Impact of the EU Biofuels Directive on the EU food supply chain[1]

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Abstract. The paper investigates the impact of the EU Biofuels Directive (BFD) on the EU agri-food supply chain using the computable general equilibrium model of the world economy named LEITAP. LEITAP is an extended version of the Global Trade Analysis Project (GTAP) model including an improved land market modeling, substitution possibilities between capital and energy as well as between different energy sources including biofuels, feed byproducts of the biofuel production process and substitution between different feed components and feed byproducts. The simulation results shows that the implementation of the EU BFD has a pronounced impact on the markets of cereals, oilseeds and sugar and shows only a limited impact on production and consumption of other agri-food commodities which are not directly affected by biofuel production. The harvested area and production of biofuel crops (grains, oilseeds) is expected to increase by 17% and 25% respectively and sugar production by 12% as a direct result the BFD. The EU-imports of these commodities are expected to rise more than twice. The increasing demand for biofuel crops and sugar will lift domestic prices of these commodities by 25% and 19% respectively but overall agri-food price inflation will be limited to 3% in the EU and to less than 1% at world market level.

Keywords: EU Biofuels Directive, food supply chain, indirect land use changes, computable general equilibrium model.

1. Introduction

Rapid development of biofuels production is expected to have a profound impact on agricultural production and land use in EU. Already in the 2007/2008 crop year, harvested oilseeds area and production in the EU increased by 4% and 13% respectively[3], and it is expected that oilseeds production increases further by 40% until 2018 [10]. This paper aims to evaluate the impact of the EU Biofuels Directive (BFD) on the EU supply chain of biofuel crops (grains and oilseeds) production and processing for food, feed and fuel purposes.

In order to project the impact of the EU BFD on EU's food supply chain, we run simulation experiments based on an extended version of the Global Trade Analysis Project (GTAP) model. This extension includes an improved land market modeling, substitution possibilities between capital and energy as well as between different energy sources including biofuels, feed byproducts of the biofuel production process and substitution between different feed components and feed byproducts.

This paper is organized as follows. Section 2 introduces the model's database and gives a short outline of the model. In Section 3, the scenario set-up is described. The following section presents simulation results concerning the impact of the BFD on the EU agri-food sector development. We close with a summary in the final section.

2. Model and data

To run simulation experiments, we have used the GTAP data based and an extended version of the GTAP model: the so-called LEITAP model [9]. This version of the model incorporates some specific features concerning the agricultural sector.

[2] This paper is base on the preliminary results of the ongoing EURURALIS project. For an EURURALIS project see: http://www.eururalis.eu/

[3] COCERAL crop forecasts: http://www.coceral.com/cms/beitrag/10010342/227949

2.1. Data

The analysis is based on a version 6 of the GTAP database [5]. This database contains consistent data on a worldwide basis for 2001. The GTAP database contains detailed bilateral trade, transport and protection data characterizing economic linkages among regions, and consistent individual country input-output databases which account for intersectoral linkages. The social accounting data were aggregated to 36 regions and 25 sectors. The sectoral aggregation distinguishes all agricultural sectors (e.g. rice, grains, wheat, oilseed, sugar, horticulture, other crops, cattle, pork and poultry, and milk). An apart from the agri-food sectors LEITAP also describes the energy sectors, e.g. the petrol and the electricity sectors using fossil (crude oil, gas and coal) as well as bioenergy inputs in their intermediate demand.

The regional disaggregation includes most of EU member states as individual countries and all important countries and regions outside EU from an agricultural production and demand point of view.

For modeling biofuel policy options and implemening first generation of biofuels, the GTAP data base has been adjusted for the intermediate input of grain, sugar and oilseeds in the petroleum industry to reproduce 2004 biofuels shares in the petroleum sector.

Besides of (bio)fuels, the biofuel production process yields feed byproducts such as Dried Distillers Grains with Solubles (DDGS) and oilsseed meals (BDBP). On the supply side, we assume a constant conversion ratio between grains and oilseeds quantities used to produce biofuels and resulting production of their byproducts On the demand-side, the GTAP data base was adjusted for intermediate inputs of byproducts as inputs in the feed production for the livestock sectors.

