How Green are Agricultural Set Asides?

An Analysis at the Global and Regional Levels

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Draft Version 2 – June 2010 (please do not cite or quote)

Paper to be presented at the Thirteenth Annual Conference on Global Economic Analysis
"Trade for Sustainable and Inclusive Growth and Development", Penang June 9-11, 2010

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1 Introduction

There is a vivid discussion in Europe about the future of the Common Agricultural Policy (CAP) which is estimated to spent about 50 Bio € annually to the benefit of farmers (Farmer et al., 2008). A group of European agricultural economists (Hofreither et al., 2009) recently proposed to abandon completely the so-called "Pillar I" of the CAP which comprises (de-) coupled income support to farmers and market interventions linked to a so-called price safety net. Instead, they propose to target the CAP towards public goods. The declaration states "the protection of biodiversity also warrants EU support because animals, ecosystems and biodiversity-threatening pollution cross borders" (Hofreither et al. 2009, p.3). Indeed, since 2003 the CAP comprises in its so-called Pillar II a strategic focus that requires EU Member States to use funds to contribute to biodiversity conservation and the maintenance of high nature value farming systems. These opt-in measures are implemented in order to support the so-called 2010 objective of stopping bio-diversity loss (EU Commission, 2006). That objective will obviously not be met (EU Commission, 2010), triggering more stringent proposals. So has the advisory board to the German environmental ministry (Sachverständigenrat für Umweltfragen, SRU) recently suggested to set-aside 10% of all farm lands for bio-diversity protection (SRU, 2009).

The proposal by the SRU certainly has some chance to impact on the current debate. First of all, rather then asking for more expensive opt-in measures, it proposes a more regulatory approach promising a limited effect on the budget, if at all. Secondly, it gives EU Member States freedom to implement it according to regional and local externalities of agriculture and national political culture. And finally, it will act somewhat like a supply control measure for EU crop production in general, carrying the promise to soften impacts on farm income by raising agricultural prices in EU markets. The paper aims at contributing to the discussion by analysing global spill-over effects of domestic programs targeting environmental public goods, taking the SRU proposal as an example. There is certainly a danger when assessing regional agricultural and agri-environmental measures to concentrate on regional externalities. However, in integrated global markets, reduced regional supply will always be accompanied by an increase and intensification of farming in other parts of the world. And these changes will impact on the environment, including global externalities such as climate change or bio-diversity loss. The discussion about induced land use change from US and EU bio-fuel mandates provides a striking example. Equally, analysis might easily miss the fact that reduced supply will trigger price increases, which in turn will intensify the (not-regulated) part of agriculture.

In here, we want to quantify global and regional, economic and environmental impacts linked to the proposed European bio-diversity supporting set-aside program in a mutually consistent way. The challenge in that analysis consists in combining economic and environmental analysis at quite different spatial scales. The European programs can be expected to show high regional variability regarding their implementation and allocation effects. The proposal suggest, e.g., that existing programs for bio-diversity preservation should be counted as already contributing to the 10% target, so that additional areas required at regional level will differ considerably. Accordingly, we chose a regionalized agricultural economic model for regionalized European analysis, the CAPRI system (Britz and Witzke, 2008). In order to especially target the question of global land-use changes, we utilize the GTAP-AEZ model (Lee et al., 2009) of global production, trade, consumption and land use which permits us to assess changes in global land cover, by Agro-Ecological Zone, along with the associated release of Green House Gases (GHGs) (Hertel et al. 2010, Taheripour et al., 2010).

The paper is organized as follows. Section two provides a literature review about historical and predicted farm supply response to set-aside policies. The third section will present the methodology, discussing how the set-aside areas are calculated and how the crop supply response to changes in prices and set-aside obligations from CAPRI is implemented in GTAP. Section four then presents our quantitative findings, starting with the global level and then discussing regional effect for the EU27. Finally, we conclude and summarize.

2 Farm supply response from the literature

Set-aside requirements have long been used as an instrument of agricultural policy. The EU, for example, introduced a set-aside regime in 1988. But with the “Health Check” of the Common Agricultural Policy (CAP) in October 2008 this program was abolished. For many years the US used set aside programs as part of a more general “supply control” strategy. With the 1990 Farm Bill reforms these were abolished in favour of a more outward-looking farm policy. However, the Conservation Reserve Program (CRP), first implemented in 1985, continues to play a similar role. By bidding for environmentally sensitive farm land, under long term contracts, the CRP effectively reduces total harvested area in the US.

