SIMULATING FARM LEVEL RESPONSE TO CROP DIVERSIFICATION POLICY

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Abstract

One of the new political instruments of the 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.

Keywords: Crop diversification, policy, impact analysis, model, Shannon diversity index

1. 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 not cultivated in the base scenario (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 some proximity rules to ex-ante predict the impact of possible scenarios at farm and landscape level. The Shannon crop diversity index (SHDI) is used as an indicator to measure the policy impact on biodiversity. The following section is an introduction to the analysed 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.

2. Policy

The new 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 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 30ha of arable land[1]. If they have more than 30ha, they need to have three crops. The first crop cannot cover more than 75%, and in case there is more than 30ha 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 adopted scenario). Some differences among these scenarios or proposals are:

1) Each scenario has different proportional requirements for different farm categories. The EC proposes to treat all farms above 3ha the same. They need to have minimum 3crops, 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 agreement have adapted requirements for smaller farms. Those in between 10 and 30ha of arable land need to have 2 crops and those above 30ha 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 agreement is a mixture of all 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, 2013c; European Parliament, 2013).

To test the impact of the four scenarios 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 scenarios 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 scenarios increase the agricultural landscape diversity or not (i.e. the impact on land cover). 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.

3. Methodology

As explained in the introduction farm not regional level positive mathematical modelling techniques are adequate to simulate the impact of crop diversification policies. Therefore we

[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).

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 can 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 surface of farmer A. To choose 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. The model is built on five assumptions discussed in the following paragraphs. As one will notice, the assumptions are relaxed variations on neoclassical theory.

The first assumption is that *every farmer wants to maximize utility*. This is probably one of the most recurrent assumptions in agricultural economic models. Most often, utility is reduced to profit maximization (Debertin, 1993; Polhill et al., 2001). In this approach, utility can be left undefined, since no explicit monetary units are used.

Here the second assumption comes at play, namely that *the observed land allocation is optimal*. This makes the model positive at its basis (Buysse et al., 2007). The farmer considers the relevant variables and makes an optimal choice. Generally, likewise assumptions are based on the homo economic hypothesis, whose optimal choices are made based on objective characteristics and perfect knowledge (Bowbrick, 1996). The empirical validity of rational-choice theory and its homo economicus hypothesis is contested by experimental evidence (Selten, 2001; Parker et al., 2003). However, since utility is left undefined, 'optimal' can be optimal in the farmer's perception. This flexibility allows for other types of utility and factors to play (e.g. social and psychological factors). For example, there could be a consensus in the farmer's network on the 'optimality' of a certain practice, an opinion where an omniscient homo economicus would disagree on.

A first implication of this second assumption is that any imposed deviation of the farmer‘s present allocation is an obstacle on the way to realize his subjective maximal 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 crop combinations, information on the relations of those crops (e.g. rotation, machinery) is also taken into account.

One should notice that a change from the present crop allocation to a new allocation is in fact a violation of the assumption of optimal choice made by farmers. However, since the environment changes, the optimal choice also changes. Hence, we introduce a third assumption, namely that *all farmers want to comply*. This is an overgeneralization. However, direct payments, becoming partially dependent on the crop diversification measure, form a considerable amount of the farm income (European Commission, 2011b). For a more demanding greening package than the one actually discussed[3], it has been estimated that in Belgium the total average cost per eligible[4] hectare would be 117 euro. This overestimated cost still lies below 30% of the direct payments per hectare (European Commission, 2011b).

[3] Option 3 in the impact assessment of the European Commission, with 10% EFA and 70% green cover, identical crop diversification and permanent grassland requirements (European Commission 2011b)

[4] Eligible agricultural area refers to the farm surface eligible for direct payments.

From this we can infer that it could be compelling for many farmers to comply. Therefore under the three assumptions mentioned, we come to full, but minimal compliance scenarios.