2.2. LEITAP model

The LEITAP model is a multi-regional, multi-sectoral, static, applied general equilibrium model based on a neo-classical microeconomic theory [7]. It is an extended version of the standard GTAP model [11],[9], using, a multilevel nested CES production function. In the primary value added nest, the multilevel CES production function describes the substitution of different primary production factors (land, labor, capital and natural resources) and intermediate production factors (e.g. energy, and animal feed components). The CES nest is also introduced to allow for substitution between different energy sources including biofuels [1]. The model uses fixed input-output coefficients for the remaining intermediate inputs.

On the consumption side, the regional household is assumed to distribute income across savings and (government and private) consumption expenditures according to fixed budget shares. Consumption expenditures are allocated across commodities according to a non-homothetic dynamic CDE expenditure function which allows for changes in income elasticities when purchasing power parity (PPP)-corrected real GDP per capita changes. Government expenditures are allocated across commodities according to fixed shares. The commodities consumed by firms, government and households are CES composites of domestic and imported commodities. In addition, imported commodities are differentiated by region of origin using Armington elasticities.

Regional endowments of labor, capital and natural resources are fixed and fully employed and land supply is modeled by land supply curves [6], which specify the relationship between land supply and a land rental rate. Labor is divided into two categories: skilled and unskilled. These categories are considered imperfect substitutes in the production process.

Land and natural resources are heterogeneous production factors, and this heterogeneity is introduced by using a CET transformation function which allocate these factors among the agricultural sectors. Capital and labor markets are segmented between agriculture and non-agriculture. Labor and capital are assumed to be fully mobile within each of these two group of sectors, but imperfectly mobile across them. This leads to differences in prices of capital and labor between agriculture and non-agriculture. This is implemented by using a dynamic CET function where changes in capital and labor supply in agricultural and non-agricultural sectors depend on relative agricultural to non-agricultural remuneration of these factors and total factor supply. With the same agricultural to non-agricultural remuneration, labor and capital grow with the same rate in both sectors that is equal to the total factor supply growth rate.

To introduce the demand of petroleum sector for biofuels, a nested CES function is implemented to enable for substitution between different categories of fossil energy and biobased inputs. The substitution elasticities were calibrated base on elasticities applied in GTAP-E model [2].

In order to model substitution between different feed components and byproducts of biofuel production, we extended the nest describing the substitution between different inputs in the animal feed mixture production with an extra level: high energy feed, composed of grain, wheat and sugar beets, and high protein feed, composed of compound feed, oil cake and feed byproducts (DDGS and BDBP). For other feed components the nesting structure remains unchanged. The elasticities in the two sub-nests are typically very high, for example 100, while the values of substitution elasticity between the different categories are relatively small.

In LEITAP, most policy instruments are represented as ad valorem tax equivalents. These create wedges between the undistorted prices and the policy inclusive prices. For the dairy and the sugar quota in the EU LEITAP has been extended for quota regulation at national level [12]. All quotas are formulated as complementarity problems allowing for an endogenous regime switch from a state when the output quota is binding to a state where the quota becomes non-binding.

The EU biofuels directive (BFD) fixes the share of biofuels in fuel used in transport. To achieve this policy target, a subsidy on bioenergy inputs in the petroleum sector is necessary to make bioenergy inputs competitive with fossil inputs. Since this policy instrument is assumed to be 'budget-neutral', these input subsidies are financed by a user tax on petrol consumption.

2. Scenario set-up

To analyse the impact of the EU BFD on EU food supply chain, we run two scenarios: the Reference (Ref) scenario which does not includes the EU BFD and a second scenario including the BFD.

The reference scenario depicts the EU and global economy development without the Biofuel Directive. Because the impact of the BFD depends on the macroeconomic development of the global economy, the reference scenario includes a set of assumptions concerning the most important macroeconomic drivers influencing the world economy in general and the agri-food sector in particular. These assumptions are related to the rates of technical progress, changes in labor and capita availability and the associated GDP growth as well as the population growth. These factors mainly determine consumer demand and production factors supply.

