The economic effects of the EU biofuel target

Bettina Kretschmer[a], Daiju Narita[a] and Sonja Peterson[a,b]

Abstract:

In this paper we use the CGE model DART to assess the economic impacts and optimality of the different aspects of the EU climate package. A special focus is placed on the 10% biofuel target in the EU. In particular we analyze the development in the biofuel sectors, the effects on agricultural production and prices and finally overall welfare implications. The main findings include that the EU emission targets alone only lead to minor increases in biofuel production. Additional subsidies are necessary to reach the 10% biofuel target. This in turn increases European agricultural prices by up to 7%. Additional welfare losses compared to a cost-effective scenario where the EU 20% emission reduction target is reached occur due to separated carbon markets and the renewable quotas. The biofuel target has relatively small negative or even positive welfare effects in some scenarios.

Keywords: CGE model, climate policy, EU, biofuels

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[a]Kiel Institute for the World Economy (IfW)

[b]Corresponding Author: Kiel Institute for the World Economy, D-24105 Kiel, Germany; sonja.peterson@ifw-kiel.de

1. Introduction

To demonstrate global leadership for a long-term international climate regime, the European Union (EU) decided a variety of climate targets in 2007/08. Besides the two targets that are the focus of the EU transition scenarios analyzed in EMF 22 (see overview article) – a reduction of at least 20% [relative to 1990] in emissions of greenhouse gases by 2020 and a 20% share of renewable energies in the EU's energy consumption by 2020 – the so-called climate-energy package that has finally passed the European Parliament in December 2008 additionally contains a 10% minimum target for the market share of renewable transport fuels, which are in effect biofuels for the most part, by 2020 (Council of the European Union, 2008).

In the context of energy security and climate protection, bioenergy is bestowed high importance. Biofuels have received growing attention particularly because they are able to replace fossil energy in the transport sector. They are seen as a valuable option since the transport sector is contributing an increasing share to global carbon emissions and other renewable energy sources usually only replace fossil fuels in the electricity sector (wind, hydro, photovoltaics) or in the provision of heat (wood pellets, geothermal energy, solar thermal energy). Currently, only Brazil is able to produce bioethanol from sugar cane at sufficiently low costs to be competitive with conventional fuels. But for the reasons just explained, in many countries including several EU members, bioenergy and biofuels are supported by government schemes such as quotas, tax exemptions and direct production subsidies, which have resulted in a growing production and consumption of biofuels worldwide. In the EU, Germany has the highest share of biofuels in total fuel consumption with slightly more than 7%; other countries among them Cyprus and Finland have biofuel shares of close to zero.[1] On average, the share in the EU was 2.6% in 2007 (EurObserv'ER, 2008). More recently, the governmental support for bioenergy has been heavily criticized especially in the context of rapidly rising food prices in 2007/2008. The heated 'food vs. fuel' debate has consequently emerged reflecting the fear that enhanced biofuel production may lead to enormous land use competition that would drive up agricultural product prices and ultimately food prices. It is therefore vital to get a better understanding of the economy-wide impacts of

[1] National biofuels reports by EU member states reporting under Directive 2003/30/EC can obtained from: http://ec.europa.eu/energy/renewables/bioenergy/ms_reports_dir_2003_30_en.htm.

enhanced bioenergy production and especially its impact on land use competition and on agricultural and ultimately food prices.

The economic effects of the EU climate policy, including those of the EU climate package, have been analyzed before (e.g. Klepper and Peterson 2006a, 2008, Wobst et al., 2007), and one of their special focuses has been the effects of the separated carbon markets with part of the emissions covered within the European emissions trading scheme (ETS) and part of the emissions outside the ETS. The main findings in those studies are that overall the negative welfare and competitiveness effects are rather small but that the separated carbon markets may lead to substantial inefficiencies. In addition, two studies analyze the effects of the EU 10% biofuel targets (Banse et al., 2008; Boeters et al., 2008). Banse et al. (2008) find a considerable impact of European biofuel policy on the global and European agricultural markets with higher feedstock prices and expansion of global agricultural land use especially due to increases in land-abundant countries. Boeters et al. (2008) find only small impacts on agricultural prices and focus on the interaction of European biofuel policy and the EU ETS in their analysis. The introduction of a mandatory 10% target reduces carbon taxes in the non-ETS sectors. This beneficial effect is, however, weakened by the negative effect of higher transport fuel prices with the net welfare effect for the EU-27 being slightly positive but negligible.

The aim of this paper is to combine the EMF's common scenarios of the EU climate package with the additional 10% biofuel target. Our study integrates the newest EU targets and also differs with respect to the implementation of biofuels (see Kretschmer and Peterson, 2008 for an overview about different modeling approaches). We model a wider set of biofuel scenarios than in the studies mentioned above. Besides the core scenario where we assume a 10% biofuel target for each of the EU countries either under full trading or in the case of separated carbon markets, we also analyze a scenario with a more efficient overall 10% target for the EU. Our focus is the effects of the biofuel targets on carbon prices and welfare compared to the scenarios without a biofuel target but also on the effects on EU and world agricultural markets.

The paper proceeds as follows: In sections 2 and 3 we briefly describe the version of the DART model that is used in this paper and the scenarios that are analyzed. In sections 4 and 5 we present the simulation results in the core scenarios and the biofuel scenarios, respectively. Section 6 concludes.

2. A brief description of the DART model with bioenergy

The DART (Dynamic Applied Regional Trade) Model is a multi-region, multi-sector recursive dynamic CGE-model of the world economy. For the simulation of European bioenergy policies, it is calibrated to an aggregation of 12 regions that include the major bioenergy producing regions (in particular Brazil; also Malaysia and Indonesia) as well as the main bioenergy consuming regions (including the USA and different EU regions). In each model region, there are 27 sectors shown in table 1. There are 13 energy sectors including different types of renewable energy, but also 11 agricultural sectors that include the most important energy crops.

The economy in each region is modeled as a competitive economy with flexible prices and market clearing. There exist three types of agents: a representative consumer, a representative producer in each sector and regional governments. All regions are connected through bilateral trade flows. CO_2 emissions are derived from the use of fossil fuels. The static model is calibrated to the GTAP6 database (Dimaranan, 2006) that represents production and trade data for 2001.