The design and the policy objectives of these programs vary and have also changed within the same program over time. In general two main objectives can be identified that policy makers are willing to achieve with set-aside policies. One is the reduction of agricultural production, mainly to reduce budgetary costs of income support programs inter alia due to WTO commitments, and/or the increase of agricultural prices by shifting the supply curve to the left. With diminishing agricultural market price support supply control measures lose however their importance. But like in the SRU-proposal environmental or climate change issues lead to a renewed interest in set-aside programs.

In the literature many studies can be found that analyse the direct and indirect effects of set-aside policies and evaluate their impacts in the light of their stated policy objectives. Most studies are based on econometric work and focus on acreage and yield changes in one region or country. Up to now, global implications and environmental impacts of set-aside policies are rarely analysed.

Table 1 presents studies on the supply response of set-aside policies. The last column describes the slippage effect that shows the relation between the percentage reduction of production and the percentage reduction of acreage.[1] A slippage rate of 100% implies no supply response (or no output change) to set-aside policies while a slippage rate of 0 indicates that the percentage change in acreage equals the percentage change in output. In the presented studies the margin of results is tremendous. Vannini et al. (2008) analysed a EU set-aside program with 6% arable land under set-aside and found decreases of the total EU agricultural supply that ranges between -1.9% to -4.7%. A slippage effect between 68.3% and 21.7% can be calculated from the results of this study. But, with up to 1% of the set-aside area planted with non food crops in the analyzed period, the slippage effect is somewhat overestimated. A theoretical analysis of Rygnestad and Fraser (1996) found that up to 30% of slippage could be feasible within the EU while Wilson et al. (2003) estimated a slippage rate of 13% for the UK. Depending on the estimation method and the data base the slippage rates in the US vary from 0% (Roberts and Buchholz, 2005) to 100% in the study of Choi and Helmberger (1996).

[1] Either the effective reduction of acreage or the policy intended change is used to measure the slippage effect.

Direct and indirect causes of the slippage effect are identified in the literature. All of them are mainly related to the profit maximizing behaviour of farmers. The first cause of **direct slippage** derives from the fact that farmers tend to use low-yielding soils to fulfill set-aside requirements. In this way the average quality of the cultivated land increases and as a consequence the aggregate per hectare yield rises. CRER (2001) found this problem more severe for non-rotational than rotational set-aside, because in the non-rotational case farmers tend to withdraw land from production on a permanent basis. The reader should note that the direct slippage effect is a function of the yield distribution over available land, so that slippage decreases when more land is forced to idle.

Secondly, a **direct area slippage** effect can occur. Both under obligatory and voluntary programs, areas already idling before program implementation might be enrolled. Choi and Helmberger (1993) found evidence that some land idled by US-farmers would have not been planted even if the farmers did not participate in the CRP-program. They call these areas "phantom" acres. A similar effect occurred e.g. in the mandatory EU programs where a general set-aside rate was fixed, but small-scale farms were exempted from the obligation.

Thirdly, direct slippage derives from productivity gains on the diverted as well as the non diverted land. Love and Foster (1990) describe, for example, that more fixed resources of a farm like quality of management or farm family labour can be allocated to the remaining areas in the short run if some land is removed from production. CRER (2001) pointed out that rotational set-aside programs may increase soil fertility and yields during the not-idling part of the rotation.

In addition to the direct effects of idling land on yields there could be **indirect effects** operating through markets in the form of price changes. Wu (2005) describes a "price feedback effect" induced by fallow land areas: the supply reduction let prices increase which in turn trigger higher production. The production increase could stem from changes in the area allocation, from using more land in agriculture or from intensification of the cultivated areas by increased use of variable inputs (e.g., fertilizer) and/or labour and capital. In the literature this is often described as "substitution effect" between land and other not restricted inputs like fertilizer. Indirect effects are more difficult to measure than the direct effects but especially in terms of the environmental dimension of set-aside policies they might be an important aspect.

