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The competitiveness effects of the EU climate policy*

Sonja Peterson and Gernot Klepper

To show global leadership and to foster the international negotiations for a long term international climate regime the EU has decided to reduce its GHG emissions by 20% relative to 1990 until the year 2020. These reductions will even rise 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". At the same time, the European council started in 2000 the so-called Lisbon process which established the issue of competitiveness as a priority area for EU policy and there is some concern about the competitiveness effects of EU climate policy.

We use the multi-sector, multi-region computable general equilibrium model DART to assess the impacts of the recent EU climate policy proposals for the competitiveness of the European economies and specific sectors. There are three general insights. First, the effects of EU climate policies on competitiveness are relatively small if one leaves out the fossil fuels themselves the consumption of which is supposed to be reduced anyway. The losses of the energy intensive industries are compensated by gains in other manufacturing sectors. Secondly, there is no uniform effect across the member states of the EU. It is the special circumstances in side the different sectors within the member states that determine whether a sector wins or looses competitiveness. And finally, the changes in competitiveness are strongly influenced by the choice of the particular policy design. A more efficient instrument choice not only reduces the competitiveness effects it also distributes the burden more equally.

Keywords: Post Kyoto, EU, emission trading, competitiveness

JEL classification: D58, Q48, Q54

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1. Introduction

Climate change is by now an accepted challenge that requires increased efforts in reducing the emissions of greenhouse gases (GHG) in order to "prevent dangerous climate change" as Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC) demands. This convention has been signed by practically all nations and has subsequently led to actions as laid out in the Kyoto Protocol that requires reductions of GHG emissions from signatory industrialized countries. The developing world and the emerging and transition economies are not required to reduce emissions. This is also the case for non-signatories like the United States. The commitments in the Kyoto Protocol have already been criticized especially by industry representatives and industry associations because the more or less unilateral commitments of the European countries are believed to strongly deteriorate the competitive position of European export oriented companies.

The Bali Action Plan from December 2007 contains a road map for negotiating a successor to the Kyoto-Protocol that entails a more encompassing coverage of countries and requires deeper cuts in emissions. It is also supported by the industrialized countries that have agreed to move towards a 50 percent reduction of greenhouse gas emissions by 2050. But even if a Post-Kyoto agreement is reached with only weak targets it seems clear that the EU will continue its assumed leadership in climate policy. Only recently it agreed on legally binding climate policy targets until the year 2020. At the same time, the European council started in 2000 the so-called Lisbon process which established the issue of competitiveness as a priority area for EU policy. Doubts about the impact of EU climate policies concerning the impact on competitiveness will thus remain and may even grow as the targets become stricter.

There is a substantial gap between the notion of competitiveness as it is used in public discussions or as it is perceived by companies and the definition of competitiveness in economics. The rather loose and vague use of the term competitiveness in public discussions needs to be made precise within an analytical concept in order to assess it appropriately. The aim of this paper is to analyze in detail the different competitiveness effects of the recent EU climate policy package. In particular, we aim to identify the different definitions of competitiveness, compute the appropriate indicators for each notion of competitiveness with the help of a numerical simulation model, and finally appropriately interpret their economic meaning. The paper proceeds as follows. In sections 2 and 3 we describe the recent developments in EU climate policy and review the concept and measurement of competitiveness as well as existing studies on the competitiveness effects of EU climate policy. In section 4 we present the DART model that is used to analyze different EU climate policy scenarios in line with the new climate package. In sections 5 and 6 we discuss the simulation results on macro-economic and sectoral levels. Section 7 concludes.

2. Recent developments in EU climate policy

In the Kyoto Protocol from 1997 the EU countries agreed to reduce their overall GHG emissions relative to the 1990 level by 8% within the first Kyoto commitment period from 2008 to 2012. In 1998, this target was differentiated between the different at that time 15 member states of the EU in the so-called EU Burden-Sharing Agreement. The "new" EU member states that joined the EU in 2004 and 2007 have their own individual Kyoto targets.

To reach the European commitments at minimal costs a European firm level emission trading scheme (ETS) for CO_2 was introduced in 2005. It covers the CO_2 emissions of facilities in energy activities, the production and processing of ferrous and non-ferrous metals, the mineral industry and the pulp, paper and board production and thus about 49% of total EU CO_2 emissions. For the first two trading periods from 2005 to 2007 and from 2008 to 2012 the allocation of permits to the ETS was subject of so-called National Allocation Plans (NAPs) in which each country determined the total quantity of allowances in the ETS and the allocation to individual operators. Especially in the first trading period the allocation to the ETS sectors was rather generous and after emissions data for 2005 were known trading prices began to fall and reached almost zero in 2007. The second NAPs reduced the allocation to the ETS sectors.

To show global leadership and to foster the international negotiations for a long term international climate regime that took place in Bali in December 2007 the EU agreed in March 2007 on legally binding EU climate policy targets that go beyond the Kyoto targets. The two key targets are (EU 2008a):

- 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".
- A 20% share of renewable energies in EU energy consumption by 2020.

To reach these targets the European Commission put forth 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). The proposal that is often denoted as "climate package" sets for the first time binding targets for the sources that are not covered by the ETS. As in the burden sharing agreement the targets are differentiated between the different states and account for differences in per capita GDP. The use of credits from CDM and JI projects by governments is limited to 3% of the GHG emission in these sectors. The ETS itself should be extended to include other GHGs and all major industrial emitters. Furthermore it is foreseen to replace the national allocation plans by auctioning or free allocation through single EU-wide rules. The allocations put on the market would be reduced annually to reach a 21% reduction from 2005 levels by 2020. The use of CDM and JI credits will be limited to the levels used in the current ETS period.

The main points of the climate package are summarized in Box 1. Tables A1 and A2 in the Appendix summarize the EU Member State's GHG emissions and emission targets.

Box 1. The EU Commission's Proposed "Climate Action and Renewable Energy Package"

Main elements:

- Commitment to reduce the EU's greenhouse gas (GHG) emissions by at least 20% below 1990 (or 14% compared to 2005) levels by 2020 and 30% below 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".
- Mandatory target to increase renewable energy from currently 8.5 % to 20% of the EU's overall energy mix by 2020, including a minimum of 10% bio-fuels in the overall fuel consumption.
- Expansion and Harmonization of the EU Emissions Trading Scheme (ETS)
- Creation of emission reduction targets at the state level for non-ETS sectors
- Legally enforceable renewable energy targets for the Member States;
- CDM
- New regulations for carbon capture and storage and environmental subsidies;

Modifications to the existing ETS system (for the proposed phase III):

- Expanded coverage: inclusion of CO_2 emissions from petrochemicals, ammonia, aviation; aluminum, nitrous oxide (N_2O) emissions from acid production, and perfluorocarbon (PFC) emissions from the aluminum sector.
- An EU-wide cap for sectors covered under the ETS of 9% below 2005 levels in 2013 that decrease linearly to 21% below 2005 levels in 2020.
- Allocations are decided at the EU commission rather than at the Member State level

Targets for sectors not covered by the ETS (non-ETS sectors):

- National targets of on average 10% below 2005 levels for non-ETS sectors, including transport, waste and buildings that account for about 60% of EU GHG emissions).
- Individual targets for Member States based on per capita GDP, allowing for both increases above 2005 levels (for those with low per capita GDP) and reductions (for those with high per capita GDP) ranging from +20% to 20% relative to 2005.
- Targets will be a combination between EU policies (such as the CO_2 standards for cars) and national ones aimed at achieving the goals.

Use of credits from CDM and JI projects:

- The annual use of credits used to achieve the reductions in the non-ETS sectors is limited to 3% of the GHG emissions in these sectors.
- The use of credits within the ETS will be limited to the levels used in the current ETS period.

Renewables:

- Overall target of 20% renewables by 2020
- Individual targets for Member States ranging from 10% to 49% in accordance with their starting points, potentials, energy mixes, and per capita GDP.
- Each Member state is left to determine the manner in which it will contribute to the target based on their national circumstances
- There is a 10% minimum target for bio-fuels across all Member States.

Carbon Capture and Storage (CCS):

- No allowances will need to be surrendered for CO_2 emissions that are geologically stored. CCS will receive no free allocation.
- A legislative framework is to be developed to provide certainty to industry and remove barriers for safe deployment of CCS.

