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Impact of EU biofuel policies on world agricultural production and land use

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ABSTRACT

The European Union aims to increase the share of renewable energy in its total energy consumption to reduce greenhouse gas emissions and make the economy more CO_2 neutral. This policy is further motivated by a desire to reduce dependency on fossil fuel imports and to stimulate rural development and the agricultural sector.

1. Introduction

The world-wide expansion in the production of biofuels is currently one of the hot topics on the agricultural and food research agenda. On the one hand the expansion in biofuels is welcomed as an additional source of income for farmers on otherwise saturated markets for agri-food products. On the other hand, however, there are growing concerns that biofuels will further increase the volatility of agricultural world prices by linking agricultural prices with the development of the price of crude oil.

This paper contributes to this discussion by discussing different options to extend the global general equilibrium model Global Trade Analysis Project (GTAP) to include biofuel crops. The standard version of the GTAP model includes 87 regions and 57 sectors. For this paper the model has been extended to include biofuels production. This extension follows a previously published extension called GTAP-E [1] and the new extension explicitly depicts the use of cereals, vegetable oils and sugar as inputs in the production of biofuels in a multi-level structure in the petroleum activity.

While this extension of the GTAP model does not present biofuels, e.g. biodiesel or bioethanol, as separate products for final consumption, it enables analysis of the impact of targeted policies such as tax exemptions and obligatory blending for the petrol sector for individual regions and countries. Blending targets in the extended version of the GTAP-E model called the LEITAP model [2,3] are presented as (exogenous) shares of biofuel crops in the intermediate demand of fuel inputs in the petrol sector.

To analyze the impact of an enhanced use of biofuels as the consequence of the EU Biofuels Directive (BFD) under different scenarios, two different baseline scenarios which describe

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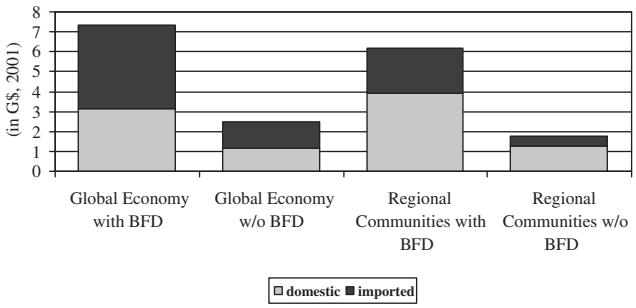

Fig. 1 – Biofuel Crops used in the European Union, 2010.

different visions of the future are calculated up to 2020 [4]. The 'Global Economy' scenario depicts a world with fewer borders and regulation compared with today. Trade barriers are removed and there is an open flow of capital, people and goods, leading to a rapid economic growth, from which many (but not all) individuals and countries benefit. Specifically, the 'Global Economy' scenario assumes

- Successful WTO negotiations leading to a stepwise elimination of almost all trade barriers,
- a phasing out of agricultural support and
- strong technological development.

The other vision, called 'Regional Communities' depicts a world split into regions with people having a strong focus on their local and regional community and preferring locally produced food. Economic growth is lower compared to the 'Global Economy' scenario. Furthermore under the 'Regional Communities' scenario it is assumed that:

- CAP subsidies increase by 10%, linked to environmental and social targets. Export subsidies are eliminated;
- Import barriers remain in place, to protect local markets against cheap imports;
- Imported goods have to comply with high EU standards regarding health, environment, and animal welfare.

For both scenarios two simulations with and without mandatory blending for biofuel use are calculated. It should be mentioned that even without a mandatory blending the use of biofuel crops changes due to changes in relative prices (biofuel crops vs. fossil fuel).

