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Simulating farm level response to crop diversification policy

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ABSTRACT

One of the new political instruments of the upcoming European Common Agricultural Policy-reform is the crop diversification measure. To comply with this measure, arable farmers will have to grow a minimum number of crops on their land, in given proportions. In this paper a non-parametric simulation model is developed to predict land cover changes while tackling the self-selection problem. Farmers' behaviour is based on their closest peer's behaviour. A comparison between the results on diversity, measured through the Shannon Diversity Index, and the policy impact on farms, shows a clear trade-of and a potential for targeting.

Introduction

Agriculture is one of the most important land uses and its management practices have strong impacts on the environment. Policy makers are trying to reduce the negative impacts and reinforce the positive ones through environmental regulation. One of the recent outcomes of this process is the greening of the EU's Common Agricultural Policy (CAP). An upcoming measure in this greening package that aims to improve diversity of agricultural landscapes, is crop diversification.

The evaluation of this measure is challenging for traditional policy simulation models. Assessing the impact by a regional simulation model is not adequate because the policy measure is very specifically targeted at the individual farm level. Crop diversification aims at stimulating farms to take up an additional crop in their crop plan. But also existing farm-level positive mathematical programming models used for policy simulation such as described by Buysse et al. (2007) have difficulty with the evaluation of crop diversification because of the so-called self-selection problem. This problem, as defined in Paris (2001), refers to the fact that a typical farm produces only a limited set of crops without a clear economic underpinning. A proposed solution is the symmetrical positive equilibrium problem methodology, where sample aggregated cost functions are used to derive the missing information in individual farms' cost functions for crops that are at first not cultivated (Paris, 2001). Unfortunately, this aggregation does not come without any problem (De Frahan et al., 2007) as the advantages of incorporating agent-level heterogeneity are lost (Rounsevell et al., 2011). A model based purely on statistics of gross margins of different crops cannot reproduce this behaviour of farms. Consequently, such models can also not deal with the decision whether to produce an additional crop or not while this is exactly what is needed to simulate the crop diversification policy measure.

Therefore, this paper proposes and develops a non-parametric mathematical programming model based on peer behaviour, to ex-ante predict the impact at farm and landscape level. The Shannon diversity index (SHDI) is used as an indicator to measure the policy impact on crop diversity. This is currently the most widely used landscape diversity index and has been adopted by CAPRI (Mittenzwei et al., 2007). The following section is an introduction to the analyzed policy proposal, followed by a methodological section, where the assumptions and the calculation of the model are described. Afterwards the simulated changes in farm level crop allocations and landscape diversity are outlined. The final section contains the conclusion, discussion and some suggestions on future research.

The EU's crop diversification measure

The latest CAP proposal by the European Commission proposed that 30% of the farmers' direct payments conditional on three agri-environmental measures. The crop diversification measure aims at

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tackling the issue of decreasing diversity in agricultural landscapes, in other words the presence of monocultures. More diversified agricultural landscapes in time and space are supposed to increase soil- and ecosystem resilience (Weibull et al., 2003; Swift et al., 2004; Lin, 2011; Schouten et al., 2013). Farmers are required to have a minimum of two crops if they have between 10 and 30 ha of arable land.[1] If they have more than 30 ha, they need to have three crops. The first crop cannot cover more than 75%, and in case there is more than 30 ha of arable land, the first two are not allowed to cover more than 95% of that land[2] (Council of the European Union, 2013c).

During the trilogue the European Commission (EC), the European Parliament (EP) and the Council of the European Union came with their own proposals. Finally a compromise was reached (further referred to as Final proposal). Some differences among these proposals are:

(1) Each proposal has different proportional requirements for different farm categories. The EC proposes to treat all farms above 3 ha the same. They need to have minimum 3 crops, the first of which not covering more than 70% of the arable land, the third needs to cover at least 5%. The EP, the Council and the final proposal have adapted requirements for smaller farms. Those in between 10 and 30 ha of arable land need to have 2 crops and those above 30 ha 3 crops. There are some small variations in the percentages these crops should cover.
(2) The Council exempts some farms from diversification requirements. Those with large parts of the arable land covered with leguminous crops, grassland, herbaceous forage or fallow; as well as farmers who interchange parts of their land and provide in crop rotation through this interchange. The EP has no such exemptions, the EC has exemptions for farmers with all of their arable land covered by grassland or fallow. The final proposal is a mixture of the three other proposals.
(3) Also important is that the Council adopts a different definition of crop in its proposal. Additional to the EC and EP definitions of crops at genus level, the Council's proposal allows summer and winter varieties to be considered as distinct crops. Moreover, regarding the Brassicaceae, Solanaeceae, Cucurbitaceae families and the genus Triticum, the distinctions between crops are proposed to be made at species level by the Council rather than at genus level. The Council's definition of crop was adopted in the final proposal, except for the genus Triticum, which is treated as a genus as most other crops (European Commission, 2011a; Council of the European Union, 2013a,c; European Parliament, 2013).

