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IMPACT OF DIFFERENT BIOFUEL POLICY OPTIONS ON AGRICULTURAL PRODUCTION AND LAND USE IN GERMANY

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1 Introduction

Biofuels have gained increasing attention from governments across the world. In 2007 they enjoyed around US$15 billion in subsidies from OECD member countries (OECD/ITF, 2008). The surge in oil prices that spanned between 2003 and the beginning of the financial crisis in 2008 intensified investments in the biofuel sector and helped further motivate governmental support. World fuel ethanol production amounted to 24 billion liters in 2003 and rose to 65 billion liters by 2008. Biodiesel output expanded from 2 billion liters to over 13 billion liters between 2003 and 2008 (F.O. LICHT, 2008)[3].

Biofuel production initiated as a response to the high oil prices of the 1970s (BANSE et al., 2008). Today ethanol and biodiesel are sponsored by national aid programs primarily because of strategic and security concerns. They reduce economic dependence from a politically unstable region, provide a solution to the rising petroleum prices and constitute a domestically produced renewable source of energy. In addition, they are labor intensive and may help solve the problem of declining farm income (HAHN, 2008).

At the present state of technology biofuels are viable only through subsidies, tax exemptions or other forms of funding, Brazil being the only exception (RAJAGOPAL and ZILBERMAN, 2007). While direct support may be necessary to nurture an industry from its infancy to a mature status, governmental intervention is also distortionary. Despite being unprofitable without external support, the U.S. are the largest producers of fuel ethanol in the world with 34 billion litres in 2008, equivalent to more than 50% of the globe's total. The highly subsidized US ethanol manufacture is derived almost uniquely from corn[4] (SCHNEPF, 2005) and it absorbed 20% of the US total corn supply in 2006 (EIA, 2007).

Currently commercial production of biofuels is obtained uniquely from food feedstock (LARSON, 2008a). Concerns over rising food prices have been growing (MITCHELL, 2008; SCHMIDHUBER, 2007). The potential for soil erosion, deforestation, increased fertilizers and pesticides use as well as an alteration of the natural landscape and biodiversity are further criticisms moved against the political and financial support granted to ethanol and biodiesel manufacture. Finally, biofuels' net contribution to a reduction in GHG emissions has also been questioned (PIMENTEL and PATZEK, 2005; FARREL et al., 2006; CRUTZEN et al., 2007)[5].

Second generation (cellulosic) biofuels do not employ food-crops as feedstock. They involve more complex and costly processing techniques that derive ethanol, biodiesel, methanol, hydrogen or Dimethyl Ester (DME) from the ligno-cellulosic biomass contained in woody crops and perennial grasses (HAMELINCK and FAAIJ, 2006). Cellulosic biofuels are meant to

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[3] Original data was given in tonnes (1 ton of biodiesel = 1176.47 litres was conversion rate adopted. Data was taken from Schumacher (2009), who refers to F.O. Licht has the source of his data.

[4] Schnepf (2005) calculates that around 90% of US ethanol is produced uniquely from corn.

[5] See OECD (2008) for an overview of the results of more than sixty LCA studies.

reduce direct competition for food crops, increase production per land area, lower feedstock costs[6] and contribute to net energy and environmental benefits. However, currently there are no commercially viable production facilities (SCHMER *et al.,* 2008; LARSON, 2008a)

The objective of this article is to analyze the impact of the current German and EU biofuel policies on food production, land use and trade. We also assess the implications of achieving a 3% share of total fuel transport in Germany via cellulosic ethanol as part of the mandated 10% target in 2020. The article proceeds by giving an overview of the most important policies in the EU and Germany, it also highlights recent literature on the topic and sketches the LEITAP model adopted here. A description of the scenarios is then followed by the simulation's results. The conclusion summarizes the results, draws comparisons with the current literature and acknowledges areas for improvement.

2 Current Biofuel Policies in the EU and Germany

The European Union has currently proposed a binding target of 20% share of renewables in energy consumption and a 10% binding minimum target for biofuels in transport by 2020. This proposal was published in January 2008 and provided the ground for the official EU Directive on Renewable Energy to be adopted by the end of 2009. The 31st of March 2010 marks the deadline for EU states to present National Action Plans on Renewables[7].

The 2003 EU Directive 2003/30/EC [8] focused its attention on the promotion of biofuels and set a 5,75% target of market penetration by 2010. The directive did not establish binding targets, though several countries decided to make the 5.75% mark mandatory over time. Austria, Finland, Germany, Luxembourg, the Netherlands, Slovakia, Spain and the UK set their respective objectives as obligatory. Each country was asked to aim at an indicative 2% share by 2005. However, biofuels accounted for only 1% of transport fuels in 2005. Similarly the 2010 goal is likely to be missed, with an expected share of 4.2%[9].