The Biofuel Directive scenario differs from the Reference scenario only for the implementation of the EU Biofuels Directive. The BFD foresees a minimum mandatory target for the use of bio-energy in the use of fuel for transportation. The target is set to 5.75% and 10% by the end of 2010 and 2020 respectively and is assumed to be implemented in all individual EU member states.

For our simulation experiment, we have taken the GDP and population growth projections provided by the USDA's Economic Research Service (ERS). We assume that the capital stock will grow with the same rate as the GDP and employment with the same rate as the population. For the projection of productivity growth in agriculture, additional information on yields is derived from FAO forecasts [2]. The sector-specific growth of sectoral total factor productivity (TFP) is implemented as so-called Hicks-neutral technical change with constant factor ratios [4].

Table 1. Main macro-economic scenarios assumptions: average yearly growth rates in 2001 – 2030

	EU	World
GDP	1.89	3.00
Population	-0.012	1.097
Technological progress	0.46	0.61
Land productivity	0.91	2.09

The scenarios are build as a recursive updating of the database in five consecutive uneven time steps from 2001 to 2020. The two first periods update data and policy variables to the 2007 situation by taking into account the European Union enlargement, the Agenda 2000 reform and the introduction of Single Farm Payments of the 2003 CAP reform and the macro-economic development of the world economy. The following three periods after 2007 analyze the consequences of the EU Biofuels Directive.

3. Simulation results

As expected, the simulation results show that the Biofuels Directive stimulates the demand for biofuel crops (i.e. grains and oilseeds) and sugar used to produce biofuels in the EU (Figure 1). The demand for other agri-food products remains similar to the level observed in the Reference scenario. The main reason for these relative small cross-effects of the EU-BFD on other agri-food products is due to the low income and price elasticities for agri-food products in general. Moreover, general price effects of the EU BFD are rather small. However, the EU Biofuels Directive results in a 0.23 percentage points lower GDP growth in EU countries in 2007 - 2020 compared with the reference scenario, which is equivalent to almost 24 billion EUR in 2001 prices. The inflationary effect induced by extra demand for biofuel crops is mitigated by the production increase encouraged by higher biofuel crops prices (Figure 2). A strong price increase can be projected for biofuel crops and sugar markets. The EU biofuel crops and sugar prices increase by 25% and 19% respectively in 2007-2020 in the BFD scenario compared with the Reference scenario. World prices of these commodities increase by 4.6% and 1.1% for biofuel crops and sugar respectively.

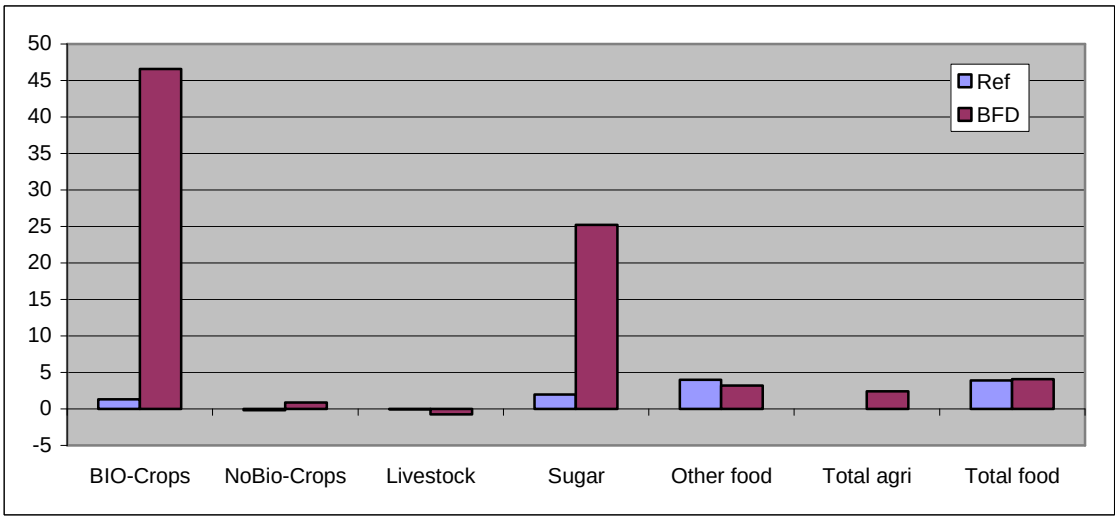

Figure 1. EU Demand for agri-food products: growth rate in 2007 - 2020 (%).

