 4. Part of the variation in rental prices can be explained by the division of Germany before 1989, by differences in soil productivity, and by structural factors. In particular, regions with high arable land rental prices in the North-West, as well as in the South-East, stick out. Relatively speaking, these patterns have remained largely unchanged as is clear from Fig. 4.

Table 3
Descriptive statistics.

Statistic	N	Mean	St. Dev.	Min	Max
Year 1999					
Average Rent	351	192.494	97.584	37.836	528.000
Grassland Rent	351	124.729	61.758	27.610	315.978
Arable Land Rent	351	205.824	98.331	37.324	517.427
Share Grassland 1999	351	0.320	0.215	0.006	0.990
Share Arable Land 1999	351	0.654	0.216	0.008	0.980
Share Ag. GDP 1999	351	0.019	0.016	0.0001	0.075
Average Altitude	351	282.776	205.541	0.702	1107.591
Share Rented Land 1999	351	0.517	0.228	0.007	2.123
Av. Farmsize 999	351	93.766	211.659	11.229	3648.000
Cows Density 1999	351	0.840	0.524	0.000	2.362
Pig Density 1999	351	1.254	1.710	0.000	13.063
Year 2010					
Average Rent	351	223.877	112.049	53	612
Grassland Rent	351	137.120	66.360	38	399
Arable Land Rent	351	242.778	112.117	57	637
Pillar 1 Payments	351	0.314	0.073	0.032	0.559
Pillar 2 Payments	351	0.096	0.068	0.0003	0.482
% Green Party	351	0.076	0.041	0.021	0.276
Share Ag. GDP 2010	351	0.013	0.012	0.0001	0.063
Cow Density 2010	351	0.720	0.513	0.000	2.419
Pig Density 2010	351	1.272	2.046	0.000	16.736
Share Grassland	351	0.305	0.213	0.000	0.993
Share Arable Land	351	0.663	0.209	0.007	0.976
Natura 2000 Farm Share	351	0.035	0.055	0.000	0.379

If we compare Fig. 4 to Fig. 1, the latter of which shows the share of farms receiving payments for Natura 2000 farming, we see that the hotspots of Natura 2000 farming are not in high-rental-price regions of Germany.

6.1. Econometric analysis

For each of our dependent variables (average rent, rent for grassland, rent for arable land) we estimate a separate Imbens and Hirano (2004) GPS model based on the zero inflated Beta (ZIB) distribution. As is described above, the model includes three stages. The first stage estimates the generalized propensity score (GPS), and the second stage produces a matched dataset to satisfy the overlap assumption. Finally, the third stage estimates the outcome by OLS. The results of the zero inflated beta model for the GPS are presented in Table 4. Note that the ZIB model and therefore the estimated propensity score is identical in all three subsequent estimations of the outcome model.

We name the first part of the ZIB model the *Zero Model*, as it estimates the probability of having not a single Natura 2000 farm within a district. First, the rental prices in 1999 could be considered as an indicator of agricultural productivity. While the average rent is positively associated with a zero percentage of Natura 2000 farmers, grassland and arable land rents show a negative relationship. A higher percentage of voters associated with the green party, as well as higher share of grassland in 1999 and a higher share of agricultural GDP in a district decrease the probability of no Natura 2000 farming. Average altitude increases the probability of having no Natura 2000 farming. Finally, the