Biofuels are mainly supported through tax reductions or exemptions. Directive 2003/96/EC on Energy Taxation specifies the tax incentives allowed to promote the targets set by the common agenda. Tax exemption can be carried out by single countries after approval of the EU Commission. They are expected to be proportionate to the blending levels, should account for raw material prices in order to avoid over-compensation and are limited in duration to six years (but may be renewed).

A combination of tax exemptions and biofuel mandates leads to substantial revenue losses for governments promoting both support policies simultaneously. According to KUTAS *et al.* (2007), in 2006 the total revenue loss due to tax exemptions amounted to €2.9 billion across member countries. Germany endured the largest deficit with a staggering €1.98 billion. Budget constraints eventually led the German government to abolish excise duty exemptions as a form of subsidy. This is a particularly important passage, as Germany is the world's main producer of biodiesel and Europe's leading member state in terms of productive capacity and fuel market penetration.

Recently the German government has reviewed the mandatory biofuel quotas that producers are required to supply the market with. From 2009 alternative fuels shall amount to 5.25% of

[6] Feedstock costs are the largest component in the price of biofuels (OECD-FAO, 2008)

[7] Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources [COM(2008) 30 final], 23.1.2008.

[8] Directive 2003/30/EC of the European Parliament and of the Council on the promotion of the use of biofuels or other renewable fuels for transport, 8.5.2003.

[9] Data disclosed in the "Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources" [COM(2008) 30 final], 23.1.2008.

total transport fuel consumption[10]. From 2010 the share should increase to 6.25% and remain at this level until 2014. In 2011 the quota measures will be reviewed. Taxation of pure biodiesel should also be reduced by € 0.03 per liter with the duty level dropping from € 0.21 to € 0.18 per liter from 2009. Ethanol does not enjoy excise duty exemptions or reductions unless it is sold in blends exceeding 85% of the fuel's volume (E85 blends or pure ethanol fuels). Pure biodiesel is also exempted from excise duties via a rebate scheme valid until the end of 2011[11].

3 Modeling of Biofuels

Biofuels are interrelated to a variety of industries. The full effects of the current policies are to be assessed via an adequate representation of food supply and demand, land and water allocation, energy markets and petroleum in the transport sector.

Two modeling approaches have been adopted to analyze the large scale implications of ethanol and biodiesel production. Partial equilibrium models limit the scope of their analysis to a selected group of sectors. In the case of biofuels, existing models of agricultural production are extended by adding the demand for biofuels through an increase in the demand for feedstock such as maize, wheat, sugar cane, sugar beet and oilseeds. The shock to the feedstock crops is either exogenously determined or it is encapsulated by linking the agricultural sector with energy or biofuel sub-models. AGLINK-COSIMO (OECD/FAO, 2008), IMPACT (MSANGI *et al*., 2006), ESIM (BANSE and GRETHE, 2008) and FAPRI (FABIOSA *et al*., 2008) are partial equilibrium frameworks that have been adapted to analyze long-run impact of biofuels on the farming industry.

Computable General Equilibrium (CGE) models cover the economic activities of the entire economy. The use of energy crops and biomass are assessed with *ad hoc* elaborations of the agricultural, energy and transport sector as well as a sufficiently detailed decomposition of land conversion and environmental pollution.

REILLY and PALTSEV (2008), DIXON *et al.* (2007) and MCDONALD *et al.* (2006) analyze the impact of biofuels and carbon targets on the US economy. ELOBEID and TOKGOZ (2006), GOHIN and MOSCHINI (2007) and BIRUR *et al*. (2007) emphasize the impact of biofuels on international trade. TAHERIPOUR *et al.* (2008) highlight the importance of including by-products when assessing biofuel manufacture and its impact on the aggregate economy. BIRUR *et al.* (2008) integrate their analysis with detailed land description using the Agro-Ecological Zones (AEZ) framework derived by LEE (2005). BANSE *et al.* (2008a) simulate the impact of first generation biofuels on agricultural production, trade and land use by adopting a nested land supply function which includes the process of land conversion and land

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[10] *Bundeskabinett beschließt Gesetz zur Änderung der Förderung von Biokraftstoffen* published on the 22.10.2008 by the Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit and available at http://www.bmu.de/pressemitteilungen/aktuelle_pressemitteilungen/pm/42433.php

[11] The latest revision of the mandatory biofuel quotas by the German *Bundeskabinet* follows the previous state support program State aid No N 57906 – Germany and the European Commission Document C(2006)7141, published on the 20.12.2006 in reference to "State aid No N 579/06 – Germany; Tax rebates for biofuels (amendments to an existing scheme)" and available at
http://ec.europa.eu/comm/competition/state_aid/register/ii/by_case_nr_n2006_0570.html#579
The official law passed in Germany actually refers to slightly higher quotas compared to the amount reported in the above mentioned document sent to the European Commission. The official mandatory data passed by the German parliament refer to *Gesetz zur Einführung einer Biokraftstoffquote durch Änderung des Bundes-Immissionsschutzgesetzes und zur Änderung energie- und stromsteuerrechtlicher Vorschriften (Biokraftstoffquotengesetz – BioKraftQuG)* available at
http://www.biokraftstoffverband.de/downloads/455/BioKraftQuG

abandonment endogenously. The latter builds upon the work of MEIJL *et al.* (2006) and EICKHOUT *et al.* (2009).