3. Measuring competitiveness

Competitiveness is a widely used term in the public discussions and policy makers claim to care much about competitiveness. However, in many cases it is not at all clear what is actually meant by an increase in or a loss of competitiveness. Sometimes it refers to the competitiveness of a whole country, sometimes to the performance of firms or industries on world markets, sometimes to a single company in its competition with other companies on the same market. This has been criticized and discussed by several authors. Reichel (2002) identifies a rather arbitrary selection of indicators. A misspecification problem between the determinants and the actual indexes of competitiveness is also seen (Alexeeva-Talebi et al. 2007). Jenkins (1998) states that the concept of competitiveness seems to be well defined at the firm level but that it becomes vague and controversial as the degree of aggregation increases.

We see three notions of competitiveness that both cover the intentions of the use of the term in the public and are grounded in economic theory. The first notion of competitiveness refers to the ability of a particular firm or industry of a country to compete on international markets. It identifies whether, e.g. the car industry of Italy, is successful on world markets. The appropriate indicator would be the development of the share of the sales of the Italian car industry on world markets. The second notion refers to the success of a particular industry within a country relative to other industries in that country. It identifies the most successful industries within a country with respect to their export performance. This notion is in trade theory commonly referred to as comparative advantage. While these two concepts relate to competitiveness at the industry level, there is finally, the most elusive concept of the competitiveness of a country overall. It is often referred to as the ability to provide a certain level of per-capita income to its citizens. It has been criticized regarding its meaning and usefulness (Krugman 1994).

The political discussion about unilateral or at least non-global climate policies such as the Kyoto-Protocol, the European Emission Trading Scheme or national mitigation policies have been largely influenced by the claim of industry representatives that the proposed or implemented climate policies have a negative impact on the competitiveness of their companies. Whereas the academic discussion was more concerned about the leakage of emissions which is in a sense the mirror image of the loss of competitiveness, the public debate centres more on the export performance of domestic firms. In this paper we focus on the sectoral notions of competitiveness, i.e., the success or lack of certain sectors on foreign markets, and the change in export performance of a sector in a specific country relative to the other sectors of the same economy. The first type of competitiveness effect is captured by the Relative World Market Shares (RWS), the second by the Revealed Comparative Advantage (RCA) and the Relative Trade Balance (RTB). The specific indices we use are defined in Box 2 and they are the basis for the computation of the competitiveness effects of the EU climate policies.

Box 2. Sectoral Competitiveness Indices

Letting X denote exports, M imports, r the regions and i the sector, we use the following definitions of sectoral competitiveness indexes:

Revealed Comparative Advantage (RCA): The RCA compares the export-import ratio of a certain sector of a certain country adjusted to the overall export-import ratio of that country in order to eliminate the trade balance effect. It is thus a measure of the relative competitiveness in different industries within the same economy. Here we use a normalized Balassa indicator as proposed by Münt (1996) with a neutral value of zero and a value range of $-1 \leq RCA \leq 1$.

$$RCA_{i,r} = \tanh * \ln\left(\frac{X_{i,r} / M_{i,r}}{\sum_i X_{i,r} / \sum_i M_{i,r}}\right)$$

The *Relative World Shares* (RWS): The RWS indicator shows how the share of exports of a certain sector in total exports in a certain countries develops relative to the share of this sector in overall world exports. Again we use in this paper a normalized version of the indicator as proposed by Münt (1996) with a neutral value of zero and a value range of $-1 \leq RWS \leq 1$.

$$RWS_{i,r} = \tanh * \ln\left(\frac{X_{i,r} / \sum_r X_{i,r}}{\sum_i X_{i,r} / \sum_{i,r} X_{i,r}}\right)$$

The *Relative Trade Balance* (RTB): The RTB indicator indicates the reaction of the trade balance in a certain sector and country relative to total trade. The RTB has without normalization a neutral value of zero and a value range of $-1 \leq RTB \leq 1$.

$$RTB_{i,r} = \frac{X_{i,r} - M_{i,r}}{X_{i,r} + M_{i,r}}$$

There are already a number of studies on the competitiveness effects of European climate policy. However, they differ with respect to the policies that have been analysed and with respect to the competitiveness indicators that have been used.

In two early papers we use the CGE model DART to analyse the competitiveness effects and efficiency of the EU ETS based on hypothetical allowance allocations (Peterson 2006a, Klepper & Peterson 2004). We calculated the RCA and sectoral output and find that the overall macroeconomic effects are rather small. The only sectors that suffer from a loss of output and exports are the energy sectors, here primarily the coal and electricity sector. DART was also used to assess the first period allocation and the plans for the allocation in the second period (Klepper & Peterson 2006, Peterson 2006b) but in these papers only welfare effects are reported. Those welfare effects remain rather small on average, especially when allowing for the purchase of CDM and JI credits. However, the overall small welfare change does not preclude larger sectoral effects.

A more recent study commissioned by the EU (Wobst et al. 2007) assesses the competitiveness effects of the EU ETS. It integrates the NAPs1 caps and assumes a further tightening of the national emission caps for the second trading period, as well as the linking to emerging domestic emission trading schemes outside Europe. Also, a scenario is run where the EU reaches its unilateral 20% reduction target by assuming a stricter allowance allocation after 2012. The main analysis of the competitiveness effects is based on the CGE model PACE that calculated resulting terms of trade effects, welfare losses, production output and the indicators RCA, RWS and RTB. The main results are that the terms of trade fall in the EU15 by 1.5 resp. 1.2 per cent in the first and second trading period. In the new member states, the effects are smaller. In general, losses in economy-wide competitiveness can be largely neutralized by means of governmental CDM use to ease the cap of the non-ETS sectors. On a sectoral level the NAPs1 lead to large competitiveness gains for the sectors covered by the ETS vis-à-vis the non-covered industries that – in the absence of CDM - have to bare most of the reduction burden. Stricter NAPs2 increase the burden for the ETS sectors and reduces the negative effects for the non-ETS sectors. Compared to outside the EU, the NAPs1 lead to small competitiveness gains of ETS sectors and the assumed NAPs2 lead to small losses. While CDM access for covered industries leaves these results unchanged, government CDM can largely balance these opposed effects of covered and non-covered EU industries. In this case, all sectoral competitiveness impacts are relatively low. Reaching the 20% target leads to competitiveness gains in the ETS sectors vis-à-vis the remaining industries of EU economies, while it may lead to losses vis-à-vis comparable sectors outside the EU.

In (EU 2008) different partial and general equilibrium models are used for an impact assessment of the EU 20-20 strategy for the EU Commission. In this study a cost efficient reference scenario is analysed as well as several other scenarios with the ETS in place and separate non-ETS targets that differ in the use of CDM, the redistribution of auctioning rights and a redistribution of the renewable targets. The climate package in 2020 leads to welfare costs ranging between -1.25 (Bulgaria, with redistribution of non ETS targets, auctioning of EU-ETS rights, trade in renewable certificates and CDM) and 2.16 (Bulgaria, cost efficient option) percent of GDP. Most countries actually gain between 0 and 1 percent of GDP, regardless of the scenario. The results show that the option with a redistribution of non ETS targets and the use of CDM consistently outperforms the other scenarios, exhibiting the lowest direct and pollution costs, average electricity prices, negative effects on GDP and employment and sectoral impacts. However, the GHG reductions and oil and gas dependency improvements are slightly smaller than of other scenarios. Overall, there are numerous differences between the results of the various scenarios. However, they all have in common a GHG reduction (both ETS and non ETS sectors), an increase in the energy costs while a decrease in the pollution costs. With respect to sectoral competitiveness issues, the impact of using CDM credits oscillates between very positive for the innovative companies to negative ones for those producing carbon intensive goods without impacting manufacturing as a whole. Additional measures were considered and their impacts over emissions and output were simulated using the CGE model PACE. Hence, global sectoral agreements would lead to substantial GHG reductions at a global level, without much affecting economic growth. Free allocation of ETS allowances to energy intensive industries offsets output losses without influencing the price of CO_2 and electricity. Also, imports of energy intensive products and access to CDM reduce the global GHG emissions. However, no single specific measure of the above can ensure the competitiveness of the exposed industries but an optimal mix could be achieved.

Finally, Alexeeva-Tabeli et al. (2008) use the CGE model PACE to simulate different general scenarios of unilateral emissions abatement within the EU and analyze the resulting competitiveness results. On one side, the EU emissions reduction target that is set sequentially at 5, 10, 15, 20, 25 and 30% of the base year level emissions and on the other side, the level of tax differentiation between carbon-intensive (non-electric) industries and the rest of the economy is varied. The ratio of implicit tax rates to achieve the exogenous emission reduction target ranges from unity (i.e. uniform carbon taxes), via factors of 2,5,10 and 20 to full exemption of carbon–intensive industries. The calculated indexes are RCA, RWS, RTB, welfare changes, leakage, carbon taxes, changes in sectoral production and terms of trade. The main results are that whether a given target is reached by a uniform tax or by sectorally differentiated carbon taxes has implications on the competitiveness effects. Uniform carbon taxation causes competitiveness losses in carbon intensive industries, while carbon–intensive sectors gain competitiveness. Losses and gains become more pronounced with more stringent targets. More pronounced tax differentiation in favour of carbon-intensive industries can largely neutralize the negative competitiveness effects of emission reductions, but leads to overall efficiency losses. As a middle course, moderate tax differentiation leads to sectorally balanced competitiveness effects and limited overall efficiency losses independent of the emission target. One result of this study is also that it is important to assess competitiveness at the sectoral level since there are various trade-offs across sectors and also since there are differences between sector effects and economy wide competitiveness effects. One final result is that the magnitude of sectoral competitiveness effects is sensitive to the selected competitiveness indicator.