Figure 2. Land use and output prices in EU in 2007 - 2020: difference between the BFD and Reference scenarios (%)

Due to the EU BFD, demand for biofuel crops and sugar increases by 45% and 23% respectively. This results in extra demand for agricultural land which leads to an upward pressure on land prices. Average EU land prices increase by 19% as the result Biofuels Directive and the average world land prices by 4%.

This leads to higher costs in agricultural production with consequently higher agri-food prices at global level. The associated overall agri-food price increase is about 3.1% and 0.8% for the EU and world respectively.

As a consequence of the Biofuel Directive, the aggregated increase in harvested area is rather modest. However, indirect land use changes are strong with significant changes amongst the composition of land use. The EU and world harvested area is projected to increase by 2.2% and 0.8% respectively, but biofuel crops area in the EU expands by 27.3% at the cost of pasture, which decrease by about 3.8%.

The consequence of high demand resulting from the Biofuel Directive implementation is an increase of biofuel crops and sugar production by 27% and 12% respectively in EU. At global level cereal and oilseed production increase by 7%, while sugar supply increase by 4% (Figure 3). Despite of a declining pasture area in the EU, total livestock production decrease only little (-1.2%) and animal production in the EU becomes more intensive. Due to slightly increasing production costs, production of other agri-food products is only slightly lower in the BFD scenario compared with the Reference scenario.

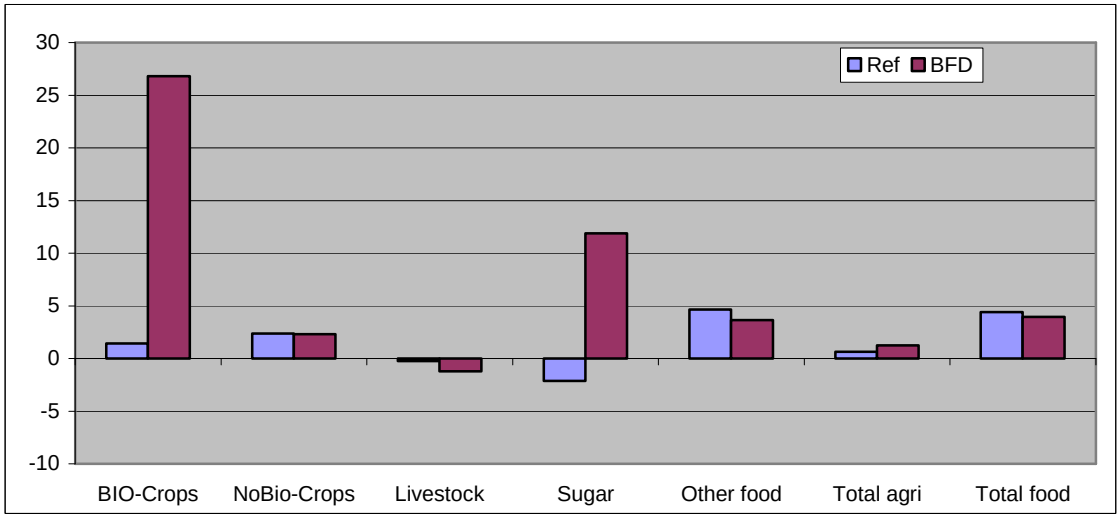

Figure 3. EU agri-food output growth in 2007 - 2020 in the Reference and BFD scenarios (%)