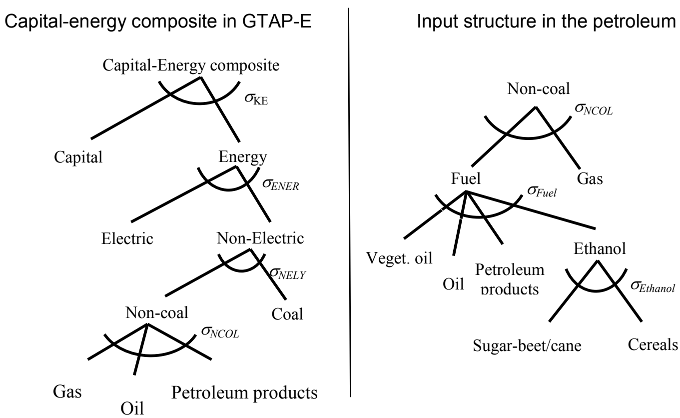
4 The LEITAP model

The analysis conducted in this paper is based upon on the LEITAP model as presented in BANSE *et al*. (2008b). LEITAP is a multi-sector, multi-region, recursive dynamic CGE model derived from the GTAP framework (HERTEL, 1997). The energy sector is a further development of the GTAP-E version written by Burniaux and TRUONG (2002). In the latter, energy substitution is introduced into the production function by allowing energy and capital to be either substitutes or complements. Energy and capital inputs are modelled as an aggregate "capital-energy" composite. The energy related inputs are further subdivided in a tree-structure that differentiates between electricity, coal and the non-coal sector. The non-coal sector includes gas, oil and petroleum products (see Figure 1).

LEITAP builds on and alters the GTAP-E energy structure to model biofuel consumption. In the current LEITAP we allow the use of biomass in all sectors. Due to very low initial values, biomass in non-energy sectors never becomes an important intermediate input. The non-coal inputs in the capital energy composite are subdivided as gas and fuel. Fuel is composed of vegetable oil, crude oil, petroleum products and ethanol. Ethanol is then derived from sugar cane, sugar beet and cereals. Demand for the agricultural crops driven by first generation biofuel production is therefore directly linked to the fuel sector.

In the energy sector the industry's demand of intermediates strongly depends on the cross-price relation of fossil- and biofuel-energy. The output prices of the petrol industry are, among other things, a function of fossil energy and bio-energy prices. The nested CES structure implies that the relative price of crude oil with respect to agricultural prices is one key variable of the demand for biofuels. The initial share of biofuels in the production of fuel is also important. A higher share implies a lower elasticity and a larger impact on the oil markets. Finally, the values of the various substitution elasticities (σ_{Fuel} and $\sigma_{Ethanol}$) are crucial. They represent the degree of substitutability between crude oil and biofuel crops. The estimates of the elasticity of substitution are taken from BIRUR *et al.*, (2007) and are based on a historical simulation of the period 2001 to 2006. They correspond to a value of 3.0 for the US, 2.75 for the EU, and 1.0 for Brazil.

Figure 1: Nesting structure in energy modelling



Prices for outputs of the petroleum industry depend on any subsidies/tax exemptions affecting the price ratio between fossil energy and bio-energy. The level of demand for biofuels is determined by any enforcement of national targets through, for example, mandatory inclusion rates or the provision of input subsidies to the petrol industries.

In this paper governmental policies are modeled as mandatory blending obligations fixing the share of biofuels in transport fuel. It should be mentioned that this mandatory blending is budget neutral from a government point of view. To achieve this in a CGE model two policies were implemented. First, the biofuel share of transport fuel is exogenously specified and set at a certain target. A subsidy on biofuel inputs is specified endogenously to achieve the necessary share. The input subsidy is needed to change the relative price ratio between biofuels and crude oil. If the mandatory share is lower than the target, a subsidy on biofuels is introduced in order to make them more competitive. Second, 'budget-neutrality' is achieved by financing the subsidy with an end user tax on petrol consumption. The tax endogenously generates the budget necessary to finance the subsidy on biofuel inputs. Consumers pay for the mandatory blending as end user prices of blended petrol increase. The higher price results from the use of more expensive biofuel inputs relative to crude oil in the production of fuel.

