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by **Bettina Kretschmer, Sonja Peterson and Adriana Ignaciuk**

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Abstract: Biofuels and other forms of bioenergy have received increased attention in recent times: They have partly been acclaimed as an instrument to contribute to rural development, energy security and to fight global warming but have been increasingly come under attack for their potential to contribute to rising food prices. It has thus become clear that bioenergy cannot be evaluated independently of the rest of the economy and that national and international feedback effects are important. In this paper we describe how the CGE model DART is extended to include first-generation biofuel production technologies. DART can now be used to assess the efficiency of combined climate and bioenergy policies. As a first example the effects of a 10% biofuel target in the EU are analyzed.

Keywords: biofuels, CGE model, climate policy, EU,

JEL classification: D58, Q48, Q54

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1. Introduction

The DART model was already developed in the late 1990s for the analysis of international climate policies. It is a recursive dynamic computable general equilibrium (CGE) model of the world economy, covering multiple sectors and regions. It is based on the Global Trade Analysis Project (GTAP) database. Applications of DART include the analysis of issues associated with the implementation of the Kyoto Protocol, the economic impacts of climate change, the effect of increased capital mobility and more recently the analysis of the European emissions trading scheme and potential international Post-Kyoto regimes.

In the past years bioenergy in general and biofuels in particular have received increased attention because they were believed to tackle various problems at once: First, it was hoped that biofuels contribute to greenhouse gas emission reductions thus mitigating climate change. They were seen as an option to reduce emissions in the steadily growing transport sector, where other renewable energy sources are not yet widely available. Second, especially in Europe and in the United States they were seen as a means of increasing energy security and thus reducing the dependence on energy imports from politically unstable regions. Third, bioenergy was hoped to provide new income sources to rural areas and to promote rural development. There has been growing evidence that the contribution to solve all three problems might actually not be as large as expected and biofuels have partly fallen in disgrace due to dramatically rising food prices in 2007/2008. The recent developments clearly demonstrated that the growing bioenergy industry cannot be evaluated independently from the rest of the economy since national and international feedback effects play an important role.

In order to get a better understanding of the market impacts of bioenergy and biofuel support policies in Germany, the EU and non-European countries and to assess the role that bioenergy can play in an effective and efficient climate policy we have extended the DART model to include the most important first-generation biofuels, i.e. bioethanol and biodiesel. The aim of this paper is to describe the chosen approach and methodology as well as the underlying data and assumptions. The set-up is as follows. The next section starts out with a description of the "conventional" DART model without bioenergy. In section 3 we describe necessary data work for including biofuels. Sections 4 and 5 explain in detail the way in which bioenergy production technologies have been incorporated and how the extended model was calibrated. Section 6 presents first results of incorporating the 10% biofuel quota in Europe. Section 7 concludes.

2. The conventional DART model without 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 19 regions that include the major bioenergy producing regions (in particular Brazil, Malaysia and Indonesia) as well as the main bioenergy consuming regions (including the USA and different EU regions)[1]. In each model region there are 21 sectors as shown in Table 1. There are now 7 energy sectors, but also 11 agricultural sectors that include the most important energy crops (wheat, corn, oil seeds, sugar cane and sugar beet).

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 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	CPA	China, Hong-Kong
USA	United States of America	MEA	Middle East & North Africa
OCD	Rest industrialized OECD	AFR	Sub-Saharan Africa
FSU	Former Soviet Union		
Production sectors/commodities			
Energy Sectors		**Agricultural Sectors**	
COL	Coal Extraction	WHT	Wheat
GAS	Natural 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
ELY	Electricity	SGR	Sugar
		MLK	Raw Milk
Other production sectors		MET	Meat
ETS	Energy intensive sectors covered by EU ETS	AGR	Rest of agriculture & food products
CRP	Chemical products	FRS	Forestry
OTH	Other Manufactures & Services		

* These sectors where disaggregated from the original GTAP6 database; see section 3.2

[1] To reduce the model complexity we decided against a full EU27 disaggregation

The economy in each region is modelled as a competitive economy with flexible prices and market clearing. Three types of agents exist in our model: a representative consumer, a representative producer in each sector and regional governments. All regions are connected through bilateral trade flows.

The DART model is **recursive-dynamic**, meaning that it solves for a sequence of static one-period equilibria for future time periods connected through capital accumulation. The major exogenous driving forces of the model dynamics are change in the labour force, the rate of labour productivity growth, the change in human capital, the savings rate, the gross rate of return on capital, and thus the endogenous rate of capital accumulation. The savings behaviour of regional households is characterized by a constant savings rate over time.

Labour supply considers human capital accumulation and is, therefore, measured in efficiency units, L(r,t). It evolves exogenously over time. The labour supply for each region r at the beginning of time period t+1 is given by:

$L(r,t+1) = L(r,t)* [1 + gp(r,t) + ga(r) + gh(r)].$

An increase of effective labour implies either growth of the human capital accumulated per physical unit of labour, *gh(r)*, growth of the labour force *gp(r)* or total factor productivity *ga(r)* or the sum of all. DART assumes constant, but regionally different labour productivity improvement rates, *ga(r)*, constant but regionally different growth rates of human capital, *gh(r)* and growth rates of the labour force *gp(r,t)* according to current projections of population growth and participation rates taken from the PHOENIX model (Hilderink, 2000) and in line with recent OECD projections.

Current period's investment augments the **capital stock** in the next period. The aggregated regional capital stock, *Kst* at period t is updated by an accumulation function equating the next-period capital stock, *Kst(t+1)*, to the sum of the depreciated capital stock of the current period and the current period's physical quantity of investment, *I(r,t)*:

$Kst(r,t+1)= (1 - d) Kst(r,t)+ I(r,t),$

where *d* denotes the exogenously given constant depreciation rate. The allocation of capital among sectors follows from the intra-period optimization of the firms.

The static model is calibrated to the GTAP6 (Dimaranan, 2006) database that represents production and trade data for 2001. The elasticities of substitution for the energy goods coal, gas, and crude oil are calibrated in such a way as to reproduce the emission projections of the IEA (IEA, 2007). For a more detailed description of the standard DART model, see Springer (2002) or Klepper et al. (2003).

3. Disaggregating sectors from the GTAP6 database

Since currently most of the bioenergy is used in the transportation sector in the form of biofuel, we decided to explicitly model the consumption of motor gasoline and motor diesel, which can then be substituted by biofuels. Furthermore, we decided to explicitly model corn production and consumption since corn is an important feedstock for the production of bioethanol. All three sectors – gasoline, diesel and corn – are part of more aggregated sectors in the GTAP6 database. Gasoline and diesel are part of "refined oil products" and corn is part of "cereal grains neglected". Using additional data on trade, input and consumption shares we thus disaggregated these sectors from the GTAP6 database. Due to differences in data availability the approaches chosen differ slightly in both cases. The data derived in the manner described below can be found in the appendix A of this paper.

3.1. Disaggregation of refined oil products

To disaggregate motor gasoline and motor diesel from "refined oil products" we generated the following data for all DART regions[2]:

- Expenditure share (net of taxes) of diesel and gasoline consumption in consumption of refined oil products
- Expenditure share (net of taxes) of diesel and gasoline in refined oil product imports
- Ad valorem tax rates of excise and value-added taxes on diesel, gasoline and other refined oil products in all DART regions.

We furthermore assumed that the input and factor shares in the production of diesel and gasoline are the same as for the entire refined oil product sector in GTAP6 (which is a reasonable approximation of reality) and also that except for the excise and value-added taxes all other relevant taxes are the same and equal to taxes in the refined oil product sector in GTAP.

For the household expenditure shares of diesel and gasoline consumption in refined oil products we used data from Boeters et al. (2008) for 2001 adapted to our regional disaggregation. For expenditure shares in the different sectors, we used detailed data from the "Umweltgesamtrechnung"[3] on the physical amounts of gasoline, diesel and other refined oil products used in different production sectors and the household sectors for the year 2000 multiplied by prices taken from IEA (2006) for Germany. Since we were not able to find information on sectoral consumption for the other DART regions, we assumed in the first step that the sectoral shares are the same as in Germany. In the second step we adjusted the shares to match the total expenditure of gasoline and diesel calculated from the physical

[2] The choice of working with shares rather then with absolute numbers stems from the fact that is very hard to match the available information on consumption of different refined oil products and grains with the GTAP data.
[3] Prepared by the German Federal Statistical Office, www.destatis.de

consumption of gasoline, diesel and other refined oil products in IEA (2003) and the prices for gasoline, diesel and other refined oil products reported in IEA (2006). Some more fine-tuning was necessary to fix remaining inconsistencies.

Unfortunately, we could not make more extensive use of the IEA data since they include all fuels used in road transportation under "Transport" and do not distribute the use to the sectors that use the transport. Another problem is that the IEA data aggregate diesel and light heating oil. For Germany the UGR provides the share of diesel and heating oil. We are unaware of similar data for other DART regions so we adopted the German shares for all regions believing that the distinction between diesel and heating oil is essential for the study at hand thus preferring approximation to non-consideration.

To derive expenditure shares (net of taxes) of diesel and gasoline in refined oil product imports German data on imports of gasoline, diesel and other refined oil products for the year 2001 are available from the MWV (2006) as well as data on imports from Germany by the other DART regions (=export data for Germany). For imports to and from OECD countries IEA (2003) provides physical data on diesel, gasoline and other refined oil imports that have been multiplied with prices from IEA (2006). Again, we had to make some assumptions on the share of diesel in the aggregate of diesel and light heating fuel. Where plausible we use the same shares as for Germany, or as for the diesel imports from Germany. Where no information was available we assumed a 50-50 share. For imports from non-OECD to non-OECD countries there were no information available. We assumed that the shares are the same as for the average of OECD country imports.

Finally, ad valorem tax rates of excise and value added taxes on diesel, gasoline and other refined oil products in all DART regions could be calculated with data from IEA (2006).

3.2. Disaggregation of other grains

To disaggregate corn from "cereal grains neglected" we generated the following data for all DART regions:

1. Expenditure share (net of taxes) of corn in bilateral trade of other grains
2. Expenditure share (net of taxes) of corn in final and intermediate consumption of other grains
3. Input and Factor shares in corn production.

Besides we made the assumption that all tax rates are identical for corn and other grains.

As data input we used FAO data for the regional production of corn and other grains, total regional consumption divided into "feed", "seed", "food" and "processing elsewhere" in physical terms as well as data on the value of bilateral imports of corn and other grains.

Furthermore the CAPRI model provided us with input quantities of intermediate inputs into corn production (CAPRI, 2007, Witzke and Britz, 2005).

The expenditure shares (net of taxes) of corn in total other grains where directly calculated from FAO data on the value of bilateral imports of corn and other grains. In some cases there was no production of corn but exports from this region. In these cases we set the exports to zero and adjusted in turn the bilateral trade flow into the other direction (e.g. the FAO data show no production of corn in Scandinavia, but there were small export flows of corn to e.g. Germany. We set this flow to zero and deducted the original number from the export of German corn to Scandinavia, so that net trade remained unchanged).

From the physical and value data of imports we derived some average regional corn prices which we used to weight the physical production and use values and then derived the share of corn use for “feed”, “seed”, “food” and “processing elsewhere”. We used the share for “seed” for the sector “grains”, “feed” for all agricultural sectors and the share for “processing elsewhere” for all other DART sectors. The “food” share was used for final consumption. These shares were finally adjusted by a factor so that total use minus imports of corn matched the share of corn production in total grain production derived from the production data. Additional small adjustments were necessary in order to prevent the inputs that remained for other grains from being negative.

Table 2. Matching CAPRI and DART inputs

Input category CAPRI	Input category DART
Seed	Chemical Products (CRP)
Plant protection	Chemical Products (CRP)
Maintenance machinery	Other Manufactures & Services (OTH)
Maintenance buildings	Other Manufactures & Services (OTH)
Electricity	Electricity (ELY)
Heating gas and oil	Other Refined Oil Products (OIL)
Fuels	Motor Diesel (DIS)
Lubricants	Other Refined Oil Products (OIL)
Other inputs	Other Manufactures & Services (OTH)
Mineral nitrogen	Chemical Products (CRP)
Mineral phosphate	Chemical Products (CRP)
Mineral potassium	Chemical Products (CRP)

Finally, to derive the input and factor share in corn production in all DART regions we started out by assuming that the same shares used in the aggregate production of grain as contained in the GTAP database also apply for corn. We then used data provided by the CAPRI model to make some adjustments for the intermediate inputs in corn production by European countries and regions. The input categories of the CAPRI data and their matching

DART sectors are given in Table 2. We used the shares calculated from the value data in CAPRI for DART. In some cases small adjustments were necessary when the GTAP input in all grains was already smaller than the input derived from the CAPRI shares.