Biofuels are modeled as latent technologies that are active from the year 2005 on. The two biofuel sectors use different feedstock inputs (wheat, corn and sugar beet/sugar cane for ethanol; vegetable oil and oil seeds for biodiesel) as well as capital, labor and electricity to produce perfect substitutes for diesel and gasoline based on fossil fuels. The different cost structures for biofuels were defined with the help of the meó Consulting Team, a consultancy that has built up potential expertise in the bioenergy industry (personal communication with meó, 2007). Costs are then scaled up by a mark-up that accounts for the cost disadvantage of biofuels compared to fossil fuels. Mark-ups are calculated based on the quality difference between bio- and conventional fuels and bio- and conventional fuel prices. Furthermore, the benchmark assumes that 2005 biofuel consumption shares remain constant until the year 2020. These shares are shown in table 2. Concerning biofuel trade, whose modeling is technically difficult for a latent technology (see Kretschmer and Peterson, 2008), we only account for the most important trade flows: Bioethanol trade only takes place between Brazil and the industrialized countries and Malaysia/Indonesia is the only region that exports biodiesel, though the amount is currently almost negligible. Vegetable oils used for the production of biodiesel can of course be traded. Import tariffs for bioenergy were calculated based on OECD/FAO (2008). For a detailed description of the implementation of biofuels into DART see Kretschmer et al. (2008).

Table 1: DART regions and sectors

Countries and regions			
EU and other Annex B		**Non-Annex B**	
DEU	Germany	BRA	Brazil
GBR	UK, Ireland	LAM	Rest of Latin America
FRA	France	IND	India
SCA	Denmark, Sweden, Finland	CPA	China, Hong Kong
BEN	Belgium, Netherlands, Luxemburg	MAI	Indonesia, Malaysia
MED	Greece, Italy, Portugal, Spain, Malta	PAS	Rest of Pacific Asia
REU	Rest of EU27	MEA	Middle East & North Africa
USA	United States of America	AFR	Sub-Saharan Africa
OCD	Rest industrialized OECD		
FSU	Former Soviet Union		
Production sectors/commodities			
Energy Sectors		**Agricultural Sectors**	
COL	Coal Extraction	WHT	Wheat
GAS	Nat. Gas Production & Distribution	COR*	Corn
CRU	Crude Oil	GRO	Other Cereal Grains
GSL*	Motor Gasoline	OSD	Oil Seeds
DIS*	Motor Diesel	VOL	Vegetable Oils and Fats
OIL	Other Refined Oil Products	C_B	Sugar Cane, Sugar Beet
BET	Bioethanol as a substitute for GSL	SGR	Sugar
BDS	Biodiesel as a substitute for DIS	MLK	Raw Milk
ELY	Non-renewable electricity + hydro	MET	Meat
SOL	Solar electricity	AGR	Rest agric. & food products
GEO	Geothermal	FRS	Forestry
WIN	Wind power	**Other Sectors**	
SBIO	Solid Biomass electricity	ETS	Energy intensive sectors in EU ETS
		CRP	Chemical products
		OTH	Other Manufactures & Services

* These sectors where disaggregated from the original GTAP6 database, see Kretschmer et al. (2008) for details.

Table 2: Shares of biofuel in total fuel consumption in 2005

	Biodiesel (oil seeds and vegetable oils)	Bioethanol			
		SUM	wheat	sugar beet/cane	corn
DEU	6.9	0.7	0.3	0.1	0.3
FRA	1.8	1.8	0.45	0.9	0.45
GBR	0.3	0.1	0.1	-	-
SCA	0.7	2.1		2.1	-
BEN	0.1	0.1	0.05	-	0.05
MED	0.5	0.5	0.25	-	0.25
REU	0.5	0.5	0.499	0.001	-
USA	0.3	2.6	-	-	2.6
BRA	0.1	40.0	-	40.0	-
OECD	0.05	0.4	-	0.2	0.2
CPA	-	1.7	1.7	-	-
IND	0.6	1.7	-	1.7	-

Source: OECD/FAO 2008, personal communication with meó Consulting Team

In the previous versions of DART, renewable energy production was incorporated in the energy bundle but its relative shares out of total energy production were invisible. In order to model the policy scenarios that include a renewable target, we here added a set of functions to DART that explicitly calculate renewable energy production besides biofuels. For simplicity and also due to data limitation, we only consider four types of renewable electricity production (wind, geothermal, solar and solid biomass: heat not included) in EU sub-regions. Hydropower is implicitly included in the production functions of conventional electricity. Data on prices and mid-term potentials for renewables are taken from IEA (2007),[2] and the input shares are based on the IER-Stuttgart MARKAL data (personal communication). Since renewable electricity is generally more expensive than conventional electricity by assumption, implementation of the 20% target policy is essentially a question of subsidy allocation, on which we take the following assumption: each EU sub-region produces renewables at least at the current level, and additional amounts to meet the target are allocated in such a way as to minimize the

[2] The sum of IEA's mid-term potentials (up to 2020) is close to the EU's target level in 2020 and in fact short of the target under our modeling assumption (see section 3). We scaled the wind power potentials by 25% to produce the quantity at the target level in the model.

total size of subsidy for the whole EU. This means that some types, such as geothermal energy in MED, are preferred over others and exploited first until the potential limit. Without the EU 20% target, renewable electricity production is increased only as much as to be in accordance with a rising electricity price. To account for the fact that we only model renewable electricity we translate the 20% renewable target for primary energy consumption into a target for renewable electricity consumption (see section 3).

The DART model is recursive-dynamic, meaning that it solves for a sequence of static one-period equilibria for different time periods connected through capital accumulation. The major exogenous drivers of the model dynamics are the change in the labor force, the rate of labor productivity growth, the change in human capital, the savings rate, and the gross rate of return on capital, which determine the endogenous rate of capital accumulation. The savings behavior of regional households is characterized by a constant savings rate over time.

Labor supply evolves exogenously over time. The growth rate is derived from the growth of the labor force (based on population and participation rate projections), the growth of the human capital and the total factor productivity. Current period's investment augments the capital stock in the next period. The aggregated regional capital stock at each period is updated by an accumulation function equating the next-period capital stock with the sum of the depreciated capital stock of the current period and the current period's physical quantity of investment. The allocation of capital among sectors follows from the intra-period optimization of the firms. Finally, the supply of the third factor land is fixed over time. The modeling horizon for this paper is the year 2020.

3. Scenarios

The DART model is used to run a business-as-usual (BAU) scenario, the four coordinated EU scenarios, plus six additional bioenergy scenarios (summarized in table 3). The BAU scenario is calibrated to reproduce the EIA energy consumption data for 2005 and the UN emission data for 2005. Furthermore, the elasticities of substitution for the energy goods, i.e., coal, gas, and crude oil, are calibrated in such a way as to reproduce the emission projections by the IEA (IEA, 2008).