Simulation experiments used version 6 of the GTAP database. The latter contains detailed bilateral trade, transport, and protection data characterizing economic linkages among regions. All monetary values of the data are in USD millions and 2001 is used as the base year. The social accounting data were aggregated to 37 regions and 13 sectors. The aggregation distinguishes agricultural commodities that can be used for producing biofuels (e.g., grains, wheat, oilseeds, sugar cane, sugar beet) and that are important from a land use perspective as well energy sectors that demand biofuels (e.g., crude oil, petroleum, gas, coal, and electricity). This paper focuses on the impact of biofuels on the German farming industry. The regional aggregation separates Germany from the remaining EU26 countries. All EU member states (apart from the Baltic states, Bulgaria and Romania) are modeled as individual countries in LEITAP. The time path of the scenario spans from 2001 to 2020 and includes the EU enlargement from 2001 to 2007. All relevant macro-economic changes such as GDP, population and factor productivity growth of the historic period 2001-2007 are implemented in the scenario. The results presented here always refer to the year 2007 as the starting point of the 'projection period'. The most important economic areas outside the EU are also included and aggregated so to include Brazil, NAFTA, East Asia and the Rest of Asia, three regions within Africa and the rest of the world.

Due to the extremely rapid developments in the biofuel sector, the GTAP database has been updated to include recent changes. The calibration of the use of biofuel crops in the model is based mainly on sources published in F.O. Licht (2007). In order to implement first generation biofuels, the GTAP database has been adjusted for the input demand for grain, sugar, and oilseeds in the petroleum industry. The total intermediate use of these agricultural products at the national level has been kept constant while the input use in non-petroleum sectors has been corrected in an endogenous procedure so to reproduce the 2004 biofuels shares in the petroleum sector (based on their energy contents).

5 Description of Scenarios

The paper analyses biofuel integration in Germany and in the European Union by implementing four alternative scenarios other than a basic simulation run with no mandatory blending. The latter provides a framework for comparisons with the results obtained once the model is shocked.

In the first scenario the latest biofuel targets set up by the German government are introduced. By 2010 a 5.25% biofuel quota is reached. In the period between 2010-2013 the share of renewable fuels rises to 6.25%. Finally in 2020 Germany is expected to comply with the European envisaged tally of 10%.

The second scenario aims to simultaneously assess the impact of German and EU biofuel targets. In addition to the above mentioned shares for Germany, the EU is exogenously required to meet specific quotas of renewable fuels. The 2003 EU Directive 2003/30/EC[12] set a 5.75% target of market penetration by 2010. Each country was asked to aim at an indicative 2% share by 2005. However, in 2005 biofuels accounted for only 1% of transport fuels. Similarly the 2010 goal is likely to be missed, with an expected share of 4.2%[13]. Given that a significant fraction of the EU's biofuels are consumed in Germany, we assume that the remaining EU countries will be able to achieve only a 3.5% quota by 2010. From this point onwards a constant increment in biofuel consumption is implemented so reach a 10% share by 2020 (see Table 1).

Table 1: Base structure of calculated scenarios

Scenario name	Country/Region affected	2007-2010	2010-2013	2013-2030
NoBFD	All EU member states	No mandatory biofuel blending		
GerAlone	Germany	5.25%	6.25%	10%
EU-27	Germany	5.25%	6.25%	10%
	EU26	3.50%	5.75%	10%
Ger2ndGenLow	2nd Generation			
	Germany	5.25%	6.25%	7%
	Land Displacement for Low Conversion Rates	0	0	972 kha
	EU26	3.50%	5.75%	10%
Ger2ndGenHigh	2nd Generation Germany	5.25%	6.25%	7%
	Land Displacement for High Conversion Rates	0	0	648 kha
	EU26	3.50%	5.75%	10%

The last two scenarios evaluate the implications of achieving a considerable fraction of renewable fuels in Germany via second generation production techniques. We assume that in 2020 3% of the total fuel consumption will be met through ethanol derived from switchgrass. Switchgrass is not modeled as a commodity in the GTAP database and it cannot be included in the framework as an aggregation of alternative goods such as cereals or grains. We tackle this problem in two steps. First, the exogenously mandated share of biofuel is set at 7% in 2020. Second, we reduce the land supply available in Germany. The reduction in land supply corresponds to the cultivated area that would be required to manufacture enough ethanol to meet the remaining 3%. The EU26 biofuel targets remain unvaried.