Table 1: Supply response of set-aside policies

Authors	Time Period	Data/Estimation notes	Slippage rate
EU-25			
Rygnestad and Fraser (1996)	n.a.	Numerical analysis of rotational and non-rotational set aside options under three types of land quality	Up to 30% is feasible
Vannini et. al (2008)	2000/01-06/07	6% set aside in EU25 approx. 1% cultivated with non food crops	68.3% to 21.7%*
Wilson et al. (2003)	n.a.	Mixed integer programming model, UK, 210 ha farm, Cereal area reduction of 61.5%, supply reduction of 53.5%	13% *
CRER	1993-1998	Approach of Love and Foster (1990) is used, accounting for weather differences between years and variable input usage, wheat and barley	No significant slippage
USA-CRP			
Choi and Helmberger (1996)	1964-88	Sensitivity estimates of corn, wheat, and soybean yields to changes in land idle	No significant supply response, 100%*
Love and Foster (1990)	1964-86	Estimation of the direct slippage rate (without market price effect)	Wheat: 29% - 37% Corn: 48% - 58%
Norton (1986)	n.a.	Estimation of total-supply equations derived from aggregate profit-maximizing assumptions	Wheat: 34% Corn: 31%
Hoag et al. (1993)	1985-88	Field level analysis of six counties in North Carolina	less than 5 % slippage on average
Roberts and Buchholz (2005)	1982-92	Regression analysis that accounts for new and existing cropland in three districts: Corn Belt, Northern Plains, and Lake States	No convincing evidence of slippage, 0%*

* Own calculation of the slippage rate based on the slippage coefficient as defined by Garner (1987): {1 – (percentage change in output) / (percentage change in acreage)}.

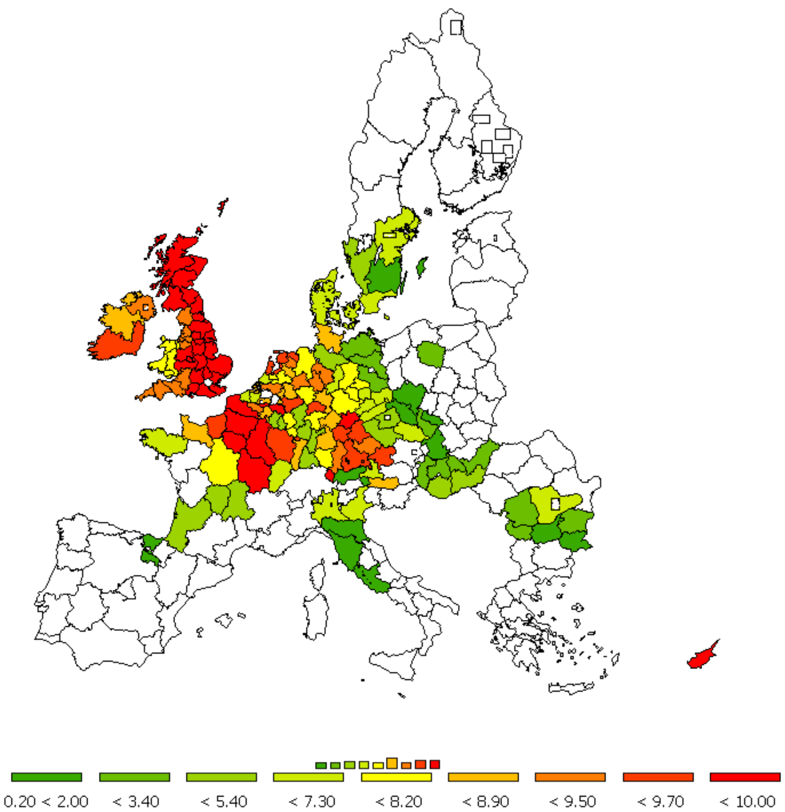
3 Methodology

3.1 Quantifying regional set-aside areas

The proposal analyzed states that the 10% ecological priority farming area required might encompass elements such as hedges, non-cropped field margins and specific types of fallow, but also extensively managed grazings and meadows. Equally, areas under so-called Agri-Environmental Measures might be included (SRU, 2009). In order to translate that somewhat open definition into a quantitative scenario, we opt for a stringent and clear assumption, which defines a kind of maximal impact of such a proposal: only areas currently in strongly protected state (Natura 2000, High Nature Value farmland) are counted as already falling under the definition. Starting with 10% of all non-grassland areas, we deduct non-grassland areas in Natura 2000 reserves and classified as High Nature Value farmland, drawing on maps provided by JRC-Ispra to find the amount of agricultural land which would to be taken out of production. That gives a kind of upper limit of environmental benefits which can be achieved in Europe from a scheme operating on arable land, but also of supply reactions in Europe and the rest of the world. Any real world implementation would most probably allow the EU Member States to also include at least some areas in existing Agri-Environmental Measures into the scheme, soften the overall impact.

