Land Use Policy 66 (2017) 49–60

Contents lists available at ScienceDirect

Land Use Policy

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

Interaction effects of targeted agri-environmental payments on non-marketed goods and services under climate change in a mountain region

Huber Robert[a,*], Snell Rebecca[b], Monin François[a], Brunner Sibyl Hanna[c], Schmatz Dirk[d], Finger Robert[a]

[a] Agricultural Economics and Policy, ETH Zürich, Sonneggstrasse 33, 8092 Zürich, Switzerland
[b] Forest Ecology, Department of Environmental Systems Science, ETH Zürich, Universitätstrasse 16, 8092 Zürich, Switzerland
[c] Planning of landscape and urban systems Department of Civil, Environmental and Geomatic Engineering, ETH Zürich, Stefano-Franscini-Platz 5, 8093 Zürich, Switzerland
[d] Landscape Dynamics, Swiss Federal Research Institute WSL, Zürcherstrasse 111, 8903 Birmensdorf, Switzerland

ARTICLE INFO

Keywords:
Agri-environmental measures
Targeting
Biodiversity conservation
Ecosystem services
Non-marketed goods and services
Agent-based modelling
Mountain region

ABSTRACT

Targeting of agri-environmental measures (AEMs) is a key to increasing the cost-effectiveness of governmental support for biodiversity conservation and the provision of ecosystem services from agriculture. Existing literature, however, often focuses on single measures without considering that policies are usually bundles of different measures addressing multiple non-marketed goods and services. Thus, interaction effects of a set of policies in a given policy mix may influence the cost-effectiveness of single measures. Recently, Swiss agricultural policy was redesigned using the Tinbergen rule as its basis, i.e., a single measure for each policy goal, including additional targeted direct payments. This facilitates testing for interaction effects of multiple targeted AEMs. Here we use a social-ecological, agent-based modelling framework to assess interaction effects of these agricultural policies while accounting for climate change impacts in our analysis. The results from our case study in a mountain region show that ecosystem service provision increases with targeted payments. However, interaction effects of the different targeted policies affect the provision levels of all goods and services. In particular, changes at the extensive margin, i.e., the total amount of land that is under production, largely determine the amount of ecosystem services provided. Thus, climate change driven productivity increases and policies that keep land in production may substantially support the provision of non-marketed goods and services in marginal agricultural production regions with a high potential for land abandonment. Consequently, the effectiveness of targeted policy measures should also consider changes at the extensive margin and be assessed in the context of bundles or portfolios of different policy measures.

1. Introduction

Agri-environmental measures (AEMs), i.e., targeted instruments that grant payments to farmers for environmental performance, have become an important pillar in agricultural policy and research interest has increased in recent years (Batáry et al., 2015; Uthes and Matzdorf, 2013). In general, research on AEMs shows that a better targeting of payments in space and time as well as a better tailoring,[1] e.g., to specific farms or regions, increase the effectiveness and cost-efficiency of these instruments (e.g. Armsworth et al., 2012; Chen et al., 2010; Meyer et al., 2015; Wätzold et al., 2008). Most of the conceptual and empirical studies on AEMs provide detailed insights into selected individual measures, but they are less apt to provide results relevant for policy recommendations, as they often neglect the role of farmers' decision-making and the available AEM budget (Uthes and Matzdorf, 2013). Decision support for agri-environmental measures must, however, take into account that policies are typically bundles of different policy tools arranged in policy mixes (Howlett and Rayner, 2013) and that financial incentives for different ecosystem services interact (Bryan and Crossman, 2013; Derissen and Quaas, 2013; Peterson et al., 2002). Here we provide a quantitative analysis of interaction effects, i.e., the reciprocal direct and indirect effects of a targeted policy instrument on other policy targets in a case study on mountain agriculture. In this context, three research challenges emerge.

* Corresponding author.
E-mail address: rhuber@ethz.ch (H. Robert).

[1] Targeting implies that a policy measure is aligned to a specific object, e.g., landscape maintenance. Tailoring refers to the adjustment of the amount of expenditure to the problem at hand, e.g., farmers' opportunity costs in a region of high landscape value (van Tongeren, 2008).

http://dx.doi.org/10.1016/j.landusepol.2017.04.029
Received 15 December 2016; Received in revised form 27 March 2017; Accepted 20 April 2017
0264-8377/

Firstly, the joint production of agricultural commodities and non-marketed goods and services (NMS), which in general underlies the design of AEMs (Wossink and Swinton, 2007), implies that changes in agricultural markets as well as in concomitant commodities programs affect the provision of ecosystem services (Duke, 2004; Laukkanen and Nauges, 2014; Sauer and Wossink, 2013). Higher market prices or competing payments increase the opportunity costs, i.e., the revenue foregone through providing NMS (e.g. Sipiläinen and Huhtala, 2012). The effect on opportunity costs depends strongly on regional agricultural production conditions and the spatial heterogeneity of land quality, the heterogeneity across farmers' preferences (Fraser, 2009; Wünscher et al., 2008) as well as on the spatial configuration of different land-uses (Bamière et al., 2011; Drechsler, 2011). The consideration of this heterogeneity is crucial when assessing interaction effects of AEMs. Recent research includes temporal aspects in the assessment of spatially explicit opportunity costs (Wätzold et al., 2015) and the consideration of preferences in the emergence of farm specific opportunity costs by using agent-based modelling approaches for the evaluation of AEMs (e.g. Brändle et al., 2015; Schouten et al., 2013; Valbuena et al., 2010).