The production of cellulosic ethanol is under great technological change and estimates of ethanol output per hectare of land may vary considerably. In order to account for the potential deviation in output per hectare, the last two scenarios implement low- and high-conversion efficiency. Low conversion efficiency implies that larger portion of cultivated land has to be dedicated to ethanol production in order to meet the required 3% target from second

[12] Directive 2003/30/EC of the European Parliament and of the Council on the promotion of the use of biofuels or other renewable fuels for transport, 8.5.2003.

[13] Data disclosed in the "Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources" [COM(2008) 30 final], 23.1.2008.

generation bio-crops. Hence, in the low conversion scenario, Germany's land supply in the model is reduced more in comparison to the high conversion scenario. The values and productivity ratios employed to determine the area of land subtracted from the original land supply are included in the Appendix. One last point is important to mention. Bio-crops such as switchgrass are perennial grasses meant to be less demanding in the type of soil used so to create a somehow smaller competition for land with food-crops. Part of the area destined for switchgrass cultivations is expected to come from waste- and secondary lands, so that only 80% of the total surface required for cellulosic ethanol production is subtracted from the original supply.

In addition, all scenarios follow policy changes that are implemented in the LEITAP framework. They include the EU CAP Health Check (phasing out milk quota, decoupling of remaining coupled payments, modulation of direct payments and transfers to 2nd Pillar) and - between 2013 and 2020 - the multi-lateral implementation of a WTO agreement according to the Falconer Proposal of December 2008.[14]

6 Scenario Results

This paper focuses on the impact of domestic and EU biofuel mandates on the German agricultural sector. We also discuss the effect of the European Biofuels Directive on the (aggregated) EU-26 countries. No special attention is drawn on the implications of these policies on the world markets.[15]

a. Production

The implementation of blending obligations alters the production dynamics of relevant agricultural commodities. Table 2 reports percentage changes in the output volume of arable crops, biofuel crops[16], oilseeds and grains over three different time intervals: 2007-2013, 2013-2020 as well as the 2007-2020 period.

Due to trade liberalization under the reference (NoBFD) scenario, arable crops production (especially cereal grains) in Germany and in the EU-26 decline after 2013. On the other hand, oilseeds are not protected by import tariffs and consequently benefit from the opening of the world markets implied in the underlying model (WTO agreement). Mandatory blending requirements will raise production of 1st generation biofuel crops. The volume of oilseed output is projected to increase in Germany under the 'GerAlone' scenario by 47% between 2007 and 2013 and by 32% between 2013 and 2020. Mandatory blending in the EU-26 will also stimulate oilseeds production, although the increment will be smaller compared to Germany. The EU26 region compensates for lower productivity with higher oilseeds imports (see Table 3). Relative to the reference (NoBFD) case, the differences in percentage change in oilseed production even out[17].

Under the two scenarios 'Ger2ndGenLow' and 'Ger2ndGenHigh', 1st generation biofuel crops are assumed to by partially replaced by switchgrass. The 2020 biofuel target in

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[14] The Falconer proposal foresees a cut in developed countries' import tariffs between 50 and 70 percent depending on their current bound rate. According to the Falconer proposal import tariffs in developing countries will decline between 33 and 47 percent depending on their current bound rate.

[15] For further analyses of EU biofuel policies on world agri-food markets please refer to Banse et al. (2008a,b).

[16] The term 'Biofuel Crops' refers to the aggregation of the agricultural commodities employed as inputs in the manufacture of biofuels. i.e. the quantity of sugar beet/cane employed to produce biofuels is counted in, not the whole production of sugar.

[17] Consider the EU-27 scenario, where biofuel mandates are implemented both in Germany and in the EU26. Over the 2007-2020 period, relative to the reference (NoBFD) case, oilseeds production changes by 52.7% and 61.2% respectively for Germany and the EU-26.

Germany is reduced to 7%, and land supply is cut down (see Appendix). The lower blending mandate leads to a decline in the demand for oilseeds so that their production in Germany increases by a lesser extent (an increment of 80% under the high switchgrass conversion rates and 76% under the low switchgrass conversion rates in comparison to the 99% upsurge in the EU27 scenario).

Imports of 1st generation biofuel crops increase insignificantly in the EU with the introduction of mandatory blending. EU members are not able to produce the required biofuel crops from domestic resources. Germany will experience an increase in oilseed imports of 128% between 2007 and 2020 ('GerAlone' scenario). In the EU-26 imports raise by more that 160% between 2007 and 2020 (see table 3).