For the coordinated policy scenarios, we derive emission targets for the sectors covered by the ETS and those outside the ETS from the National Allocation Plans, the EU climate package and recent emission data relative to 2005 emissions. We assume that non-ETS emissions from 2005 and ETS emissions from 2012 are reduced linearly to reach the 2020 targets shown in figure 1 below. In the scenarios with an emission trading scheme covering all sources of CO_2 (i.e., the scenario group UNI in table 3), the regional carbon targets are the sum of the targets for the ETS sectors and the targets for the non-ETS sectors. In the scenarios with separated carbon markets (i.e., the scenario group NETS in table 3), only the sectors ETS, CRP, OIL, GSL, DIS and ELY are included in the ETS. The targets in the non-ETS sectors are reached by a uniform regional carbon tax or a regional emission trading scheme within the non-ETS sectors. The tax is distributed in a lump-sum fashion to consumers. For simplicity, the possibility of using CDM and JI credits is not considered in all scenarios. For the USA and the remaining OECD countries, we assume that emissions are started to be reduced in 2012 to reach a 50% reduction by 2050. The targets are also reached by a uniform carbon tax. Figure 1 shows the different emission reductions targets in 2020 relative to the year 2005.[3]

[Figure 1. EU CO_2 reduction targets in 2020 relative to 2005]

The renewable target for the EU is a 20% share of renewable energy in total final energy consumption. DART, however, is only able to model renewable energy in the electricity sector (and biofuels separately). A rough calculation shows that assuming a fixed share of biofuels at current levels the 20% renewable target implies a 30% share of renewables in the electricity sector (see also the paper by Böhringer et al. in this volume that use the same target). These renewable energy targets are not imposed on each individual EU member state or sub-region but on the entire EU, and are set to achieve the 30% level by 2020.

[3] Note that implementing the relative emission targets for the ETS and the non-ETS sectors as announced by the EU leads to only 16% overall emission reduction relative to 2005 with the emission split in the DART model – and not as the EU calculates 20%.

Table 3: Overview of scenarios

EU Emission and renewable targets	Biofuel target	[UNI]: full EU CO_2-trading	[NETS]: ETS + regional CO_2-tax in non- ETS
EU's 2020 emission targets	no biofuel target	UNI_20	NETS_20
EU's 2020 emission targets + 30% renewable target	no biofuel target	UNI_20_20	NETS_20_20
EU's 2020 emission targets + 30% renewable target + 10% biofuel target	10% in each EU country	UNI_20_20_10a	NETS_20_20_10a
	10% in entire EU	UNI_20_20_10b	NETS_20_20_10b
EU's 2020 emission targets + 10% biofuel target (sensitivity runs discussed in section 5.3)	10% in each EU country		NETS_20_10a
	10% in entire EU		NETS_20_10b

To analyze the effects of the additional biofuel target we define two sets of additional scenarios that are simulated both for full EU emissions trading and separated carbon markets. In the first group (UNI_20_20_10a and NETS_20_20_10a), the 10% biofuel target is reached individually by each EU region of DART. This is achieved by an endogenous subsidy on the national production of biofuels. In the second group (UNI_20_20_10b and NETS_20_20_10b), there is one overall EU target. The EU renewable energies directive proposal in principle establishes an individual target for each country and does not really provide for a burden-sharing in meeting the 10% biofuel target but only for "statistical transfers of a specified amount of energy from renewable sources to be transferred from one Member State to another Member State" (article 7, Council of the European Union, 2008). Given this background, we examine the effects of a hypothetical biofuel policy designed as an overall EU target, which would entail a more efficient allocation of biofuel production. Concerning the renewable electricity, the introduction of a 10% EU biofuels target enables the renewable share to be reduced, and we set the share at 25%. Since this assumption is rather ad-hoc and since our model does not explicitly capture the linkages between the renewable and the biofuel target, we run two more scenarios where the biofuel target is added to the scenarios with separated carbon markets and the 20% emission target only (NETS_20_10a/b). These scenarios are only used in the sensitivity analysis of the welfare effects of the 10% biofuel target in section 5.3. Table 3 gives an overview of all analyzed scenarios.

4. Simulation results of the core scenarios

Before we analyze the effects of the 10% biofuel target – which is the focus of this paper – we briefly summarize the main results of the six core scenarios. Figure 2 shows the carbon prices for the year 2020 in these scenarios[4], while figure 3 shows the welfare changes relative to the business-as-usual scenario measured as equivalent variation.

[Figure 2. Welfare relative to BAU for core scenarios in 2020]

[Figure 3. Carbon prices for core scenarios in 2020]

The results are as expected and in line with the existing studies. The welfare effects of reaching the EU targets efficiently, that is, the welfare gain by implementing a uniform carbon price throughout Europe, are comparatively small (scenario UNI_20) on average (-2% in 2020 relative to the BAU scenario) but differ across regions (from -2.8% in the Mediterranean countries to -1.3 % in Eastern Europe and France). The carbon price rises to almost 70 Euro/tCO_2 in 2020. The separated carbon markets where only part of the emissions are included in the EU-ETS create wedges between the carbon price within the ETS and outside the ETS which can be substantial as figure 3 shows. In Scandinavia, for example, the carbon tax outside the ETS is almost five times as high as the price in the ETS. In most other regions, it is still twice or three times the price in the ETS. This creates

[4] All values are in 2005 Euro.

additional welfare losses. On average, the EU now loses 2.6% relative to BAU. In countries with large wedges, welfare losses may even double. Based on our results, only in Eastern Europe the current targets for ETS vs. non-ETS are close to an optimal split. In all other regions, one could improve welfare by reducing the burden for the non-ETS sectors and tightening the allocation to ETS sectors. If there is now an additional 30% renewable target for electricity, the carbon prices fall since part of the necessary emission reductions are already achieved by subsidized renewable electricity. In the ETS, the price decreases by 22% and 33% under full and partial carbon trading, respectively. The reduction of the carbon tax outside the ETS is only up to 7%. Welfare losses are larger due to the additional constraint. As one can see reaching a 30% renewable target is already very expensive and almost doubles the welfare losses since the renewable potentials are almost exploited to the limit in the EU. When modeling a 20% renewable target, the losses are substantially lower. Sensitivity analysis with respect to the specification of the renewable electricity production function and production cost would be necessary to prove the reliability of this finding, but go beyond the scope of this paper.

5. The effects of the biofuel target

We now assess the effects of an additional 10% biofuel target in different scenarios. The focus is on three issues: changes in the biofuel sectors, effects on the agricultural sectors and finally overall welfare implications. All these results are compared with the effects of the climate package without this target – this is with scenarios UNI_20_20 and mainly with NETS_20_20 as well as with the BAU scenario. Again, we focus on the year 2020.

5.1 Biofuel production and trade

The first finding is that the EU climate targets alone do hardly increase the production and consumption of biofuels in Europe. Scandinavia is the only region where bioethanol production increases as a result of climate policy in the scenarios without a renewable target, but has little effect on the overall EU biofuel share.