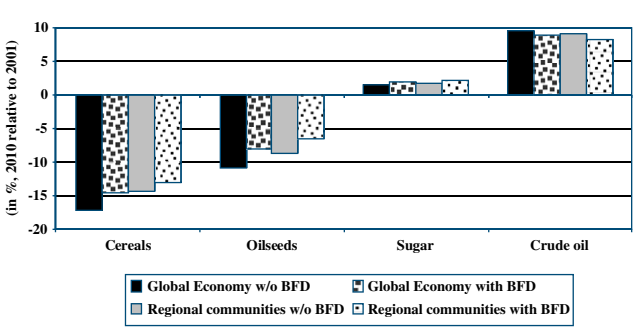

Fig. 2 – Changes in real world prices.

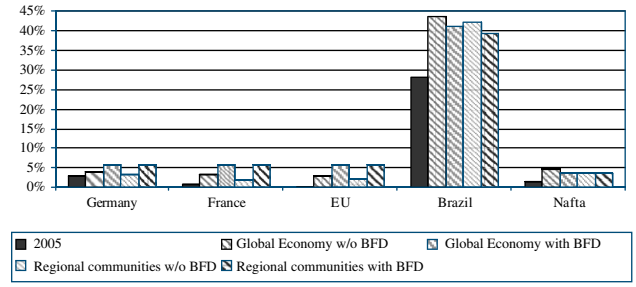

Fig. 3 – Development of share of biofuels in fuel consumption for transportation for selected regions, in %, 2005 and 2010.

2. Ambitious targets

Ambitious goals have been set by the EU BFD for the transport sector: the minimum share of biomass or other renewable transport fuels must be 2% by 2005 and 5.75% by 2010. The 2% target in 2005 was not mandatory and most EU member states had a share of biofuels in transportation fuel of less than 2% [5]. For 2020 the EU target is set at 10% under the condition that the so-called 2nd generation biofuel technology then will be available. Currently bio-energy is coming from both waste material and growing first generation biofuel crops. To meet the ambitious future targets, large scale production of crops used for biofuel production in Europe will be necessary. In the 'Global Economy' scenario the demand for biofuel crops used in the petrol sector in 2010 is projected to be 7.3 G$ (in 2001 values) under the minimum blending of 5.75%. Around 42% of these inputs will be produced domestically and 58% of biofuel crops used in the petrol sector will come from imports, see Fig. 1.

If mandatory blending is not enforced the use of biofuel crops is much lower in all scenarios; only 2.5 G$ under the 'Global Economy' scenario and only 1.7 G$ under the 'Regional Communities' scenario. The lower demand under 'Regional Communities' is due to smaller increase in income compared to the 'Global Economy' scenario.

The degree of openness under both scenarios is also reflected in Fig. 1. Under the 'Global Economy' scenario without mandatory blending the share in imported biofuel crops used for biofuel production is 53.5% while under the higher protection in the 'Regional Communities' scenario, imported biofuel crops contribute only 28.5% to total biofuel production.

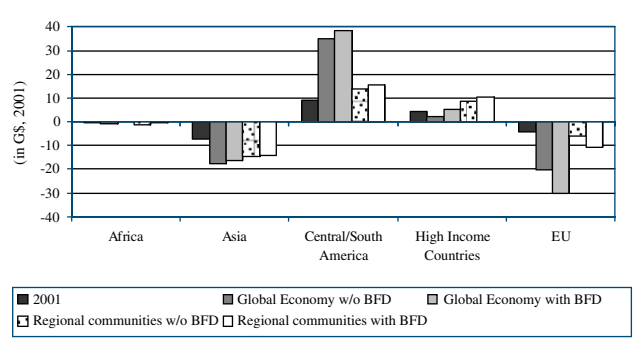

Fig. 4 – Balance in biofuel crop trade. 2001 and 2010 under different scenarios.

Table 1 – Changes in agricultural production, in %, 2010 relative to 2001.