Table 2: Change in Agricultural production in Germany and the EU-26, in %

	Germany			EU-26		
	2007-13	2013-20	2007-20	2007-13	2013-20	2007-20
Arable Crops						
NoBFD	2.0	-0.3	1.7	1.4	-1.4	0.0
GerAlone	6.5	3.0	9.6	1.5	-1.3	0.2
EU-27	9.2	4.9	14.5	4.8	2.2	7.2
Ger2ndGenLow	9.2	0.4	9.6	4.8	2.2	7.2
Ger2ndGenHigh	9.2	1.4	10.7	4.8	2.2	7.2
Biofuel Crops /1						
NoBFD	2.9	2.6	5.6	-0.1	0.4	0.2
GerAlone	10.5	8.8	20.2	0.2	0.7	0.9
EU-27	13.8	11.3	26.7	11.7	12.0	25.0
Ger2ndGenLow	13.8	6.2	20.9	11.7	11.8	24.9
Ger2ndGenHigh	13.8	7.0	21.8	11.7	11.8	24.8
Oilseeds						
NoBFD	17.6	24.6	46.5	6.3	10.6	17.5
GerAlone	47.2	32.1	94.5	7.9	11.8	20.6
EU-27	53.9	29.5	99.2	38.9	28.7	78.7
Ger2ndGenLow	53.9	14.5	76.3	38.9	28.2	78.1
Ger2ndGenHigh	53.9	17.0	80.0	38.9	28.2	78.1
Grains						
NoBFD	1.2	-3.9	-2.7	1.7	-1.3	0.3
GerAlone	4.6	1.4	6.0	1.7	-1.3	0.4
EU-27	11.1	10.4	22.6	12.9	10.3	24.5
Ger2ndGenLow	11.1	5.4	17.0	12.9	10.2	24.5
Ger2ndGenHigh	11.1	6.3	18.1	12.9	10.2	24.4

Remark: /1: This aggregate summarizes total average production change of sugar beet/cane, cereals and oilseeds regardless of their final use as inputs for food, feed or fuel purposes.

However, the developments of cereal grains imports and exports different substantially between Germany and the remaining EU-26 member countries. In the rest of the EU imports increase and exports decrease in order to meet the higher internal demand driven by biofuel production. On the other hand, Germany's cereal grain imports remain relatively constant across all scenarios while its exports actually increase once the biofuel mandates of the entire EU region are taken into consideration (EU-27 scenario). The simulations suggest that the German agricultural sector will expand significantly its production of cereal grains and partially feed the demand coming from the EU-26 members.

In addition, dependency on biofuel crop imports would decline if a significant share of renewable fuels could be met via switchgrass based ethanol. Under the 'Ger2ndGenLow' and

‘Ger2ndGenHigh’ scenarios the imports of oilseeds increase at a lower rate compared to the ‘GerAlone’ and ‘EU-27’ simulations.

Table 3: Change in Agricultural trade in Germany and the EU-26, in %

	Germany			EU-26		
	2007-13	2013-20	2007-20	2007-13	2013-20	2007-20
Imports						
Oilseeds						
NoBFD	14.1	16.5	32.9	5.5	2.9	8.5
GerAlone	56.1	46.4	128.6	5.4	2.6	8.1
EU-27	57.5	51.4	138.4	71.7	56.2	168.1
Ger2ndGenLow	57.5	27.3	100.4	71.7	56.0	167.8
Ger2ndGenHigh	57.5	26.2	98.7	71.7	56.0	167.7
Grains						
NoBFD	-0.7	-3	-3.8	7.3	19.8	28.6
GerAlone	1.0	0.4	1.4	6.7	18.6	26.5
EU-27	-0.7	-0.3	-1.0	60.6	87.5	201.1
Ger2ndGenLow	-0.7	-0.5	-1.1	60.6	86.8	200
Ger2ndGenHigh	-0.7	-1.3	-2.0	60.6	87.4	200.9
Exports						
Oilseeds						
NoBFD	11.1	21.0	34.4	11.5	24.6	38.9
GerAlone	-14.0	-18.5	-29.9	31.9	39.6	84.1
EU-27	27.8	8.4	38.6	-9.6	-11.6	-20.1
Ger2ndGenLow	27.8	20.2	53.7	-9.6	-20.9	-28.5
Ger2ndGenHigh	27.8	27.7	63.3	-9.6	-21.2	-28.7
Grains						
NoBFD	7.4	-18.6	-12.5	4.7	-27.5	-24.1
GerAlone	3.7	-24.3	-21.5	5.1	-26.7	-23.0
EU-27	28.7	12.8	45.2	-6.6	-38.7	-42.7
Ger2ndGenLow	28.7	11.5	43.6	-6.6	-38.6	-42.6
Ger2ndGenHigh	28.7	14.1	46.9	-6.6	-38.7	-42.8

b. Land Use

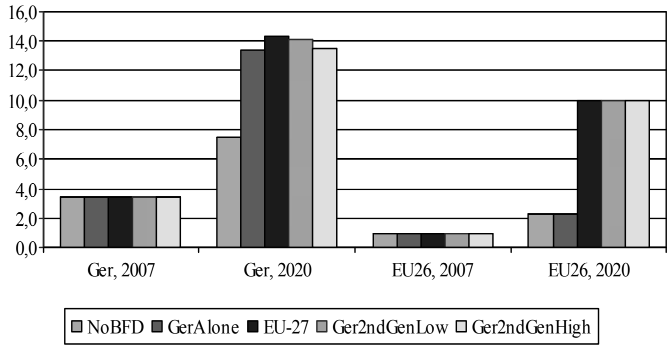
Land use will be significantly affected by the EU’s attempt to substitute away oil with biomass in the transport sector.