The effective set-aside rate calculated is shown in Figure 1. It is important to note that Natura 2000 areas and High Nature Value farmlands are typically marginal areas, managed in an extensive way. The set-aside rate is hence high in areas where little such land is found, so that we have a kind of “adverse” slippage effect at regional scale: the required reduction is higher in more productive regions. That is also intended by the SRU: the so-far existing measures are all of an opt-in nature where with low uptake rates in high yielding regions.

Figure 1: Effective additional set-aside % required on arable land[1)]



[1)] The white regions are already complying with the SRU-proposal.

3.2 Integrating a response surface for EU crop supply in a global economic model

Both CAPRI and GTAP predict endogenously changes in crop supplies. In order to achieve a mutually consistent GE-PE analysis, we build on the response surface approach by Britz and Hertel (2009) based on a crop production possibilities frontier, now extending by taking a domestic policy shock into account. Compared to Britz and Hertel (2009), the approach is however refined.

As in the previous paper, we parameterize a normalized quadratic revenue function for EU arable crops in GTAP. The revenue function works as an aggregator function driving returns to production factors employed in the production of EU arable crops. An increase in revenue attracts production factors, and thus expands the production possibility set for EU arable cropping. The supply response for a single crop to a price increase is the combined effect of substitution between crops keeping total primary factor and intermediate input use for arable crops constant and the expansion effect.

The expansion effect in GTAP affects all crops identically in relative terms. The relation between uncompensated price elasticities $\varepsilon_{i,j}^{u}$ and compensated ones $\xi_{i,j}$ is the uniform additive expansion effect provoked by the relative revenue increase of the aggregate provoked by a change in one of the crop's prices:

$$\varepsilon_{ij}^{u} = \varepsilon_{ij}^{c} + \varepsilon^{e} \frac{\partial R p_j}{\partial p_j R} \quad (1)$$

The expansion elasticity ε^{e} describes the effect of increased primary factor and intermediate input use in the arable crop sector on output of each crop if the revenue in the aggregate increases by 1% at unchanged input use. In the original application we determined compensated point elasticities with CAPRI in sensitivity experiments along the crop production frontier by keeping intermediate inputs and primary factor input constant and used the unchanged CET parameters linked to the expansions effect from GTAP-AEZ.

In order to a ensure a mutual comparable reaction of EU arable crop supply and land use in GTAP and CAPRI to a change in prices, coherence of both compensated elasticities and the expansion effects are the key factors. Accordingly, we now parametrize GTAP such that both the compensated elasticities and the expansion effect come close to CAPRI, which should also ensure compatible uncompensated responses to shocks and prices.

We therefore proceed as follows. Based on sensitivity experiments in CAPRI, we determine uncompensated elasticities relating to changes in crop prices and introduction of set-aside. Next, we determine the expansion effect by changing all crop prices simultaneously.

Let p* denote the normalized prices – where the crop with the largest revenue share is used as the denominator – and k,l the remaining n-1 crops. We need now to find a positive, definite Hessian matrix (H) to parameterize the revenue function:

$$H_{kl} = \frac{\partial Q_k}{\partial p_l^*} = \varepsilon_{kl}^{c} \frac{Q_k}{p_l^*} \quad (2)$$

such that the matrix compensated elasticities ε^{c} including the numeraire crop is symmetric and row wise adds up to zero to fulfill the homogeneity condition. We are doing so by solving an constrained optimization problem which minimizes squared difference between the uncompensated point elasticities as derived from CAPRI and the term defined in (1), while using as constraints (a) the definitorial relation in (2), (b) symmetry and homogeneity conditions for the compensated elasticities, (c) a LL' Cholesky decomposition of H to ensure finiteness and correct curvature, and (d) the definition of $\frac{\partial R p_j}{\partial p_j R}$ from the functional form to ensure (1).