The model decides upon peer farms based on the three following *variables*: The first one is crop surface. Danckaert et al. (2012) showed that the number of crops and/or their proportional allocations on a farm depend on the farm size. More precisely, small farms comply less with the proposed diversification requirements. This argument, together with the fact that policy makers are interested in the impact on different sizes of farms and the structural change of the sector (Buysse et al., 2007)[5], make the choice for absolute crop surfaces as matching variable reasonable. Second, as the idea is to simulate full but minimal compliance scenarios, linked to entrance- and exit costs, the eligible peer farms are limited to those with maximum two types of crop more than the original farm. A third variable, the geographical distance between the farms' communities, is also incorporated to further distinguish the peers. A smaller distance goes together with higher chances of sharing economic, physical and social conditions and characteristics. Respective examples could be similar transport costs, soils and social networks.

A fourth assumption is that *changes in land allocations do not affect prices to such an extent that farmers would consider to shift their production pattern*. Although utility is left undefined, one should assume price is an important determinant of farmers crop allocation. The assumption can partly be justified because of the size of the case study region, it is too small to consider endogenous price shifts. In addition, the predicted crop area changes in Flanders are very likely insufficient to have a noticeable effect on commodity prices.

Finally, to receive the payments linked to the crop diversification measure, farmers also will have to maintain at least 95% of their *permanent grassland*[6] (European Commission, 2011a; European Parliament, 2013; Council of the European Union, 2013a). In other words, lowering a farm's relative surface of permanent grassland goes against the incentive for crop diversification. On the other hand, increasing the surface of permanent grassland goes together with future limitations of land use, and thus decreasing land prices of the newly classified permanent grassland (Vanoost, 2007). To prevent unrealistic changes, the choice of reference farms B is limited to those with relative surfaces of permanent grassland within a range of 95 to 100% of the relative permanent grassland surface of the noncomplying farm A. This assumption is supported by expert opinions that indicate that farmers have developed a great fear of creating nature amenities because of limitations on future land use decisions.

To implement the model, we use data on the region of Flanders in Belgium. Because of the obligatory, annual crop declaration for farmers there is a full coverage of data on farms' crop allocations. It is also an area which has some dominant crops, which is a problem targeted by the measure under investigation. The raw data on Flemish crop land is provided by the Flemish Agency for Agriculture and Fisheries. This dataset provides the cover for each agricultural parcel for the year 2012, of 24.839 farmers (Agentschap voor Landbouw en Visserij, 2012). Farms are categorized by communities (Agiv, 2000) and crops by crop categories.

Next we identify the closest peer to project its crop allocation on the total surface[7] of the original to make the latter complying. Let's consider a set of *n* farms, with the possibility to grow *c* crops. Among those crops, several need to be specified independently as they are related to different rules in the policy packages. Hence *p* represents permanent grassland, *g*

[5] Two notes have to be made here. 1) Several proposals increased the lower threshold for the diversification rule, so the smallest farms do not have to comply anymore (see Section 1.4). 2) Farms that choose the small farmers scheme, a special measure that regulates the subsidies for small farmers, do not have to comply with the greening measures to receive their full direct payments (European Commission 2011a).

[6] Grassland is classified as permanent as soon as it remains 5 years on the same parcel (European Commission 2011a). This is the same criterion as for permanent crops, hence it is not considered arable land according to the terms set by the EC (2011a).

[7] Both permanent and arable crops are included in the model.

stands for temporary grassland, *h* is herbaceous forage, *f* is the index for fallow and leguminous crops are indexed by *l*. Equation (1) identifies the closest peer for farm n , referred to as *peer* . Variables are represented by Greek symbols. α is a dummy variable with value 1 if the conditions in (2) regarding permanent grassland measure of the greening package are met, the high weight refers to the final assumption, without which it makes no sense to adapt the crop configuration. The same goes for β, a dummy variable with value 1 if the condition in (3) regarding the number of crops is met and where the presence of a crop on a farm is accounted for by δ a dummy variable. It receives a relatively high weight to prevent a farmer of adopting too many crops. The surface allocated to each crop is depicted by the variable σ. Equation (1) takes the sum of the absolute differences in hectare per crop type between the farms. Finally, γ represents the geographical distance between the communities of the respective farms, to distinguish between farms with an equal outcome of the former variables, therefor the low weight.