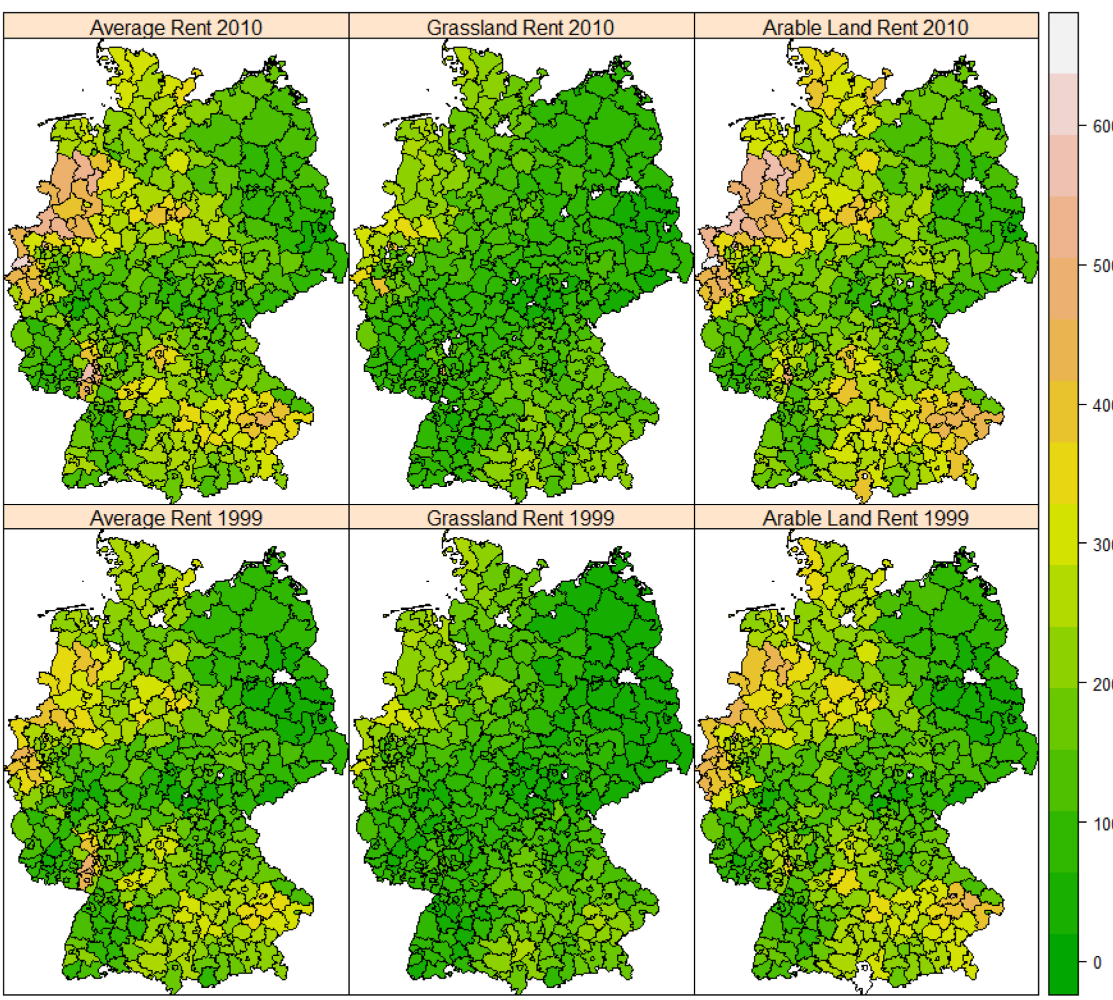

Fig. 4. District average land rental prices in € per hectare in Germany in 2010 and 1999.

Table 4
Estimation results of the zero inflated Beta model used to compute the generalized propensity score. The dependent variable is the share of Natura 2000 farms in a district.

Model (Link)	Beta model (logit)	Sigma (log)	Zero model (logit)
(Intercept)	−2.073	3.017***	3.231
	(1.489)	(0.106)	(3.975)
Average Rent 1999	−0.009*		0.033**
	(0.003)		(0.011)
Grassland Rent 1999	0.001		−0.014*
	(0.002)		(0.007)
Arable Land Rent 1999	0.006**		−0.029**
	(0.002)		(0.009)
% Green Party	−4.979**		−20.467***
	(1.780)		(4.429)
Share Grassland 1999	0.713		−9.598*
	(1.539)		(4.224)
Share Arable Land 1999	−0.836		−1.444
	(1.367)		(3.756)
Share Ag. GDP 1999	−11.098**		−41.362**
	(4.169)		(13.290)
Average Altitude	−0.001***		0.006***
	(0.000)		(0.001)
Share Rented Land 1999	0.349		0.420
	(0.287)		(1.123)
Pigs per ha 1999	0.118**		−0.705**
	(0.036)		(0.220)
Cows per ha 1999	−0.533		3.379***
	(0.279)		(0.710)
Log(Farmsize 1999)	0.157		−0.027
	(0.087)		(0.301)
Num. obs.		354	
Nagelkerke R^2		0.471	
Generalized AIC		−528.889	

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

impacts of pig and cow density are respectively negative and positive.