	Africa	Asia	Central-South America	High Income Countries	EU	World
Arable Crops						
Global Econ. w/o BFD	113.1	70.1	87.5	19.2	22.8	54.4
Global Econ. with BFD	113.4	70.2	90.0	19.5	24.2	55.0
Regional com. w/o BFD	96.1	60.2	50.8	26.1	3.9	41.5
Regional com. with BFD	96.4	60.2	52.2	26.4	6.8	42.2
Biofuel Crops						
Global Econ. w/o BFD	183.8	115.6	143.6	33.6	−18.8	70.1
Global Econ. with BFD	187.8	116.5	150.9	34.7	−12.7	73.3
Regional com. w/o BFD	126.2	95.9	64.5	33.3	−1.5	49.5
Regional com. with BFD	128.3	96.2	67.5	34.0	11.1	52.5
Oilseeds						
Global Econ. w/o BFD	178.2	108.0	131.1	99.4	7.6	99.7
Global Econ. with BFD	181.1	108.6	135.4	102.0	26.0	103.6
Regional com. w/o BFD	119.6	88.2	69.7	75.8	15.3	71.9
Regional com. with BFD	124.3	88.9	76.9	78.6	40.1	77.0

If the Biofuels Directive is enforced, imports in biofuel crops strongly increase even under the more protected 'Regional Communities' scenario.

With these strong changes in import demand, world prices for biofuel crops are affected by EU policies. The following figure presents the changes of biofuel prices at the global level. With an enhanced biofuel consumption as a consequence of the EU Biofuels Directive, prices of agricultural products tend to increase. This is especially the case for those products which are directly used as biofuel crops. Under the 'Global Economy' scenario without a mandatory blending, real world prices for agricultural products tend to decline to conform to their long term trend, see Fig. 2. This is caused by an inelastic demand for food in combination with a high level of productivity growth. Under the 'Global Economy with BFD' scenario, world prices rise relative to the scenario without the BFD. The real price of oilseeds shows a positive development in contrast to their long term trend. Compared to the US and Brazil where ethanol consumption dominates the biofuel sector, the EU biofuel sector is based on biodiesel, which is reflected in the increase in prices of these products. This analysis is limited to the production of either biodiesel or bioethanol. Crops used as inputs for biofuel production are grouped together as 'biodiesel/bioethanol crops' and other biomass such as 'second-generation' biofuel crops are not considered. Under the 'Regional Communities' scenario similar changes can be observed, however, at lower level. The crude oil price increases by slightly less due to the lower growth in world income. However, also under this scenario the implementation of the EU Biofuel Directive will reduce the increase in crude oil prices.

Even without a enforced use of biofuel crops through a mandatory blending, the share of biofuels in fuel consumption for transportation purposes increases, see Fig. 3. This endogenous increase in biofuel production is due to the fact that the ratio between crude oil price and prices for biofuel crops changes in favour of biofuel crops, see Fig. 2. Under the 'Global Economy w/o BFD' scenario, biofuel shares increase. The highest increase is in the already integrated market of Brazil where the initial 2005 share of more than 29% expands to more than 42% in 2010. In Germany and France the endogenous growth of biofuel shares leads to biofuel consumption for transportation in 2010 of 4.0% in Germany, 3.4% in France and 2.9% for average EU. These results reveal that without a mandatory blending the 5.75% biofuel share will not be reached in the member states of the EU.

With a mandatory blending, the EU member states fulfil the required targets of 5.75% under both scenarios presented in Fig. 3. However, this happens at the expense of non-European countries. Under both of the BFD scenarios the share of biofuel use declines in Brazil by around 6%. Under the 'Global Economy with BFD' scenario the biofuel share in fuel used for transportation decreases by more than 20% in the NFTA countries. This decline in biofuel production in non-European countries is due to the increase in relative prices between biofuel crops and

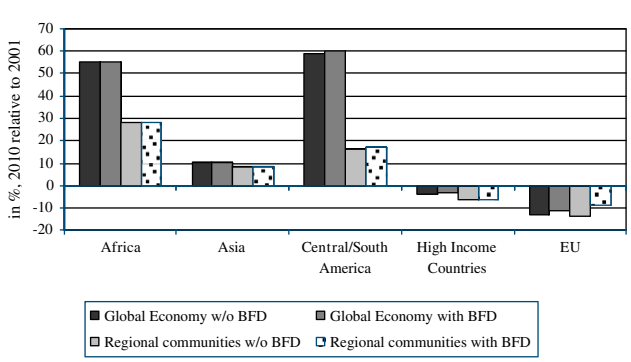

Fig. 5 – Changes in agricultural land use.