In 2007 around 3.8 % of agricultural land is cultivated with crops employed as biofuel inputs (Figure 2). With the introduction of mandatory blending, in 2020 the share of soil dedicated to biofuel crops increases in Germany to around 14%. The use of 2nd generation production techniques does not reduce significantly the share of land cultivated for biofuel inputs once the area for switchgrass cultivation has been taken into consideration[18].

In the EU26 region a 10 % blending share in transportation fuel will also lead to an expansion of agricultural land used for energy crops. Under the ‘EU-27’ scenario around 10% of all arable land is projected to be used for cultivation of biofuel inputs.

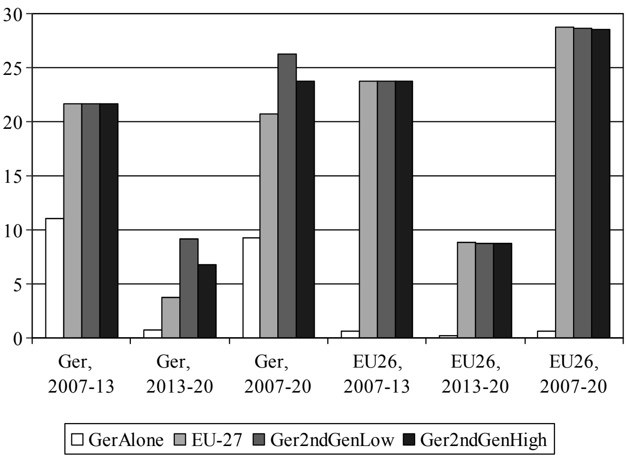
[18] The exogenously calculated area for switchgrass cultivation has been taken into consideration in the estimation of land shares shown in Figure 2.

Figure 2: Share of agricultural land used for biofuel crops in 2007 and 2020, in %



The price of land is also affected by the higher demand for of biofuel crops. Under the reference scenario (NoBFD) the intensity of agricultural production declines due to a cut in price and income support (EU Health Check and WTO agreement). This development leads to a decline in land prices for agriculture. Figure 3 shows the changes in land price relative to the NoBFD case. With the introduction of mandatory biofuel blending land prices in all EU member states strongly increases. In Germany the cost of cultivable soil surges between 21% and 26% and in the EU-26 by around 28 %. The stronger price reaction in the EU-26 indicates a tighter land market in comparison to Germany.

Figure 3: Change in the price for agricultural land in 2020 relative to the reference scenario (NoBFD), in %



7 Summary and Conclusions

The analysis shows that the current EU policy targets will have a strong impact on Europe's agricultural production, land use and trade. The production of crops used as biofuel feedstock will increase substantially which contributes to revert the negative trends set by the implementation of the EU Health Check and the introduction of a WTO agreement in the base scenario (NoBFD).

The rise in agricultural production will increase land prices and farm output in all regions covered in this analysis. Land-scarce countries and regions such as most of the EU member states will not produce domestically the entire feedstock needed to generate the required biofuel crops and will run into a higher agricultural trade deficits.

Our findings correspond to the results obtained in other publications. Europe's output of arable crops (cereal grains and oilseeds in particular) will expand considerably (HERTEL *et al.* (2008), BANSE and GRETHE (2008)). Among EU member states the rise in production is matched by a large drop in exports and higher imports of biofuels feedstock (GOHIN and MOSCHINI (2007)). The share of land devoted to the cultivation of energy crops will grow consequently.

Our study also provides a new key insight. Germany's agricultural sector will partially feed the rest of the EU's increased appetite for biofuel feedstock. The model's simulations suggest that current EU policies will translate into a higher production of cereal grains in Germany. Part of the German harvest will be exported to fellow EU member countries in order to compensate for their inability to produce domestically the required biofuel inputs. Germany has a more flexible land supply, which allows its farming industry to benefit from the envisaged European blending mandates and improve its balance of trade in cereal grains.

The adoption of cellulosic biofuels indicates the possibility to ease competition between the use of agricultural products for food and energy purposes. However, land allocation will be similarly affected by first and second biofuel manufacturing technologies.

