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Analysis

Spatial targeting of agri-environmental policy and urban development

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ABSTRACT

Widespread public support exists for the provision of natural amenities, such as lakes, rivers or wetlands, and for efforts to preserve these from agricultural pollution. Agri-environmental policies contribute to these efforts by encouraging farmers to adopt environmentally friendly practices within the vicinity of these ecosystems. A spatially targeted agri-environmental policy promotes natural amenities and may thereby affect household location decisions. The purpose of this paper is to investigate the extent of these impacts on the spatial urban structure. We extend a monocentric city model to include farmers' responses to an agri-environmental policy. Our main findings are that the implementation of a spatially targeted agri-environmental policy may lead to some additional urban development, which could conflict with the aim of the policy.

1. Introduction

Agri-environmental policies focus on protecting and preserving natural resources and ecosystem services, although they differ throughout the world in terms of design and level of importance. Despite their international variability, agri-environmental policies (AEPs) share some common features: farmers are enrolled in environmental programs on a voluntary basis in exchange for payment (Baylis et al., 2008; Wunder et al., 2008). AEP implementation has raised several efficiency concerns. First, informational asymmetries between the contractors (i.e. farmers as 'agents' and the State as 'principal') can induce inefficiencies. These arise either due to the fact that farmers' implementation costs are unknown to the principal (adverse selection: e.g. (Canton et al., 2009; Latacz-Lohmann and Van der Hamsvoort, 1997)), or because the principal cannot control farmers' actions after contract implementation (moral hazard: e.g. (Choe and Fraser, 1999; Ozanne et al., 2001)). Secondly, as a result of budget constraints, not all of the land can be included within an AEP. This calls for targeting strategies. Babcock et al. (1997) have shown the superiority of benefit-cost targeting strategies over environmental benefits or land costs targeting strategies. When land development is frequent, land-use change should also be accounted for within an AEP spatial targeting strategy, in order to secure benefits from future land-use conversions (Newburn et al., 2005, 2006). Thus, the efficiency of AEP targeting is highly dependent upon the correlation between costs and benefits (Babcock et al., 1997). In this paper, we argue that this is likely to be the case in urban-influenced areas and that this correlation is positive, meaning that parcels of land that need the most regulations are also the most expensive ones.

We propose a theoretical analysis of the interplay between urban development and agri-environmental policies. At the rural–urban fringe, farmland is more expensive because it capitalizes the option value of future land development (Capozza and Helsley, 1989). This has consequences in terms of farming systems. Close to cities, farmland

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is substituted by non-land inputs[1] and farming is more intensive (Beckmann, 1972; Cavailhès and Wavresky, 2007; Heimlich and Barnard, 1992). Many ecosystem services such as open spaces, aesthetic and cultural landscapes, and ground and surface water quality are by-products of farming (Hodge, 2008). These ecosystem services may be in jeopardy near cities. Further away, farming is more extensive and consequently is more environmentally good, assuming that crop production remains the same across space. This spatial distribution of farming externalities also influences residential development which, in turn, modifies ecosystems. Irwin and Bockstael (2004) have shown that land conservation policies that aim to preserve landscape and natural amenities, have an indirect side-effect in terms of the development of surrounding parcels of land. These results were also supported by Roe et al. (2004) using a conjoint analysis, and Towe (2010) and Geniaux and Napoleone (2011), respectively, studying US and European cases using a propensity score matching method. Consequently, in our approach, the AEPs may affect both farming (directly) and urban development (indirectly) and the net effects of AEPs on ecosystems are undetermined.