$$\text{Minimize} \quad 10^5\alpha_{n,peer} + 10^3\beta_{n,peer} + \sum_c |\sigma_{c,n} - \sigma_{c,peer}| + 10^{-4}\gamma_{n,peer} \tag{1}$$

s.t.

$$0.95\frac{\sigma_{p,n}}{\sum_c \sigma_{c,n}} \leq \frac{\sigma_{p,peer}}{\sum_c \sigma_{c,peer}} \leq \frac{\sigma_{p,n}}{\sum_c \sigma_{c,n}} \rightarrow \alpha_{n,peer} = 1 \tag{2}$$

$$\sum_c \delta_{c,peer} \leq \sum_c \delta_{c,n} + 2 \rightarrow \beta_{n,peer} = 1 \tag{3}$$

However, not all farms are eligible as representative farm. Each scenario has some options for compliance. For each of those a subset of equations is added to the general equations (1-3), where the largest crop on a farm is represented by index *1*, the second largest by *2* and the third largest by *3*. The variable ρ is introduced to distinguish the arable surface of a farm from the total surface, because the latter also comprises permanent grassland and permanent crops. It is also necessary to introduce the index n^* to represent farm *n* after the simulation. More precisely, for the EC's 'normal' way of compliance these equations are:

$$\rho_{n^*} > 3 \tag{4}$$

$$\sigma_{1,peer} < 0.7\,\rho_{peer} \tag{5}$$

$$\sigma_{3,peer} \geq 0.05\,\rho_{peer} \tag{6}$$

Equation (6) represents the requirement related to the total arable surface after the simulation. If the projected arable surface is more than 3 hectare, the eligible peer farms have to comply with the rules represented in equation (7) and (8). The first crop cannot cover more than 70% of the arable surface while the third crop has to cover more than 5% of the arable surface. The other options for compliance are exemptions from diversification requirements and each contains only one additional equation:

to have less than 3 hectare of arable land,

$$\rho_{n^*} \leq 3 \tag{7}$$

to have the arable surface completely covered by grassland,

$$\rho_{peer} = \sigma_{g,peer} \tag{8}$$

or to have the arable land completely laying fallow

$$\rho_{peer} = \sigma_{f,peer} \tag{9}$$

For each combination of *n* and *peer*, the right set[8] of equations gives an outcome in equation 1. The combination with the lowest outcome for farm *n* is the basis for the last step, which is the projection of the new crop configuration on the total surface of the perturbed farm. After this projection the formerly non-compliant farm become compliant[9]:

$$\sigma_{c,n^*} = \sigma_{c,peer} * \frac{\sum_c \sigma_{c,n}}{\sum_c \sigma_{c,peer}} \quad (10)$$

An overview of the options and their respective set of equations can be found in Table 1. Note that the Council's compliance options related to agri-environmental measures and the interchange of land are not modelled, neither is the option on interchange of land of the final measure modelled. This is due to uncertainty about future agri-environmental measures and insufficient data on the interchange of land.

Table 1: Overview of the scenarios and their respective options and equations.