Table 2 presents compensated own and cross price supply elasticities derived from the CAPRI-model and the uncompensated elasticities derived from the GTAP-Model. Compared to Britz and Hertel (2009) the compensated own price elasticities of supply as shown by the diagonal elements of the table are more responsive for most crops. These changes are mainly due to two methodological improvements in CAPRI. Firstly, CAPRI does now include price dependent yields for major arable crops in the range of 0.25-0.3% which increase the overall supply elasticity. And secondly, a land supply function and substitution between arable and permanent grass lands were integrated in CAPRI, again increasing the supply elasticities. Both features bring GTAP and CAPRI closer.

To meet the CAPRI-expansion effect of 0.523 the Constant Elasticity of Transformation (CET) parameters of the GTAP-model are adjusted. In the AEZ-GTAP model, a nested CET structure of land supply is implemented. In the first nest the land owner decides among three land cover types (forest, cropland and grazing land) whereby the decision is based on relative returns to land. To achieve the same expansion effect than CAPRI the absolute value of the CET parameter is set to -0.184. In the second nest the land owner decides among the allocation of land between various crops. Here the CET parameter is set at -0.46. Both elasticities are slightly smaller than in the original AEZ-GTAP model. Here, the elasticities are -0.2 for nest one and -0.5 for the second nest (Hertel et al., 2009).

Table 2: CAPRI-Compensated and GTAP-uncompensated price elasticities[1)] for the EU27

	Rice	Wheat	CGrains	Oilseeds	Sugar	OthCrop
Rice	0.080	-0.053	-0.096	-0.029	-0.016	0.113
	0.085	*0.005*	*-0.033*	*0.002*	*0.002*	*0.497*
Wheat	-0.003	1.584	-0.494	-0.006	-0.004	-1.077
	0.000	*1.662*	*-0.436*	*0.025*	*0.013*	*-0.702*
Cgrains	-0.005	-0.453	1.686	0.030	-0.028	-1.229
	-0.002	*-0.400*	*1.770*	*0.061*	*-0.011*	*-0.856*
Oilseeds	-0.003	-0.011	0.062	0.972	0.007	-1.027
	0.000	*0.048*	*0.127*	*1.014*	*0.024*	*-0.652*
Sugar	-0.003	-0.015	-0.104	0.012	0.468	-0.359
	0.000	*0.044*	*-0.041*	*0.043*	*0.490*	*0.022*
OthCrop	0.001	-0.159	-0.198	-0.079	-0.015	0.450
	0.004	*-0.103*	*-0.137*	*-0.049*	*0.002*	*0.834*

[1)] in intalics

Source: Own Calculations.

3.3 Comparison of quantity responses

The methodology described above provides a first order approximation of the uncompensated supply elasticities and to a certain extent of factor demand elasticities in GTAP to point elasticities derived in CAPRI in sensitivity analysis. In a combined application, mutually compatibility will largely depend on how compatible deviations from the point elasticities in CAPRI and GTAP are.

Table 3 shows quantity responses taking into account the set-aside shock and the price change simulated with GTAP. The first column gives the percentage quantity change if the compensated and expansion elasticities from above are used without applying the model themselves, whereas columns 2 and 3 show the simulation results from GTAP and CAPRI, respectively. The table highlights two important points. Firstly, a comparison of the first column with the remaining ones show that the supply responsiveness both in GTAP and is somewhat lower compared to the point elasticities, i.e. in both systems point elasticities are declining for larger shocks. Secondly, the match between CAPRI and GTAP as seen by comparing column two and three is rather satisfactory, which is linked to the choice of functional form in GTAP for the crop revenue function. Heckelei (2002) indeed shows that as long as the basis does not change, the Hessian of a programming model with a quadratic objective and linear constraints is fixed. The differences between CAPRI and GTAP are in the 0.1-0.3 percentage point range in our experiments. For those crops which occupy larger share of the EU land base, cereals and oilseeds, the fit is actually very good, and the effects in between the cereals mostly compensate. We might conclude that the quantity responses are close enough to term a combined analysis as mutually consistent.

Table 3: Percentage quantity change as derived from CAPRI's point elasticities and simulated by GTAP and CAPRI in response to a change in ecological set aside *requirements of* 10% (SRU proposal) and the resulting price change as simulated by GTAP

	Estimated based on CAPRI point elasticities	GTAP-CAPRI	CAPRI
Rice	-0.27	0.13	-0.07
Wheat	-2.11	-1.56	-1.68
Cgrains	-1.3	-0.79	-0.52
Oilseeds	-2.64	-2.06	-2.08
Sugar	-0.63	-0.15	-0.33
OthCrop	-0.59	-0.19	-0.07

Source: Own Calculation.