Figures 4 and 5 give an overview of the allocation of biofuel production in the year 2020 globally and within the EU, respectively, if the 10% biofuel target is imposed. Looking at global production, it is clear that Brazil with its highly developed ethanol industry is the dominant producer of biofuels in the absence of European biofuel policy. This can be seen when comparing the bars of the BAU scenario. Introducing the 10% target leads to massive expansion in European biofuel production with the result of aggregate EU27 biofuel production slightly surpassing or at least catching up with Brazilian production. The US also increases its production in the policy scenarios, which will be explained by the trade balances discussed below.

[Figure 4. Biofuel production in 2020 (in billion real 2005 Euro)]

Figure 5 splits the EU27 production into the different member states or regions, which allows us to identify the effects of the alternative biofuel target designs (see table 3 for scenario categorizations: ‘a’ stands for a 10% target in each member state whereas ‘b’ stands for an aggregate 10% EU target). Imposing the 10% target for the EU as a whole should lead to a more efficient allocation of biofuel production according to regional competitiveness, which is determined by input prices, fossil fuel prices and biofuel markups. This implies that some countries and regions will show lower production volumes while others will increase their production relative to the policy scenarios of category ‘a’. As seen in Figure 5, Germany, the Benelux countries and the rest of EU belong to the former group while Great Britain, France, the Mediterranean and the Scandinavian countries increase production and thus become main contributors to meeting the EU 10% target. A further analysis can be conducted along the lines of the ETS scenario with separated carbon markets vs. the full trade scenario with a uniform carbon price across all sectors. While the design of the trading scheme hardly matters in the scenarios with individual 10% targets it substantially changes the biofuel production at least for some regions for an aggregated EU biofuel target. The reason is that carbon prices differ considerably between the two scenarios UNI and NETS which affects production costs of fossil and biofuels. Also we observe that the model reacts very sensitively to price changes in (bio)diesel versus (bio)gasoline that lead to a shift in what type of biofuels are produced.

[Figure 5. European biofuel production in 2020 (in billion real 2005 Euro)]

Since the biofuel targets are defined in terms of consumption, imported biofuel counts towards the quota. Figure 6 therefore shows net exports of selected model regions for the year 2020. One feature is easily detected: The introduction of European biofuel policy diverts Brazilian exports away from the USA to the European Union. Referring back to the paragraphs above on biofuel production, this is the main explanation why US biofuel production increases with the European 10% target in place. In the BAU scenario, the United States relied to a larger degree on imports in order to fulfil their imposed benchmark share. Meanwhile, it is clearly shown that the EU imports more in the presence of an aggregate 10% target than with individual 10% targets, and that it also imports more with full carbon trading in place compared to the NETS scenarios. The explanation lies in the gasoline and diesel prices in the different scenarios and in the size of overall fuel consumption. The higher the gasoline and diesel prices in the EU27, the more competitive is Brazilian ethanol and the more is imported. Also, the larger overall fuel consumption, the larger the necessary biofuel use to achieve the same quota. In the scenarios with an aggregate biofuel target production costs for EU biofuels are lower than in the scenarios with individual 10% targets. On the other hand, carbon prices in the ETS are slightly higher, leading to increased production costs of fossil fuels that are part of the ETS. Obviously the latter effect dominates. Gross gasoline prices, for example, are on the EU average about 5% higher in the scenarios with an aggregate 10% target compared to the scenarios with individual 10% targets (see also figure 8). The same effect is at work when comparing scenarios with uniform carbon markets (UNI) to scenarios with separated carbon markets (NETS). In NETS, ETS prices are lower than in UNI and so are fossil fuel prices. Also, total fuel consumption is higher in the scenarios with an aggregate biofuel target than in the scenarios with regional biofuel targets, and it is higher under uniform trading than under separated carbon markets.

[Figure 6. Biofuel net exports in 2020 (in billion real 2005 Euro)]

5.2 Effects on agricultural and fuel prices

Having in mind the contentious food vs. fuel debate we have witnessed with agricultural prices rising sharply in 2007/2008, we assess the agricultural sector effects of biofuel production. For the purpose of illustration, we focus on the results for the NETS scenarios only – these are in fact closest to reality. We first present European weighted-average prices in 2020 compared to the price of the model base year 2001 for the NETS biofuel benchmark and policy scenarios. We see from figure 7 that even in the NETS biofuel benchmark scenario biofuel feedstock prices increase by up to factor 120% from 2001 to 2020. This will help to put the additional price effects caused by biofuel policy into perspective.

[Figure 7. Growth in agricultural prices in 2001 to 2020]

These additional effects are given in figure 8 while figure 9 presents the impact of biofuel policy on sectoral production. In these two figures, percentages refer to deviations of the 2020 policy scenario compared to the values of the same scenario excluding biofuel policy (i.e. NETS_20_20). The price effects in figure 8 are as expected much more pronounced for the production-weighted EU27 prices than for production-weighted world prices. This would of course change once we considered biofuel policy in other regions than the EU. The European prices for biofuel feedstocks rise between 4% and 7.4% while crude oil and fossil fuel prices drop due to the associated decrease in demand. The sectors GRO – other grains – and AGR – rest of agriculture – also witness substantial price increases mainly because they are close substitutes for the energy crops competing for the scarce factor land and also because their production is crowded out as shown in figure 9. The fact that world price effects are larger with an aggregate EU target than with individual member state targets is in line with the trade data from figure 6, where we observed higher European imports in the former scenarios (met by higher Brazilian exports).

[Figure 8. Price effects, in % deviation from the 2020 reference value]

While production in the biofuel feedstock sectors is expanded considerably, production in the remaining agricultural sectors such as GRO and AGR is crowded out. With inelastic demand for the respective goods, this leads to higher prices as seen in figure 8. In line with the price effects, the impacts on sectoral production are generally higher for Europe than for the world as a whole. A striking feature is that production of raw sugar in the EU increases considerably in the NETS_20_20-10b compared to the _10a scenario and to a lesser extent also corn production, while oilseeds and wheat production decrease. These effects can be well explained by first looking at overall biodiesel and ethanol production in the two scenarios. While overall biofuel production is higher in the _10a scenario, ethanol production is actually higher in the _10b scenario implying an overly proportionate decrease in biodiesel production, hence the decrease in oilseed production. The bioethanol feedstock sugar beet is the only feedstock used for bioethanol production in Scandinavia and the dominant feedstock in France, two regions with increased ethanol production in the _10b scenario. REU uses primarily wheat for ethanol production and experiences a considerable drop in ethanol production in the _10b scenario, which serves as an explanation for the drop in wheat output.