We built a model of a monocentric city where this interplay is made explicit. Existing urban economics models assume that amenities are either exogenous (Brueckner et al., 1999; Wu, 2006; Wu and Plantinga, 2003) or proportional to agricultural land share (Bento et al., 2011; Cavailhès et al., 2004). We modify these models by allowing the level of amenities to vary spatially with farmers' behaviour. In this endogenous setting, farming is more intensive and more polluting close to the city. We then introduce an AEP which is spatially targeted to protect a given watershed in the urban-influenced area. The implementation of the AEP depends on its adoption by the farmers, which in turn depends on the opportunity cost of the land. When adopted, the AEP enables water pollution from agriculture in the watershed to be regulated. However, it also increases the attractiveness of the watershed for residential development. Inevitably, and in accordance with empirical findings by Hascic and Wu (2006) and Atasoy et al. (2006), the subsequent urban development lowers the environmental efficiency of the AEP. Thus, our model is in line with land use models and empirical evidence developed by Newburn et al. (2006) and Langpap et al. (2008). We provide a rigorous framework with which to analyze these policies in an urban setting. Contrary to Wu and Irwin (2008), who provide an insightful analysis of the dynamic of a city, our approach is static, focusing on the AEP effects. We believe that our analysis is of particular importance to European countries for two reasons. First, the AEPs are poorly targeted in Europe (Uthes et al., 2010). While the law offers the opportunity for Member States to target benefits and costs[2], most European agri-environmental policy is focused on Habitat Protection Zones (Natura 2000) and Nitrate Pollution Vulnerable Zones designated by local (sub-national) authorities. With the exception of a few specific cases (Kuhfuss et al., 2012), the AEPs in Europe are not cost-benefit targeted. Secondly, European countries are densely populated and urban sprawl is an important concern (EEA, 2006). The remainder of the paper is as follows. In the first section, we develop a static monocentric model of an urban area with an AEP. In the second section we present a numerical application of the model. We discuss the policy implications of our findings in the final section, and conclude by evoking some ideas for future work.

2. A Model of Location Decision

This section develops a model that conforms to the basic assumptions of the monocentric city model, including an exogenously determined central business district (CBD) to which households commute for employment. Households have identical incomes and preferences, and commuting costs depend on the distance between the residential location and the CBD. Land developers have identical technologies, and the market for residential development is competitive. The model assumes a Thünenian organisation of suburban agriculture, so that the farmers' behaviour is influenced by the city.

The landscape is represented by a cartesian coordinate plane $\mathbb{R}^2$, with the CBD located at (0,0) and the horizontal and vertical axes representing the West–east and North–south directions, respectively. The distance between the CBD and any residential site located at (u, v) is given by $x = \sqrt{(u^2 + v^2)}$, which together with the angle of incidence θ also determines the location of agents, where $(u, v) = (x \cos \theta, x \sin \theta)$. The landscape is characterised by an area-featured amenity source such as a lake. All residential sites are differentiated by their proximity to this lake. As a pure public good, the lake – or more specifically the level of amenities provided by the lake – is supposed to be both non-excludable and non-rivalrous. The farmers and households located within the lake's watershed produce a residual pollution that affects the quality of amenities provided by the lake. The agri-environmental policy will therefore be aimed at limiting the pollution of the lake, as a public good.

2.1. The Household Location Decision

Households make a trade-off between accessibility to the CBD and land consumption. Each household chooses a combination of residential space q_h, location (u, v), and a numeraire non-housing good s to maximise their utility subject to the budget constraint $w = r(u, v)q_h + s + \tau x$; where w is the gross household income, τ is the round-trip commuting cost per kilometre, and $r(u, v)$ is the housing rent at (u, v). The households derive utility from the amenities $a(u, v)$ provided by the lake ecosystem (i.e. scenic lake views, fishing, recreational activities, etc.).

As indicated by numerous hedonic studies on property values, the level of amenity at each location in the landscape depends on its distance from the source of the amenity. Let a_L be the maximum level of amenity provided close to the lake (u_L, v_L) and z be the distance between the household's location (u,v) and the lake. The level of natural amenity at any location (u, v) is given by:

$$a(u,\ v) = 1 + a_L e^{-\eta z} \tag{1}$$

where η is the decreasing rate of amenity as distance from the lake increases and 1 is the level of amenity at locations that are distant from the lake.

The lake is subject to pollution produced both by farms and developed parcels of land, when they are located within the lake's watershed. The total flow of pollution that reaches the lake reduces the level of amenities that the lake ecosystem provides. Therefore, the maximum level of lake amenities can be written as

$$a_L = a_0 - E(W) \tag{2}$$

where a_0 is the original level of lake amenities (without pollution). The specification of the total flow of pollution $E(W)$ depends on the farmers' behaviour, discussed in Section 2.4, and on the amount of urbanised land within the watershed.

The household utility function is assumed to be a Cobb–Douglas: $U(q_h, s, a(u, v)) = q_h^{\beta} s^{1-\beta} a(u, v)^{\gamma}$ where $0 < \beta < 1$ and $\gamma > 0$. The first-order conditions for the utility maximisation problem define the optimal choice of housing space and non-housing space at any location:

$$s^*(u,\ v) = (1-\beta)(w-\tau x) \tag{3}$$

$$q_h^*(u,\ v) = \frac{\beta(w-\tau x)}{r^*(u, v)}. \tag{4}$$

[1] Gears, chemicals, pesticides, etc.
[2] Art. 39–4 of the European Council Regulation n°1698/2005.