Secondly, targeting of AEMs is further complicated by the fact that there are also important interdependencies *between* NMS (Bennett et al., 2009; Briner et al., 2013b; Bryan et al., 2015). Extensively used grassland, for example, contributes simultaneously to biodiversity conservation and the provision of scenic beauty (Lindemann-Matthies et al., 2011). Various studies reveal the interaction between different ecosystem services and different management strategies to support a more effective and efficient design of AEMs (Galler et al., 2015). The studies show that targeted payments often ignore possible knock-on effects for other services provided by the same piece of land (Reed et al., 2014). Thus, even if a payment is targeted to a specific environmental goal, concomitant environmental effects occur that influence the cost-effectiveness of the instrument (Meyer et al., 2015; Uthes et al., 2010). This phenomenon of interdependencies among multiple NMS is a key challenge in the context of double counting in ecosystem service valuation and makes an efficient design of AEMs difficult (Ekroos et al., 2014). From a policy design perspective, the challenge is that windfall effects occur, i.e., that farmers would adopt an environmentally friendly practice without a specific payment (Chabé-Ferret and Subervie, 2013). Windfall effects reduce the efficiency of AEMs by expending resources to pay for practices that are already supported by other policy instruments.

Thirdly, targeted AEMs have to deal with the inherent and dynamic heterogeneity of agronomic and economic conditions in space and time (Barraquand and Martinet, 2011). For instance, their effectiveness is also increasingly influenced by climate change which alters yields and the spatial provision of ecosystem services. Thus, it is important to consider temporal dynamics when assessing interaction effects in policy mixes. Depending on the severity of the climate change impact, gains or losses in yields could reduce or increase the incentive to participate in AEMs (Troost and Berger, 2014). This is of specific interest in mountainous and dry areas where climate change is predicted to strongly influence vegetation periods and precipitation (Huber et al., 2013).

All three factors, i.e., heterogeneity, interdependencies and temporal dynamics are relevant for the design of AEMs. However, up till now, there has been no analytical investigation of the interaction effects of multiple targeted payments for NMS provision that considers heterogeneity, interdependencies and dynamics in space and time as well as across farms and farmers' preferences. We aim to fill this gap by providing a comprehensive analysis that addresses the interactions of three targeted direct payments schemes in Switzerland (payments for extensive grassland, payments for use of grassland on steep slopes, payment for secure supply of food). To this end, we use a spatially explicit social-ecological agent-based simulation framework to assess the impact of different policy mixes and climate change on the provision of three NMS (biodiversity conservation, landscape maintenance and food production). We use the share of extensively used grassland, the Shannon index for land-use diversity and a food index as indicators for biodiversity conservation, landscape maintenance and food production respectively. Model results with respect to these three indicators are synthesized using regression analysis.

Our dynamic modelling framework explicitly takes into account the joint production of agricultural commodities, NMS provision and climate change impacts in the evaluation of the environmental outcome of the three payment instruments. In addition, the agent-based framework used here explicitly allows us to consider the heterogeneity of farm decision-making with respect to AEMs. The research questions addressed are:

1. To what extent do targeted payments for one non-marketed service (e.g., for biodiversity conservation) affect the provision of other services (e.g., landscape maintenance) in a given policy mix?
2. What is the effect of climate change impacts on these interactions?

We analyse these questions using a case study of agriculture in an inner-Alpine mountain valley in Switzerland, where agricultural production and NMS provision are characterised by a high dependency on direct payments and climate change impacts are expected to be large (e.g. Briner et al., 2013a). Moreover, since recent Swiss agricultural policy reforms were based on the Tinbergen rule, i.e., each individual instrument should address a single goal (Mann and Lanz, 2013), the use of a Swiss case study provides the opportunity to assess combinations of different targeted payments schemes in the context of real-world policy portfolios.

2. Policy background

The agricultural policy program in Switzerland is organized around five general goals: i) ensuring food supply; ii) maintenance of cultural landscapes; iii) biodiversity conservation; iv) improvement of landscape quality; and v) development of close-to-nature and animal friendly production systems. One or several payment schemes were established for each of these goals. Table 1 summarizes these schemes according to the policy goals and the size of the subsidies per ha (CHF), in total (CHF million) and the corresponding payment's share in overall subsidies (%). Specific targets were defined for each of the goals (Lanz, 2012). Almost 40% of the direct payments in Switzerland are intended to contribute to the goal of ensuring a secure food supply. More specifically, the aim is to maintain the current level of production (measured in joules) and to reduce the loss of productive agricultural land. Payments aiming to maintain the current landscape amount to 18% of the total payments and focus mainly on mountain areas. Their goal is to reduce the rate of forest encroachment in these areas by 20%. CHF 364 million or 13% of total direct payments are spent for biodiversity conservation. These measures include area-based payments to increase the quantitative amount of extensively used grassland, performance-based payments to enhance the quality of these ecological compensation areas as well as agglomeration payments. The principal instrument is the payment for extensively used grassland, which restricts fertilization and mowing (i.e., late cut with specific dates for agricultural production zones according to altitude). As a result of the late cut, fodder quality is lower in these areas. A smaller amount of the subsidies (2.5%) are payments for collaborative projects that contribute to the goal of improving landscape quality by maintaining and developing regionally typical landscapes. Finally, the Swiss government supports environmental and animal friendly production practices with CHF 445 million (16% of total payments). These measures aim to increase N- and P- efficiency, reduce NH_3 emissions and motivate participation in animal welfare programs. Farmers only receive direct payments if they meet environmental and social requirements. With respect to the environment, they must provide a so-called proof of