4. Including latent technologies for bioenergy

Bioenergy technologies are modeled as so-called 'latent technologies'. A latent technology is inactive in the base year due to the higher costs than traditional technologies but its production may take off due to changes of relative prices and cost structures following changes of the market forces and policies. The approach of latent technologies is often used in the context of carbon-free backstop technologies that are activated at a certain price. This approach also fits to the market situation of biofuels where at the beginning of this millennium the technology for producing biofuels existed, but basically no biofuels were produced yet (the exception being Brazil).

The production of biofuels depends on several factors. On the one hand, these are the direct factors influencing the cost of biofuels; prices of agricultural feedstock inputs and tax exemptions, and indirect factors such as blending targets or other political support measures. On the other hand, the production of biofuels is related to the corresponding fossil fuel prices. To take these into account, in our model, we use the appropriate cost shares for each biofuel technologies for each region and incorporate the so called mark ups to account for the difference between production costs and prices.

The cost shares are calculated for seven different technologies; biodiesel based on (i) vegetable oil,(ii) soy, (iii) palm oil, (iv) rape oil and bioethanol based on (v) sugar cane or sugar beet, (vi) sugar cane (for Brazil) and (vii) wheat or corn (Table 3). These include the following inputs: the feedstock, electricity, and a value-added composite of capital and labor. 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). The technologies are assumed to be available in the countries where we observe some production until the year 2005 (see Table 4 in the next section).

Mark ups for bioenergy were calculated based on the quality difference between bioenergy and the corresponding fossil energy source and the difference between bioenergy and conventional energy prices, which have been collected from IEA (2006) and other sources[4]. The quality ratios used are 0.65 for bioethanol and 0.91 for biodiesel. Due to differing prices, mark ups differ across regions. For bioethanol they vary between 1.7 in Scandinavia and 2.4 in the United States and for biodiesel between 2.8 in Benelux and 3.3 in Germany.

Table 3. Cost shares of bioenergy production

	Biodiesel from				Bioethanol from		
	veg. oil	soy	palm	rape	sugar cane/ beet	Sugar cane in Brazil	wheat/ corn
feedstock	0.80	0.76	0.73	0.79	0.62	0.59	0.62
electricity	0.04	0.04	0.05	0.04	0.15	0.17	0.15
capital	0.15	0.19	0.21	0.16	0.20	0.22	0.20
labour	0.01	0.01	0.01	0.01	0.03	0.02	0.03

Figure 1 displays the nesting structure for the production of the latent bioenergy technologies in DART. The feedstock input needed is represented by the intermediate input nest and can either be derived from domestic production or be imported. Note that the input factor land is not represented explicitly in the nesting structure. It is instead implicitly contained in the production of the agricultural inputs used.

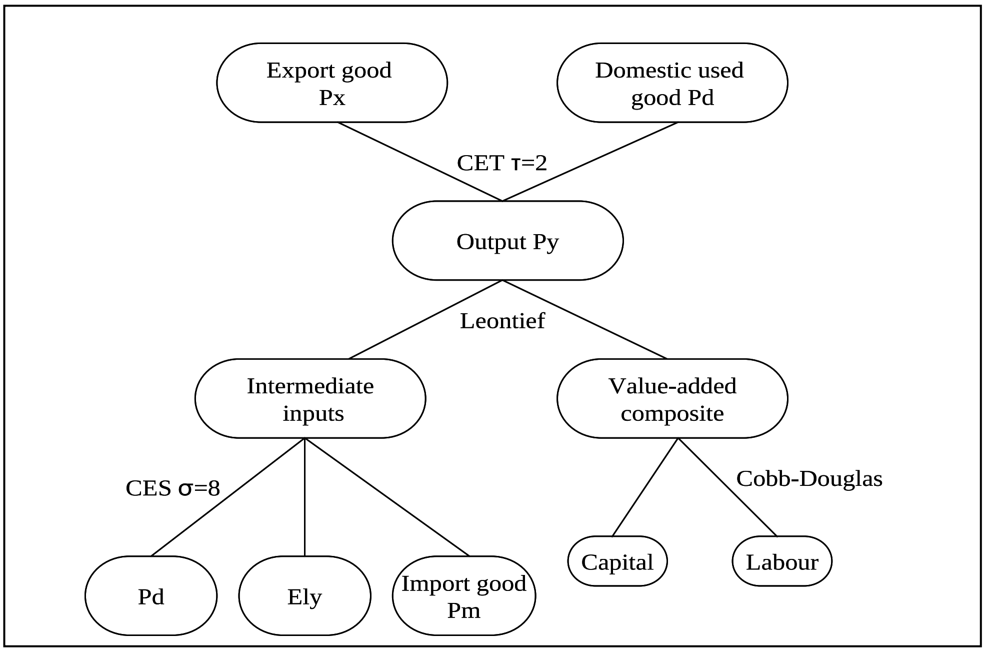


Figure 1. DART latent technologies production structure

We have so far presented the production side of biofuels. The crucial elements on the consumption side are that biodiesel and bioethanol perfectly substitute for conventional diesel and gasoline, respectively. In order to model the substitution of biodiesel and bioethanol for the respective conventional fuels, the disaggregation of diesel and gasoline from the aggregated GTAP sector "refined oil products" was necessary as described in section 3.1.

[4] Data on Brazilian sugar prices are obtained from UNICA (2008), monthly and annual US prices (FOB prices Omaha, Nebraska) obtained from http://www.neo.ne.gov/statshtml/66.html.

5. Calibrating DART with biofuels

After having introduced the latent technologies for the production of biofuels in the different DART regions we calibrate the model to match the production and trade structure that we observe in reality. Without any biofuel support policy only Brazil is able to produce biofuels competitively. Here, we adjusted the cost advantage of bioethanol relative to conventional motor gasoline such that the market penetration in 2005 was as in reality around 40%, the actually observed share in that year. In the other DART regions we imposed a subsidy on the production of biofuels whose level is determined endogenously such that the share of biofuel in total fuel consumption matches the data shown in table 4. This subsidy represents policies such as tax exemptions, quotas and explicit subsidies that have led to the current production of biofuels.

Table 4. 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
FSU	-	-	-	-	-
BRA	0.1	40.0	-	40.0	-
LAM	-		-	-	-
OECD	0.05	0.4	-	0.2	0.2
MAI	-	-	-	-	-
PAS	-	-	-	-	-
CPA	-	1.7	1.7	-	-
IND	0.6	1.7	-	1.7	-
MEA	-	-	-	-	-
AFR	-	-	-	-	-

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

Having calibrated the model to 2005 production data, the second issue is the inclusion of trade in biofuels. To meet a biofuel target such as the EU 10% quota, it is also possible to rely on imported biofuels, which is a very likely scenario given the rather limited biofuel production potential within Europe[5]. It is thus very important to model trade in biofuels but nevertheless difficult due to limited data availability and limitations of the latent technology

[5] Current EU legislative proposals envisage an obligation of meeting certain sustainability criteria for biofuels imported from third countries in order to actually count for the fulfilment of the quota. The policy scenarios reported below will take these circumstances into account. The most recent legislative developments unveil that the binding character of the 10% quota is further subject to second-generation biofuels becoming commercially available (Council of the European Union, 2008).

approach. For bioethanol, there are some trade data available. The largest trade flows are exports from Brazil to Europe and the US. Furthermore there is some internal EU trade. The problem with the approach of modelling biofuels as latent technologies is that it is difficult to calibrate the model to a certain trade structure that is not fully developed yet but will potentially evolve rapidly. Since our main focus is on analyzing EU biofuel policy and since in the near future major exports from any other region are not very likely we assume that bioethanol trade only takes place between Brazil and the industrialized countries.

There are no data on biodiesel trade. World production is much lower than for ethanol with Germany being the largest producer in the world and the EU being responsible for more than 60% of global production. Some trade takes place within the EU. In 2007, the US exported B99 to the EU. This was, however, only possible due to high subsidies in the US. Argentina is a potential exporter of biodiesel and Brazil has a biodiesel program in place but no exports yet. In Asia there are only small biodiesel production capacities but probably no exports to the EU right now. However, it is believed that Malaysia and Indonesia could potentially develop a significant export potential (meó Consulting Team, personal communication, 2008). We therefore include small initial shares of biodiesel exports for our model region MAI in order to account for the possibility of future exports. Vegetable oils used for the production of biodiesel can of course be traded.

Furthermore, we made sure to use the correct import tariffs for biofuels. For excise duties we calculated the according ad-valorem tariff and changed these over time to mimic fixed absolute tariffs. The raw data on tariffs and excise duties underlying the calculated import tariffs as shown in table 5 have been obtained from OECD/FAO (2008).

Table 5. Biofuel import duties in ad-valorem terms

Biodiesel	Importers			**Bioethanol**	Importers		
	EU27	USA	OECD		EU27	USA	OECD
MAI	6.5%	4.6%	0%[6]	BRA	70,6%	58,1%	17,2%

Source: Own calculations based on OECD/FAO(2008)

6. Analyzing the EU climate package and the 10% biofuel target

To show global leadership and to foster the international negotiations for a long term international climate regime the EU agreed in March 2007 on legally binding EU climate policy targets that go beyond the Kyoto targets. The two key targets are a reduction of at least 20% (relative to 1990) in greenhouse gases by 2020 – rising to 30% if there is an international agreement committing other developed countries to “comparable emission reductions and economically more advanced developing countries to contributing adequately according to their responsibilities and respective capabilities” and a 20% share of renewable

[6] Based on OECD/FAO (2008) information for Canada.

energies in EU energy consumption by 2020 (see EU 2008a). To reach these targets the European Commission put forward an integrated proposal for Climate Action in early 2008 including a directive that contains these two targets and additionally a 10% minimum target for the market share of biofuels by 2020 (EU 2008a, 2008b).

6.1. Scenarios

As a first application of the extended DART model we analyze the economic effects of a 10% quota on biofuels until the year 2020 as it was put forward by the EU additional to the target of a 20% reduction in EU carbon emissions. In order to simulate a policy target share for biofuels, a quota is imposed on the Armington supply in order to simulate the fact that a quota requirement may be met either by domestic production or by imported biofuel. For now we run the following three scenarios:

[REF]: In our reference scenario we assume that the share of biofuels in total fuel consumption stays at the level of 2005. This is achieved by a subsidy on domestic production of biofuels. Furthermore, the EU reaches the target of a 20% reduction in CO_2 emissions relative to 1990 as announced in the EU climate package. There is emission trading among the sectors covered by the European emissions trading scheme (ETS). The emission targets for the non-ETS sectors are reached by means of a uniform national carbon tax. The targets for the ETS and the non-ETS sectors are derived from the national allocation plans and the EU climate package. For simplicity we assume that CDM and JI are not used.

[10Q]: This is the same scenario as [REF] except that we now impose a 10% quota on the use of biofuels in each EU country/region by 2020. The quota may be met by both domestically produced and imported biofuels.

[10QNT]: This scenario corresponds to [10Q] with the difference that only domestically produced biofuels count towards the 10% EU quota. The rationale for having such a scenario is that the EU legislative proposals envisage that biofuel imported from third countries need to meet certain sustainability criteria in order to count for the fulfilment of the quota. This scenario thus assumes that the setting up of an international certification scheme for biofuels will not be achieved and the quota has to be met by domestically produced biofuels only.

For the sensitivity analysis in section 6.3, some scenarios are suffixed by SENSUP and SENSDO in order to denote scenario runs with increased and decreased mark ups, respectively.

Details about the implementation of the EU climate package and the targets for the ETS and non-ETS sectors can be found in Peterson & Klepper (2008).

6.2. Simulation Results

When presenting the results we focus on three different issues: changes in the biofuel sectors, effects on the agriculture sectors and finally the overall welfare implications of the biofuel target. Also, we focus on the year 2020.

We start with the effects on biofuel production and consumption. Figure 1 illustrates consumption quotas for bioethanol and biodiesel for the three scenarios. The first result is that EU climate targets alone do not increase the production and consumption of biofuels. In the reference scenarios, where the 20% target is reached by emissions trading in the energy-intensive sectors and a uniform carbon tax in the non-trading sectors the biofuel shares never exceed the actually observed biofuel shares of the year 2005 that were imposed as a constraint on biofuel production in the different regions[7]. In the [10Q] scenario we enforce a 10% share of biofuel use in total fuel use.