The *Beta* model is interpreted conditional on the presence of Natura 2000 farming in a district. Here, the mean parameter is again affected by 1999 land rental prices, but here the signs are opposite to the Zero Model, and only significant for average rent and arable land rent. This means that given a positive percentage of Natura 2000 farmers, a higher average rent in 1999 will be associated with a lower percentage of Natura 2000 farmers in 2010, while a higher arable land rent is associated with a higher percentage of Natura 2000 farmers. Surprisingly, the Beta model suggests that a higher percentage of green party voters is associated with a lower percentage of Natura 2000 farmers. A possible explanation of this counter-intuitive result is that the presence/absence decision is made at higher policy level (i.e. state level), while the actual participation may still be protested by farmers. The green party is particularly strong in more urbanized districts, which may in turn have less potential for Natura 2000 site designation in general. Mainly rural districts, where voters are more generally conservative and vote for other parties than the greens, have more farmland that can be subject to Natura 2000. Finally, a higher share of agricultural GDP as well as a higher average altitude is are associated with a lower percentage of Natura 2000 farmers. Interestingly, a higher density of pigs is significantly associated with a higher percentage of Natura 2000 farmers.

After matching, and thereby reducing the dataset from 354 to 265 observations, we estimate the outcome model by regressing the log of rent on the GPS, the Natura 2000 indicator, and a set of state dummies. We started with a second order approximation of the GPS and treatment indicators and then removed the interaction term, as well as the squared treatment term due to consistent insignificance. The results are shown in Table 5. The results clearly show a negative association between the Natura 2000 farming indicator and the log of land price for all three land categories. As a robustness check, we added models including additional controls. In particular, we have added Pillar 1 and 2 subsidies and livestock densities, for each dependent variable. Parameters on the pillar 1 payments robustly show a positive sign, while the payments channeled through the second pillar are negative in two out of three models. As the second pillar payments are usually attached to additional production constraints, these signs make sense. Finally, pig density has been suspected of driving high land rents particularly in Germany, and all models show a significant positive parameter on this variable. Pig densities are particularly high in the north-western areas of Germany, where land prices are also highest. In contrast, cow density seems to drive grassland prices, but may be negatively associated with average rents. It has to be kept in mind that our matching procedure

Table 5
Results of the outcome model regressing the log of 2010 rent on the Natura 2000 farm share and the generalized propensity score (GPS) by OLS using heteroscedasticity robust standard errors. Note that all models were estimated by including state dummies (not shown for brevity). Table generated with the `texreg` R package (Leifeld, 2013).

Dependent Variable	log(average rent)		log(arable land rent)		log(grassland rent)	
(Intercept)	4.248***	4.689***	4.088***	4.504***	3.792***	4.254***
	(0.217)	(0.160)	(0.207)	(0.149)	(0.172)	(0.151)
Natura 2000 farm share	−1.898***	−2.732***	−1.239**	−1.898***	−1.162***	−1.712***
	(0.426)	(0.483)	(0.451)	(0.442)	(0.338)	(0.476)
GPS	0.906	0.661	1.368*	1.097	0.662	0.264
	(0.562)	(0.631)	(0.553)	(0.593)	(0.552)	(0.561)
GPS^2	−1.650*	−1.492	−1.837*	−1.576*	−0.996	−0.486
	(0.722)	(0.820)	(0.736)	(0.781)	(0.700)	(0.718)
Pillar 1 Payments	1.351**		1.180**		1.130***	
	(0.434)		(0.427)		(0.297)	
Pillar 2 Payments	−0.914*		−0.741		−1.099**	
	(0.398)		(0.407)		(0.398)	
Cows/ha	−0.147**		−0.063		0.225***	
	(0.055)		(0.055)		(0.052)	
Pigs/ha	0.086***		0.078***		0.043**	
	(0.016)		(0.016)		(0.015)	
R^2	0.663	0.542	0.648	0.563	0.653	0.550
Adj. R^2	0.639	0.516	0.622	0.539	0.628	0.525
Num. obs.	265	265	265	265	265	265
RMSE	0.299	0.346	0.299	0.331	0.270	0.305

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

was aimed improving overlap for Natura 2000 farming, therefore the additional explanatory variables may suffer from endogeneity problems. All estimated models show heteroscedasticity robust standard errors computed using the sandwich estimator (Zeileis, 2004).