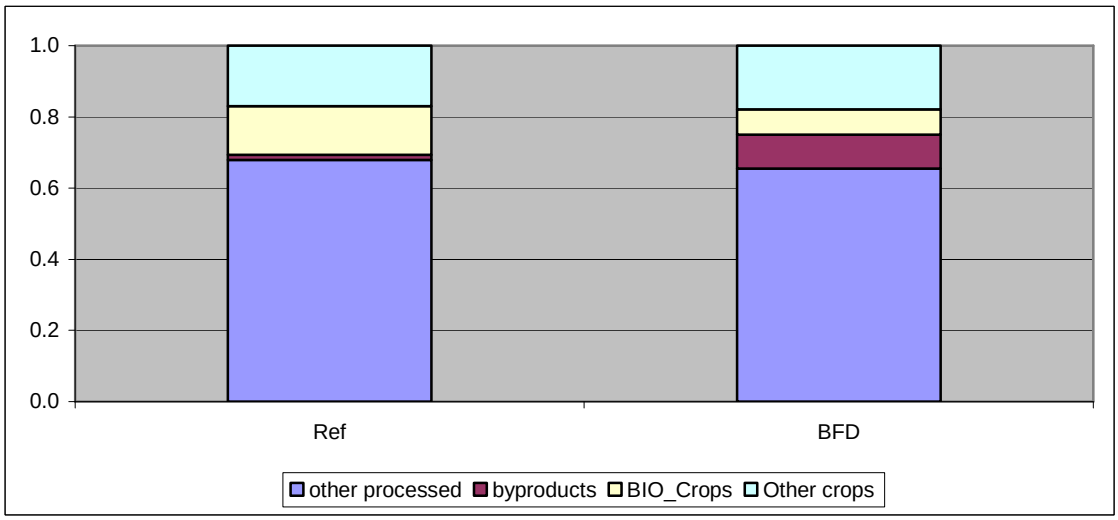

Figure 4. The composition of average animal feedstock in the EU in 2020 in the Reference and BFD scenarios

The EU BFD has two effects; a) a direct effect with an increase in biofuel crops production directly used in the petroleum sector and b) an indirect effect where the use of biofuel crops is redirected from feed use to fuel use. The high biofuel production in the BFD scenario results in significant changes in the

composition of animal feed. Grains and oilseeds (the biofuel crops) are replaced by compound feed and especially by feed byproducts. Figure 4 shows that the share of the compound feed (that includes byproducts and other processed feed) in the animal feedstock increases from 69% in the Reference scenario to 75% in the BFD scenario in 2020. At the same time, the byproducts share increases from 1.5% to 9.5% and biofuel crops share decreases from almost 14% to 7%. Also the use of other crops in animal feed increases slightly in the BFD scenario compared with the Reference scenario.

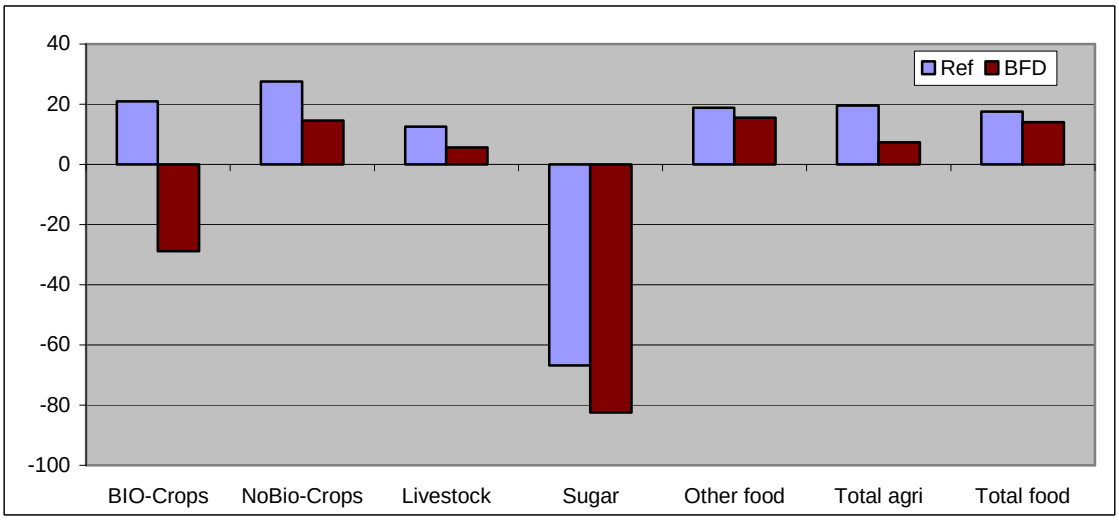

Figure 5. EU agri-food exports growth in 2007 - 2020 in Reference and BFD scenarios (%)