[Figure 9. Sectoral production effects, in % deviation from the 2020 reference value]

5.3 Welfare effects of the biofuel target

We now turn to the welfare effects of the biofuel scenarios. First of all, expectedly, the welfare is higher for a scenario with one overall 10% biofuel target for the EU27. The difference to the scenario with a biofuel target of 10% in each DART EU region is rather small, though. Welfare in the more efficient scenario increases on average by 0.2-0.3%. As one exception France and the Mediterranean countries slightly lose under separated carbon markets.

When comparing the welfare to the scenarios UNI_20_20 and NETS_20_20 without the biofuel targets, welfare increases counter-intuitively to what one would expect. EU27 welfare losses relative to the BAU decrease by 16 to 20% depending on the biofuel scenario even though an additional constraint should always lead to additional welfare losses. The main reason for this finding is our assumption that it is optimal and cost-effective to increase renewable electricity to 30% in our scenarios with the EU renewable target while biofuel shares stay the same. We then exogenously decrease the renewable electricity target to 25% in the biofuel scenarios. The resulting increase in welfare in the biofuel scenarios thus indicates that it would indeed be preferable to have a lower renewable electricity target (between 25 and 30%) and more biofuel production (between the 2005 shares and 10%). To get a better impression of the welfare changes implied by the biofuel target, we ran two additional scenarios with only the 20% EU emission reductions plus the 10% biofuel target for the case of separated carbon markets, excluding a renewable electricity target. As in table 3, these scenarios are denoted NETS_20_10a (for a separate biofuel target for each EU regions) and NETS_20_10b (for an overall 10% biofuel target for the EU27).

Figure 10 shows the welfare changes relative to BAU for the year 2020 for the two new scenarios as well as the relevant scenarios defined in table 3.

[Figure 10: Welfare changes in the EU27 relative to BAU in 2020 in different NETS scenarios]

Comparing the welfare in these two additional scenarios to the welfare in scenario NETS_20 we find that welfare losses indeed slightly increase (by 0.2 percentage point) for the scenario NETS_20_10a. But for the scenario with one overall EU biofuel target NETS_20_10b welfare increase again. The welfare loss relative to BAU is 0.2 percentage points lower than in the NETS_20 scenario. This is an interesting finding that is more difficult to explain. In a static, partial equilibrium world this would indeed not be possible: adding an additional biofuel target can not bring down total abatement costs. If it would be cost effective to rather produce biofuels than reach emission reductions elsewhere this would already be included in a scenario NETS_20. In the case of a CGE model that also accounts for equilibrium effects, there are also effects of subsidizing biofuels on fuel prices which are not accounted for when the model solves for the cheapest emission reductions. Klepper and Peterson (2006b) have shown how marginal abatement cost curves react to energy prices. They show that the higher energy prices gross of carbon cost, the higher the marginal abatement cost of reaching the same target and the higher overall welfare costs relative to a BAU scenario. In Klepper and Peterson (2006b), welfare costs of reaching the same regional emission target increase if other regions also undertake emission reductions so that world wide energy prices net of carbon prices fall. This in turn would lead to higher energy use and emissions under a no-policy case for the region under scrutiny. Thus carbon prices increase and so do welfare losses. In this paper we have the opposite effect: As a result of the biofuel policy gasoline and diesel prices net of carbon prices increase, while gross prices decrease due to decreased carbon prices in the ETS which are by 30% lower than in the NETS_20 scenario. For scenario NETS_20_10b this effect is obviously bigger than the welfare losses from subsidizing biofuels with high abatement costs[5].

6. Summary and Conclusions

In this paper we examined the economic impacts and optimality of the different aspects of the EU climate package with the help of the CGE model DART. Our special focus was the significance of a 10% biofuel target in the EU, which materialized as an actual policy target in the recent legislation. Scenario runs were conducted to estimate changes in biofuel production, effects on other agricultural production and prices and finally overall welfare implications. The results show that the EU emission targets alone only lead to minor increases in biofuel production, and therefore additional subsidies are necessary to reach the 10% biofuel target. The augmented demand for biofuels by the 10% target considerably affects its trade flows, most strongly for the EU and for Brazil, but also for some other regions such as the US. Also, there is heterogeneity in competitiveness of the biofuel sectors within EU regions, reflected in a marked difference in patterns for the scenarios with a collective biofuel target for the entire EU and those with a target for individual EU members. Agricultural prices are significantly increased with the biofuel target, giving some ground for the concerns expressed in the ‘food vs. fuel’ debate. Average EU agricultural sector prices in 2020 increase up to 7% in the biofuel scenarios, while world agricultural prices are affected less and only increase by up to 3.5% in 2020. These increases in agricultural prices do not seem dramatic compared to e.g. overall European price increases that reach 140% from 2001-2020 in our scenarios, but also not negligible.

[5] Cf. Boeters et al. (2008) who also find a small but negligible increase in EU27 welfare in a biofuel policy compared to a policy benchmark scenario, which they attribute to the decline in distortionary carbon taxes in the non-ETS sectors.

The results obtained so far clearly support the view that it is important to account for the linkage of biofuel and agricultural markets. Additional welfare losses compared to a cost-effective scenario where the EU 20% emission reduction target is reached occur mainly due to separated carbon markets and also the renewable target. The biofuel target has relatively small negative or even positive welfare effects in some scenarios. This leads to our result that the 10% biofuel target is rather preferable to the upscaling of renewable electricity to a 30% share, which is costly and more distinctively decreases welfare. Once additional biofuel targets in other countries are taken into account, the distortionary effects would probably lead to larger welfare losses and one would surely see larger increases in world agricultural prices.