6.2. Impact of Natura 2000

The negativity of the Natura 2000 indicator suggests that indeed, Natura 2000 designation affects land prices negatively. We can interpret the parameters of the Natura 2000 estimator as the semi elasticity of rental prices with respect to Natura 2000. For example, a 1 percentage point increase in Natura 2000 farms will decrease average rental prices by between 1.9% and 2.7%, depending on the model. This effect seems relatively large, and in practice it may differ between the different Natura 2000 implementation models. Currently, the share of farmers receiving Natura 2000 payments is relatively low (6% on average), and our results should only be interpreted within the vicinity of current values. More responsive nonlinear functions could be estimated if more reliable data become available.

The impact on grassland rents is smaller than for average rents, and so is the effect for arable land rent. It suggests that rental prices of *other* land use types such as permanent crops could be particularly affected by Natura 2000 designation. We tested three indicators to describe the impact of Natura 2000 designation on land prices. For consistency, we used the Natura 2000 indicator derived from the farm structure survey rather than indicators constructed from Corine Land Cover (CLC) data. The CLC indicator may be imprecise, as data are generated from digitized large-scale aerial photographs and digitized to a 10 ha resolution.

The negativity of the total effect of Natura 2000 designation is consistent with the conjecture that the land designated to Natura 2000 should be used under protective and less intensive agricultural practice, which often shows relatively lower land productivity, in order to protect biodiversity. With regard to our theoretical model, the effect could be explained as follows. If the subsidy in company with potential input cost reductions does not sufficiently compensate the productivity loss, rents will be reduced. The effect will be stronger at the district aggregate level, if Natura 2000 designation does not increase competition for non-Natura 2000 farmland, which could push up average rental prices.

Our findings have implications for the future design of (agri-) environmental policy. As has been argued, farming and keeping open landscapes is seen as an integrative part of species conservation within Natura 2000 sites. But not fully compensated productivity impairments could lead to the abandonment of farming in marginal areas nonetheless, as farmers decide to stop cultivating their land. The lack of a profitable future of the business may increase difficulties in finding a successor (MacDonald et al., 2000; Visser et al., 2007; Bignal and McCracken, 2000). While the impact of farm abandonment on biodiversity is difficult to predict, the study by MacDonald et al. (2000) found that negative biodiversity impacts were to be expected in 15 out of 24 mountainous case study regions across Europe. In addition, abandonment of traditional farming practices may lead to monotonization or natural succession of landscapes. If the integrity of traditional landscape should be conserved in the long run (Plieninger et al., 2006), strategies to preserve or improve traditional farming methods need to be developed. As Plieninger et al. (2006, p. 320) point out, “a sustainable landscape development is impossible without the involvement of land-users and local people, i.e. of the sculptors of the landscape”.

Even though our results are in line with the theoretical arguments outlined in the literature, the magnitude of our findings cannot be directly compared to other studies. For example, while Letort and Temesgen (2014) also study the effect of environmental policy on land prices, the policy under investigation differs substantially from Natura 2000 designation in its focus as well as in breadth. In addition, we use a different method (the generalized propensity score), and we use district aggregate data rather than farm level data. Many studies on the incidence of subsidies on land values have applied some form of spatial regression model (e.g. Feichtinger and Salhofer, 2016; Letort and Temesgen, 2014), which can help to alleviate some spatial spillover effects (i.e. spatial lag and error terms), but not easily combined with other types of analysis (e.g. matching). While our results are robust and consistent with the theory, current measures in Natura 2000 farming are too diverse across states to provide more detailed policy recommendations from this aggregate study. Follow-up studies should examine specific programs at the farm level, possibly with data on actual farmer behavior rather than program prescriptions.