ρ_{n^*} (ha)	n / peer requirements	Comments
European Commission		
≤ 3	/	Farms up to 3ha are exempted
> 3	$\sigma_{1,peer} < 0.7\ \rho_{peer}$ $\sigma_{3,peer} \geq 0.05\ \rho_{peer}$	Proportional requirements for first and third crop
$= \sigma_{g,n^*}$	/	Farms with the arable land completely covered by grassland are exempted
$= \sigma_{f,n^*}$	/	Farms with the arable land completely laying fallow are exempted
European Parliament		
< 10	/	Farms below 10ha are exempted
≥ 10 and ≤ 30	$\sigma_{1,peer} \leq 0.8\ \rho_{peer}$	Respective proportional requirements
> 30	$\sigma_{1,peer} \leq 0.75\ \rho_{peer}$ $\sigma_{1,peer} + \sigma_{2,peer} \leq 0.95\ \rho_{peer}$	Respective proportional requirements
Council of the European Union		
< 10	/	Farms below 10ha are exempted
≥ 10 and ≤ 30	$\sigma_{1,peer} \leq 0.75\ \rho_{peer}$ or $\sigma_{1,peer} < \rho_{peer}$ $\sigma_{1,peer} = \sigma_{g,peer}$	Respective proportional requirements, incl. the derogation with relaxed proportional but still two crops need to cover the arable land
> 30	$\sigma_{1,peer} \leq 0.75\ \rho_{peer}$ $\sigma_{1,peer} + \sigma_{2,peer} \leq 0.95\ \rho_{peer}$ or $\sigma_{1,peer} + \sigma_{2,peer} < \rho_{peer}$ $\sigma_{1,peer} = \sigma_{g,peer}$	Respective proportional requirements, incl. the derogation with relaxed proportional but still two crops need to cover the arable land
$\leq 4/3\ (\sigma_{g,n^*} + \sigma_{f,n^*} + \sigma_{l,n^*} + \sigma_{h,n^*})$	/	Exemption for farms where 75% of the arable land is covered by grassland or other herbaceous forage, leguminous crops or laying fallow
Exemption related to eligible agricultural area:		
$3/4 \sum_c \sigma_{c,n^*} \leq \sigma_{g,n^*} + \sigma_{p,n^*}$	/	Exemption for farms where 75% of the total el. area is covered by grass (permanent – and/or temporary)
Final adopted scenario		
< 10	/	Farms below 10ha are exempted
≥ 10 and ≤ 30	$\sigma_{1,peer} \leq 0.75\ \rho_{peer}$ or $\sigma_{1,peer} < \rho_{peer}$ $\sigma_{1,peer} = (\sigma_{g,peer}\ or\ \sigma_{h,peer}\ or\ \sigma_{f,peer})$	Respective proportional requirements, incl. the derogation with relaxed proportional but still two crops need to cover the arable land

[8] In the EC scenario the possible sets are: 1-6 / 1-3, 7 / 1-3, 8 / 1-3, 9
[9] Compliant farms remain the same since they will be the 'closest peer' to themselves.

> 30	$\{\sigma_{2,peer} < 0.75 * (\rho_{peer} - \sigma_{1,peer})$ or $\sigma_{2,peer} = (\sigma_{g,peer}\ or\ \sigma_{h,peer}\ or\ \sigma_{f,peer})\}$ $\sigma_{1,peer} \leq 0.75\ \rho_{peer}$ $\sigma_{1,peer} + \sigma_{2,peer} \leq 0.95\ \rho_{peer}$ or $\sigma_{1,peer} + \sigma_{2,peer} < \rho_{peer}$ $\sigma_{1,peer} = (\sigma_{g,peer}\ or\ \sigma_{h,peer}\ or\ \sigma_{f,peer})$	Respective proportional requirements, incl. the derogation with relaxed proportional but still two crops need to cover the arable land
$\leq 4/3\ (\sigma_{g,n^*} + \sigma_{f,n^*} + \sigma_{l,n^*} + \sigma_{h,n^*})$	$\{\sigma_{2,peer} < 0.75 * (\rho_{peer} - \sigma_{1,peer})$ or $\sigma_{2,peer} = (\sigma_{g,peer}\ or\ \sigma_{h,peer}\ or\ \sigma_{f,peer})\}$ $\rho_{peer*} - (\sigma_{g,n^*} + \sigma_{f,n^*} + \sigma_{l,n^*} + \sigma_{h,n^*}) \leq 30$	Exemption for farms where 75% of the arable land is covered by grassland or other herbaceous forage, leguminous crops or laying fallow
Exemption related to eligible agricultural area:		
$3/4 \sum_c \sigma_{c,n^*} \leq \sigma_{g,n^*} + \sigma_{p,n^*}$	$\rho_{peer*} - (\sigma_{g,n^*} + \sigma_{f,n^*} + \sigma_{l,n^*} + \sigma_{h,n^*}) \leq 30$	Exemption for farms where 75% of the total el. area is covered by grass (permanent – and/or temporary)

Finally, the last step is the evaluation of the crop landscape diversity in each scenario. Diversity matters more at landscape level than farm level (Swift et al., 2004), hence the SHDI is measured at community level (LAU2-level), which serves as a proxy for the former. The SHDI measures the number of crops, to calculate the richness (m), and also their relative shares (P), which are used to calculate the evenness (Weibull et al., 2003; Brady et al., 2007).

$$SHDI = -\sum_{i=1}^{m} (P_i * \ln P_i) \quad (11)$$

Also the diversification efforts at farm level are measured, the number of adapting farms is calculated and the quantity and quality of land cover changes. How much land and how many farmers are affected and which crops become more or less present.