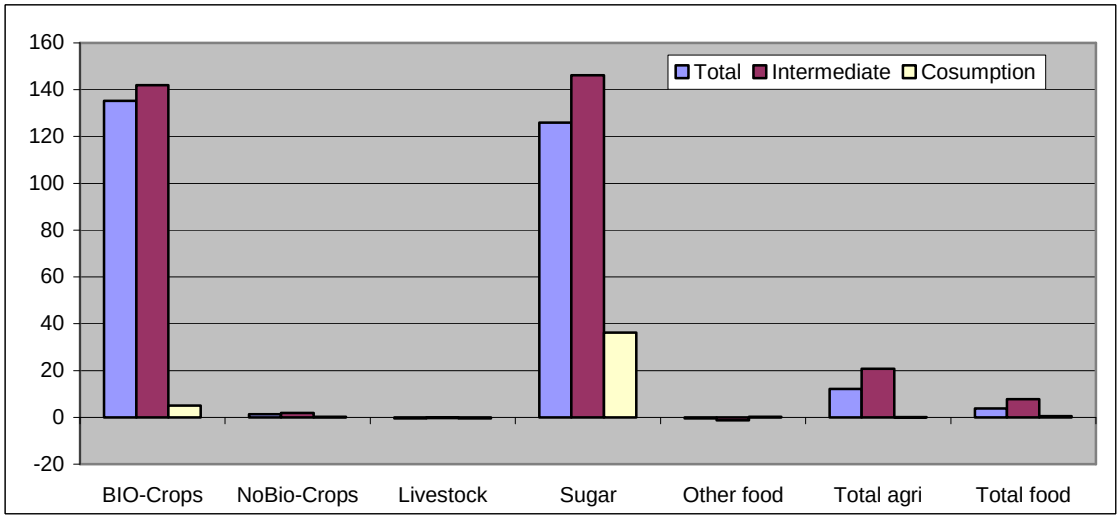

Figure 6. EU agri-food import growth by a destination in 2007 - 2020: difference between the BFD and Reference scenarios (%)

The higher domestic output prices in the BFD scenario have a negative impact on agri-food exports (Figure 5). The deterioration of the EU trade balance in agri-food products is due to additional import demand and declining exports of biofuel crops. The strongest changes in exports are projected for biofuel crops and for animal feed. Biofuel crops exports decreases by almost 30% in the BFD scenario while it increases by 20% in the Reference scenario. Also, other crops and sugar exports are significantly lower (by 13% and 15% respectively) in the BFD scenario compared with the Reference scenario.

The Biofuels Directive implementation influences mainly imports of those commodities used for biofuels: biofuel crops (Figure 6). The imports of these commodities in the BFD scenario are more than two times higher than under the Reference scenario. However, the impact of the Biofuel Directive on total

agricultural and food exports is rather modest: 12% and 4% increase respectively to compare with the Reference scenario.