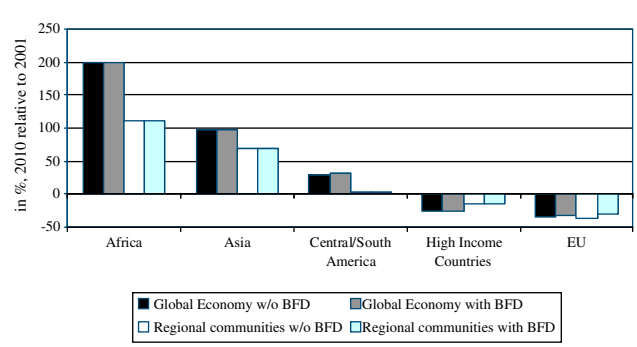

Fig. 6 – Development in agricultural income.

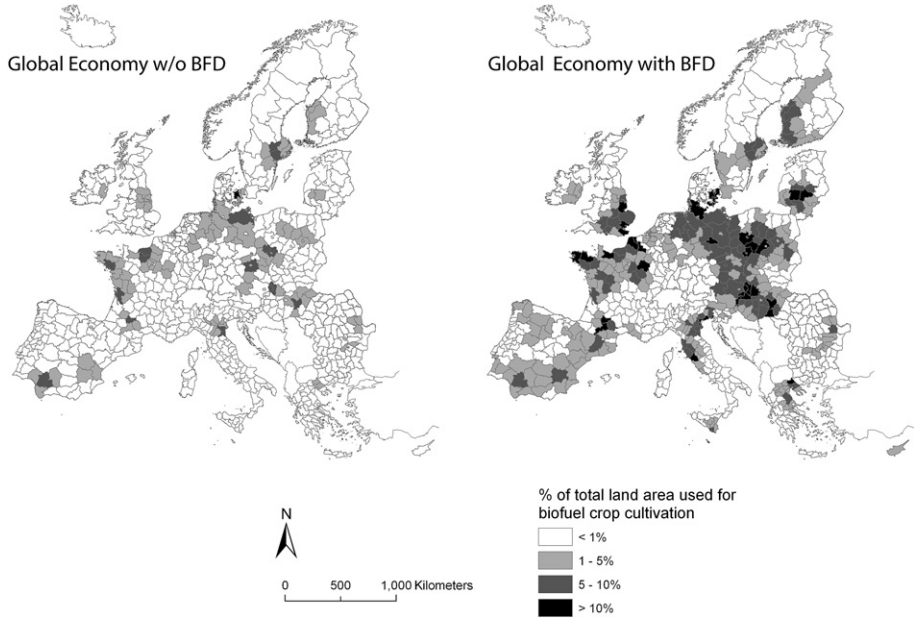

Fig. 7 – Biofuel crop cultivation in each NUTS2-region in 2010 (given as percentage of total land area).

crude oil. The enhanced demand for biofuel crops in the EU under the BFD scenarios leads to an increase in world prices for these products and hence to a decline in the profitability in fuel production compared to crude oil. However, the increase in biofuel crop demand in the EU over-compensates the decline in non EU countries and at global level the use of biofuel crops for fuel production increases under the BFD scenarios. A good indicator for this development is the decline in crude oil price under the BFD scenarios compared to their respective scenarios without BFD, see Fig. 2. Whether increasing in biofuel production leads also to a decline in GHG emissions remains questionable [6]. Searchinger et al. [7] indicate that an increase in biofuel production may also increase GHG emissions. However, due to the revised statutory requirements, the RFS2 program is expected to reduce GHG emissions [8].