This paper explicitly focuses on the competitiveness of a concrete EU climate policy and tries to capture existing targets and plans as precisely as possible. The main difference to the studies mentioned above is that we not only include the actual NAPs2 but also the newest EU targets as announced in the EU climate package. We also include a simulation of the 30% target. Also, we use a more detailed sectoral disaggregation then in Wobst et al. (2007) and assess the implications of extending the ETS to more sectors.

4. Simulation of policy scenarios

An assessment of the competitiveness effects of the EU 20% target requires at least two modeling steps. The first consists of setting up an appropriate economic model with which the European economy can be simulated until 2020. The second step involves the design of concrete policy scenarios. As a simulation tool we use the DART-model which will be shortly characterized in section 4.1. We then derive different policy scenarios that are in line with the current EU proposal in section 4.2.

4.1 The DART-Model

The DART (Dynamic Applied Regional Trade) Model is a multi-region, multi-sector CGE-model of the world economy. For the simulation of the EU climate policy scenarios, it is calibrated to an aggregation of 12 regions and 11 sectors shown in Table 1. 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. The DART-model has a recursive-dynamic structure solving for a sequence of static one-period equilibria. The major exogenous drivers are the rate of productivity growth, the savings rate, the rate of change of the population, and the change in human capital. The model horizon goes until the year 2050 but in this study we run DART until the year 2020 only. The model is calibrated to the GTAP6 database (Dimaranana & McDougall 2002) that represents production and trade data for 2001. For a non-technical description of the DART model, see Appendix B.

Table 1: DART Regions and Sectors

Countries and regions			
EU-West		**EU-East**	
DEU	Germany	BAL	Estonia, Latvia, Lithuania
GBR	UK	POL	Poland
SCA	Finland, Sweden, Denmark	EEU	Bulgaria, Check Republic, Hungary, Romania, Slovakia, Slovenia
FRA	France		
BEN	Belgium, Luxemburg	**Non-EU**	
NLD	Netherlands	USA	USA
MED	Greece, Malta, Cyprus	LAM	Latin America
ITA	Italy	OAB	Australia, N-Zealand, Canada, EFTA, Japan
IRL	Ireland	CPA	China, Hong-Kong
AUT	Austria	IND	India
ESP	Spain	FSU	Former Soviet Union
PRT	Portugal	ROW	Rest of the World
Production sectors/commodities			
Energy Sectors		**Non-Energy Sectors**	
COL	Coal Extraction	IMS	Iron, Metal, Steel
GAS	Natural Gas	PPP	Pulp & Paper Products
CRU	Crude Oil	CRP	Chemical, Rubber, Plastic Products
OIL	Refined Oil Products	AGR	Agricultural Products
EGW	Electricity	MOB	Transportation Services
		OTH	Other Manufactures & Services

4.2 Policy scenarios for the EU

For assessing the competitiveness effects of the EU emission reduction targets put forward in the climate package, we first run a "business-as-usual" (BAU) reference scenario that does not include any climate policy measures beyond the DART base year 2001. This BAU scenario is then compared with different policy scenarios which allow for an assessment of the mix of current policies. The first four scenarios simulate the impact of reaching a 20% emission reduction in the EU until 2020. The national emission targets start with BAU emissions in 2005 and are then reduced linearly such that the Kyoto/Burden sharing targets are reached in 2012. To arrive at the 20% target all 2012 targets are then reduced by the same percentage. The four scenarios differ in how efficiently the target is reached:

[OPT]: The EU target is reached efficiently. There is full EU emissions trading covering all sources of CO_2. There is no limit on the use of CDM/JI credits from the non Annex B regions resp. the Former Soviet Union. The other Annex B regions USA and "Other Annex B" (OAB) do not undertake any climate policy.

[limCDM]: This is the same scenario as [OPT] but now the use of CDM credits is limited. The limits for each country are defined consistent with the combined CDM limits for the ETS and non-ETS sectors as defined in the climate package and the national allocation plans for the 2nd trading period. They are the sum of the limits defined in the next scenario [ETS].

[ETS]: There is emissions trading only among the ETS sectors. 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 NAPs and the EU climate package (see Table A2 in the Appendix). The use of CDM/JI credits by governments to ease the reduction target of the non-ETS sectors is consistent with the climate package and limited to 3% of the non-ETS emission in 2005. The use of CDM in the ETS sectors is limited according to the NAPs for the 2nd trading period of the ETS.

[ETS+]: From 2012 on, the ETS is extended to cover the chemical industry and the transport sector. The relative ETS and non-ETS targets remain the same as in [ETS], but are now relative to the new amount of emissions covered/not covered by the ETS. The CDM/JI limits remain the same percentage share as in [ETS].

Finally there is one scenario where the non-EU countries also undertake emission reductions so that the EU is willing to reduce their GHG emission by 30% relative to 1990:

[30P] Until 2012 this is the same as [ETS]. From 2013 on, the non-EU countries face emission reduction targets that are determined by assuming that per capita emission rights converge until 2050 and that global emissions are reduced by 50% relative to 2005. They also buy CDM/JI credits[1]. The EU ETS and non-ETS targets are multiplied by the factor 0.7/0.8 = 0.875 to reach a 30% instead of a 20% reduction. The non-ETS sectors are allowed – according to the climate package - to cover 50% of the extra reduction by CDM credits.

These five scenarios allow for an assessment of different aspects of the climate package. [OPT] shows the minimal costs of reaching the 20% target. A comparison of [OPT] with [limCDM] show the efficiency loss and extra cost associated with the supplementary criterion that states that major emission reductions should be achieved domestically. The [ETS] scenario tries to mimic the current climate policy measures as closely as possible. When compared to [OPT] and [limCDM] the welfare costs of separated carbon markets where only part of the emissions are covered under the ETS become visible. Comparing the two scenarios [ETS] and [ETS+] shows how much the EU can gain from including further sectors. For both the chemical industry and the transportation sector that includes aviation and public transportation there is some discussion on including these into the ETS. Also a comparison can show the different competiveness effects for energy intensive sectors when included in the ETS and when not. The last scenario [30P] finally shows the extra costs of a tighter EU target. More detailed information on the definition of the scenarios is in the appendix.

5. Macro-economic simulation results

To give an overview of the aggregated economic effects and as a prerequisite to an assessment of the competitiveness effects we start by analyzing the European emission trading market and the macroeconomic effects of the five scenarios[2]. Figure 1 shows the allowance prices in the different scenarios. For the first two scenarios [OPT] and [limCDM] the price is the price that emerges from a full EU emission trading scheme. For the other scenarios the price is the allowance price in the current or extended EU ETS that only covers the energy intensive sectors.

[1] It is not necessarily true that all non-Annex B countries will sell allowances - e.g. Peterson & Klepper (2007). In the tendency this assumptions is correct though.

[2] Note that our approach is to quantify the economic costs of the climate-package compared to an unconstrained, hypothetical business-as-usual situation without climate policies. Since we chose to neglect the economic benefits from controlling global warming the macroeconomic effects of the climate package are necessarily negative.