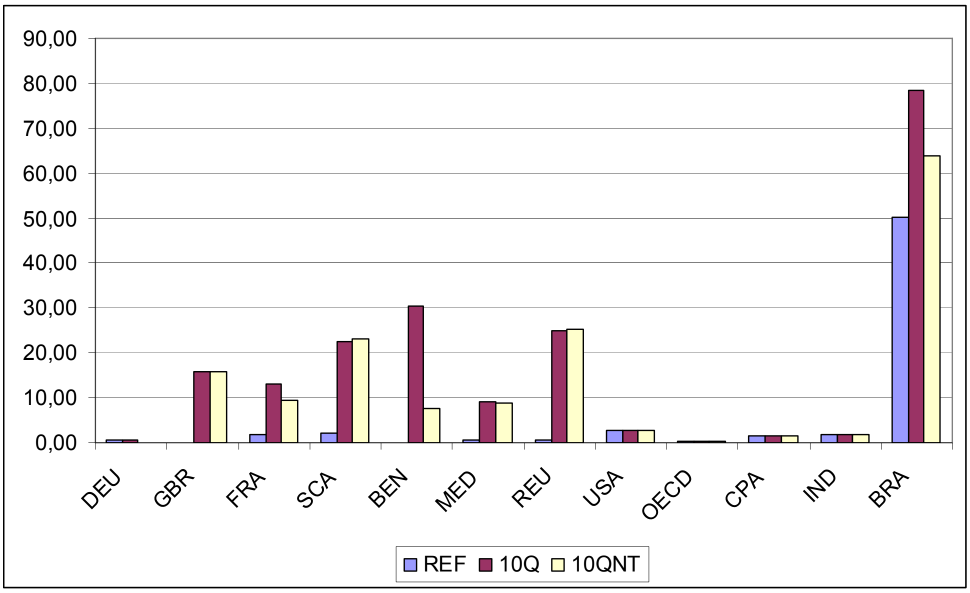


Figure 1a. Biofuel quota in % (Armington consumption) for *bioethanol* out of total gasoline consumption

Figures 1a and 1b show that it differs across countries whether this quota is met by increased biodiesel or bioethanol shares or both. While Germany increases biodiesel production only, Great Britain, Scandinavia and REU (remaining, mostly Eastern European countries) increase bioethanol production only. France, the Benelux countries and the Mediterranean countries increase both.

[7] The only exception is ethanol in Brazil, where the mark-up had initially been adjusted so as to replicate observed 2005 shares and where production does increase steadily over the projection period without any policy support.

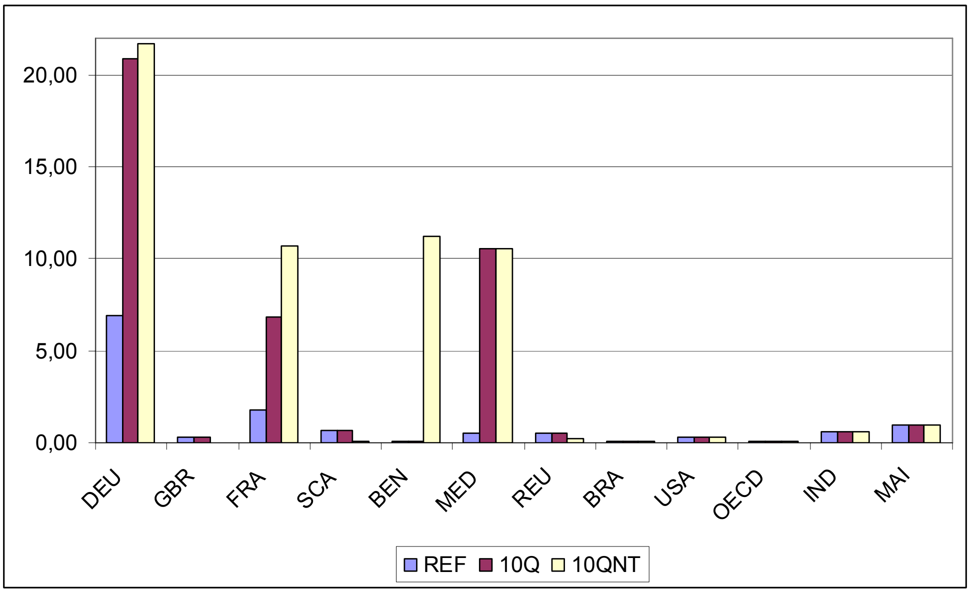
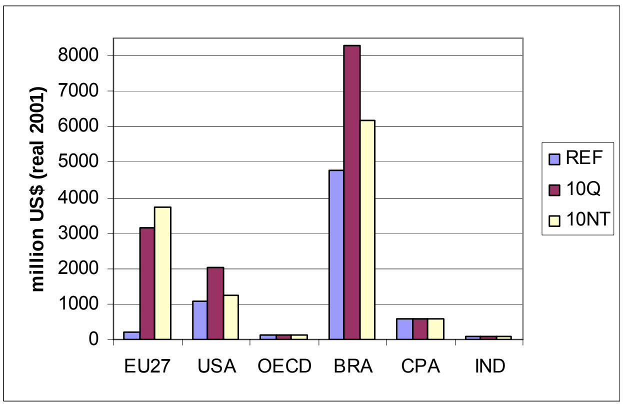


Figure 1b. Biofuel quota in % (Armington consumption) for *biodiesel* out of total diesel consumption

Figure 2 represents the total value of biofuel production in the year 2020 in selected regions. As expected, today's world leaders in ethanol and biodiesel production, being Brazil and the EU, respectively, remain the biggest producers over the projection period. The no-trade scenario leads to substantial ethanol production losses in Brazil compared to the [10Q] scenario. The EU makes up for this loss in imports mostly by expanding biodiesel production, but partly also by increasing its ethanol production. Due to the 10% quota, the EU actually becomes the second biggest ethanol producer by the end of the projection period, overtaking the US. This would surely change once the US Energy Independence and Security Act of 2007 is taken into account that calls for 36 billion gallons of biofuels out of total transportation fuels by the year 2022. Taking into account biofuel targets beyond Europe is a next step in this research process. As concerns biodiesel production, the EU remains well ahead of all other regions.



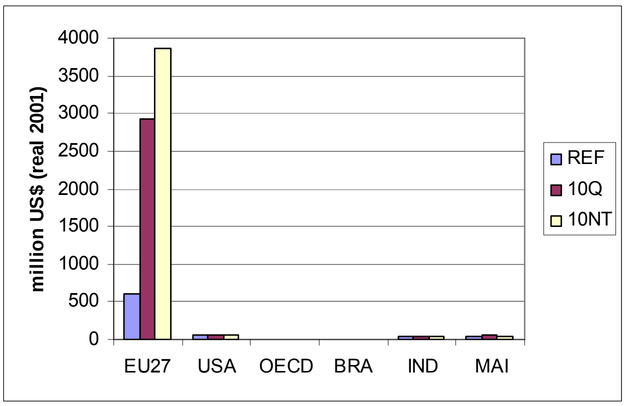


Figure 2. *Bioethanol* (left panel) and *biodiesel* (right panel) production in 2020. Data source: table B1 appendix

Figure 3 shows the trade balances for selected regions[8]. The largest trade flows are ethanol from Brazil to the US in the reference and to the EU in the [10Q] scenario with exports shifting back to the US in the no-trade scenario. Having a closer look at the imports of biofuels in the different EU countries reveals that biodiesel import shares remain low across scenarios (due to the limited export potential of Malaysia/Indonesia) while the share of ethanol imports varies a lot between countries, from 0.7% for REU to 75.8% for the Benelux countries in the reference scenario and from 9.6% for the Mediterranean to 97.4% for the Benelux countries in the [10Q] scenario (see tables in appendix).

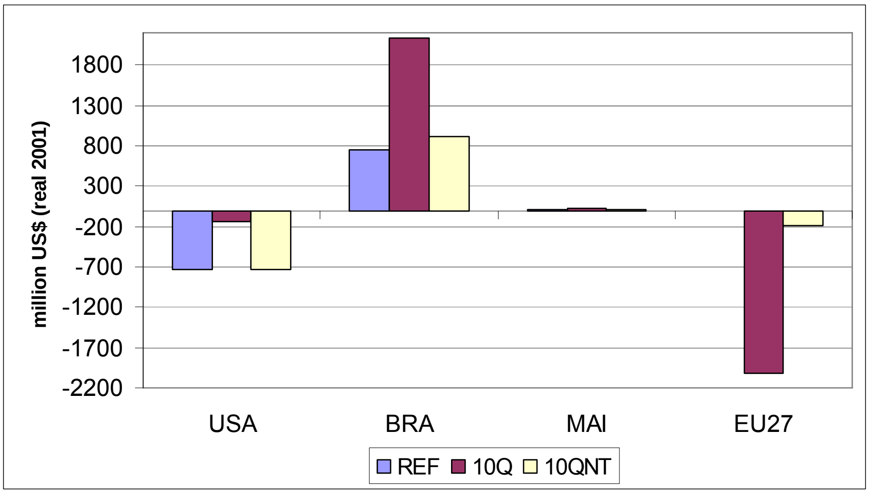


Figure 3. Biofuel net exports in 2020

The question that we address now is the impact of the expanding biofuel production on prices and production especially in the agricultural sectors. Biofuel production was blamed by many to be among the principal reasons underlying the massive increases in feedstock prices of 2007/2008. Even in our reference scenario without additional biofuel production agricultural prices increase substantially from the base year 2001 to 2020. European and world price increases reach from 100 to 160%. Compared to this, additional price increases due to increased biofuel production are not large, but yet not insignificant. Figure 4 below presents the effects on prices of imposing a biofuel quota for selected DART sectors in the year 2020 compared to the reference scenario. Agricultural sectors are obviously most affected and we thus focus on them in our presentation of results. The effects are significant, reaching around 6% for some sectors and scenarios. This supports the view that an increase of biofuel production potentially contributes to higher grain and food prices. Somewhat surprisingly perhaps, the milk sector is affected most indicating that the rise in agricultural product prices drives up input (cattle feed) costs in the milk sector considerably. Unsurprisingly, the no-trade scenario [10QNT] leads to even higher price effects since the

[8] Note that biofuel trade in the EU27 in the no-trade scenario is slightly larger than zero since even without subsidies bioethanol from Brazil can compete with conventional fuels.

need to fulfil the 10% with domestically produced biofuel only raises demand for agricultural inputs further. Prices in the fossil fuel sectors are negatively affected, which is readily explained by reduced demand for conventional sources of energy.

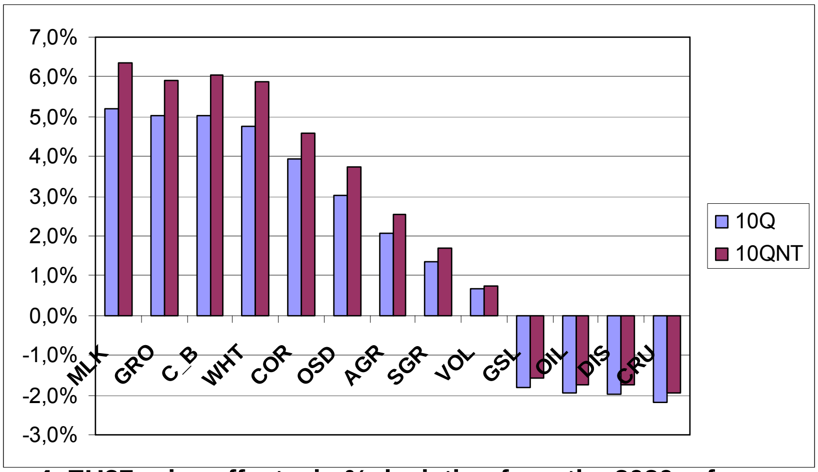


Figure 4. EU27 price effects, in % deviation from the 2020 reference value

We will next take a look at the production effects displayed in figure 5. As can be expected, production of all feedstocks for bioenergy increases. While production of corn, wheat and sugar beet increase only moderately by 3 to 5%, the overwhelming effect is found in the oilseeds sector (OSD) that increases by more than 25%. This highlights the fact that the EU relies most heavily on biodiesel produced from oilseeds in order to meet the 10% target. The increase in oilseeds production and the other feedstocks leads to a diversion of other agricultural activities, most notably milk and other grains. Furthermore, one notices that conventional diesel and gasoline production decrease considerably. The pattern across the different quota scenarios is as expected. The no-trade scenario leads to a greater expansion of production compared to the [10Q] scenario because even more biofuel is produced domestically.