7. Concluding remarks

Protection of environmental resources such as biodiversity has become a major concern in the European Union. Agriculture can be a threat to biodiversity, but can also be used to foster it. In particular, traditional extensive farming methods can play a large role in protecting priority habitats and species (Gliessman, 2014; Ostermann, 1998).

However, protecting valuable farmland comes at a cost. Farmers are reduced in their capacity to make profit maximizing decisions and need to be compensated accordingly in order to keep farming marginal land. The literature has provided several theoretical and empirical explanations of how payments to farmers influence farmland prices (Ciaian et al., 2012, 2014; Feichtinger and Salhofer, 2016; Kilian et al., 2012; Michalek et al., 2014) and how environmental policy may influence land prices (Letort and Temesgen, 2014). We add to this growing body of knowledge by investigating the effect that designation of Natura 2000 protected areas and compensation payments has on farmland values as represented by their rental prices. By using generalized propensity score matching, we find a significant negative relationship between Natura 2000 farming and land rental prices.

Our results suggest that concerns of landowners and farmers were justified. Apart from increasing monetary incentives, authorities could support local producers in improving the marketability of Natura 2000 areas, e.g. through sustainable tourism (Mellon and Bramwell, 2016; Hawkins, 2004; Woodland and Acott, 2007), regional branding of products (Getzner, 2010; Hjalager and Johansen, 2013), or other strategies, if they are in line with biodiversity objectives. This could help to improve the acceptance of integrated conservation schemes such as Natura 2000. As we have seen from the literature, acceptance by the stakeholders (i.e. landowners and farmers) is a key aspect to effective conservation.

Conflict of interest

None declared.

References

Batáry, P., Báldi, A., Kleijn, D., Tscharntke, T., 2011. Landscape-moderated biodiversity effects of agri-environmental management: a meta-analysis. Proc. R. Soc. Lond. B: Biol. Sci. 278 (1713), 1894–1902.

Besnard, A.G., Secondi, J., 2014. Hedgerows diminish the value of meadows for grassland birds: Potential conflicts for agri-environment schemes. Agric. Ecosyst. Environ. 189, 21–27.

Bignal, E.M., McCracken, D.I., 2000. The nature conservation value of European traditional farming systems. Environ. Rev. 8 (3), 149–171.

Ciaian, P., Kancs, D., Swinnen, J., 2012. Income Distributional Effects of Decoupled Payments: Single Payment Scheme in the European Union. SSRN Scholarly Paper ID 2135480. Social Science Research Network, Rochester, NY.

Ciaian, P., Kancs, D., Swinnen, J., 2014. The impact of the 2013 reform of the common agricultural policy on land capitalization in the European Union. Appl. Econ. Perspect. Policy 36 (4), 643–673.

European Commission, 2014. Establishing conservation measures for Natura 2000 sites. A review of the provisions of Article 6.1 and their practical implementation in different Member States. Technical report. European Commission, Brussels, Belgium.

Feichtinger, P., Salhofer, K., 2013. What do we know about the influence of agricultural support on agricultural land prices? German J. Agric. Econ. 62 (2), 71–85.