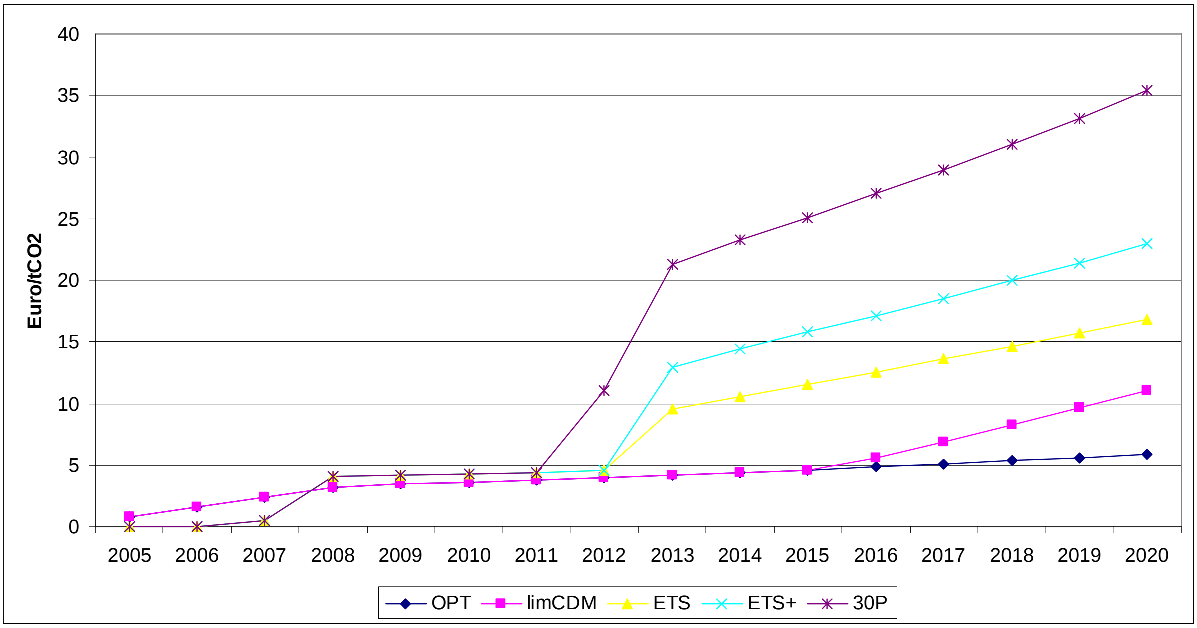

Figure 1: Allowance prices

With full EU emissions trading and the unlimited use of international CDM/JI credits [OPT], the carbon prices are relatively low, starting from 0.8 €/tCO_2 in 2005 and rising to only 5.9€/tCO_2 in 2020. The current limits on the use of CDM and JI projects only become relevant after 2015 and then lead to a moderate increase of carbon prices to 11.1 €/tCO_2 in 2020 in scenario [limCDM].

If we simulate the actual ETS based on the published NAPs, the price path has steps at the end of each trading period. In the first trading period the overall allocation leads to almost zero prices, as were also observed in reality from May 2007 on when it became clear that the endowment with emission rights would exceed the expected emissions. According to our simulations the price in the second period grows moderately to around 4.5€/tCO_2, which is considerably below the prices of around 18 - 25 €/tCO_2 we observe in the moment. Likely reasons for this discrepancy[3] include the fact that existing uncertainties about the market development are not included in our model exercise, that risk aversion against future price increases may increase the willingness to pay, and also that only part of the cost saving potential from CDM and JI projects is so far realized. If we run an additional scenario that is similar to scenario [ETS] but where we do not allow for any CDM and JI credits to be used, we get an ETS allowance price of almost 10€/tCO_2 in 2012.

With the current plans for the third trading period, prices will rise after 2012 and reach in the central scenario [ETS] 16.8 €/tCO_2 in 2020. The difference between the prices in [ETS] and [OPT] is a measure of the efficiency loss due to separated carbon markets. With an extended ETS, prices will even rise since the now included sectors require more additional emissions than the additional allocation assumed here. Reaching the 30% target leads as expected to higher carbon prices - resulting both from a stricter reduction target and higher CDM and JI prices due to the additional demand from other Annex B countries after 2012.

[3] Note that other studies such as Wobst et al. (2007) report comparable low allowance prices.

For the scenarios with a separated carbon market, the flip side of the ETS prices are the implicit carbon taxes in the non-trading sectors. These differ considerably across country, time and scenario and show again the inefficiencies of separated carbon markets. Figure 2 shows these prices for the year 2020 in the scenarios [ETS], [ETS+] and [30P].

Figure 2 shows that the carbon tax in the non-ETS sectors reaches from zero in the Eastern European countries (EEU) to over 200 €/tCO_2 under a 30% EU reduction target in Scandinavia (SCA). On the very right of figure 2 we show the allowance price for a comparison. The large difference shows the potential gains from full emissions trading. The scenario [ETS+] also shows that the difference between the ETS carbon price and the implicit tax becomes mostly much smaller if the sectors mobility and chemical industry become included into the ETS. This is not true for Ireland because here the two included sectors had comparatively low abatement costs.

The EU climate package affects not only the emission market. The different sectors are affected through the necessity to buy allowances or to pay carbon taxes and react by reduced production levels and/or by substituting away from carbon intensive fossil fuel inputs. Furthermore, EU wide carbon abatement also affects international export and import prices and thus the terms-of-trade. The most important effects are changes on international fuel markets where the reduced demand for fossil fuels leads to a drop in prices. While energy importing regions gain from this effect, energy exporting regions lose. In order to analyze the overall effects we look at the welfare changes that serve as a general economic indicator quantifying the overall economic impacts of certain policy scenarios. We calculate welfare changes – or changes in aggregate utility – in terms of the Hicksian Equivalent Variation (HEV) which represents the income change that is equivalent to the induced change in utility. Figure 3 shows the welfare impacts for the different scenarios for the year 2020 for the EU27 and for selected countries that diverge visibly from the EU average.

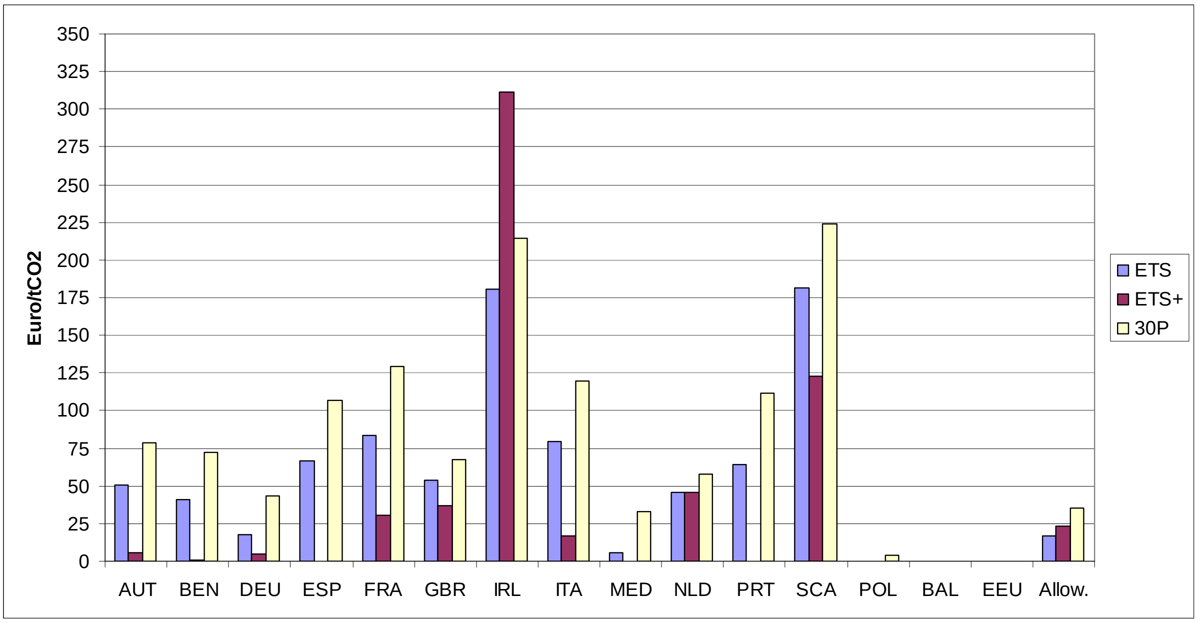

Figure 2: Carbon prices in the non-ETS sectors in 2020

According to figure 3, the overall level of EU welfare losses from a 20% reduction of EU emissions is very low (around 0.2% in 2020) under an efficient and all encompassing allowance market (scenario [OPT]). Even if the use of CDM and JI is restricted [limCDM], the loss only amounts on average 0.5%. Depending on the national gaps to the Kyoto targets and on the sectoral structure, some countries experience larger welfare losses (such as e.g. the Netherlands (NLD) with a loss in [OPT] of 0.7% and 1.2% in [limCDM]), while the Eastern European regions (EEU) with excess emission rights would even gain from the EU allowance market. In the most realistic scenario [ETS] the average loss rises to 1.6% which shows again the inefficiency of the separated carbon markets. If one at least includes the mobility sector and the chemicals into the current ETS, the inefficiencies would become slightly smaller. In scenario [ETS+] the EU27 welfare loss is only 1.2%.