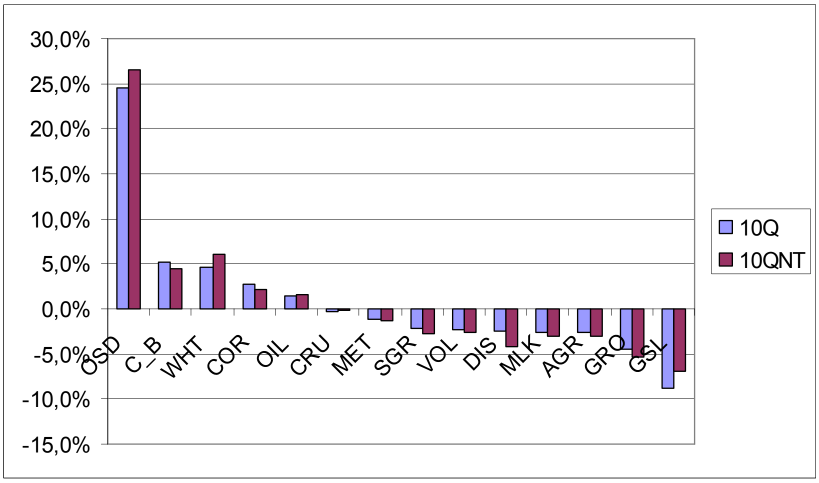


Figure 5. EU27 sectoral production 2020 in % deviation from the 2020 reference value

The macroeconomic effects resulting from our scenarios summarize overall impacts. Figure 6 displays the welfare effects measured in terms of equivalent variation. Welfare effects for the EU as a whole are somewhat ambiguous with hardly an effect found for the [10Q] scenario and negative effects for the no-trade and free-trade scenarios, the former outweighing the latter. The effects for single countries/regions are partly quite considerable, with Germany and REU (Eastern Europe) being very much negatively affected while the Scandinavian and Mediterranean countries reap considerable welfare gains. The Benelux region relies heavily on imports, which explains the sharp drop in welfare from the [10Q] to the no-trade scenario. Brazil is the only non-EU region that actually displays any welfare gains, which is not surprising given its increased export market due to the imposition of a 10%. The no-trade scenario consequently shows a substantial reduction in its welfare gains.

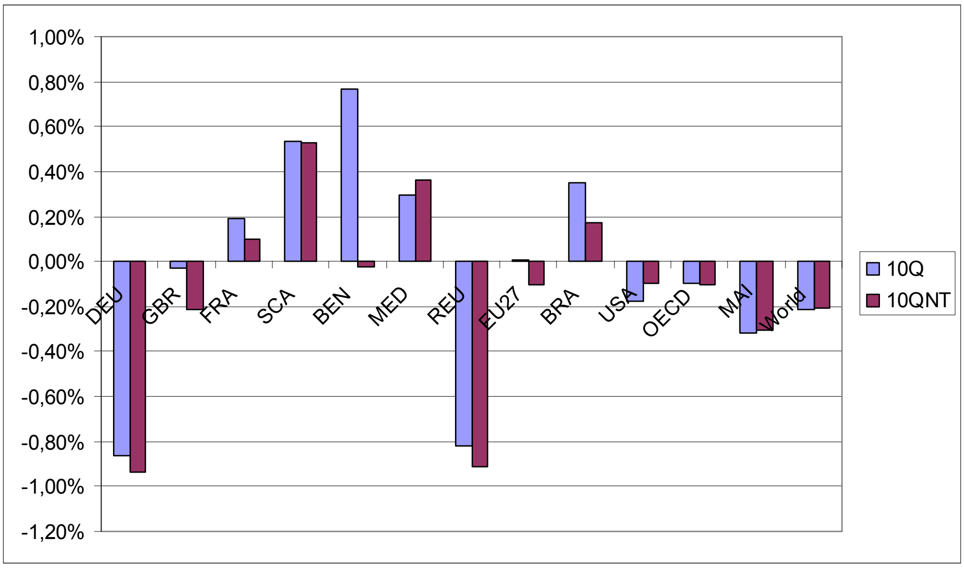


Figure 6. Welfare effects in the year 2020 relative to the reference scenario

The result that the 10% biofuel quota does on average only lead to insignificant welfare changes in Europe is surprising. Obviously, the additional economic inefficiencies of the quota are offset by other developments. The main reason for the negligible welfare effects become obvious when looking at the carbon prices in the ETS but also in the sectors not covered by the ETS. These are shown in Figure 7.

As expected, additional biofuel targets decrease the pressure to reduce emissions and thus lower carbon prices. While prices in the ETS are only slightly affected (they are reduced by around 8%) the decreases in the carbon taxes outside the ETS are more considerable. This has the effect that ETS prices and non-ETS carbon prices move closer together, which is an indicator of the inefficiencies of the targets in the separated carbon markets with different carbon prices. There is a clear correspondence between the regions where carbon taxes fall most strongly and those with the largest welfare gains through the biofuel targets. Partly, the negligible welfare effects can also be explained with the fact that a quota also subsidizes cheap Brazilian ethanol which can compete with conventional fuels. The almost negligible welfare effects may change though with different carbon targets. With full EU emissions trading, an additional biofuel target will clearly lead to welfare losses.

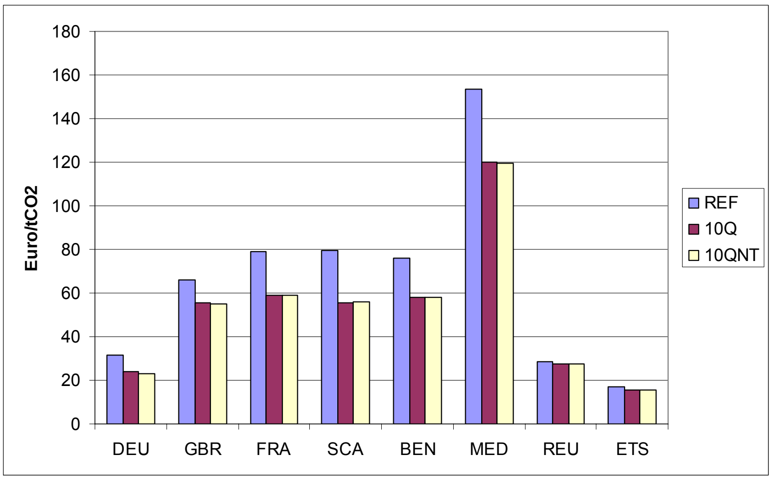


Figure 7. 2020 carbon prices in the EU ETS and non-ETS sectors

6.3. Sensitivity Analysis

As a first sensitivity analysis we vary the original level of the mark ups on bioenergy production. On the one hand, technological improvement can decrease mark ups. On the other hand, our mark ups for 2005 are only estimations based on weak assumptions for some countries and strongly depend on input prices. We thus run the two scenarios [REF] and [10Q] with mark ups increased and decreased by 50% for both biodiesel and bioethanol in all countries except for Brazilian ethanol production[9]. In other words, we assume in the sensitivity analysis, that biofuels are more either more expensive (suffix SENSUP) or cheaper (suffix SENSDO) than in the reference scenario. Figure 8 displays bioethanol production for selected regions as well as biodiesel production for the EU in the year 2020.

Production in the [REF_SENSUP] scenario, the reference scenario with increased mark ups, hardly changes since the EU, the USA, the OECD and China (CPA) only fulfil their respective benchmark shares of the year 2005 in both reference scenarios. Comparing the results of the quota scenarios [10Q] and [10Q_SENSUP] reveals as one would expect that with increased mark ups Europe relies more heavily on imported biofuel in order to meets its quota, which is represented by large production increases in Brazil and a considerable drop in European biodiesel production. Additionally, the increase in mark ups seems to bring about a shift in the relative cost and price structures underlying ethanol and biodiesel production that leads to a slight expansion of EU ethanol production despite the increased mark up.

[9] The ethanol mark up in Brazil is calibrated to replicate actually observed ethanol shares in 2005 and does not reflect any policy support measures.

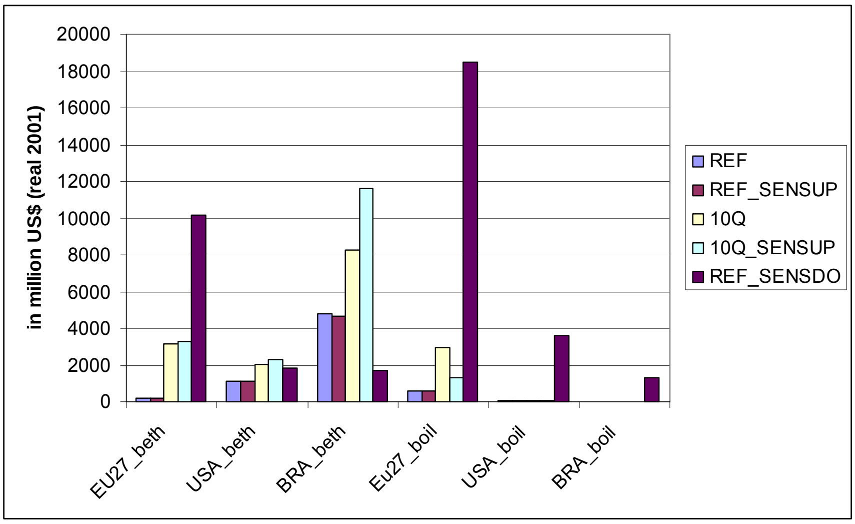


Figure 8. Biofuel production in 2020, sensitivity analysis

In the case of decreased mark ups we only represented the results for the reference scenario and selected regions, since it turns out that the enhanced competitiveness of biofuels alone is sufficient to meet the 10% biofuel quota, at least in our setting of EU climate policy. Especially EU biofuel production increases considerably, but also US and Brazilian biodiesel production realize large gains. These expansions divert resources away from ethanol production in Brazil and also – though to a much less dramatic extent – in the US.

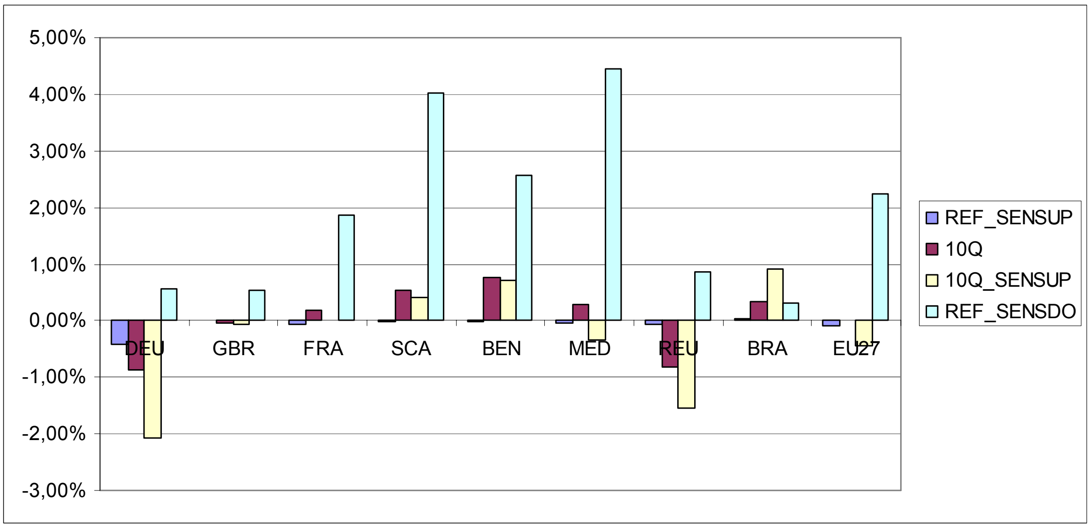


Figure 9. Welfare effects in the year 2020 relative to the reference scenario [REF]

Looking at the welfare implications in figure 9 shows changes in welfare in the sensitivity scenarios compared to their original counterpart. A rise in mark ups implies a more expensive biofuel production technology, while a decrease implies less expensive production, so that the results are as expected. Under increased mark ups welfare decreases compared to the respective original scenarios, under decreased mark ups welfare increases considerably. Brazil reaps clear gains in the quota scenario with increased mark ups because its competitiveness increases further compared to other ethanol producers and demand for its exports consequently rises. We decreased mark ups, this competitiveness effect vanishes but welfare remains higher than in the other two reference scenarios. We also see that under increased mark ups, the quota leads to clear overall welfare losses in Europe, which were slightly positive in the original quota scenario. Overall, the results are thus very sensitive to changing mark ups.