To test the impact of the four proposals we model the impact of them in the Flemish case. The Flemish case is interesting because there are a lot of relative small farms, it has a dominant crop (maize) and it has very detailed spatial information on the crops. The prime question is whether the different crop diversification proposals reverse homogenization. Although a positive relation was found between the composition of a crop mosaic and biodiversity (Weibull et al., 2003; Swift et al., 2004; Bennett et al., 2006; Billeter et al., 2008; Gardiner et al., 2009), we do not quantify nor make conclusions with respect to the policy impact on biodiversity. Hence, in this paper only the first step of the impact analysis on biodiversity is investigated, namely whether the crop diversification proposals increase the crop diversity or not. The diversification requirement can be perceived as a public claim on former private property rights (Rodgers, 2009) and requires cautious implementation, which makes the standard ex-ante impact assessment procedures relevant (Thiel, 2009). The methodology suited to perform such an impact assessment is described in the following section.

Methodology

As explained in the introduction not regional – but farm level positive mathematical modelling techniques are adequate to simulate the impact of crop diversification policies. Therefore we choose another modelling route which is based on 'mimicking' behaviour in the sense that we assume that farmers confronted with the introduction of a new crop will act similar as farmers who may already fulfil the crop diversification requirement. Or in other words, we assume he is likely to come to the same conclusion as other farmers in the same context, he might even copy the behaviour of a successful peer (Polhill et al., 2001). This forms the basis of the model proposed.

To predict the reaction of farmer A to a newly imposed rule that requires him to change his crop allocation, we look at farmer B. The relative crop shares of farmer B are projected on the total area of farmer A. To choose this farmer B we take the best matching farmer to farmer A in terms of crop allocation. Of course only those farms which projections result in a new complying crop configuration of farmer A are eligible to be farmer B. This type of approach focuses on observable proxies and the farmers' response. The model is built on four assumptions discussed in the following paragraphs. As one will notice, the assumptions indirectly allow farmers' behaviour to reflect more objectives than merely a profit maximizing one.

The first assumption is that *every farmer wants to maximize utility*. This is probably one of the most recurrent assumptions in agricultural economic models. Contrary to many models, we do not limit utility to profit (Debertin, 1993; Polhill et al., 2001). Since no explicit monetary value is used in the model, utility can be left undefined and comprise all elements considered by the farmer. The second assumption, *the observed land allocation is optimal*, makes the model positive at its basis (Buysse et al., 2007). The farmer optimizes his utility by making a decision on crop allocation he perceives as optimal. This decision is determined by many factors (monetary- and non-monetary variables, social- and psychological factors, etc.).

A first implication of this second assumption is that any imposed deviation of the farmer's present allocation obstructs the maximization of his perceived utility. A second implication is that when a farmer changes his allocation due to the crop diversification rule, he would follow the reasoning of complying farmers, since they have already made their optimal choices, determined by economic, social and other arguments. Both implications together imply that the already existing, complying crop combination that differs the least from the farm's present crop allocation can be used as reference to predict a farmer's reaction to an newly imposed constraint, here the crop diversification measure.

One of the advantages of this mechanism is that by looking at realized crop combinations, many factors can be taken into account, factors often unknown to – or beyond the possibilities of modellers. For example information on the relations among crops such as rotation and complementary machinery, or factors determined by the period where the crop choice is determined, e.g. weather and prices. Many of these factors are equal to – or shared among farmers. This creates overlap in the individual decision-making contexts. By looking at the closest peer, the overlap is maximized.

[1] Arable land, as considered by the European institutions, hence in this paper, is distinct from land covered by permanent grassland and – crops. Those permanent covers are non-rotational. They are considered as such as soon as they occupy the land for five consecutive years or longer (European Commission, 2011a).

[2] There are also a series of exemptions related to land covers considered ecologically valuable, eg. grassland and land lying fallow (a complete overview of the final proposal can be found in Council of the European Union, 2013c).