The country specific welfare losses are also influenced by the design of the NAPs. Figure 2 shows e.g. that in Scandinavia (SCA) and Ireland (IRL) the NAPs imply a very inefficient sharing of the emission reductions between trading and non-trading sectors. This leads to comparatively high welfare losses. The Mediterranean countries (MED) on the other hand, have on average low prices in the non-ETS sectors and relatively low welfare losses. The Eastern European countries (EEU) can no longer sell their credits from emission reductions in non-ETS sectors, and thus also lose overall. For a reduction of 30% compared to 20% the losses rise from 1.6% in [ETS] to 2.4% in [30P]. It becomes apparent that the European economies experience a marginal abatement cost curve that is quite convex already at an expansion of emissions reductions from 20 to 30 percent.

If we look at welfare changes over time, which are not shown here, we see that the allocation in the second trading period and also the allocation that we assume for the third commitment period are already more efficient then allocation for the first trading period.

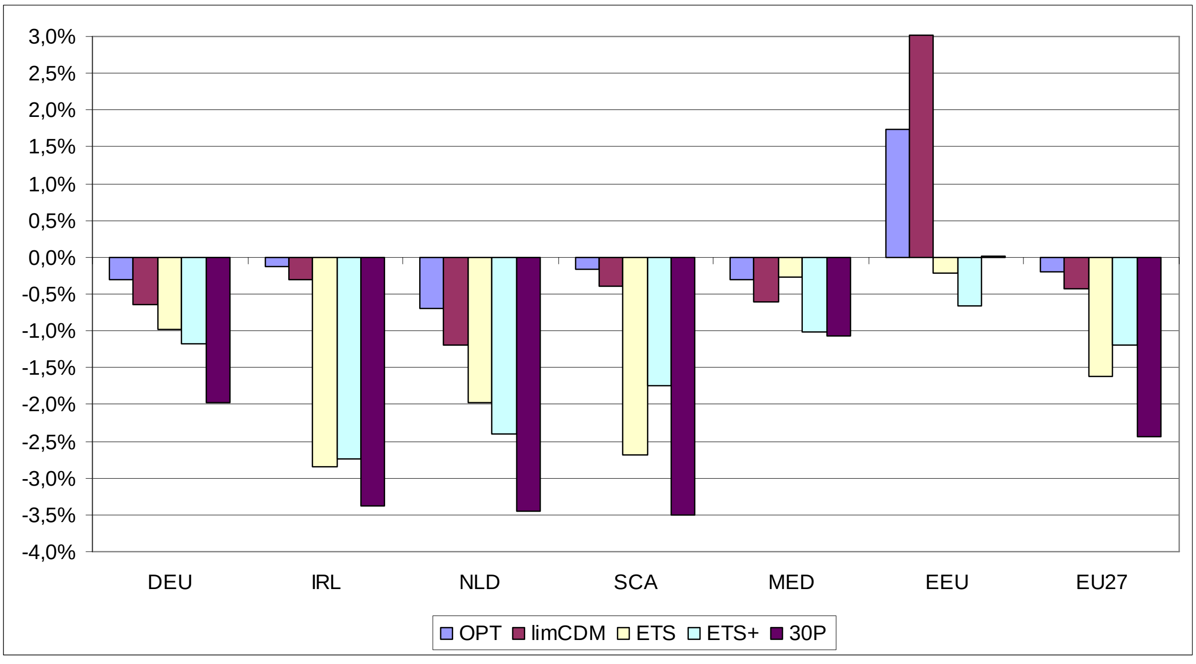

Figure 3: Welfare changes in 2020 relative to business as usual

Before looking at the sectoral competitiveness effects in the different scenarios in detail, we analyze changes in the terms of trade as an overarching indicator for competitiveness effects. Terms of trade changes i.e. the changes in the ratio between exports and imports prices imply a secondary benefit or burden from climate policy that can significantly alter the economic implications. Figure 4 reports relative changes in the national terms of trade for the same selected countries and regions as before. We also report results from some more regions outside the EU that show significant welfare changes.

We find that the terms of trade slightly increase in most European regions through the different European climate policy scenarios. The reason is that most European regions are energy importing regions and they have a comparative disadvantage in energy use. The EU wide climate policy leads – as explained above – to lower international energy prices from which the EU countries can benefit. In most EU countries the picture is the same as in e.g. Germany (DEU) or the Mediterranean countries (MED), with some variation in the absolute changes. As a general tendency the effects for the same target are stronger the more inefficient the target is reached. In addition, the effects increase with a stricter target. The effects for the non-EU regions are positive for energy importing regions such as India (IND) and negative for energy exporting regions such as the Former Soviet Union (FSU). The effects tend to be larger for energy exporters. In the 30P scenario the distribution of the emission rights is the decisive mechanisms. Since India is allowed to even increase emissions it will gain from lower energy prices in addition to the sales of emission permits.

A comparison to the study of Wobst et al. (2007) where climate policies decreases the terms of trade, shows that this results obviously depends on the model specification. With e.g. lower trade elasticities as those in the DART model and thus lower responsiveness of trade flows to changes in prices, the energy price effect is less pronounced. Here, the effect that EU production sectors face gross of allowance prices higher energy prices which increases export costs and decreases overall exports, dominates. The effects also differ across countries depending on the emission targets and the importance of energy imports. Overall our results are that in a closed EU economy the negative effects of the climate policy would be larger. The international interlinkages actually lower the negative effects.

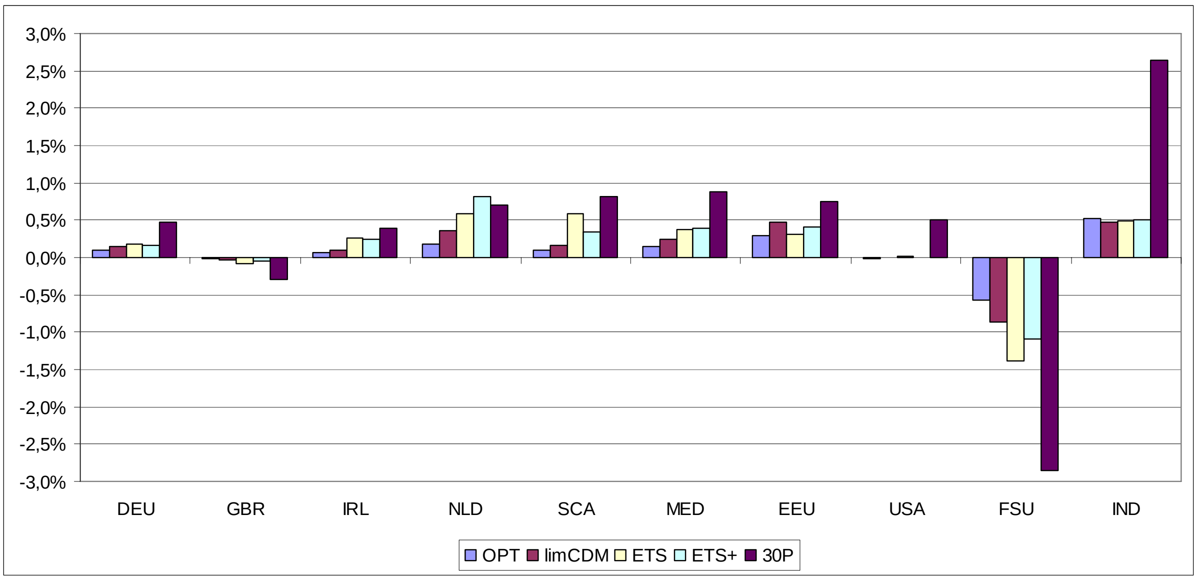

Figure 4: Terms of trade effects in 2020 of selected countries

6. Sectoral competitiveness effects

To measure sectoral competitiveness the model generates indices as defined in Box 2 for all scenarios and additionally sectoral production levels. It turns out that the competitiveness effects of the EU climate policy scenarios are much more diverse then in Wobst et al. (2007) where only the results for the entire EU region are shown and the sectoral disaggregation is confined to two sectors, the trading and the non-trading sector. In contrast, we find a significant variation in competitiveness effects between the different sectors. They also vary in the different countries and differ across the scenarios. The following discussion can therefore only highlight some of the most striking results. Since two of the three competitiveness indicators represent different notions of competitiveness it is clear that the model results can lead to different signs in the indicators for the same sectors. In the CGE simulation it becomes clear that the reaction of the different sectors to policy changes depends amongst others on the sectoral composition of the economy, the carbon intensity of production, the carbon targets and the trade structure. It is therefore not surprising that the different economies and the different sectors do not show a pattern that can easily be generalized. The detailed results are available on request for both years 2010 and 2020 and for all countries, sectors and scenarios. In Appendix D we report for the year 2020 the values of all indicators in the benchmark and in the ETS scenario as well as the RCA in all scenarios. These data are also the source of the following graphs and the interpretation of the competitiveness effects of the different scenarios. We start with summarizing some common trends before having a closer look at the different scenarios.

