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Modeling a farm population to estimate on-farm compliance costs and environmental effects of a grassland extensification scheme at the regional scale

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ABSTRACT

We used a farm-level modeling approach to estimate on-farm compliance costs and environmental effects of a grassland extensification scheme in the district of Ostprignitz-Ruppin, Germany. The behavior of the regional farm population ($n = 585$) consisting of different farm types with different production orientations and grassland types was modeled under the presence and absence of the grassland extensification scheme using the bio-economic model MODAM. Farms were based on available accountancy data and surveyed production data, while information on farm location within the district was derived from a spatial allocation procedure. The reduction in total gross margin per unit area was used to measure on-farm compliance costs. A dimensionless environmental index was used to assess the suitability of the scheme to reduce the risk of nitrate-leaching.

Calculated on-farm compliance costs and environmental effects were heterogeneous in space and farm types as a result of different agricultural production and site characteristics. On-farm costs ranged from zero up to almost 1500 Euro/ha. Such high costs occurred only in a very small part of the regional area, whereas the majority of the grassland had low on-farm costs below 50 Euro/ha. Environmental effects were moderate and greater on high-yield than on low-yield grassland. The low effectiveness combined with low on-farm costs in large parts of the region indicates that the scheme is not well targeted. The soft scheme design results from an attempt to achieve environmental and rural development objectives with only one scheme. Improving the efficiency of the scheme would require designing separate instruments for the two distinct objectives. This is in line with the Tinbergen rule, which states that consistent economic policy requires that the number of instruments equals the number of targets.

1. Introduction

A cost-effective implementation of nature conservation programs requires information on conservation costs and benefits. Several studies, however, have outlined the difficulties in estimating the benefits and costs of conservation programs, such as agri-environment schemes in the European Union (EU), from empirical data (e.g., Primdahl et al., 2003; MacMillan and Marshall, 2006; Kleijn et al., 2006; Matzdorf et al., 2008b). Problems in measuring conservation benefits result from a lack of linearity and immediacy of environmental effects, unequivocal causalities (effects are subject to a multitude of influences, only one of which is the policy to be evaluated), and often high costs of measurement (Primdahl et al., 2003; Kronvang et al., 2008). The possibilities of estimating on-farm compliance costs are also limited, for example, because access to spatial farm data is restricted for reasons of data protection (cf. Reidsma et al., 2006; Schmit et al., 2006). On-farm compliance costs reflect foregone agricultural production resulting from the conservation effort. Knowledge of on-farm costs is essential to calculate payment rates, to forecast participation rates and to plan the budgets for conservation programs.

Model-based assessments have therefore become of increasing relevance to support evaluation and better targeting of agri-environment schemes (Deumlich et al., 2006; Kersebaum et al., 2006; Drechsler et al., 2007; Wätzold et al., 2008; Ohl et al., 2008; Piorr et al., 2009). Such studies can help to overcome data constraints and methodological problems of empirical assessments but entail other methodological challenges, such as the appropriate level of detail, the bridge between different scales and error propagation (Wossink et al., 2001).

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The aim of this study is to estimate environmental effects and on-farm compliance costs of a grassland extensification scheme at the regional scale using a farm-level modeling approach. The analysis involves modeling an entire spatially localized farm population in terms of crop production, grassland use and livestock production. The farm population was reconstructed from available farm data, regional data and geo-referenced information on the spatial distribution of arable land and grassland in the area investigated. The overall goal is to show that farm-level modeling can be used to support the evaluation process of agri-environment schemes and to draw conclusions for the future implementation of the analyzed grassland extensification scheme. Our particular interest is to analyze how the combination of different farm characteristics (production orientation, farm size) and site characteristics affects the extent and distribution of environmental effects and compliance costs of grassland extensification both in space and among different farm types. Such an evaluation at both farm and regional scale is confronted with a number of challenges. First, it is necessary to create a link between available economic farm type data, agronomic production data for different grassland site types, and the spatial extent and distribution of grassland site types (see pre-modeling steps in Section 3.2). Second, to estimate the benefits and costs of grassland extensification, the behavior of the farm population needs to be assessed under the presence and absence of the scheme (see Sections 3.3 and 3.4).