7. Summary and Conclusions

In this paper we have described how the multi-regional, multi-sectoral computable general equilibrium (CGE) model DART has been extended to include first generation biofuels – that is biodiesel produced from oil seeds and vegetable oils and bioethanol from corn, sugar beet, sugar cane and wheat. The necessary steps include a disaggregation of relevant sectors (diesel, gasoline, corn) from the GTAP data base, an introduction of regionalized latent production technologies for biofuels and a calibration of the extended model. As a first application we have analysed the economic effects of the 10% biofuel target for the EU. In all three scenarios we assume that the EU meets its climate target of a 20% reduction of carbon emissions relative to 1990 by means of the European emissions trading scheme (ETS) and by a uniform national carbon tax in the sectors not covered by the ETS. We then analyse two scenarios where additionally the 10% biofuel target is met. The scenarios differ in the extent of biofuel imports from Brazil (bioethanol) and Malaysia/Indonesia (biodiesel). In one of the scenarios, only domestically produced biofuel counted for fulfilling the quota.

There are a number of interesting results, even though this study should be considered as preliminary. The first main result is that in our reference scenario the EU emission reduction target alone does not lead to increased production and consumption of biofuels in any EU country/region. Additional subsidies are necessary to go beyond the biofuel shares observed in 2005 and to reach the 10% biofuel target. Yet, this additional target does not much affect EU welfare on average though individual countries/regions do reap gains or suffer losses. The economic inefficiencies of such a quota are offset by decreasing inefficiencies in the separated carbon markets. This can be very different though once there is e.g. full EU emission trading. The second main result is that agricultural prices in the EU are significantly increased by introducing a 10% quota. Average EU agricultural sector prices in 2020 increase from 0.7-5.2% in the basic quota scenario and up to 6.4% in the no-trade scenario. World agricultural prices are affected less as expected and increase by up to 1.9% and 2.2% in 2020, respectively. These increases in agricultural prices do not seem dramatic compared to e.g. overall European and world price increases in the range of 100-160% from 2001 – 2020 in our scenarios, but also not negligible. Once additional biofuel targets in other countries are taken into account, one would surely see larger increases in world prices as well. The results obtained so far clearly support the view that it is important to account for the linkage of biofuel and agricultural markets. Further results indicate that restrictions on the trade of biofuels from abroad – e.g. by requiring that biofuels are certified – have the expected negative welfare impacts, though these are not dramatic. In this context though it becomes important to analyse possible future trade flows of biofuels in more detail, since this study only analysed bioethanol exports from Brazil and biodiesel exports from Malaysia/Indonesia. Also, there are clearly winners and losers of biofuel support. While the agricultural sector gains on average, fossil fuel sectors lose. Furthermore sectors outside the ETS profit more from the reduced pressure on carbon prices than the sectors covered by the ETS.

Some limitations of the way bioenergy is modelled remain (see also Kretschmer and Peterson, 2008 for a general discussion of the difficulties to introduce bioenergy into CGE models). This includes the modelling of biofuel trade, the level of the mark ups that determine the future biofuel production structure and finally and most importantly the effects of land-use restrictions. Future research will aim for a better modelling of these issues and also include sensitivity analyses of further important parameters. A first sensitivity analysis with respect to the level of the mark up has shown that results may change substantially with respect to biofuel production and welfare. A special focus in the course of further research will be on modelling land-use restrictions – by including land-supply curves into DART and by coupling DART to an agricultural sector model for Germany. Furthermore, we will undertake a more detailed analysis of the effects of different bioenergy targets worldwide analysing a much wider set of scenarios than in this study.

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Appendix

A. Disaggregated data for diesel, gasoline and corn

Table A1. Fuel share in consumption of refined oil products in the different DART sectors and regions

	DEU	GBR	FRA	SCA	BEN	MED	REU	USA	OECD	FSU	BRA	LAM	CPA	IND	MAI	PAS	MEA	AFR
Gasoline																		
WHT, GRO, OSD, C_B	0,066	0,084	0,173	0,094	0,021	0,097	0,111	0,281	0,097	0,179	0,186	0,520	0,116	0,031	0,178	0,027	0,143	0,119
FRS	0,113	0,144	0,298	0,162	0,036	0,167	0,190	0,482	0,167	0,307	0,319	0,669	0,199	0,053	0,305	0,047	0,246	0,204
VOL, SGR, MLK, MET	0,028	0,036	0,074	0,040	0,009	0,041	0,047	0,119	0,041	0,076	0,079	0,221	0,049	0,013	0,076	0,012	0,061	0,050
AGR	0,072	0,092	0,190	0,103	0,023	0,107	0,122	0,308	0,107	0,196	0,204	0,572	0,128	0,034	0,195	0,030	0,157	0,130
COL, GAS	0,038	0,049	0,100	0,055	0,012	0,056	0,064	0,163	0,056	0,103	0,108	0,301	0,067	0,018	0,103	0,016	0,083	0,069
CRU	0,145	0,185	0,382	0,208	0,046	0,215	0,244	0,619	0,214	0,394	0,410	0,668	0,256	0,068	0,392	0,060	0,316	0,262
OIL	0,235	0,300	0,619	0,336	0,074	0,348	0,395	0,903	0,347	0,638	0,664	0,928	0,415	0,110	0,635	0,098	0,512	0,424
EGW	0,011	0,014	0,029	0,016	0,003	0,016	0,019	0,047	0,016	0,030	0,031	0,087	0,019	0,005	0,030	0,005	0,024	0,020
ETS	0,068	0,087	0,179	0,097	0,021	0,101	0,114	0,290	0,100	0,185	0,192	0,538	0,120	0,032	0,184	0,028	0,148	0,123
CRP	0,003	0,004	0,008	0,004	0,001	0,004	0,005	0,013	0,004	0,008	0,008	0,024	0,005	0,001	0,008	0,001	0,007	0,005
OTH	0,080	0,102	0,210	0,114	0,025	0,118	0,134	0,340	0,118	0,216	0,225	0,630	0,140	0,037	0,215	0,033	0,173	0,144
Households	0,564	0,719	0,359	0,550	0,721	0,453	0,561	0,771	0,880	0,825	0,780	0,680	0,600	0,630	0,360	0,660	0,660	0,600
Diesel																		
WHT,GRO, OSD, C_B	0,681	0,427	0,619	0,765	0,937	0,868	0,837	0,230	0,326	0,414	0,498	0,311	0,457	0,570	0,352	0,480	0,349	0,339
FRS	0,851	0,533	0,696	0,828	0,936	0,795	0,747	0,287	0,407	0,517	0,623	0,253	0,570	0,712	0,440	0,599	0,436	0,423
VOL, SGR, MLK, MET	0,300	0,188	0,272	0,449	0,550	0,510	0,526	0,101	0,144	0,182	0,219	0,137	0,201	0,251	0,155	0,211	0,154	0,149
AGR	0,503	0,315	0,457	0,753	0,922	0,854	0,794	0,169	0,241	0,305	0,368	0,230	0,337	0,421	0,260	0,354	0,258	0,250
COL, GAS	0,502	0,315	0,456	0,752	0,921	0,853	0,882	0,169	0,240	0,305	0,368	0,230	0,337	0,420	0,260	0,354	0,257	0,250
CRU	0,724	0,454	0,592	0,759	0,929	0,738	0,635	0,244	0,346	0,440	0,530	0,331	0,485	0,606	0,374	0,510	0,371	0,360
OIL	0,002	0,001	0,002	0,003	0,004	0,003	0,004	0,001	0,001	0,001	0,001	0,001	0,001	0,002	0,001	0,001	0,001	0,001
EGW	0,067	0,042	0,061	0,100	0,123	0,114	0,118	0,023	0,032	0,041	0,049	0,031	0,045	0,056	0,035	0,047	0,034	0,033
ETS	0,182	0,114	0,165	0,273	0,334	0,309	0,319	0,061	0,087	0,111	0,133	0,083	0,122	0,152	0,094	0,128	0,093	0,091
CRP	0,010	0,006	0,009	0,015	0,018	0,017	0,018	0,003	0,005	0,006	0,007	0,005	0,007	0,008	0,005	0,007	0,005	0,005
OTH	0,479	0,301	0,435	0,718	0,879	0,814	0,842	0,162	0,230	0,291	0,351	0,219	0,321	0,401	0,248	0,338	0,246	0,239
Households	0,110	0,111	0,221	0,040	0,259	0,137	0,139	0,083	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Table A2. Share of gasoline in exports of refined oil products

	DEU	GBR	SCA	FRA	BEN	MED	REU	OECD	USA	FSU	BRA	LAM	MAI	PAS	CPA	IND	MEA	AFR
DEU	0,000	0,186	0,202	0,288	0,154	0,373	0,100	0,100	0,000	0,029	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
GBR	0,207	0,217	0,234	0,127	0,456	0,000	0,729	0,230	0,041	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
SCA	0,046	0,000	0,464	0,136	0,241	0,198	0,000	0,415	0,000	0,041	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
FRA	0,179	0,152	0,131	0,000	0,076	0,158	0,000	0,023	0,000	0,000	0,000	0,174	0,000	0,000	0,000	0,000	0,058	0,023
BEN	0,264	0,316	0,260	0,183	0,216	0,194	0,490	0,070	0,002	0,037	0,000	0,077	0,000	0,000	0,000	0,000	0,000	0,087
MED	0,075	0,006	0,026	0,315	0,067	0,091	0,000	0,058	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,016	0,015
REU	0,234	0,000	0,000	0,000	0,000	0,012	0,329	0,000	0,000	0,177	0,000	0,172	0,000	0,000	0,000	0,000	0,000	0,000
OECD	0,026	0,000	0,000	0,681	0,664	0,070	0,032	0,000	0,000	0,111	0,000	0,014	0,000	0,000	0,000	0,000	0,000	0,000
USA	0,466	0,755	0,506	0,821	0,523	0,840	0,000	0,470	0,000	0,491	0,525	0,337	0,000	0,241	0,845	0,000	0,219	0,074
FSU	0,078	0,000	0,239	0,000	0,239	0,278	0,000	0,000	0,000	0,182	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
BRA	0,495	0,329	0,000	0,000	0,495	0,245	0,000	0,000	0,000	0,596	0,000	0,169	0,000	0,340	0,878	0,000	0,110	0,037
LAM	0,495	0,329	0,000	0,000	0,495	0,245	0,000	0,000	0,000	0,596	0,763	0,169	0,000	0,340	0,878	0,000	0,110	0,037
MAI	0,000	0,000	0,000	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,046	0,878	0,000	0,110	0,000
PAS	0,000	0,000	0,000	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,046	0,878	0,000	0,110	0,000
CPA	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,182	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,040
IND	0,000	0,000	0,000	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,046	0,878	0,000	0,110	0,000
MEA	0,000	0,000	0,000	0,548	0,000	0,305	0,000	0,000	0,000	0,000	0,000	0,169	0,000	0,046	0,878	0,000	0,110	0,040
AFR	0,078	0,218	0,000	0,159	0,000	0,223	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,040