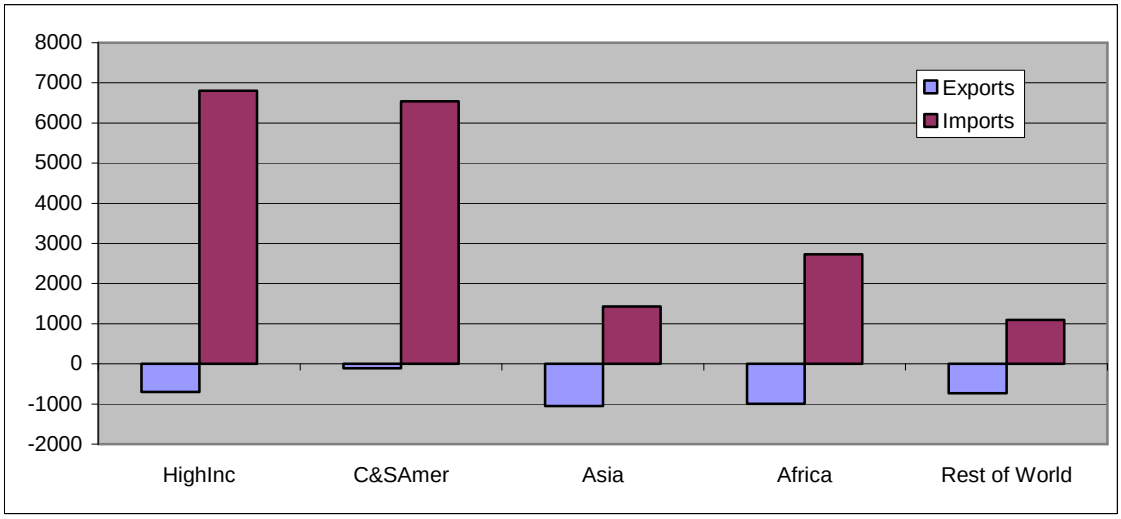

Figure 7. EU agri-food exports and import value (mil 2001 USD) per group of counties in 2020: difference between the BFD and Reference scenarios (%)[4]

The additional biofuel crops imports are mainly used as an intermediate input in the petrol sector. In the sugar case, about 25% the additional exports is used as intermediate inputs for food and feed producing industry, 5% goes to consumers and the remaining exports are used to produce biofuels.

The regional agri-food trade development shows that biofuel crops and sugar are imported from the all over the world. However, other High Income countries and Central and South America contribute most to additional EU biofuel crops imports (about 90% in 2020) while African countries contribute almost 45% of the total sugar imports. In total, the EU trade balance in agri-food products deceases by 22 billion USD as the result of the Biofuel Directive implementation.

4. Conclusions

The simulation results shows the Biofuel Directive implementation has a pronounced impact on grains, oilseeds and sugar supply and use but an limited impact on production and consumption of other agri-food products.

The harvested area of biofuel crops (grains and oilseeds) is projected to increase by 17%, while production increases by around 25% as a result of increasing intensification of EU biofuel crops production. Sugar production is expected to increase by 12% as a result the EU Biofuels Directive. The imports of these commodities are expected to increase by more than two times and exports are expected to fall by about 50% for biofuel crops and 15% for sugar. The increasing demand for biofuels crops and sugar will raise domestic prices of these commodities by 25% and 19% respectively.

Due to the EU BFD, the use of biofuel crops in the EU petrol sector increases by almost 10 times. As the result, less biofuel crops are available to feed animals but additional feed byproducts are produced. Therefore, the share of byproducts used in compound feed increases from 1.5% to 9.5% while the share of biofuel crops decreases from almost 14% to 7% in animal feed.

The Biofuels Directive leads to an increase of land and agri-food products prices at global level. Land prices increase by 19% in the EU and 4% globally. The associated increase in aggregated agri-food prices is projected to be 3.1% for the EU and 0.8% at world level relative to the Reference scenario. The

[4] HighInc (high income countries) includes: NAFTA, Japan, Korea, New Zeeland and Australia; Rest of World includes: Former Soviet Union, Rest of Europe and Turkey.

additional demand for biofuel crops leads to lower EU agri-food exports and a deterioration of EU agri-food trade balance.

The analysis shows that apart from direct effects of an enhanced demand for bioenergy on production and land use, the indirect effects of the EU BFD dominates. Additional production of biofuel crops within and outside the EU leads to strong indirect land use changes which are partly compensated for a higher availability of feed byproducts of biofuel production. Increasing supply of byproducts such as DDGS and BDBP with a high content of protein, enables to substitute for feed cereals in compound feed which are now used as inputs in the biofuel production.

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