There are number of model-based studies that deal with the assessment of alternative agri-environmental policies at the farm and regional level (see Rossing et al., 2007; Zander et al., 2008; Piorr and Müller, 2009). Most studies focus on on-farm adaptation strategies by modeling the behavior of representative or showcase farms with either a direct or indirect spatial reference (Wossink et al., 2001; Pacini et al., 2004; Berentsen et al., 2007; Schuler and Sattler, 2010). Some studies use statistical aggregation to produce regional results (Wossink et al., 2001), while others are based on a regional farm approach (Flury et al., 2005). In recent years, significant progress has been made to overcome existing problems of scale, e.g. by developing methods that bridge between the field, farm, regional and market scales (Van Ittersum et al., 2008; Therond et al., 2009). However, for the evaluation of agri-environment schemes, the most important group of measures within the rural development policy of the EU, and specific political questions, e.g. related to spatial targeting, the farm-level representation and spatial resolution of most existing approaches is still relatively aggregated (cf. Uthes et al., in press). Model-based studies that seek to assist the policy evaluation process of agri-environment schemes are therefore rare. Of the studies that have explicitly referred to agri-environment schemes two modeling strategies can be distinguished:

- Studies from the natural sciences that estimate the spatial vulnerability for different environmental problems to assess ex-post the targeting degree of schemes (e.g., share of supported measures located in vulnerable areas) (Deumlich et al., 2006; Kersebaum et al., 2006). Such approaches make use of raster-based modeling of environmental processes and provide detailed insights into where measures should be conducted from a nature-conservation point of view, e.g., in areas vulnerable for groundwater pollution or water erosion. Conservation costs, however, are usually not considered.
- Studies that consider spatially heterogeneous benefits and costs of schemes but neglect farm-level decision-making (e.g., Wätzold and Drechsler, 2005; Drechsler et al., 2007; Wätzold et al., 2008). Benefits are usually estimated with ecological models (e.g., population models). Costs are usually based on the average income forgone (e.g., from published figures) and some expert-based top-up value to account for additional costs. However, the decision-making units in these approaches (deciding whether to participate in a conservation program or not) are land parcels or other spatial units. In reality, land parcels are managed by farmers. The influence of farm structures on the magnitude of estimated on-farm costs is therefore not considered (for example, land parcels managed by extensive suckler cow farms are more likely to "participate" in grassland extensification schemes due to lower on-farm costs than intensive dairy farms).

Studies that used farm-type based models operating at fine geographic resolution to evaluate both the spatial distribution of on-farm benefits and costs of conservation measures and also among different farm types are missing in the existing literature (Canton et al., 2009; Bryan et al., in press). This paper seeks to perform such an analysis.

2. Study area

The administrative district of Ostprignitz-Ruppin is located in northeastern Germany in the federal state of Brandenburg (see Fig. 1) and covers about 2510 km^2. The district is sparsely populated (43 inhabitants per km^2) and dominated by agricultural land use. Ostprignitz-Ruppin has a per capita gross domestic product (GDP), at purchasing power parity, of 17,800 Euro, which is less than 70% of the EU27 average (25,100 Euro in 2006) (EUROSTAT, 2009a). The region has a relatively high unemployment rate of 17.5%, compared to the German average of 8.4% (EUROSTAT, 2009b). About 35% of its total area is arable land and 15% meadows and pastures. The overall landscape structure is versatile, including water bodies, heath land and swamp areas. The region provides rather poor conditions for crop production due to a high share of sandy soils and a low yearly precipitation, which amounts to

Fig. 1. The study area: Ostprignitz-Ruppin in Germany.