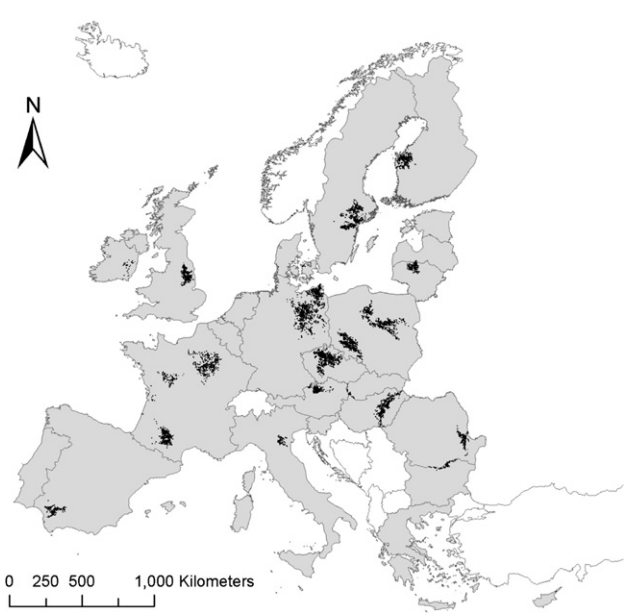

Fig. 8 – Potential hotspots of biofuel crops in 2010: i.e. locations where biofuel crops are allocated by the EUruralis biofuels model in all of 4 different scenarios.

Fig. 4 shows that the EU will increase its deficit in trade of agricultural commodities used for the production of biofuels under the biofuel scenarios. South and Central America as well as other high income countries expand their net-exports in agricultural products for biofuel production. The model does not consider trade in biofuels directly. The trade figures presented here show only trade in feedstock which are processed to biofuels at a later stage.

Compared to world income growth, the annual growth rates of agricultural production are quite moderate in the reference scenario. In the EU and in the region of high income countries, production of biofuel crops is also negatively affected by the liberalization which is implemented in the 'Global Economy'. At aggregated level total agricultural production increases in the reference and both policy scenarios. In all regions mandatory blending also leads to an increase in total agricultural output, see Table 1. Comparing the results of the 'Global economy' scenario with and without the BFD, the strongest relative increase in agricultural output takes place in the EU and South and Central America.

Table 1 presents the results for changes in oilseed production which strongly expands under the policy scenarios. Oilseed production in the EU increases from 7.6% in the 'Global economy w/o BFD' scenario to 26% in the 'Global Economy with BFD' scenario. The BFD also creates similar effects under the 'Regional Communities' scenario.

This expansion in production leads to a similar pattern of expansion in land use (Fig. 5). Land use increases in all regions when comparing the impact of the EU Biofuel Directive. In the EU the decline in agricultural land use, as a consequence of the liberalization in the 'Global economy' scenario, is smaller under the BFD scenarios. This expansion of agricultural land use on a global scale and especially in South America might

indicate a decline in biodiversity in these countries as land use is an important driver for biodiversity.

Apart from the direct impact of an increase in biofuel demand on prices and production, the changes in agricultural income from agricultural production are significant, see Fig. 6. The income losses will be a bit smaller under the BFD scenarios. The positive development in incomes is mainly due to higher agricultural prices. Agricultural income outside the EU increases; in Africa, Asia and South and Central America.

3. Side effects

The results of changes in the production of biofuel crops presented above can have important environmental side effects. Biofuel crop production requires scarce resources such as land, water and agricultural inputs like fertilizers. This will have impacts on the environment – CO_2 balance, erosion –, on the landscape and on biodiversity. The geographical location and spatial arrangement of biofuel crops will greatly determine the actual environmental effects of these crops. Therefore, a spatially explicit analysis at regional level is needed to show that the introduction of biofuel crops will have a greater impact in regions with a high ecological or landscape value.