Results

Decomposing the Farm Supply Response of CAPRI

Table 4 shows the percentage changes in yield per hectare after the implementation of the SRU-proposal. Here, the yield slippage is isolated from other effects and presents only the changes in yield per hectare. In contrast to previous programs the SRU proposal results in an "adverse slippage" effect for wheat, oilseeds and sugar while the yield of "other crops" is increased.

What are the driving forces behind the adverse slippage effect? To answer this question a decomposition of the results is implemented. The decomposition enables us to identify the variables that influence the aggregated result. For wheat a slippage rate of -0.1% is measured. The negative sign stems from the change of -0.5% in regional composition. This reflects the fact that high yielding regions set aside disproportionally more land than low yielding regions (compare also Figure 1). The negative result of the regional composition is partly compensated by the effect of 0.4% from the endogenous input-output coefficients. They are positive for all products and mirror the positive own price elasticities.

For oilseeds the aggregated yield response is -0.6. Here, the influences of price changes and the regional composition on the aggregated effect are similar than for wheat. Additionally, a negative effect of -0.6 occurs for other factors which is mainly due to a change in the product composition of oilseeds. Low yielding regions do not only show lower yields for single oilseeds such as rape seed, but also higher shares of low yielding oilseeds such as sunflower seeds.

For "other crops" a positive slippage effect of 0.7% arises. That is mainly due to the fact that sugar beet, which show the highest yield in the aggregate and still operating under a quota regime, are affected less.

Table 4: Supply response of the SRU-proposal in the EU 27

	Yield	**Decomposition: The effects of…**			
	Slippage rate	endogenous IO coefficients	changed technology shares	changed regional composition	other factors
Rice	**0.0%**	0.0%	0.0%	0.0%	0.0%
Wheat [1)]	**-0.1%**	0.4%	0.0%	-0.5%	0.0%
Cgrains	**0.0%**	0.4%	0.0%	-0.6%	0.1%
Oilseeds	**-0.6%**	0.3%	0.0%	-0.4%	-0.6%
Sugar	**-0.2%**	0.0%	0.0%	-0.2%	0.0%
OthCrop	**0.7%**	0.0%	0.0%	-0.3%	1.0%

1) simple average of drum and soft wheat.

Source: Own Calculation.

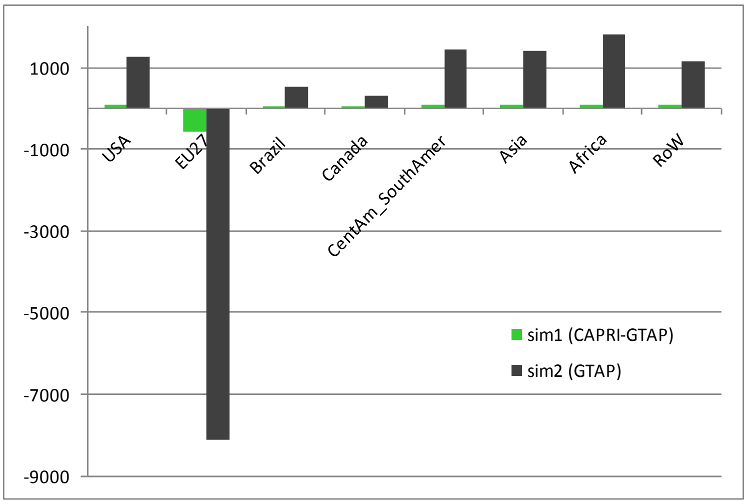
Land use change at European and global level

Scenarios: We introduce a policy shock according to the SRU-proposal along the lines described and implemented in the previous Chapters. In a first experiment we implement the set aside requirements in the coupled CAPRI-GTAP-framework. To illustrate how important the information of the CAPRI model for the GTAP-simulations are, we run a second experiment. In this experiment we utilize the GTAP model without integrating additional information of the set aside experiment from CAPRI. Here, it is simply assumed that a set-aside rate of 10% will decrease the output of a particular crop by 10%.

Global Trade Impacts: The implementation of the set aside policies reduces the supply of agricultural crops in the EU. This result is reflected by the change in the trade balance. In the EU the imports increase relative to the exports and the change in the trade balance for crop products becomes negative. At the same time exports in relation to their imports increase in all other countries and regions of the world.