7. References

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Appendix: Figures 1-10

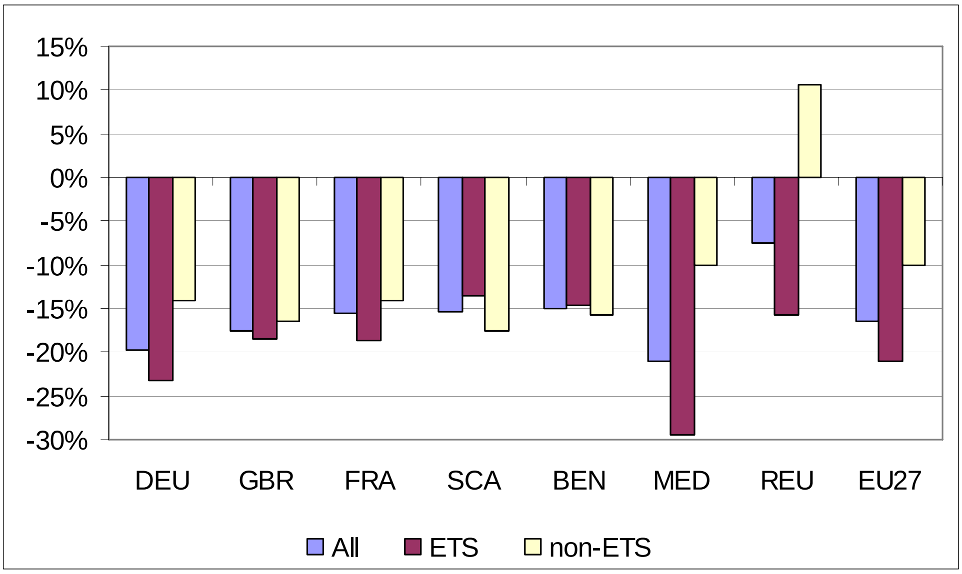

Figure 1. EU CO_2 reduction targets in 2020 relative to 2005

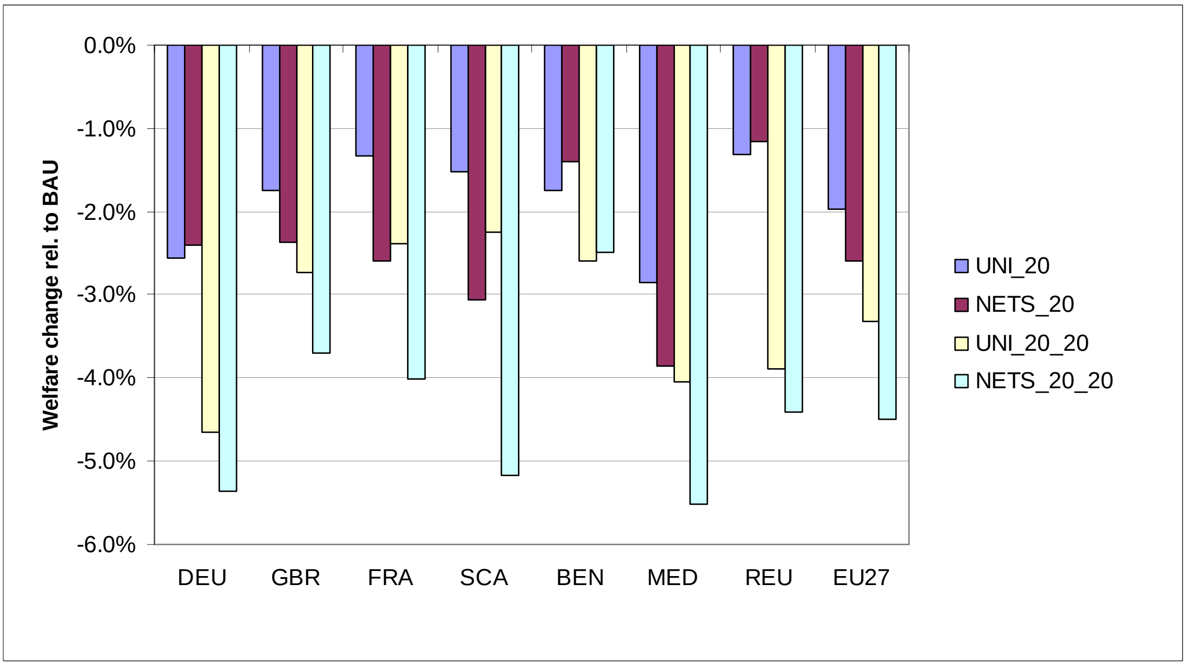

Figure 2. Welfare relative to BAU for core scenarios in 2020

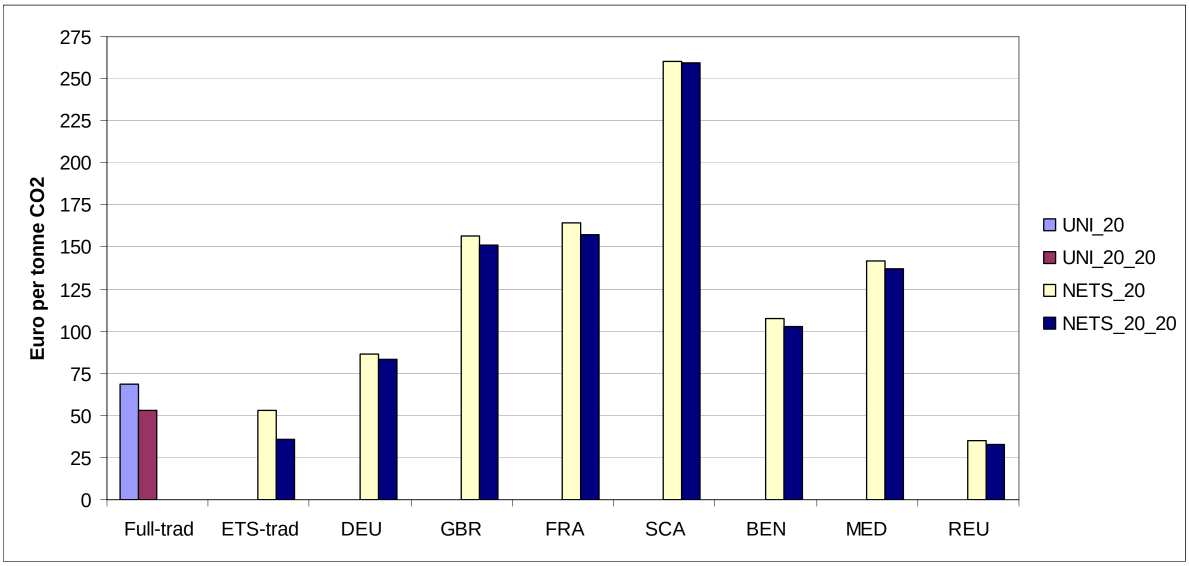

Figure 3. Carbon prices for core scenarios in 2020

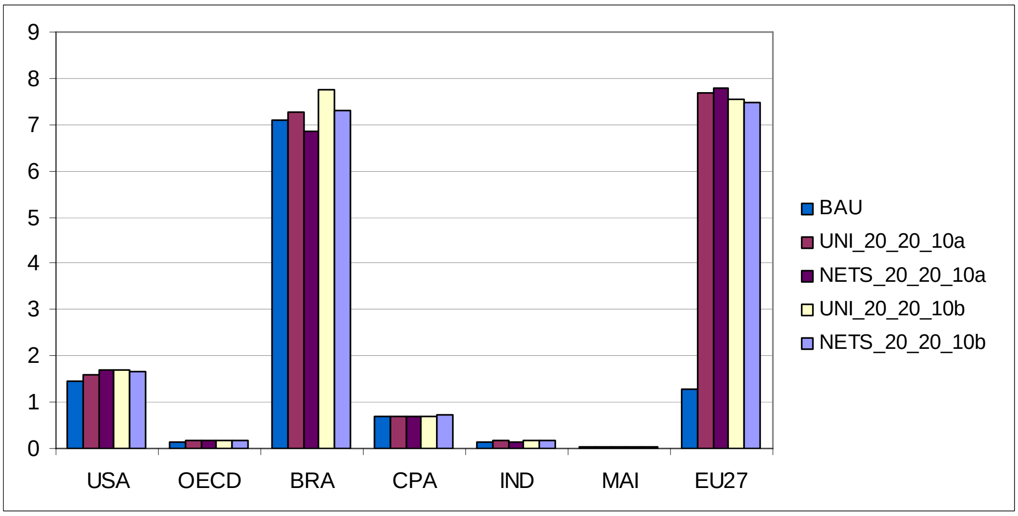

Figure 4. Biofuel production in 2020 (in billion real 2005 Euro)