4. Results

The simulated crop allocations are presented in this section. First, we look at the impact of the original EC proposal. In this scenario 35% of all farmers need to change their crop allocation to comply. On the total of 24.839 farms, this results in the average adoption of 0,4 crops per farm, this is 1,1 crops per perturbed farm. In the EP proposal, due to the exemption of farms below 10ha and the moderate requirements for farms between 10 and 30ha, only 11% of the farms need to adapt their crop configuration. In the category of farms between 10 and 30ha adapting farms have 0,9 additional crops after the simulation, while above 30ha farms increase their number of crops by 1,1. The Council's proposal has the smallest impact on farms as well as on diversity. Only 8% of Flemish farms need to change their crop surfaces to comply. This is because of the similar two threshold system as in the EP proposal and the adapted definition of crop, plus the exemptions related to grassland, herbaceous forage, fallow land and leguminous crops. The final adopted crop diversification scenario is, regarding impact, very similar to the EP's scenario. 11% of the farms are estimated to be change their crop surfaces, which adopt on average 1,027 crop per farm.

Danckaert et al. (2012) found that the EC's proposal, calculated with another definition of crop, would result in a smaller impact on farms with a larger surface of arable land compared to their smaller counterparts. These findings can be confirmed for the crop data of 2012 (Agentschap voor Landbouw en Visserij, 2012) in combination with the proposed crop definition from the EC (European Commission, 2012), the Council (Council of the European, Union 2013b) and the final definition (Council of the European Union, 2013c). Note also the difference in compliance in the EC and EP scenarios among the largest farms, caused by the differences in proportional requirements (max. 70% vs 75% for the first crop).

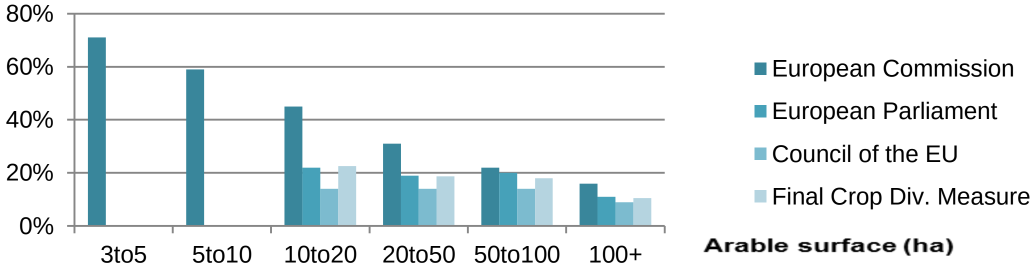

Figure 1: Non-complying farms represented by arable surface for all scenarios.

As for the EC's proposal, the adapting small farms also change a higher proportion of their farms' surfaces to become compliant, and they adopt a higher number of crops. Figure 2 and 3 show respectively the average number of adopted crops per perturbed farm and average proportion of the total eligible farm surfaces adapted per perturbed farm. In the EP, Council and final scenarios, the largest among the adapting farms seem to diverge most from their original crop configuration. This is partly because of the two threshold system with stronger requirements for the farms above the second threshold. The EP's relaxed requirements for farms above the first threshold makes the total adapted surface in the respective category 61% smaller than in the EC's case. The implementation in the EC's proposal of this isolated part of the EP amendments would result in a decrease of 22% the EC's total adapted surfaces. Regarding the smallest farms it should be mentioned that in the EC's scenario, 7.849ha or 22% of the adapted farm surface comes from farms below 10ha.