In the CAPRI-GTAP-framework (simulation 1) the trade balance of the EU changes by -564 Mio. US$. A GTAP-only scenario (simulation 2) would result in a trade balance change of -8110 Mio. US$. These results show the importance of the CAPRI information. Without consideration of the CAPRI results the supply response would be overestimated by approximately 1400%.

Figure 2: Changes in Trade Balance of Crop Products in Mio. US$



Source: Own Calculation.

Changes in land cover: But is the change in supply and trade pattern also reflected in changes in land cover? CAPRI shows for the EU 27 an increase in set-aside areas of around 3.6 Mio ha, but also an increase in total area used in agriculture by around 1.4 Mio ha, as a response to higher prices. Cropped areas are hence reduced by -2.2 Mio ha, of which about -1.2 Mio ha are reduced fodder areas, mainly extensive permanent grass lands with -0.5 Mio ha. These changes are not astonishing: agricultural land gets scarcer with the set-aside program implemented while output price increases, so that extensive farming practises are reduced in favour of crops generating higher returns per ha of land.

Interestingly, and perhaps against a priori expectations, is the observation that farm lands are simulated to slightly expand also in some regions where set-aside is implemented. That can be explained with the medium term character of CAPRI where primary factors are implicitly assumed to be not fully mobile. Larger parts of the capital stock in agriculture are rather specific. If after the set-aside program, the capital stock is operating with a low capacity load, and there is hidden unemployment in agriculture, farmers might indeed increase their profits by renting additional land. But clearly, that effect will vanish once the capital stock is depreciated or farm labour can leave agriculture. That reaction is however different from the functioning of factor markets in the applied version of GTAP.

Table 5 presents the changes in crop land coverage for other regions in the world as calculated with the CAPRI-GTAP framework. While the cropland coverage in the EU is reduced cropland expands in all other countries or regions. The largest expansion is in Canada with 86.8 thousand hectares. Canada is followed closely by Brazil where crop land expands by about 65.7 thousand hectares. In terms of percentage changes in total land cover the changes on cropland cover is rather small and ranges between 0.2% in Canada and 0.003 in Asia.

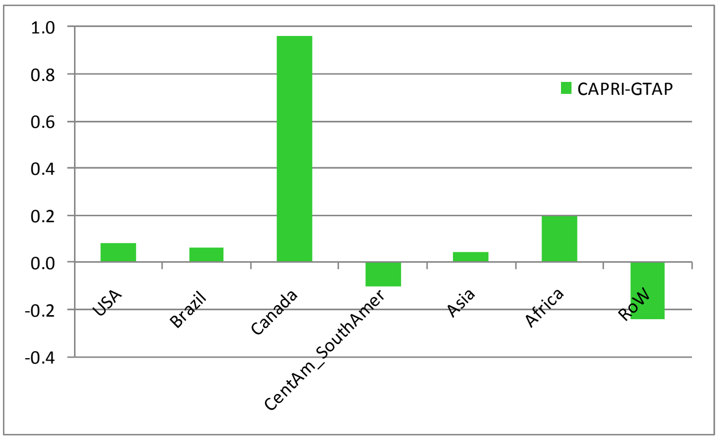
Table 5: Changes in Crop Land Cover by region

	USA	Brazil	Canada	Latin America	Asia	Africa	RoW
Thousand hectares	37.05	65.71	86.75	29.66	15.17	189.31	64.49
Percentage change	0.02	0.13	0.20	0.03	0.00	0.08	0.02

Source: Own Calculation.

As a consequence of global crop land conversion the emissions rise in all non EU countries by 41.8 MMT CO_2. Figure 3 reports the estimated distribution of Global GHGs in all non-EU-regions. Canada shows the highest GHG emissions from land cover change and contributes with 96 % to the total effect. In contrast Brazil that also converts a relatively high amount of land has a lower GHG emission rate. The reason for this observation is the origin of the converted land. While Canada converts mainly forest land into cropland, in Brazil the additional crop land is expected to come from pasture land.