Future research may attempt to tackle two aspects of our research. Firstly, our modeling of cellulosic biofuels was simplistic. We did not include the production structure and the associated costs of second generation biofuels due to limitations in the underlying databases. In addition, uncertainties associated with the evolution of future technologies may alter for the better the outcome of our simulations. At the moment large-scale second generation biofuel technology is not available. Intensified investments on research and development should account for the positive effects of cellulosic production techniques, as these promise to be more cost effective and contribute to a greater reduction in GHG emissions. Secondly, the modeling of biofuels by-products may better help analyze the impact of mandatory blending on the cattle sector (TOKGOZ *et al.* (2007), TAHERIPOUR *et al.* (2008)

Appendix

This paper assumes 6 tons of switchgrass per acre as a reasonable yield. A conservative estimate of current conversion technology for second generation biofuels suggests that 1 ton of switchgrass produces 60 US gallons of ethanol. This gives us 360 gallons of ethanol per acre. We also consider a more efficient conversion process, such that 90 gallons of ethanol may be produced from 1 ton of switchgrass (Table 4).

LARSON (2008b) investigates switchgrass yields in Tennessee. On East Tennessee Dandridge soil (pasture land) an average of 5.7 tons per acre was obtained. The more fertile West Tennessee Loring soil (crop land) averaged 9.1 tons per acre. CARRIER and CLAUSEN (2008) report 5 tons per acre as the standard yield of switchgrass by comparing alternative studies. SCHMER *et al.* (2008) conducted experiments on 10 farms in the Northern Great Plains in the US (Nebraska, North Dakota and South Dakota) and reported annual yields of established fields averaged 2.1-4.5 tons of switchgrass per acre[19]. KSZOS *et al.* (2002) refer to a study conducted by the Virginia Polytechnic Institute and State University (VPI) and the Auburn University (AU). Average dry switchgrass in the 1992-2001 period ranged between 3.2 and 7.6 tons per acre. The best crop variety averaged 6.8 tons per acre across all sites in 2001[20].

Table 4: Conversion Ratios

1 acre	=	0.404686	hectare (ha)			
1 gallon (gal)	=	3.748544	liter (l)			
1 liter of ethanol	=	0.7894	kilogram (kg)			
1 tons (t) of ethanol	=	0.638	ton of oil equivalent (toe)			
Switchgrass Yield	=	6	t/acre			
Low Conversion	=	60	gal/t	=	1.679441	toe/ha
High Conversion	=	90	gal/t	=	2.5191615	toe/ha
Energy supply from second generation ethanol				=	2041	kToe
Required Land Surface (Low Conversion Rate)				=	1.215	million ha
Required Land Surface (High Conversion Rate)				=	0.810	million ha
Actual reduction in available land due switchgrass cultivations						
Low Conversion Case	=	0.972	million ha			
High Conversion Case	=	0.648	million ha			

The figures that report average switchgrass yields may vary considerably due to fertilizers use, type of crop, land and weather conditions. However, the 6 tons per acre yield adopted in this paper should be a reasonable middle value among current experimental results.

The conversion ratio of switchgrass into ethanol is another crucial factor in determining the land required to provide a given quantity of fuel. PERKIS *et al* (2008) provide two conversion estimates. A conservative figure would see 67.6 gallons of ethanol per ton of dry switchgrass, while a more optimistic quotient would assume an output of 79.0 gallons per ton[21]. Schmer (2008) on the other hand assumes a conversion rate of 100 gallons of ethanol per ton of

[19] Original data was given as 5.2-11.1 $Mg \cdot ha^{-1}$. Data has been converted into tonnes per acre in order to be comparable with other studies.

[20] Original figures where in Mg/ha.

[21] Perkis *et al.* (2008) derive their "conservative" estimates from McLaughling *et al.* (1999), Spatari *et al.* (2005), while they take their more optimistic version from Tiffany (2007).

switchgrass[22]. In our calculations we considered the two extreme cases, namely a conservative approach with 60 gallons of ethanol per ton of switchgrass and a more optimistic view with 90 gallons of ethanol per ton.

The PRIMES model estimates that in Germany energy demand for transport will be equivalent to 68029 kToe[23]. Our model calculates that cellulosic ethanol will supply 3% of the latter, and equivalent to 2.04 mToe. Based on the conversion rates given below, The latter amounts to a required surface of 1.215 million ha of cultivated for switchgrass given conservative conversion estimates and 0.810 million ha for more optimistic processing technologies.

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[22] Original value was 0.38 litres/kg. Schmer (2008) takes this value from the Renewable and Applicable Energy Laboratory, *Energy and Resources Group Biofuel Analysis Meta-Model* (University of California, Berkeley), (2007).

[23] One can find this data on page 23 on the following file: http://ec.europa.eu/environment/climat/pdf/climat_action/analysis_appendix.pdf

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