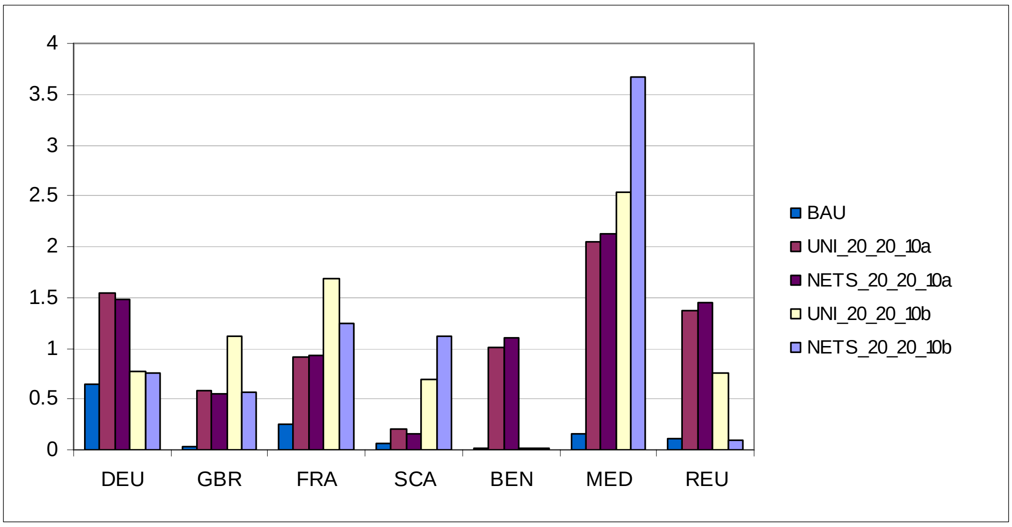

Figure 5. European biofuel production in 2020 (in billion real 2005 Euro)

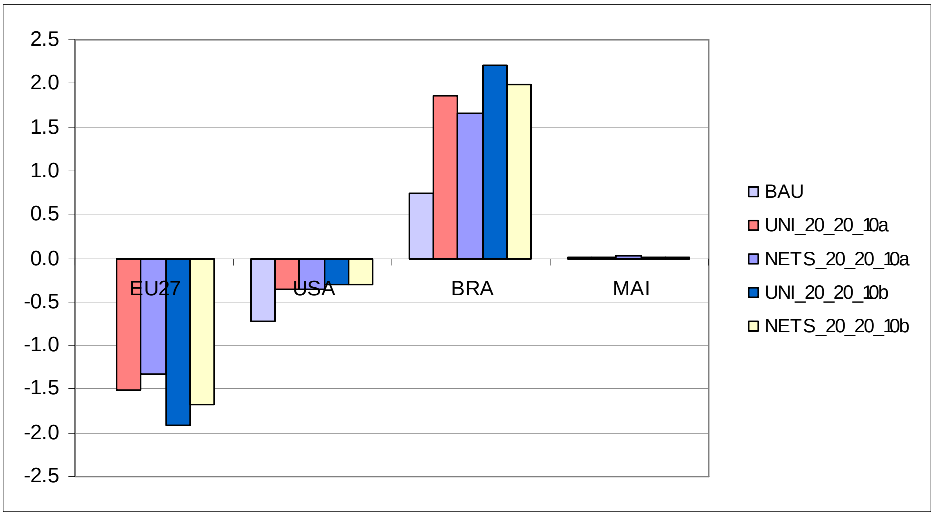

Figure 6. Biofuel net exports in 2020 (in billion real 2005 Euro)