Figure 3: Share of Global CO2 Emissions by Region (without EU)



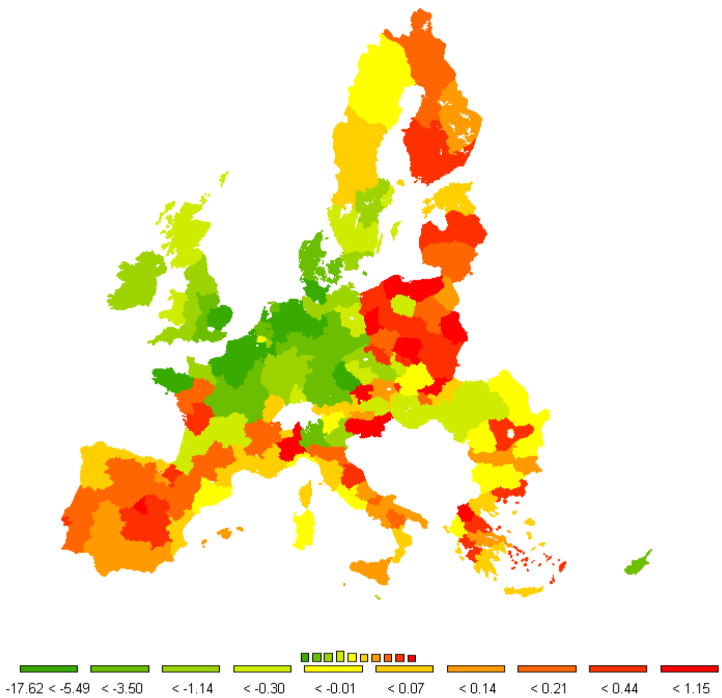
Source: Own Calculation.

Environmental indicators at EU level

At EU level, major environmental indicators all show smaller decreases. Emissions of gases relevant for climate change expressed in CO2 equivalents are simulated to drop by about -1.5%. Crop nitrogen need fall by -1.5%, allowing to reduce mineral nitrogen fertilizer use by -2.7%, which together with a reduction in nitrogen in manure of about -0.2% let surpluses decrease by -1.1%. The reduced manure output is a consequence of slightly reduced animal herds due to higher feed costs resulting from increased crop prices. Reduced organic and mineral nitrogen use reduced also ammonia emissions by about -0.4%.

The map below reveals however that the changes are far from uniformly distributed. In the high yielding regions where larger set-aside percentage are needed (see also figure 1), crop production and nitrogen use decreases, leading to reduced surpluses, while in the Mediterranean, Scandinavia and new Member States, higher prices stimulate farm intensification and let surpluses increase. The changes are however relatively small, and mainly concentrated in areas with a low level of surplus. An analysis for France drawing on the 1x1 km downscaling component of CAPRI (Paracchini and Britz, 2010) concluded that the program indeed improves the bio-diversity status in more intensive regions.

Figure 2: Change in nitrogen surplus in kg/ha



Source: Own Calculation.

Summary and conclusion

Britz and Hertel (2009) contribute to the recent discussion about induced land use change by analysing regional and global environmental consequences of EU biofuel mandates, combining GTAP and CAPRI. We take that methodology as a starting point to compare regional and global environmental effects of a proposed set-aside program for the EU targeting bio-diversity. The proposed set-aside program differs both from opt-in programs such as the voluntary set-aside programs in the EU or the CRP in the US, but also from the past and now abandoned obligatory supply control set-aside programs of the EU. The latter difference is that while being obligatory and requesting a 10% share of ecological "priority areas" at farm level, existing commitments of farmers e.g. by participating in agri-environmental opt-in measures are taking into account. Accordingly, the share of additionally extensified or idling land is highest in high yielding regions with so far low participation rates in opt-in measures. From a national or EU wide perspective, that provokes a negative slippage effect: areas are taken from the most productive regions, so that the relative reduction in production exceed relative area changes, an effect not offset by yield response to higher prices.

The analysis at a regional level shows an improved environmental status in the high yielding regions due to the increase in idling land. Price increases trigger however intensification across Europe, and let pressures increase in the more marginal areas where little or no additional land is taken out of production. The global analysis adds the interaction between land use changes across regions: the loss of 2.2 Mio ha of arable land in the EU is compensated by an increase of 0.5 Mio ha in other regions of the globe. The improvement in the environmental status in the EU is bough to a certain extent by intensification and loss of forest and grass land areas elsewhere, shown also by an increase in GHG emission of 41.8 MMT CO_2.

The improved methodology for linking the GTAP-AEZ and CAPRI allows for an elegant model linkage while showing a sufficiently similar supply response to price changes and the introduction set-aside program to allow for mutually consistent analysis across regional scales and environmental impacts.

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