Table A3. Share of diesel in exports of refined oil products

	DEU	GBR	SCA	FRA	BEN	MED	REU	OECD	USA	FSU	BRA	LAM	MAI	PAS	CPA	IND	MEA	AFR
DEU	0,000	0,122	0,149	0,047	0,111	0,000	0,111	0,251	0,000	0,116	0,000	0,000	0,000	0,261	0,000	0,000	0,000	0,000
GBR	0,267	0,003	0,104	0,015	0,103	0,033	0,033	0,000	0,000	0,224	0,000	0,000	0,000	0,345	0,000	0,000	0,000	
SCA	0,035	0,000	0,086	0,049	0,204	0,000	0,009	0,208	0,000	0,191	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
FRA	0,212	0,127	0,183	0,000	0,237	0,197	0,000	0,283	0,029	0,259	0,000	0,087	0,000	0,059	0,000	0,000	0,039	0,093
BEN	0,051	0,069	0,067	0,022	0,164	0,042	0,000	0,144	0,019	0,123	0,000	0,006	0,000	0,142	0,000	0,000	0,096	0,057
MED	0,073	0,069	0,078	0,029	0,139	0,233	0,000	0,250	0,007	0,224	0,000	0,010	0,000	0,130	0,000	0,000	0,037	0,061
REU	0,200	0,000	0,000	0,000	0,000	0,118	0,164	0,000	0,000	0,193	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
OECD	0,139	0,000	0,000	0,030	0,014	0,001	0,008	0,000	0,000	0,224	0,000	0,032	0,000	0,000	0,000	0,000	0,000	0,000
USA	0,013	0,025	0,049	0,033	0,003	0,026	0,000	0,099	0,000	0,152	0,025	0,060	0,000	0,072	0,000	0,000	0,024	0,035
FSU	0,000	0,000	0,306	0,000	0,033	0,120	0,000	0,000	0,013	0,195	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
BRA	0,013	0,096	0,000	0,000	0,046	0,260	0,000	0,000	0,056	0,076	0,000	0,030	0,000	0,036	0,000	0,000	0,033	0,087
LAM	0,013	0,096	0,000	0,000	0,046	0,260	0,000	0,000	0,056	0,076	0,012	0,030	0,000	0,036	0,000	0,000	0,033	0,087
MAI	0,000	0,000	0,000	0,087	0,023	0,027	0,000	0,000	0,160	0,000	0,000	0,000	0,000	0,071	0,000	0,000	0,033	0,000
PAS	0,000	0,000	0,000	0,087	0,023	0,027	0,000	0,000	0,160	0,000	0,000	0,000	0,000	0,071	0,000	0,000	0,033	0,000
CPA	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,040	0,195	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,077
IND	0,000	0,000	0,000	0,087	0,023	0,027	0,000	0,000	0,160	0,000	0,000	0,000	0,000	0,071	0,000	0,000	0,033	0,000
MEA	0,000	0,000	0,000	0,000	0,133	0,015	0,000	0,000	0,000	0,000	0,000	0,030	0,000	0,071	0,000	0,000	0,033	0,077
AFR	0,000	0,000	0,000	0,094	0,000	0,122	0,000	0,000	0,012	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,077

Table A4. Share of inputs in corn production

	DEU	GBR	SCA	FRA	BEN	MED	REU	FSU	OECD	USA	BRA	LAM	PAS	MAI	CPA	IND	MEA	AFR
OIL	0,104	0,000	0,000	0,042	0,017	0,092	0,025	0,032	0,061	0,000	0,000	0,013	0,032	0,000	0,006	0,000	0,032	0,032
EGW	0,005	0,000	0,000	0,009	0,006	0,012	0,010	0,012	0,008	0,000	0,012	0,009	0,012	0,000	0,012	0,012	0,012	0,012
CRP	0,454	0,000	0,000	0,647	0,670	0,410	0,419	0,430	0,476	0,000	0,344	0,430	0,215	0,000	0,215	0,430	0,172	0,430
OTH	0,412	0,000	0,000	0,294	0,291	0,449	0,522	0,507	0,442	0,000	0,625	0,538	0,748	0,000	0,763	0,558	0,765	0,517
DIS	0,025	0,000	0,000	0,008	0,016	0,037	0,023	0,020	0,013	0,000	0,020	0,010	0,010	0,000	0,004	0,000	0,020	0,010

Table A5. Share of corn in production of other grains

DEU	GBR	SCA	FRA	BEN	MED	REU	FSU	USA	OECD	BRA	LAM	PAS	MAI	CPA	IND	MEA	AFR
0,155	0,000	0,000	0,537	0,919	0,546	0,524	0,090	0,973	0,284	0,775	0,417	0,804	1,000	0,879	0,261	0,421	0,431

Table A6: Corn share in consumption of other grains in the different DART sectors and regions

DEU	GBR	SCA	FRA	BEN	MED	REU	FSU	USA	OECD	BRA	LAM	PAS	MAI	CPA	IND	MEA	AFR
WHT, OSD, C_B, FRS, VOL, SGR, MLK, MET, AGR																	
0,223	0,107	0,014	0,544	0,507	0,625	0,56	0,126	0,978	0,576	0,962	0,446	0,94	0,955	0,927	0,895	0,519	0,764
GRO																	
0,106	0	0	0,254	0,613	0,098	0,109	0,011	0,766	0,048	0,831	0,568	0,578	1	0,774	0,377	0,076	0,368
COL, CRU, ETS, OIL, DSL, GSL, CRP, EGW, OTH																	
0,861	1	0,987	0,939	1	0,994	0,65	0,572	0,995	0,966	0	0,945	0,966	0,983	0,99	1	0,945	0,885
Households																	
0,183	0,226	0,000	0,745	0,453	0,605	0,085	0,000	0,783	0,987	0,809	0,760	1,000	0,913	0,407	0,481	0,339	0,514

Table A7. Share of corn in exports of other grains

	DEU	GBR	SCA	FRA	BEN	REU	EEU	FSU	USA	OECD	BRA	LAM	PAS	MAI	CPA	IND	MEA	AFR
DEU	1,000	0,501	0,181	0,666	0,268	0,187	0,067	0,028	0,002	0,083	0,000	0,013	0,013	0,179	0,729	0,195	0,014	0,082
GBR	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
SCA	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
FRA	0,608	0,928	0,894	0,000	0,365	0,461	0,381	0,034	0,429	0,338	0,000	0,067	0,113	0,805	0,026	0,085	0,050	0,244
BEN	0,418	0,849	0,859	0,529	0,161	0,180	0,047	0,117	0,107	0,064	0,000	0,047	0,014	0,055	0,171	0,000	0,204	0,027
REU	0,716	0,421	0,065	0,916	0,449	0,687	0,685	0,588	0,755	0,465	0,000	0,758	0,243	0,591	0,954	1,000	0,187	0,607
EEU	0,738	0,421	0,003	0,911	0,439	0,660	0,657	0,595	0,714	0,345	1,000	0,780	0,301	0,846	1,000	1,000	0,188	0,951
FSU	0,041	0,152	0,000	0,000	0,128	0,592	0,595	0,329	0,025	0,011	1,000	0,087	0,000	1,000	0,000	1,000	0,012	0,259
USA	0,297	0,472	0,943	0,628	0,480	0,982	0,978	0,479	1,000	0,913	0,925	0,662	0,947	0,855	0,989	0,458	0,936	0,614
OECD	0,045	0,074	0,102	0,461	0,003	0,504	0,410	0,020	0,105	0,020	0,000	0,005	0,048	0,100	0,009	0,000	0,013	0,030
BRA	1,000	0,950	1,000	0,000	0,700	1,000	1,000	1,000	0,937	1,000	1,000	0,973	1,000	0,900	1,000	1,000	0,944	1,000
LAM	0,413	0,949	0,999	0,846	0,618	0,998	1,000	0,961	0,945	0,625	0,287	0,755	0,999	0,900	0,795	1,000	0,999	0,991
PAS	0,005	0,000	0,535	0,000	0,531	0,000	0,000	0,973	0,166	0,104	0,973	0,715	0,931	0,851	0,716	0,227	0,888	0,174
MAI	0,000	0,487	0,000	0,000	0,000	0,033	0,033	1,000	0,505	0,927	0,000	0,052	0,534	0,697	0,470	0,280	0,016	0,080
CPA	0,004	0,000	0,000	0,108	0,007	0,464	0,464	0,817	0,021	0,663	0,000	0,281	0,981	0,893	0,730	0,988	0,388	0,655
IND	0,000	0,000	1,000	0,755	0,000	0,000	0,000	1,000	0,689	0,425	0,000	0,000	0,968	0,854	0,526	1,000	0,391	0,172
MEA	0,959	0,000	0,000	0,951	0,425	0,183	0,182	0,378	0,124	0,378	0,000	0,734	0,825	0,305	1,000	0,210	0,357	0,546
AFR	0,669	0,892	0,990	0,688	0,265	0,924	0,922	0,981	0,082	0,999	0,149	0,978	0,960	0,900	0,998	0,531	0,588	0,725

B. Additional results from the scenario runs

Table B1. Biofuel production in 2020 (in million, real 2001 US$)

		DEU	GBR	FRA	SCA	BEN	MED	REU	USA	OECD	BRA	CPA	IND	MAI	EU	World
REF	boil	427,6	10,3	71,8	11,2	5,9	47,1	39,4	53,3	6,6	4,1	0,0	32,3	34,9	613,1	744,3
	beth	48,4	5,4	80,1	21,3	0,9	27,1	25,8	1084,2	137,5	4788,1	579,2	96,7	0,0	208,9	6894,6
10Q	boil	1350,7	10,8	304,7	12,7	6,2	1202,0	39,4	54,0	6,6	4,3	0,0	33,5	51,9	2926,5	3076,7
	beth	43,0	502,3	585,8	252,5	34,3	534,3	1208,1	2021,8	141,8	8279,5	594,5	99,9	0,0	3160,3	14297,8
10NT	boil	1417,5	0,0	492,4	0,9	718,6	1218,4	19,6	53,9	6,6	4,2	0,0	33,4	38,2	3867,4	4003,7
	beth	0,0	967,3	445,0	306,4	105,2	553,0	1340,4	1233,1	137,6	6159,2	594,2	99,8	0,0	3717,3	11941,2

Table B2. Biofuel net exports in 2020 (in million, real 2001 US$)

		DEU	GBR	FRA	SCA	BEN	MED	REU	USA	OECD	EU27	BRA	MAI
REF	boil (from MAI)	-2,0	-0,1	-1,5	-0,1	0,0	-2,1	-0,3	-0,2	0,0	-6,1	0,0	6,2
	beth (from BRA)	-0,3	-0,3	-0,5	-6,1	-1,6	-0,6	-0,1	-734,9	-5,9	-9,6	750,4	0,0
10Q	boil (from MAI)	-8,2	-0,1	-7,0	0,0	0,0	-7,4	-0,5	0,0	0,0	-23,2	0,0	23,2
	beth (from BRA)	-4,5	-503,3	-32,2	-58,5	-1288,4	-22,3	-84,8	-144,5	-0,8	-1994,0	2139,3	0,0
10QNT	boil (from MAI)	-1,2	0,0	-1,5	0,0	-0,4	-5,9	0,0	0,0	0,0	-8,9	0,0	9,0
	beth (from BRA)	0,0	-35,6	-1,8	-38,6	-89,0	-7,3	-4,7	-737,5	-5,4	-176,9	919,8	0,0

Table B3. Biofuel import shares in 2020

		DEU	GBR	FRA	SCA	BEN	MED	REU	BRA	USA	OECD	IND
REF	boil	0,5%	1,0%	2,2%	1,1%	0,4%	4,5%	0,7%	0,0%	0,3%	0,0%	0,2%
	beth	1,0%	9,5%	1,1%	32,9%	75,8%	3,9%	0,7%	0,0%	55,8%	4,1%	0,0%
10Q	boil	0,7%	0,8%	1,9%	0,1%	0,0%	0,7%	1,2%	0,0%	0,0%	0,0%	0,0%
	beth	22,0%	63,7%	13,8%	33,9%	97,4%	9,6%	15,0%	0,0%	13,6%	0,9%	0,0%
10QNT	boil	0,1%		0,3%	0,0%	0,1%	0,5%	0,2%	0,0%	0,1%	0,0%	0,0%
	beth		5,9%	0,7%	17,7%	59,1%	2,2%	0,6%	0,0%	49,6%	3,7%	0,0%

Table B4. Price effects of imposing the 10% quota, [10Q] relative to [REF]