In addition to the LEITAP model, an extension of the CLUE-s model has been developed to explore the spatial distribution of biofuel crops within the EUruralis project [9]. The CLUE-s model provides a long term perspective until 2030, presenting insights on which land use types are likely to be replaced by biofuel crop production, and on the EU-wide geographical location and pattern of biofuel crops under the different scenario assumptions.

4. Geographical patterns

In Fig. 7, the area of biofuel crops in each region in 2010 is given as a percentage of the total land area of the region for the Global Economy scenario with and without the EU Biofuels Directive. The total area with biofuels differs substantially between the two scenarios indicating the effect of the EU Biofuels Directive. To expand the biofuel production area new regions emerge as important contributors to the biofuel production. Under the BFD scenario most of the additional production of crops for biofuel production is allocated to the Northwest and the Eastern part of Europe. The projection of the extra growth in biofuels in Northwest Europe is the result of the LEITAP model, which projects most growth in biofuel crops in those countries which are also countries cultivating a high share of these crops at present. Large areas of biofuel crops are allocated in Eastern Europe due to the low labour costs and the agricultural potential in these countries.

The spatial allocation of biofuel crop production is determined by the accessibility to processing locations (that have good access to year-round feedstock supply), preferable conditions for efficient production (i.e. no marginal areas) and fit within the cropping cycle [9]. Furthermore, the regional allocation of production areas depends on the scale and allocation of processing industries and national policy implementations. In order to deal with these uncertainties, four different scenarios of regional allocation patterns were studied and compared for consistency.

Despite the (important) differences between the scenarios, the same countries are facing most growth. In addition, within countries, a number of regions can be identified that show most growth in biofuel crops in all the scenarios. These locations have in common a combination of well-developed infrastructure and large areas of suitable arable land. This means that potential 'hotspots' of biofuel crop cultivation can be identified in Europe, in which substantial areas of biofuels emerge in all scenarios, see Fig. 8.

Hotspots of biofuel production in the EU include NE-Germany, parts of Poland, Lithuania, Czech Republic, agricultural areas around Paris, and parts of Hungary. In these regions, biofuels will most certainly change the landscape. Based on this information it is possible to estimate the environmental impact of the cultivation of biofuel crops, e.g. on biodiversity [10].

5. Summary and conclusion

The analysis shows that enhanced demand for biofuel crops under the EU biofuel directive has a strong impact on agriculture at global and European level. The long term trend of declining real world prices of agricultural products slows down or may even be reversed for the feedstock used for biofuels. The incentive to increase production in the EU tends to increase land prices and farm income in the EU and other regions. Since the EU is not able to domestically produce sufficient biofuel crops to fulfil the BFD, it must import biofuel crops and run a higher agricultural trade deficit. Biofuel crop production expands in other highly industrialized countries and especially in South and Central America (Brazil). The results depend heavily on the development of the crude oil price. The higher the crude oil price, the more competitive biofuel crops become in transportation fuel production.

Without mandatory blending to stimulate the use of biofuel crops in the transportation fuel sector, the targets of the EU Biofuels Directive will not be reached in 2010. A mandatory blending leads to higher petrol prices as feedstock are not profitable to use in fuel production given the current technologies. The increased demand for feedstock raises their price relative to the oil price, and adds therefore to the challenge of making biofuels competitive. Therefore, if biofuels are to be competitive in the long run, investments in R&D are needed to obtain higher yields or better conversion technologies. However, in this paper the analysis focuses only on 1st generation biofuels as we focus on the period until 2010. Decisions on R&D investments should take into account the 2nd generation biofuels as these promise to be more cost effective and more effective in reducing greenhouse gas emissions.

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