6.1 Trends in sectoral competitiveness effects

In general, the EU climate policies tend to reduce production and thus also exports, indicating a deterioration of competitiveness. However, the effects are in most cases not dramatic. As one would expect, the energy sectors and the energy intensive sectors tend to be among those sectors affected most strongly. The decrease of the RWS in these sectors indicates that there is some leakage to non-EU countries taking place. The rest of manufacturing can increase its share in world markets slightly which indicates that the increased cost of fossil energy do in fact reduce the exports of highly energy intensive products but those are compensated by the increased competitiveness in other sectors on world markets by those European firms that are responsible for the majority of industrial activities in the EU.

In a few cases sectors with a high comparative advantage in energy intensive products can even profit from the climate policy. That is e.g. the case in the electricity sector in countries with a high share of renewable or nuclear energy such as the Scandinavian countries or France. This shows the role of the carbon intensity in sectoral output with the consequence that the electricity sectors with a low carbon intensity benefit from carbon targets.

Only in very few cases a sector changes from being a net exporter to becoming a net-importer through the EU climate policy. Examples are the electricity sector in Germany that moves from a small comparative advantage to a comparative disadvantage in terms of RTB and RCA and the “Iron Metal Steel” (IMS) sector in Italy.

There are also some common sectoral trends. For coal (COL) and gas (GAS), any changes in competitiveness are essentially insignificant since basically all EU regions produce only negligible amounts of both fossil fuels but import them from abroad. They thus have a strong negative comparative advantage in these sectors that is hardly influenced by climate policy. The competitiveness in terms of all four indicators of refined oil products (OIL) is reduced with a few exceptions, in all countries and in all scenarios. This is even more the case in a system where the carbon markets are separated and the refined oil products are included in the emissions trading. The impact on the electricity sector is often similar, but here, as mentioned before, we also see European countries such as Austria (AUT), Belgium (BEN), France (FRA), and Scandinavia (SCA) improving their competitiveness in some scenarios. In the two energy intensive sectors "Pulp and Paper Products" (PPP) and "Iron Metal Steel" (IMS) many countries lose competitiveness, but again there are exceptions. In the Netherlands these sectors both profit slightly from climate policy. Transportation services (MOB) generally lose with respect to world market shares (RWS) as well as with respect to other sectors in their economies. The chemical sector (CRP) reacts very differently across scenarios, countries and indicators. The largest part of industrial activities takes place in the sector OTH that contains all of those sectors that are not particularly energy intensive and are not covered by the ETS. These industries actually gain slightly in comparative advantage due to the deteriorating situation of the energy intensive sectors. Hence the impact of the ETS does not trickle down very much to those sectors that use some of the ETS covered products.

The focus in this paper is on the competiveness effects in Europe. However, a short note on the impact of the scenarios on the non-EU countries is helpful. Energy exporting regions such as the Former Soviet Union (FSU), Latin America (LAM), the Rest of the World (ROW) and Other Annex B (OAB) can gain competitiveness especially in the energy and energy intensive sectors. The energy importing regions such as the USA, India (IND) and China (CPA) show a more diverse picture and the countries lose competitiveness in many sectors. The detailed results are in the appendix.

6.2 The sectoral competitiveness effects of the central scenario ETS

Since the scenario ETS is our "best-guess-scenario, we analyze its sectoral competitiveness effects in more detail. Figure 5 shows the three indicators RTB, RCA and RWS for selected EU countries. We represent the indices in the [BAU] scenario without climate policy by the blue bars and the change in scenario [ETS] vs. [BAU] by the red bars. The absolute value of the index in scenario [ETS] is thus the blue bar for [BAU] plus or minus the red bar. In the sectors that are not shown (mostly the fossil fuel sectors), there is either no production in this country, or all indicators are close or equal to -1 and there is no change through the introduction of the EU climate package.

We start with the coal and gas sectors. As mentioned above, basically all EU regions produce only negligible amounts of both fossil fuels but import them from abroad so that the changes in competitiveness are irrelevant. Poland (POL) is the only country with some production of coal and the coal sectors has a high positive comparative advantage. Under the ETS scenario, production in Poland's coal sector decreases by almost 10% relative to BAU. The RWS and RCA stay basically the same, but the RTB of coal increases indicating that the reduction in imports relative to the export performance is the main driver of the change in competitiveness. For gas, Great Britain (GBR) and the Netherlands (NLD) are the only producers that show positive competitiveness indices in the benchmark. Under EU climate policy, gas production decreases by 5.1 resp. 1.9%. Nevertheless, the export success is due to the reduced demand inside the countries.

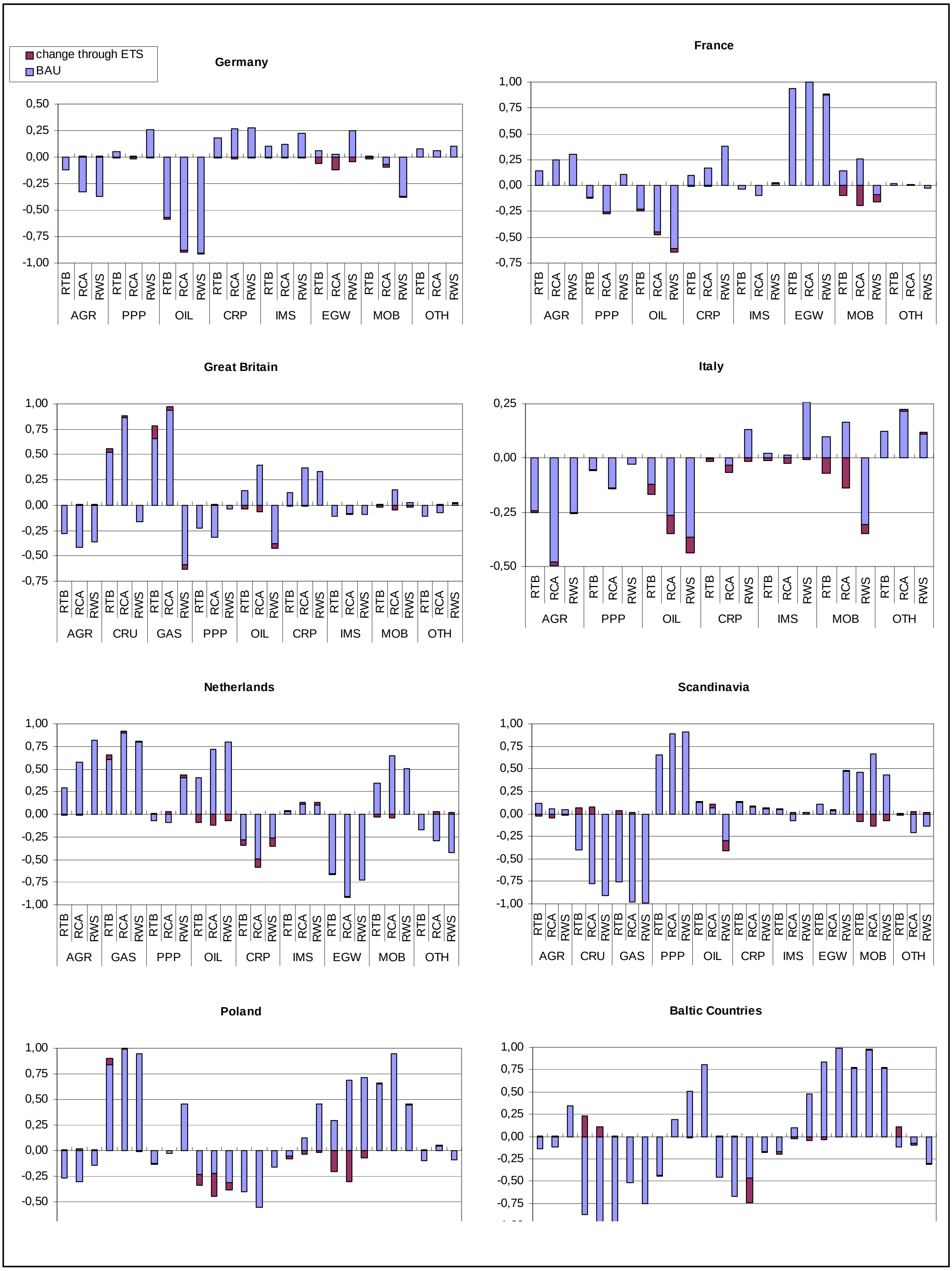

Figure 5: The competitiveness indicators ETS vs. BAU in 2020 in selected countries