	DEU	GBR	FRA	SCA	BEN	MED	REU	USA	OECD	FSU	BRA	LAM	CPA	IND	MAI	PAS	MEA	AFR	World	EU
WHT	9,9%	5,6%	4,6%	2,7%	2,8%	4,1%	3,7%	1,9%	1,2%	0,4%	3,7%	0,7%	0,2%	-0,1%		0,5%	0,2%	0,4%	1,1%	4,8%
GRO	10,0%	5,6%	5,2%	2,2%	3,3%	4,3%	3,5%	1,7%	1,2%	0,2%	4,4%	0,7%	0,2%	0,0%	0,7%	0,5%	0,2%	0,5%	1,6%	5,0%
OSD	4,7%	5,6%	5,6%	1,8%	2,7%	4,9%	3,5%	1,8%	1,2%	0,4%	4,1%	0,7%	0,4%	0,0%	0,8%	0,5%	0,3%	0,5%	0,4%	3,0%
C_B	11,5%	5,4%	5,0%	2,3%	2,6%	4,0%	3,2%	2,0%	1,3%	0,3%	4,3%	0,7%	0,2%	0,0%	0,7%	0,5%	0,2%	0,4%	0,8%	5,0%
FRS	0,0%	-0,5%	-0,4%	-0,5%	-0,4%	-0,7%	-0,2%	-0,3%	-0,3%	-0,4%	0,1%	-0,3%	-0,5%	-0,2%	-0,3%	-0,3%	-0,4%	-0,3%	-0,3%	-0,4%
VOL	0,5%	0,5%	0,7%	0,1%	0,6%	1,8%	0,5%	0,7%	0,4%	-0,1%	2,9%	0,3%	0,8%	-0,1%	-0,1%	0,6%	0,0%	0,1%	0,3%	0,7%
SGR	4,6%	0,8%	0,8%	0,2%	1,1%	1,0%	1,0%	0,2%	0,2%	0,1%	2,4%	0,2%	0,2%	-0,1%	0,4%	0,2%	0,0%	0,1%	0,5%	1,4%
MLK	11,4%	5,4%	4,9%	3,0%	3,0%	4,0%	2,9%	1,4%	1,2%	0,2%	4,8%	0,7%	0,4%	0,0%	0,7%	0,5%	0,2%	0,4%	1,9%	5,2%
MET	1,6%	0,3%	1,0%	0,3%	0,7%	0,9%	0,6%	0,0%	0,1%	0,0%	2,3%	0,1%	0,3%	-0,1%	0,3%	0,3%	0,1%	0,1%	0,4%	0,8%
AGR	4,1%	1,3%	2,3%	1,0%	1,3%	2,0%	2,0%	0,5%	0,4%	0,3%	3,0%	0,4%	0,3%	-0,1%	0,5%	0,4%	0,2%	0,3%	0,8%	2,1%
COL	0,4%	0,2%		0,2%		0,2%	0,3%	-0,5%	-0,5%	-0,6%	-1,3%	-0,4%	-0,7%	-0,4%	-0,5%	-0,5%	-0,5%	-0,5%	-0,5%	0,3%
CRU	-2,2%	-2,2%		-2,0%	-2,3%	-2,0%	-3,0%	-1,4%	-1,7%	-1,9%	-7,7%	-1,5%	-1,5%	-1,4%	-1,5%	-1,5%	-1,6%	-1,8%	-1,7%	-2,2%
GAS	-1,2%	-0,3%		-0,5%	0,2%	-1,5%	-0,4%	-0,5%	-0,4%	-0,5%	-1,8%	-0,6%	-0,7%	-0,4%	-0,4%	-0,4%	-0,5%	-0,5%	-0,5%	-0,4%
OIL	-1,9%	-2,1%	-1,8%	-1,8%	-2,1%	-1,8%	-2,1%	-1,3%	-1,3%	-1,5%	-5,8%	-1,3%	-1,3%	-1,4%	-1,3%	-1,5%	-1,4%	-1,3%	-1,5%	-2,0%
ELY	-1,0%	-0,9%	-0,5%	-0,5%	-0,7%	-0,9%	-0,9%	-0,4%	-0,4%	-0,5%	-0,2%	-0,6%	-0,5%	-0,3%	-0,4%	-0,4%	-0,6%	-0,4%	-0,5%	-0,8%
ETS	-0,6%	-0,4%	-0,5%	-0,4%	-0,4%	-0,5%	-0,5%	-0,4%	-0,4%	-0,4%	-0,3%	-0,3%	-0,4%	-0,3%	-0,4%	-0,4%	-0,5%	-0,3%	-0,4%	-0,5%
CRP	-0,8%	-0,6%	-0,7%	-0,5%	-1,0%	-1,0%	-0,3%	-0,4%	-0,4%	-0,3%	0,0%	-0,3%	-0,3%	-0,3%	-0,3%	-0,5%	-0,6%	-0,4%	-0,5%	-0,7%
OTH	-0,6%	-0,4%	-0,5%	-0,4%	-0,4%	-0,5%	-0,4%	-0,4%	-0,3%	-0,4%	0,1%	-0,3%	-0,3%	-0,2%	-0,3%	-0,3%	-0,4%	-0,3%	-0,4%	-0,5%
COR	9,6%	5,8%	5,1%	2,5%	3,2%	4,2%	3,5%	1,7%	1,2%	0,2%	4,4%	0,7%	0,3%	0,0%	0,7%	0,4%	0,2%	0,5%	1,3%	3,9%
GSL	-1,9%	-2,1%	-1,8%	-1,8%	-2,1%	-1,8%	-2,1%	-1,3%	-1,3%	-1,5%	-5,5%	-1,3%	-1,3%	-1,4%	-1,3%	-1,5%	-1,4%	-1,3%	-1,4%	-1,8%
DIS	-1,9%	-2,1%	-1,8%	-1,8%	-2,1%	-1,8%	-2,1%	-1,3%	-1,3%	-1,5%	-5,8%	-1,3%	-1,3%	-1,4%	-1,3%	-1,5%	-1,4%	-1,3%	-1,7%	-2,0%
boil	74,7%	58,8%	64,1%	21,1%	26,7%	29,8%	78,6%	-0,1%	-0,5%		-5,8%			-0,7%	39,7%				67,7%	66,6%
beth	79,4%	67,2%	66,3%	20,6%	83,5%	32,4%	77,9%	-8,4%	-2,0%		3,3%		-1,3%	-1,4%					23,7%	59,8%

Table B5. Price effects of imposing the 10% quota, [10QNT] relative to [REF]

	DEU	GBR	FRA	SCA	BEN	MED	REU	USA	OECD	FSU	BRA	LAM	CPA	IND	MAI	PAS	MEA	AFR	World	EU
WHT	11,2%	8,9%	5,4%	3,0%	3,7%	4,8%	4,2%	0,7%	1,5%	0,7%	2,9%	1,0%	0,5%	0,3%	#DIV/0!	0,7%	0,6%	0,8%	1,6%	5,9%
GRO	11,3%	8,9%	6,1%	2,5%	4,4%	5,0%	4,0%	0,6%	1,5%	0,5%	3,3%	1,0%	0,5%	0,4%	1,0%	0,8%	0,6%	0,9%	2,0%	5,9%
OSD	5,3%	8,9%	6,6%	2,3%	3,3%	5,6%	4,1%	0,7%	1,4%	0,8%	3,3%	1,0%	0,7%	0,4%	1,1%	0,8%	0,6%	0,9%	0,3%	3,7%
C_B	12,9%	8,6%	5,9%	2,6%	3,5%	4,6%	3,8%	0,8%	1,6%	0,5%	3,3%	1,0%	0,6%	0,4%	1,0%	0,8%	0,5%	0,7%	1,2%	6,1%
FRS	0,0%	-0,6%	-0,5%	-0,6%	-0,6%	-0,8%	-0,2%	-0,4%	-0,4%	-0,5%	-0,1%	-0,4%	-0,5%	-0,4%	-0,4%	-0,5%	-0,5%	-0,4%	-0,4%	-0,5%
VOL	0,5%	0,9%	0,9%	0,1%	0,7%	2,1%	0,6%	-0,2%	0,5%	0,0%	1,2%	0,4%	0,9%	0,2%	-0,1%	0,7%	0,2%	0,3%	0,2%	0,7%
SGR	5,2%	1,4%	0,9%	0,2%	1,6%	1,1%	1,2%	-0,1%	0,2%	0,3%	1,8%	0,3%	0,5%	0,3%	0,5%	0,4%	0,1%	0,2%	0,5%	1,7%
MLK	12,9%	8,6%	5,7%	3,4%	4,0%	4,6%	3,3%	0,4%	1,4%	0,5%	3,6%	1,0%	0,7%	0,4%	0,9%	0,8%	0,6%	0,8%	2,2%	6,4%
MET	1,9%	0,6%	1,2%	0,4%	0,9%	1,0%	0,8%	-0,2%	0,1%	0,1%	1,6%	0,2%	0,5%	-0,1%	0,4%	0,4%	0,3%	0,3%	0,4%	1,0%
AGR	4,6%	2,1%	2,6%	1,1%	1,8%	2,3%	2,3%	0,0%	0,5%	0,5%	2,2%	0,5%	0,6%	0,3%	0,7%	0,6%	0,4%	0,5%	1,0%	2,5%
COL	0,4%	0,3%		0,2%		0,2%	0,3%	-0,4%	-0,4%	-0,5%	-0,9%	-0,3%	-0,6%	-0,4%	-0,4%	-0,4%	-0,4%	-0,4%	-0,4%	0,3%
CRU	-2,0%	-1,9%		-1,7%	-2,0%	-1,7%	-2,8%	-1,2%	-1,4%	-1,7%	-4,6%	-1,2%	-1,2%	-1,1%	-1,2%	-1,3%	-1,3%	-1,4%	-1,4%	-1,9%
GAS	-1,3%	-0,4%		-0,5%	0,2%	-1,7%	-0,5%	-0,4%	-0,3%	-0,5%	-1,2%	-0,5%	-0,6%	-0,5%	-0,5%	-0,4%	-0,4%	-0,4%	-0,5%	-0,5%
OIL	-1,7%	-1,9%	-1,5%	-1,6%	-1,8%	-1,5%	-1,9%	-1,1%	-1,1%	-1,3%	-3,5%	-1,1%	-1,1%	-1,1%	-1,1%	-1,2%	-1,1%	-1,1%	-1,3%	-1,7%
ELY	-1,1%	-1,0%	-0,6%	-0,6%	-0,8%	-0,9%	-0,9%	-0,4%	-0,4%	-0,4%	-0,3%	-0,6%	-0,7%	-0,4%	-0,5%	-0,6%	-0,6%	-0,5%	-0,6%	-0,9%
ETS	-0,7%	-0,5%	-0,5%	-0,4%	-0,5%	-0,5%	-0,5%	-0,4%	-0,4%	-0,4%	-0,3%	-0,4%	-0,5%	-0,4%	-0,4%	-0,5%	-0,5%	-0,4%	-0,5%	-0,5%
CRP	-0,8%	-0,6%	-0,7%	-0,5%	-1,0%	-1,0%	-0,3%	-0,4%	-0,4%	-0,3%	-0,1%	-0,4%	-0,4%	-0,4%	-0,3%	-0,5%	-0,6%	-0,4%	-0,5%	-0,7%
OTH	-0,6%	-0,5%	-0,6%	-0,4%	-0,5%	-0,5%	-0,4%	-0,4%	-0,4%	-0,4%	-0,1%	-0,4%	-0,4%	-0,3%	-0,4%	-0,4%	-0,5%	-0,4%	-0,4%	-0,5%
COR	10,8%	9,1%	5,9%	2,7%	4,3%	4,8%	4,0%	0,6%	1,4%	0,5%	3,3%	1,0%	0,7%	0,4%	1,0%	0,8%	0,6%	0,9%	1,2%	4,6%
GSL	-1,7%	-1,9%	-1,5%	-1,6%	-1,8%	-1,5%	-1,9%	-1,1%	-1,1%	-1,3%	-3,4%	-1,1%	-1,1%	-1,1%	-1,1%	-1,2%	-1,1%	-1,1%	-1,2%	-1,6%
DIS	-1,7%	-1,9%	-1,5%	-1,6%	-1,8%	-1,5%	-1,9%	-1,1%	-1,1%	-1,3%	-3,5%	-1,1%	-1,1%	-1,1%	-1,1%	-1,2%	-1,1%	-1,1%	-1,4%	-1,8%
boil	-3,9%	-100,0%	-7,0%	5,5%	-6,5%	-10,7%	2,5%	0,1%	-0,3%		-3,5%			-0,5%	1,2%				3,1%	0,1%
beth	-100,0%	-7,9%	-6,3%	-9,7%	2,0%	-8,8%	-2,8%	-1,3%	-1,5%		2,3%		-1,1%	-1,1%					6,9%	-7,0%

Table B6. Production effects of imposing the 10% quota, [10Q] relative to [REF]