Feichtinger, P., Salhofer, K., 2016. The Fischler reform of the common agricultural policy and agricultural land prices. Land Econ. 92 (3), 411–432.
Floyd, J.E., 1965. The effects of farm price supports on the returns to land and labor in agriculture. J. Polit. Econ. 73 (2), 148–158.
Gantioler, S., Rayment, M., ten Brink, P., McConville, A., Kettunen, M., Bassi, S., 2013. The costs and socio-economic benefits associated with the Natura 2000 network. Int. J. Sustain. Soc. 6 (1–2), 135–157.
Geitzenauer, M., Hogl, K., Weiss, G., 2016. The implementation of Natura 2000 in Austria – a European policy in a federal system. Land Use Policy 52, 120–135.
Getzner, M., 2010. Impacts of protected areas on regional sustainable development: the case of the Hohe Tauern National Park (Austria). Int. J. Sustain. Econ. 2 (4), 419–441.
Gliessman, S.R., 2014. Agroecology: The Ecology of Sustainable Food Systems, 3rd edition. CRC Press Google-Books-ID: AVi3BgAAQBAJ.
Goodwin, B.K., Mishra, A.K., Ortalo-Magné, F.N., 2003. What's wrong with our models of agricultural land values? Am. J. Agric. Econ. 85 (3), 744–752.
Guastella, G., Moro, D., Sckokai, P., Veneziani, M., 2014. The capitalization of area payments into land rental prices: a panel sample selection approach. In: 2014 International Congress, August 26–29, 2014. Ljubljana, Slovenia, 186375. European Association of Agricultural Economists.
Halada, L., Evans, D., Romao, C., Petersen, J.-E., 2011. Which habitats of European importance depend on agricultural practices? Biodivers. Conserv. 20 (11), 2365–2378.
Hawkins, D.E., 2004. A protected areas ecotourism competitive cluster approach to catalyse biodiversity conservation and economic growth in Bulgaria. J. Sustain. Tour. 12 (3), 219–244.
Hjalager, A.-M., Johansen, P.H., 2013. Food tourism in protected areas – sustainability for producers, the environment and tourism? J. Sustain. Tour. 21 (3), 417–433.
Imbens, G., Hirano, K., 2004. The propensity score with continuous treatments. In: Gelman, A., Meng, X.-L. (Eds.), Applied Bayesian Modelling and Causal Inference from Missing Data Perspectives. Wiley.
Keenleyside, C., Beaufoy, G., Tucker, G., Jones, G., 2014. High Nature Value farming throughout EU-27 and its financial support under the CAP. Report Prepared for DG Environment Contract No ENV B.1/ETU/2012/0035. Institute for European Environmental Policy, London, Brussels, Belgium.
Kilian, S., Antón, J., Salhofer, K., Röder, N., 2012. Impacts of 2003 CAP reform on land rental prices and capitalization. Land Use Policy 29 (4), 789–797.
Klaiber, H.A., Salhofer, K., Thompson, S.R., 2017. Capitalisation of the SPS into agricultural land rental prices under harmonisation of payments. J. Agric. Econ.
Lakner, S., Kleinknecht, U., 2013. Ecological optimisation of grassland by means of FFH-Managementplans in Saxony. In: Bahrs, E., Becker, T., Birner, R., Brockmaier, M., Dabbert, S., Doluschitz, R., Grethe, H., Lippert, C., Thiele, E. (Eds.), Challenges of the global change for the agricultural development and global nutrition. Conference 48th Proceedings of the German Association of Agricultural Economists (Gewisola). Landwirtschaftsverlag. pp. 85–96 (in German).
Leifeld, P., 2013. texreg: Conversion of statistical model output in R to LaTeX and HTML tables. J. Stat. Softw. 55 (8), 1–24.
Lence, S.H., Mishra, A.K., 2003. The impacts of different farm programs on cash rents. Am. J. Agric. Econ. 85 (3), 753–761.
Letort, É., Temesgen, C., 2014. Influence of environmental policies on farmland prices in the Bretagne region of France. Rev. Agric. Environ. Stud. 95 (1), 77–109.
MacDonald, D., Crabtree, J.R., Wiesinger, G., Dax, T., Stamou, N., Fleury, P., Gutierrez Lazpita, J., Gibon, A., 2000. Agricultural abandonment in mountain areas of Europe: Environmental consequences and policy response. J. Environ. Manage. 59 (1), 47–69.