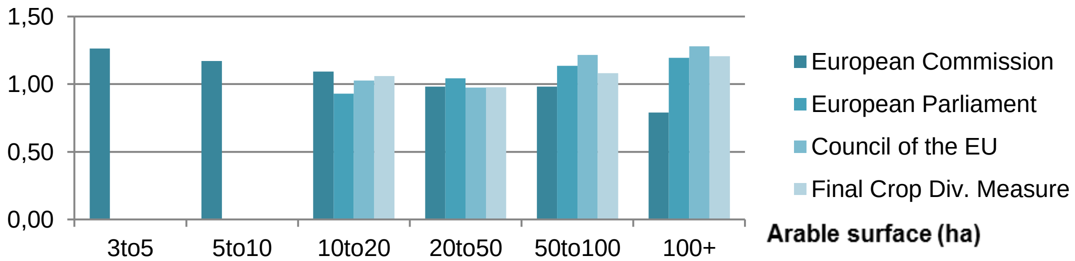

Figure 2. Average number of adopted crops per perturbed farm, represented by arable surface.

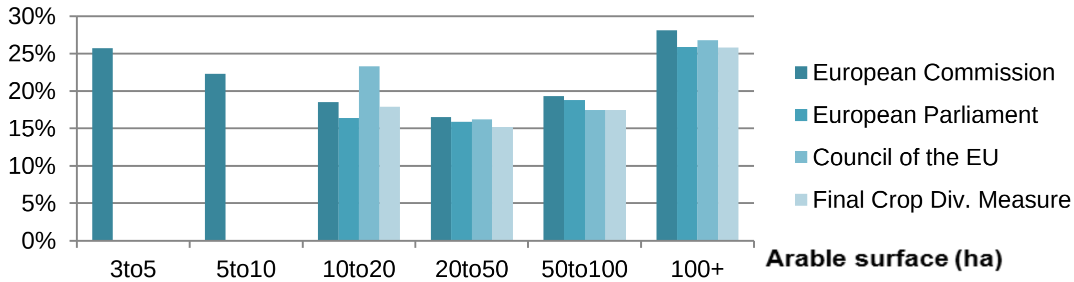

Figure 3. Average proportion of the eligible farm surface adapted per perturbed farm, represented by total arable surface.

Table 2 shows that a substantial part of the aggregated maize surface goes to other dominant crops. This effect is the most pronounced in the EC's proposal, followed by the scenario of the EP and Council respectively (Table 2). The different results for temporary grassland also indicate that the exemptions related to grassland (EC and Council) have an effect on the aggregated grassland surface.

Table 2. Changes in crop surfaces compared to the null-scenario (2012).

	Before (ha)	Eur. Commission (%)	Eur. Parliament (%)	Council of the Eur. Union (%)	Final Measure (%)
Maize	191270	-7	-3	-3	-4

Permanent grassland	145531	-1	0	0	0
Temporary grassland	84713	+3	-1	+2	+2
Winter Wheat	55658	+6	+3	+2	+3
Potato	47809	+8	+4	+2	+3
Sugar beets	22250	+7	+4	+4	+4
Rest	86179	+5	+3	+2	+2

The magnitude of changes in crop surfaces is in line with the changes of SHDI scores at community level. Table 3 shows that the EC scores best. It has the highest mean SHDI score, followed by respectively the final measure, the EP and the Council. They all are higher than the mean SHDI score before the simulations. The Wilcoxon signed rank test (Table 4) was performed on the differences between the simulated scenarios and the previous situation. The results indicate statistically significant increases of the SHDI's in all scenarios. Also shown in Table 4 are the effect sizes. Since the data is non-normal, Cliff's delta was used to calculate these. Contrary to the robust statistical significance, there is considerable overlap between SHDI scores before and after the simulation. Nevertheless, the EC simulation has almost double the effect of the EP - and final compromise scenario. It triples the effect of the Council's scenario.

Table 3. Descriptive statistics of the SHDI's at community level in all scenarios.