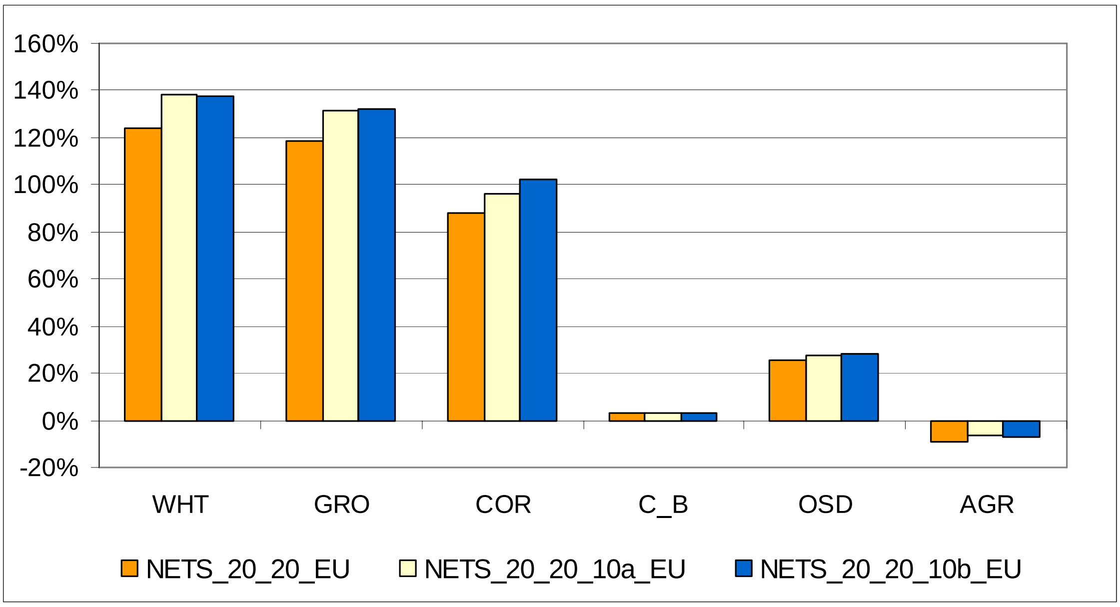

Figure 7. Growth in agricultural prices 2001 to 2020

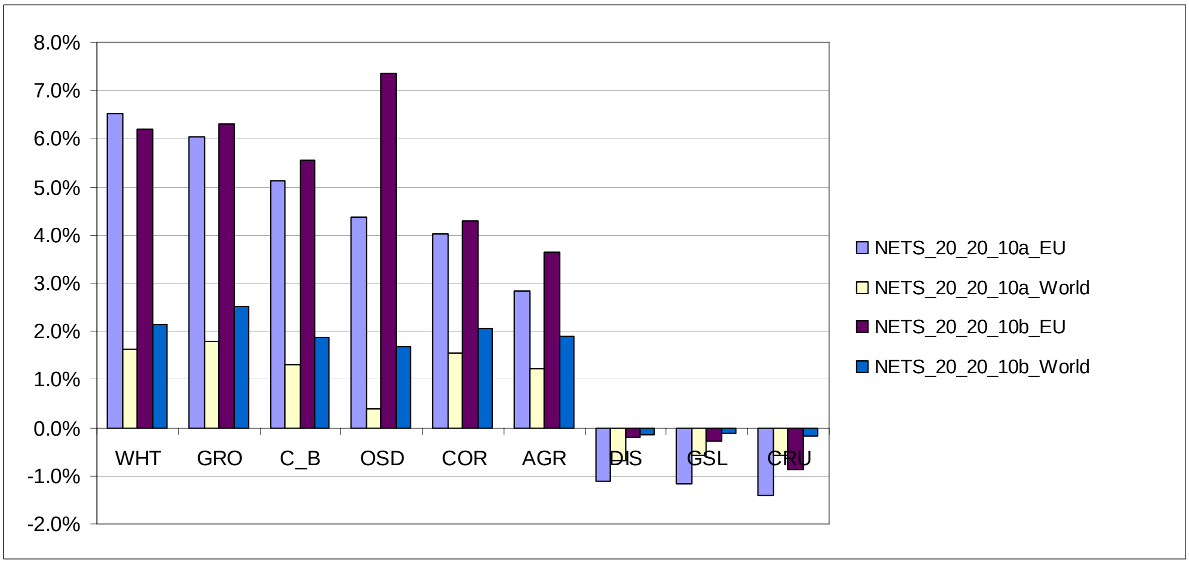

Figure 8. Price effects, in % deviation from the 2020 reference value

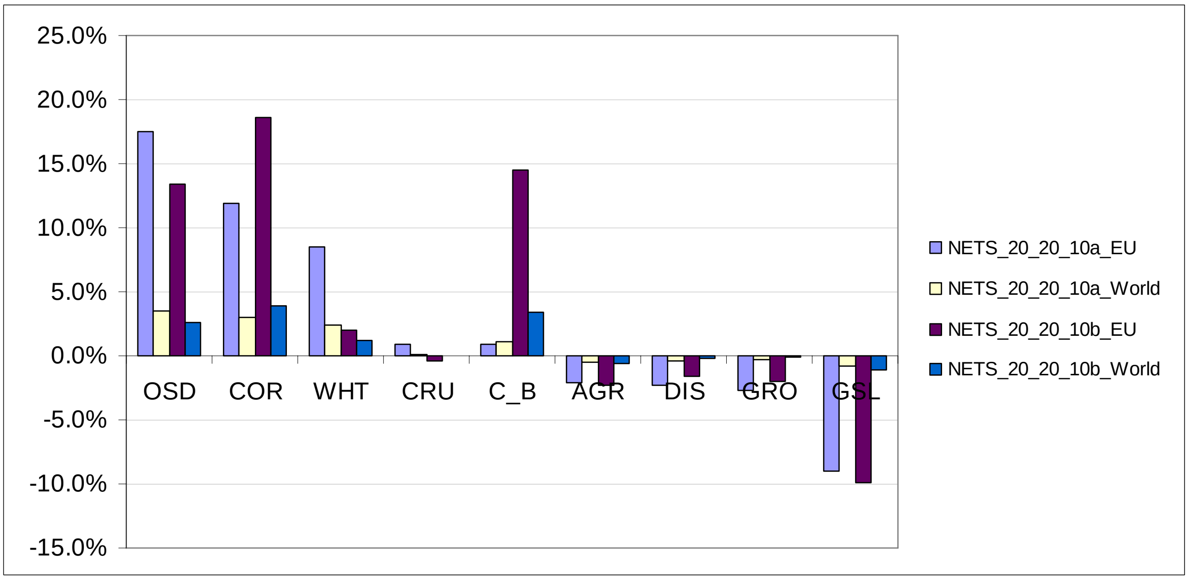

Figure 9. Sectoral production effects, in % deviation from the 2020 reference value

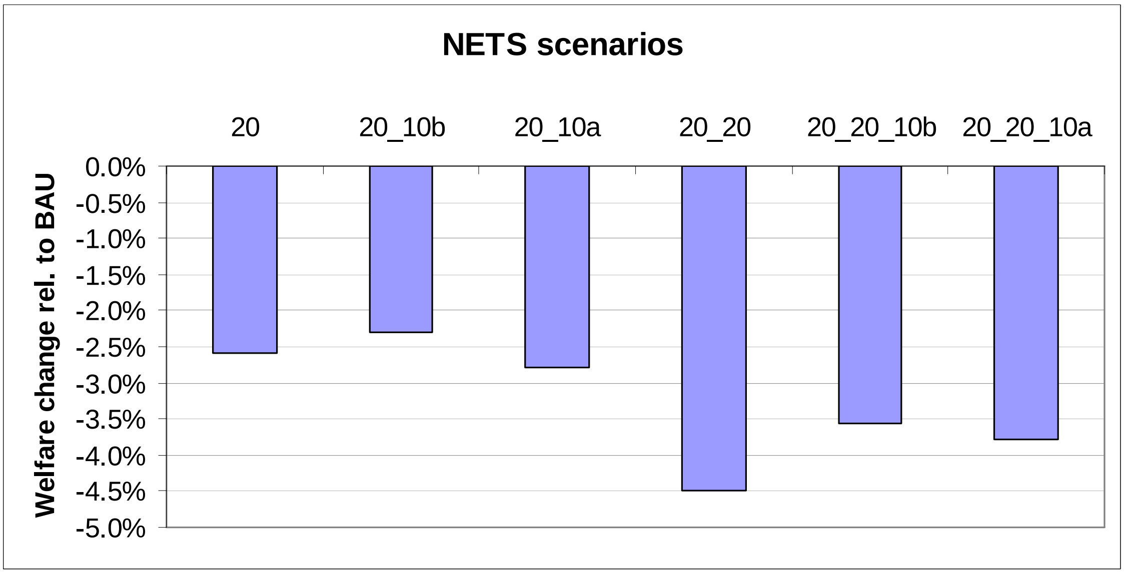

Figure 10: Welfare changes in the EU27 relative to BAU in 2020 in different NETS scenarios