Mellon, V., Bramwell, B., 2016. Protected area policies and sustainable tourism: influences, relationships and co-evolution. J. Sustain. Tour. 24 (10), 1369–1386.
Michalek, J., Ciaian, P., Kancs, D., 2014. Capitalization of the single payment scheme into land value: generalized propensity score evidence from the European Union. Land Econ. 90 (2), 260–289.
Morgan, S.L., Winship, C., 2015. Counterfactuals and Causal Inference. Cambridge University Press.
Olmeda, C., Keenleyside, C., Tucker, G., Underwood, E., 2014. Farming for Natura 2000. Guidance on how to support Natura 2000 farming systems to achieve conservation objectives, based on Member States Good Practice Experiences. Technical report. European Commission, Brussels, Belgium.
Ospina, R., Ferrari, S.L.P., 2010. Inflated beta distributions. Stat. Pap. 51 (1), 111.
Ospina, R., Ferrari, S.L.P., 2012a. A general class of zero-or-one inflated beta regression models. Comput. Stat. Data Anal. 56 (6), 1609–1623.
Ospina, R., Ferrari, S.L.P., 2012b. On bias correction in a class of inflated beta regression models. Int. J. Stat. Probab. 1 (2), 269.
Ostermann, O.P., 1998. The need for management of nature conservation sites designated under Natura 2000. J. Appl. Ecol. 35 (6), 968–973.
Pe'er, G., Zinngrebe, Y., Hauck, J., Schindler, S., Dittrich, A., Zingg, S., Tscharntke, T., Oppermann, R., Sutcliffe, L.M., Sirami, C., Schmidt, J., Hoyer, C., Schleyer, C., Lakner, S., 2017. Adding some green to the greening: improving the EU's Ecological Focus Areas for biodiversity and farmers. Conserv. Lett. 10 (5), 517–530.
Plieninger, T., Höchtl, F., Spek, T., 2006. Traditional land-use and nature conservation in European rural landscapes. Environ. Sci. Policy 9 (4), 317–321.
Poudyal, N.C., Hodges, D.G., Merrett, C.D., 2009. A hedonic analysis of the demand for and benefits of urban recreation parks. Land Use Policy 26 (4), 975–983.
Rauschmayer, F., van den Hove, S., Koetz, T., 2009. Participation in EU biodiversity governance: how far beyond rhetoric? Environ. Plan. C: Govern. Policy 27 (1), 42–58.
Reiter, K., Sander, A., 2010. Halbzeitbewertung von PROFIL. Zahlungen im Rahmen von Natura 2000 und Zahlungen im Zusammenhang mit der Richtlinie 2000/60/EG (ELER-Code 213). Technical report, Johann Heinrich von Thünen-Institut, Bundesforschungsinstitut für Landläche Räume, Wald, und Fischerei, entera Umweltplanung & IT, Braunschweig, Germany.
Rigby, R.A., Stasinopoulos, D.M., 2005. Generalized additive models for location, scale and shape (with discussion). Appl. Stat. 54, 507–554.
Sauer, A., Luz, F., Suda, M., Weiland, U., 2005. Steigerung der Akzeptanz von FFH-Gebieten. Technical report. Bundesamt für Naturschutz, Bonn, Germany.
Schafer, J., 2015. causaldrf: Tools for Estimating Causal Dose Response Functions.
Stasinopoulos, M.D., Rigby, R.A., Heller, G.Z., Voudouris, V., Bastiani, F.D., 2017. Flexible Regression and Smoothing: Using GAMLSS in R. CRC Press.
Tietz, A., Bathke, M., Bormann, K., Eberhard, W., Forstner, B., Grajewsk, R., Koch, B., Pohl, C., Raue, P., Reiter, K., Roggendorf, W., 2007. Ländliche Entwicklungsprogramme 2007 bis 2013 in Deutschland im Vergleich - Finanzen, Schwerpunkte, Maßnahmen. Technical Report 315, Landbauforschung Völkenrode - FAL Agricultural Research, Braunschweig, Germany.
Visser, M., Moran, J., Regan, E., Gormally, M., Skeffington, M.S., 2007. The Irish agri-environment: How turlough users and non-users view converging EU agendas of Natura 2000 and CAP. Land Use Policy 24 (2), 362–373.
Woodland, M., Acott, T., 2007. Sustainability and local tourism branding in England's South Downs. J. Sustain. Tour. 15 (6), 715–734.
Wooldridge, J.M., 2010. Econometric Analysis of Cross Section and Panel Data. MIT Press.
Zeileis, A., 2004. Econometric Computing with HC and HAC Covariance Matrix Estimators. J. Stat. Softw. 11 (10), 1–17.