	N	Mean	Std. Deviation	Minimum	Maximum
EC	304	2,035	0,263	0,787	2,604
Final	304	2,001	0,277	0,796	2,594
EP	304	2,000	0,274	0,796	2,601
Council	304	1,992	0,277	0,796	2,573
Before	304	1,966	0,286	0,796	2,567

Table 4. Wilcoxon signed rank test & Cliff's delta.

	EC - Before	EP – Before	Council - Before	Final - Before
Z	-14,251[a]	-15,087[a]	-15,087[a]	-15,087[a]
Asymp. Sig. (2-tailed)	,000	,000	,000	,000
Cliff's delta	-0,13	-0,07	-0,05	-0,07

a. Based on negative ranks

5. Discussion and conclusion

Several researchers proclaimed their doubts on the effectiveness of the crop diversification measure on farmland diversity and its farm level impact (Stoddard et al., 2012, Westhoek, et al. 2012; Matthews, 2012). This study has tried to respond to these doubts by elaborating a new approach for the modelling of farm behaviour. The results of this intuitive approach, applied on the Flemish case, showed that the implementation of the proposed diversification mechanism carries the potential of being a positive alternative to the homogenization of farmland.

Monocultures are the implicit target of the crop diversification measure and it is indeed maize, the most dominant crop, which would see the largest reduction in surface. In this sense, the mechanism is effective. However, the largest part of the 'freed' area was absorbed by other dominant crops. Hence, it remains an open question whether the diversification effect on farmland is sufficient to reduce the loss in the broader farmland biodiversity. It is advisable to conduct further research on this issue, on how the crop diversification measure can be refined to correspond with the series of goals it has to meet. A plausible research direction was indicated by Matthews (2012) who suggested targeting through the definition of crop.

Contrary to the general trend of larger farms determining the impact of a land use policy (Walford, 2002), small farms play a significant role in the overall diversification impact in Flanders. In the final measure it was opted for a discriminatory approach, reducing the impact on small farms but also the diversifying impact. Because of this contradiction and because there are other ways to achieve soil- and ecosystem resilience (Angileri et al., 2011), which possibly yield similar diversity effects as the EC's proposal, further research on complementary mechanisms should be conducted, including the implemented exemption for farms practicing rotation and interchange of land (Council of the European Union, 2013c) and other types of landscape diversification (Lin, 2011).

With respect to the methodology there are also some points of discussion and conclusions to be mentioned. Because of the trend reversal in largest farms impacts, less farms need to adapt their surfaces in this category, however, if they adapt, they change a larger proportion of their farm surface. This might reflect reality but it might also indicate a problem in the model, namely the dependence on closest peers. If the closest peer strongly differ from a given farm, the changes might be overestimated. Rare crop configurations have a higher chance of this type of overestimation since they have less (close) peers. For these farms a more normative approach could be followed, where crop configuration projections would depend on the minimum requirements for compliance. I.e. a farmer would change to the threshold of compliance and no further, in between the old and projected crop configuration.

Related to this, is the problem of 'outdated' reference farms. The decision making environment of 2012 will be outdated when the crop diversification measure comes into full force (2015). Coping strategies specific to crop diversification are not fully simulated, for example diversification into winter and summer varieties. Also the general European (economic) context will differsuch as the EU-wide changing crop surfaces, the implementation of the ecological focus area measure and auto-adjusting market mechanisms. Ideally the developed methodology could be part of more dynamic models.

A third methodological issue is related to the unconsidered cropping possibilities. The option of non-compliance was not modelled. The crop diversification measure seems to induce a higher burden for some farm categories. Full compliance might be unrealistic in those categories. Additionally, two of the options for compliance in the Council's scenario were not modelled[10]. Hence the reaction of a set of farmers might be different than those simulated, and is probably overestimated.

Depending on the policy context the methodology might need some refinements to deliver accurate impact assessments. Nevertheless we believe the methodology is innovating in the sense that it indicates a path through which the self-selection problem can be tackled. Of course the model approach would benefit from an ex-post validation, Further in terms of policy impact analysis, it would be good to investigate the link between increasing (the specific type of) crop diversity and the effect on the broader biodiversity.

6. References

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