The energy sectors “refined oil products” (OIL) and “electricity” (EGW) which are both in the ETS show varying and in some parts strong reactions to the imposition of the ETS. While all EU countries produce at least some refined oil products, most have a comparative disadvantage in this sector, i.e. they predominantly import those products. Regardless whether a country has a positive RCA or a negative one, in general it experiences a reduced comparative advantage (lower RCAs) and the competitiveness effects are accompanied by production decreases of between 5 to 20%. The exception is Scandinavia where the RCA improves slightly. In the electricity sector, Belgium (BEN), Great Britain (GBR), Italy (ITA), the Mediterranean countries (MED) and the Netherlands (NLD) have a comparative disadvantage; the other regions have a comparative advantage. The countries with the largest comparative advantage are Austria (AUT), France (FRA), Ireland (IRL), Portugal (PRT) and the Baltic countries (BAL). Under EU climate policy, production of electricity decreases by 1 to 3% in most countries. In the Mediterranean countries (MED) and Poland (POL) it decreases by 6.6 resp. 8.3%. In three regions electricity production increases, these are Austria (AUT), France (FRA) and Scandinavia (SCA), all countries with a low carbon intensity of electricity production due to high share of renewable electricity of nuclear energy. These countries can also increase their competitiveness in the ETS system, while the electricity sector loses in all other EU regions.

The two “classical” energy intensive sectors are “Pulp and Paper Production” (PPP) as well as “Iron, Metal, Steel" (IMS) which are both covered by the ETS. Despite their above average energy intensity the changes in competitiveness are very small. Production losses are mostly below 1%. For pulp and paper production only the RTB reacts visibly in the Netherlands (NLD) (it increases) and Germany (DEU) (it decreases). For iron, metal, steel production goes down by 3% in Belgium (BEN) and 2.8% in the Mediterranean countries (MED). The RTB increases somewhat for the Netherlands (NLD) and Belgium (BEN) and less so in Scandinavia (SCA) although it is not entirely clear what the causes are.

The other energy intensive sector, chemical products (CRP), is not included in the ETS (except for the large incineration facilities). Nevertheless the changes in the competitive position of the chemical industries are similar to the reactions in PPP and IMS. In those countries that have a generous allocation of emissions to the ETS sectors the chemical industry needs to take up the burden with the rest of the economy and is thus more affected than the energy sectors that are part of the ETS. In Belgium (BEN) the Netherland (NLD) production decreases by 5.2 resp. 12.5 %. In the remaining countries, production remains rather stable and does not change by more than 1%.

In agriculture finally and also in the rest of the economy (OTH) both non-energy intensive non-ETS sectors, the effects are very limited. The rest of the economy will improve its comparative advantage by definition as the reduced export performance of the energy intensive sectors automatically leads to an improvement of the other sectors. The change, however, remains small since the sector OTH is by far the largest sector in the DART model, hence small changes are hardly visible in the indices used here.

The non-EU countries (see Appendix) are little affected by the European climate policy as given in the scenario [ETS]. The production of fossil fuels decreases - but less than 1% - due to the reduced European demand. Production in the other sectors increases slightly. The same is on average true for all competiveness indicators. The most affected sector is coal where China can significantly increase its competitiveness while all other non-EU regions tend to lose.

6.3 The sectoral competitiveness effects in the different scenarios

After having discussed the competitiveness effects in the central scenario ETS we look at the effects across scenarios. For this we focus on the revealed comparative advantage (RCA) which is commonly used in analyses of sectoral competitiveness. Figure 6 shows the RCA value across all scenarios in selected EU countries for the year 2020.

It is apparent that only in a few sectors it does make a difference which scenario is chosen. Across all countries it is first of all the oil products (OIL) whose RCA reacts to the imposition of different policy scenarios. In some countries the chemical industry (CRP) and the electricity sector (EGW) react differently to the scenarios as well. In all other sectors it does not make much of a difference whether the current system (ETS) or more efficient systems such as a full trading with (OPT) or without (limCDM) the Kyoto mechanisms is imposed. Even the higher target of 30 percent reduction has a limited effect.

As expected, the full trading scheme [OPT] has in all cases the smallest change in the RCA indicating the smallest loss in competitiveness. In many cases no loss relative to the no-policy situation is observable. The limitation of CDM and JI credits only slightly increases the negative competitiveness effect because it still results in low allowance prices (see Figure 1).

Comparing the scenarios [ETS] and [ETS+] shows the impacts of including new sectors in the ETS. The inclusion of the chemical industry (CRP) as well as of the transport sector (MOB) brings mixed results, although also on a small scale. The negative competitiveness effects for the chemical industries (relative to the current ETS) are slightly increased in Germany, Poland, and the Baltic countries. Production e.g. goes down by 2 – 5%. The RCA rises slightly in Italy and the UK. Output changes for the transport sector are mostly in the range of 1 – 6 %, but the RCA is hardly influenced. Only France, Italy, and Scandinavia show a significant improvement in the RCA. The likely reason for this is the fact that moving the transport sector into the ETS will lower the carbon prices it is facing. In those three countries the implicit carbon prices outside the ETS are the highest within the EU (see Figure 2).

The scenario with a 30 percent reduction in EU emissions but under the condition of an international climate program under a contraction and convergence approach [30P] when compared to the current ETS scenario with a unilateral 20 percent reduction target includes two effects that compensate each other. The international climate agreement reduces the competitiveness effects, and the increase in the emission reductions target from 20 to 30 percent increases the potential loss in competitiveness. The simulation shows that in general these two effects balance each other. The only exceptions in scenario [30P] are the oil products and the electricity sectors in some countries. Poland loses competitiveness significantly in the oil products and strongly in electricity, presumably since its electricity production heavily depends on coal. In contrast, Scandinavian electricity producers win because of their low carbon content.

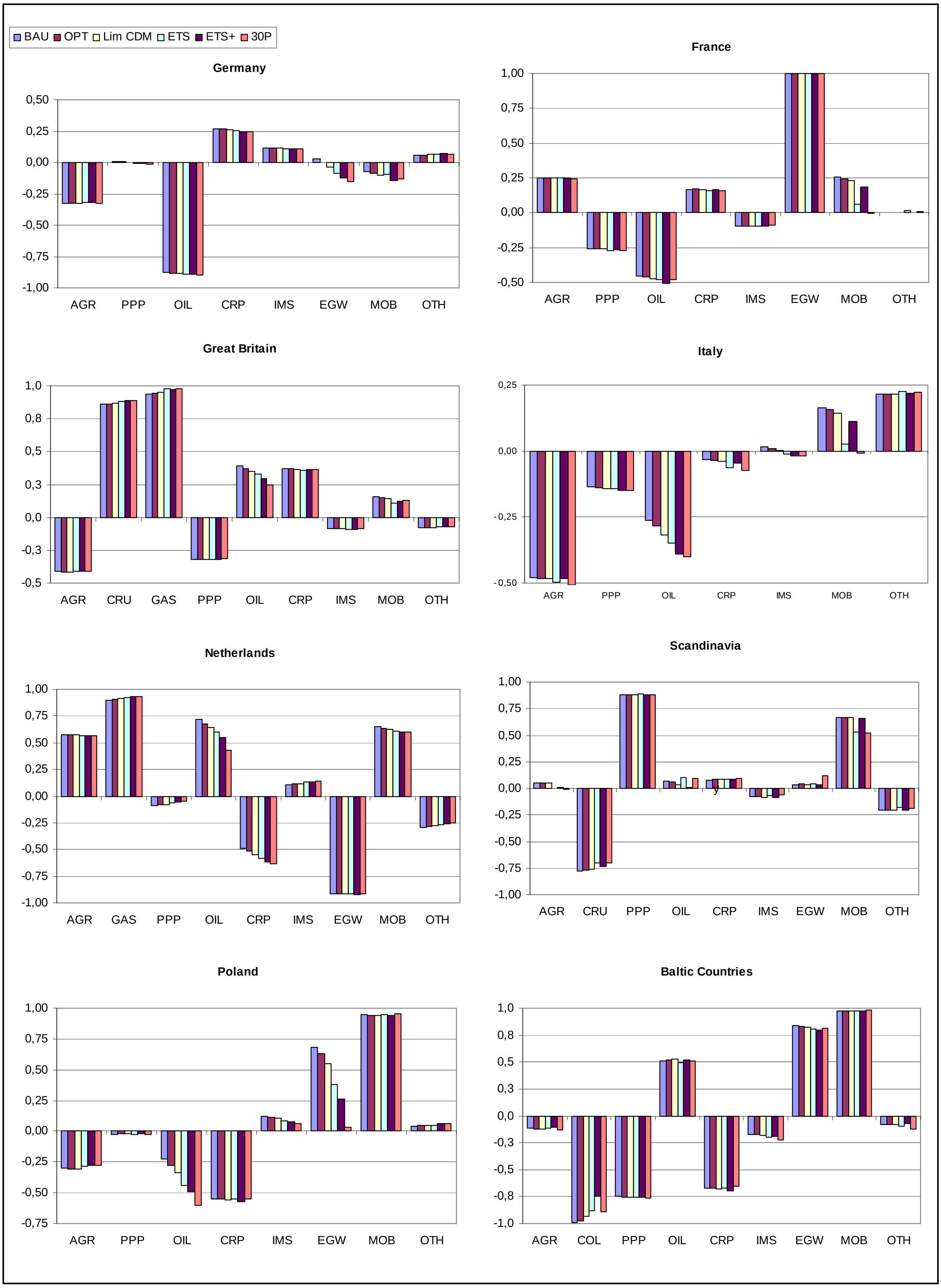

Figure 6: The RCA in 2020 in BAU and in the climate policy scenarios in selected countries