	DEU	GBR	FRA	SCA	BEN	MED	REU	USA	OECD	FSU	BRA	LAM	CPA	IND	MAI	PAS	MEA	AFR	EU	World
WHT	-22,6%	15,5%	4,1%	1,1%	6,3%	-2,6%	14,9%	-4,1%	0,8%	0,4%	-17,2%	3,0%	1,3%	-0,1%		3,9%	1,4%	6,2%	4,6%	1,5%
GRO	-12,3%	-4,1%	-6,8%	0,5%	2,9%	-2,3%	-1,4%	-0,7%	1,4%	0,2%	-2,9%	0,7%	4,4%	-0,2%	3,4%	-2,2%	2,1%	-0,5%	-4,5%	-0,8%
OSD	43,7%	-10,5%	20,6%	0,4%	33,8%	22,3%	0,6%	-0,2%	5,2%	1,2%	-3,7%	3,3%	6,1%	-0,1%	3,9%	2,7%	2,1%	1,0%	24,5%	4,5%
C_B	-6,8%	-1,8%	30,5%	65,6%	-1,4%	-0,9%	-0,4%	-0,5%	0,1%	-0,1%	31,3%	-0,3%	-0,2%	-0,2%	-0,4%	-0,1%	-0,2%	-0,1%	5,1%	5,0%
FRS	-1,2%	0,1%	0,1%	0,1%	0,2%	0,5%	-0,3%	-0,1%	0,0%	-0,1%	-0,8%	-0,1%	-0,1%	-0,1%	-0,2%	-0,1%	-0,2%	-0,1%	-0,1%	-0,1%
VOL	-1,3%	-1,0%	-1,8%	-0,1%	-2,9%	-5,5%	-1,0%	-0,9%	-0,9%	0,5%	-4,1%	-0,5%	-5,0%	0,1%	2,3%	-3,8%	0,2%	-0,3%	-2,3%	-0,4%
SGR	-6,6%	-1,8%	-1,8%	-0,2%	-1,4%	-1,9%	-1,2%	-0,5%	-0,1%	0,4%	-3,3%	-0,2%	0,5%	-0,1%	-0,4%	0,0%	-0,4%	0,1%	-2,2%	-0,7%
MLK	-6,7%	-1,7%	-3,4%	-0,5%	-1,4%	-2,4%	-0,8%	-0,5%	-0,2%	-0,2%	-1,8%	-0,3%	-0,1%	-0,2%	-0,1%	-0,4%	-0,3%	-0,3%	-2,6%	-1,0%
MET	-3,1%	-0,5%	-1,4%	-0,1%	-1,0%	-1,1%	-0,8%	-0,2%	0,1%	0,0%	-2,6%	-0,3%	-0,2%	1,2%	-0,4%	-0,4%	-0,4%	-0,2%	-1,1%	-0,6%
AGR	-6,4%	-1,5%	-3,5%	-0,5%	-1,4%	-2,3%	-1,7%	-0,5%	-0,2%	0,1%	-2,7%	-0,2%	0,0%	0,2%	-0,2%	0,0%	0,0%	0,1%	-2,6%	-0,8%
COL	2,1%	1,3%		0,8%		1,3%	2,0%	-0,1%	-0,2%	-0,1%	-1,8%	-0,1%	-0,2%	-0,2%	-0,3%	-0,2%	-0,2%	-0,1%	1,9%	0,0%
CRU	-0,2%	-0,2%		-0,1%	-0,3%	-0,2%	-0,5%	-0,2%	-0,3%	-0,2%	-1,7%	-0,3%	-0,1%	-0,2%	-0,3%	-0,2%	-0,2%	-0,3%	-0,2%	-0,2%
GAS	6,1%	3,8%		1,5%	1,9%	8,5%	0,0%	0,0%	-0,1%	-0,1%	-1,2%	-0,4%	0,0%	-0,6%	-0,4%	-0,2%	-0,1%	-0,2%	3,4%	0,1%
OIL	1,5%	1,9%	2,6%	2,4%	0,4%	2,6%	0,7%	0,3%	0,3%	0,3%	9,7%	-0,6%	0,2%	0,3%	0,0%	0,6%	0,0%	-0,7%	1,5%	0,6%
ELY	0,4%	0,3%	-0,3%	-0,1%	0,0%	-0,1%	0,6%	-0,1%	-0,1%	-0,2%	1,1%	0,0%	-0,2%	-0,2%	-0,1%	-0,1%	-0,1%	-0,2%	0,1%	-0,1%
ETS	0,6%	0,0%	0,1%	-0,1%	0,1%	0,2%	-0,1%	-0,1%	-0,1%	-0,2%	-0,2%	-0,2%	-0,1%	-0,3%	-0,3%	-0,2%	0,0%	-0,3%	0,2%	-0,1%
CRP	1,0%	0,0%	0,4%	-0,2%	2,7%	1,2%	-1,0%	-0,2%	-0,1%	-0,4%	-0,6%	-0,3%	-0,3%	-0,3%	-0,9%	-0,1%	0,0%	-0,5%	0,6%	0,0%
OTH	0,2%	0,1%	0,2%	0,1%	0,1%	0,1%	-0,1%	0,0%	0,0%	-0,2%	0,0%	-0,1%	-0,2%	-0,2%	-0,2%	-0,1%	-0,2%	-0,1%	0,1%	0,0%
COR	-24,4%	-1,2%	2,6%	0,0%	11,8%	19,8%	-1,8%	3,6%	-2,0%	0,3%	-5,5%	0,3%	0,4%	-0,1%	0,7%	3,0%	1,1%	-0,2%	2,8%	1,8%
GSL	2,5%	-11,4%	-7,9%	-11,8%	-20,4%	-2,4%	-20,8%	0,5%	0,8%	-0,1%	-57,5%	0,7%	0,3%	0,7%	-0,1%	0,2%	0,3%	0,4%	-8,8%	-1,9%
DIS	-13,9%	1,9%	-1,7%	3,3%	0,9%	-4,0%	0,8%	0,4%	0,6%	-0,2%	5,0%	0,4%	0,3%	0,4%	0,1%	0,4%	0,3%	0,4%	-2,4%	-0,4%
boil	266,0%	6,6%	332,3%	11,5%	7,7%	2432,6%	0,5%	1,0%	0,6%		4,5%			0,9%	38,7%				364,1%	276,8%
beth	-9,5%	9877,5%	631,6%	569,2%	1183,0%	1951,0%	2112,7%	36,5%	7,3%		106,0%		0,4%	0,7%					1139,4%	116,3%

Table B7. Production effects of imposing the 10% quota, [10QNT] relative to [REF]

	DEU	GBR	FRA	SCA	BEN	MED	REU	USA	OECD	FSU	BRA	LAM	CPA	IND	MAI	PAS	MEA	AFR	EU	World
WHT	-24,9%	27,6%	0,8%	2,6%	10,0%	-1,8%	18,1%	6,4%	0,6%	0,5%	-10,9%	2,8%	1,2%	-0,1%		3,3%	1,6%	6,8%	6,0%	2,1%
GRO	-13,5%	-9,3%	-7,3%	0,8%	1,3%	-2,5%	-1,4%	4,9%	1,1%	0,2%	-0,8%	0,2%	4,6%	-0,3%	2,5%	-3,1%	2,3%	-0,5%	-5,3%	-0,8%
OSD	48,4%	-18,6%	40,6%	-6,8%	59,0%	21,6%	-6,1%	3,4%	6,0%	1,6%	1,7%	3,1%	5,6%	0,0%	3,1%	2,1%	2,2%	1,0%	26,5%	6,0%
C_B	-7,4%	-3,2%	20,5%	87,4%	-2,2%	-0,9%	-0,4%	0,0%	0,1%	0,0%	15,0%	-0,2%	0,0%	-0,2%	-0,4%	-0,2%	-0,1%	0,0%	4,4%	2,7%
FRS	-1,3%	0,1%	0,3%	0,1%	0,5%	0,6%	-0,3%	0,0%	0,0%	0,0%	-0,3%	0,1%	0,1%	0,4%	0,0%	0,2%	0,1%	0,2%	0,0%	0,1%
VOL	-1,4%	-2,2%	-2,1%	-0,1%	-3,7%	-6,5%	-1,0%	0,9%	-1,1%	0,4%	-1,6%	-1,0%	-6,0%	-2,3%	2,6%	-4,5%	-0,6%	-1,2%	-2,7%	-0,3%
SGR	-7,1%	-3,4%	-1,9%	0,0%	-2,2%	-2,0%	-1,3%	0,0%	-0,1%	0,3%	-2,1%	-0,1%	0,0%	-0,1%	-0,4%	0,0%	-0,2%	0,2%	-2,8%	-0,6%
MLK	-7,3%	-3,0%	-3,7%	-0,2%	-2,4%	-2,5%	-0,8%	0,2%	-0,2%	-0,1%	-1,1%	-0,2%	0,1%	-0,2%	0,1%	-0,3%	-0,1%	-0,3%	-3,1%	-0,9%
MET	-3,3%	-0,9%	-1,5%	0,1%	-1,5%	-1,1%	-0,8%	0,2%	0,1%	0,1%	-1,6%	-0,2%	-0,3%	1,7%	-0,2%	-0,4%	-0,4%	-0,1%	-1,3%	-0,4%
AGR	-7,0%	-2,7%	-3,7%	-0,2%	-2,4%	-2,4%	-1,8%	0,2%	-0,2%	0,1%	-1,7%	-0,1%	0,0%	0,2%	-0,1%	0,0%	0,0%	0,2%	-3,1%	-0,7%
COL	2,1%	1,4%		0,9%		1,4%	1,9%	0,0%	0,0%	-0,1%	-0,9%	0,2%	0,0%	0,0%	0,0%	0,0%	0,1%	0,0%	1,9%	0,1%
CRU	-0,2%	-0,1%		-0,1%	-0,2%	-0,1%	-0,4%	-0,1%	-0,2%	-0,1%	-0,9%	-0,2%	-0,1%	-0,1%	-0,2%	-0,1%	-0,1%	-0,2%	-0,2%	-0,2%
GAS	7,1%	4,0%		1,5%	2,2%	9,0%	-0,1%	0,0%	0,0%	0,0%	-0,7%	-0,1%	0,0%	-0,1%	0,0%	0,1%	0,2%	0,1%	3,7%	0,3%
OIL	1,4%	2,0%	2,5%	2,4%	0,6%	2,5%	0,8%	0,3%	0,3%	0,3%	5,4%	-0,3%	0,3%	0,5%	0,1%	0,6%	0,0%	-0,4%	1,6%	0,6%
ELY	0,4%	0,6%	-0,2%	0,0%	0,2%	0,0%	0,8%	0,1%	0,0%	-0,1%	0,6%	0,2%	0,1%	0,2%	0,2%	0,2%	0,2%	0,1%	0,3%	0,1%
ETS	0,6%	0,1%	0,2%	-0,2%	0,3%	0,3%	0,0%	0,0%	0,0%	-0,1%	-0,1%	0,1%	0,2%	0,2%	0,0%	0,2%	0,2%	0,0%	0,2%	0,1%
CRP	1,1%	0,2%	0,4%	-0,1%	2,6%	1,4%	-1,0%	-0,1%	-0,1%	-0,4%	-0,4%	0,0%	0,0%	0,1%	-0,6%	0,1%	0,2%	-0,2%	0,7%	0,1%
OTH	0,3%	0,2%	0,3%	0,1%	0,2%	0,3%	0,0%	0,1%	0,0%	0,0%	0,1%	0,1%	0,1%	0,2%	0,0%	0,2%	0,1%	0,1%	0,2%	0,1%
COR	-30,4%	-2,1%	-0,3%	0,1%	7,2%	20,6%	-1,8%	-2,3%	-0,5%	0,4%	-3,3%	1,2%	0,7%	-0,2%	1,3%	4,4%	1,5%	-0,1%	2,1%	-0,4%
GSL	2,3%	-11,6%	-4,8%	-13,7%	-2,8%	-2,4%	-22,7%	0,4%	0,6%	-0,1%	-32,0%	0,6%	0,4%	0,8%	0,1%	0,3%	0,3%	0,5%	-6,9%	-1,2%
DIS	-14,5%	2,1%	-5,0%	4,4%	-8,8%	-4,1%	1,7%	0,3%	0,5%	-0,3%	2,9%	0,4%	0,3%	0,6%	0,2%	0,5%	0,3%	0,4%	-4,1%	-1,0%
DIS	283,9%	-100,0%	583,3%	-96,9%	12383%	2464,3%	-83,9%	0,8%	0,5%		2,7%			1,0%	1,8%				491,0%	370,7%
GSL	-100,0%	18975%	462,2%	756,1%	3709%	2018,2%	2516,9%	-23,6%	4,0%		52,0%		0,5%	0,8%					1399,0%	79,6%