7. Summary and Conclusions

In this paper we have used the computable general equilibrium model DART to simulate several scenarios of possible EU climate policy formulations until the year 2020. To assess their impact on the competitiveness of European industries and the economies overall we computed and evaluated the most commonly used competitiveness indiactors.

We use two generic reference scenarios, a business as usual scenario without climate policies beyond those already in place in 2001 and a scenario which simulates an efficient climate policy within the EU by having full trading of all internal EU emissions and full use of the flexible mechanisms of the Kyoto-Protocol. The policy scenarios refer to limitations either with respect to the use of the Kyoto mechanisms or with respect to the inclusion of sectors into the emission trading scheme. Finally a stronger reduction target is simulated that corresponds to the promise of the EU to increase their reductions if other countries agree to reduce emissions as well.

We find that all climate policies have relatively low welfare costs. However, these costs increase the more inefficiencies are introduced into the policies. Carbon prices in the trading sectors as an indicator for the efficiency of these policies are up to four times higher in the constrained scenarios than in the optimal policy with complete trading within the EU. The reduction targets as laid out in the NAPs for the ETS lead in some countries to extremely high implicit carbon prices for the non-trading sectors. The welfare impacts also indicate that a more stringent target of 30 percent reduction instead of 20 percent will increase the welfare costs significantly. It is apparent that the European economies experience a marginal abatement cost curve that is quite convex already at an expansion of emissions reductions from 20 to 30 percent.

However, these overall welfare results do not directly lead to the same effects when the competitiveness especially of the energy intensive sectors is analyzed. Even in the sectors which have the highest potential of loosing competitiveness the standard indicators do not show much of an effect. The sectoral competitiveness measured by the revealed comparative advantage (RCA) shifts slightly in favor of the non-energy- intensive sectors and shows small losses in some energy intensive sectors such as electricity, mobility services, and chemical products.

The sectors that are most affected are oil products and electricity generation, both covered by the ETS. They both experience a loss in comparative advantage due to the impact of carbon prices. The other two sectors within the European emissions trading scheme (ETS) are pulp and paper production and iron, metal and steel production which are in several EU countries net exporters of their products. Nevertheless they experience only a small reduction in their RCAs indicating that their competitive position within the country does not change very much. This result is in a sense an overstatement of the likely competitiveness effects since our simulation assumes that the high implicit carbon tax that is necessary to achieve the Kyoto-target is imposed on these sectors in the same way as on other sectors that are not subject to foreign competition to the same degree. If one would exempt those sectors facing world market competition the competitiveness effects on them would be lower and at the same time the negative welfare effects would be stronger.

The majority of industrial activities take place in those sectors that are not particularly energy intensive and are not covered by the ETS. They actually gain in comparative advantage due to the deteriorating situation of the energy intensive sectors, although only by a few percentage points.

However, this is due to the size of this sector. If it were further disaggregated one would find stronger improvements in competitiveness in some of the subsectors.

The performance of the different industry sectors in world markets measured by the relative world market share (RWS) falls in general in the sectors covered by the ETS. This indicates that there is some leakage taking place. However, it is concentrated on oil products whereas the other ETS sectors show only small changes in the RWS. The rest of manufacturing which covers most of the economies can increase its share in world markets slightly which indicates that the increased cost of fossil energy do not impact negatively on the competitiveness of these European firms in world markets.

The size of the impact of the EU climate policies on competitiveness is very much influenced by the choice of the instruments. The current design of the ETS puts a high burden on the sectors not covered by the ETS. The scenario with full emissions EU trading indicates that an efficient climate policy instrument would distribute the burden of climate policies much more equally across the different industry sectors apart from the fact that it has lower welfare costs. Finally, a successful Post-Kyoto process that would include all countries would eliminate the leakage effects and would thus only lead to the changes in competitiveness that are related to the relative price effect of energy prices versus other goods. Despite the 50 percent increase in the reduction target, the RCAs are thus affected much less than the strong increase in the reduction target would indicate.

In summary, the simulation of the different measures of competitiveness produces three general insights. First, the effects of EU climate policies on competitiveness are relatively small if one leaves out the fossil fuels themselves the consumption of which is supposed to be reduced anyway. The losses of the energy intensive industries are compensated by gains in other manufacturing sectors. Secondly, there is no uniform effect across the member states of the EU. It is the special circumstances inside the different sectors within the member states that determine whether a sector wins or looses competitiveness. And finally, the changes in competitiveness are strongly influenced by the choice of the particular policy design. A more efficient instrument choice not only reduces the competitiveness effects it also distributes the burden more equally.

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Appendix

A EU Climate Targets and Emissions

The following tables summarize the emissions and the different targets of the EU member states at the national and sectoral level.

Table A1: The emissions and Kyoto targets of the EU-Member States

	Base year emissions MtCO2	2005 emissions Mt CO2	Kyoto target rel. to base year	Kyoto target rel. to 2005
Austria	79.0	93.3	-13.04	-26.37
Belgium	146.9	143.8	-7.49	-5.49
Bulgaria	132.1	69.8	-8.02	74.07
Cyprus	6.0	9.9	0.00	
Czech Republic	196.3	145.6	-8.00	24.04
Denmark	69.3	63.9	-20.92	-14.24
Estonia	43.0	20.7	-7.91	91.30
Finland	71.1	69.3	0.00	2.60
France	563.9	553.4	0.00	1.90
Germany	1232.5	1001.5	-21.00	-2.78
Greece	111.1	139.2	24.93	-0.29
Hungary	123.0	80.5	-5.93	43.73
Ireland	55.8	69.9	12.90	-9.87
Italy	519.5	582.2	-6.51	-16.58
Latvia	25.9	10.9	-8.11	118.35
Lithuania	48.1	22.6	-7.90	96.02
Luxembourg	12.7	12.7	-28.35	-28.35
Malta	2.2	3.4	0.00	
Netherlands	214.6	212.1	-6.01	-4.90
Poland	586.9	399.0	-6.00	38.27
Portugal	60.9	85.5	27.09	-9.47
Romania	282.5	153.7	-8.00	69.10
Slovak Republic	73.4	48.7	-8.04	38.60
Slovenia	20.2	20.3	-7.92	-8.37
Spain	289.4	440.6	15.00	-24.47
Sweden	72.3	67.0	4.01	12.24
United Kingdom	779.9	657.4	-12.50	3.80

Source: EEA (2007)

Table A2: Sectoral emissions and targets of the EU Member States

	Emissions in MtCO2 in 2005		ETS targets in MtCO2 p.a. (rel. to 2005)			Use of project based mechanisms	
	ETS	non-ETS	2005-07	2008-12	non-ETS target in MtCO2 (rel. to 2005)	non-ETS in MtCO2e p.a.	ETS in % of ETS target
Austria	33.4	59.9	33.0 (0.99)	30.7 (0.92)	49.84 (0.83)	9.0	10.0
Belgium	55.58	88.22	62.1 (1.12)	58.5 (1.05)	70.95 (0.80)	7.0	8.4
Bulgaria	40.6	29.2	42.3 (1.04)	42.3 (1.04)	35.16 (1.20)		
Cyprus	5.1	4.8	5.7 (1.12)	5.48 (1.07)	4.63 (0.97)		
Czech Rep.	82.5	63.1	97.6 (1.18)	86.8 (1.05)	68.73 (1.09)		
Denmark	26.5	37.4	33.5 (1.26)	24.5 (0.92)	29.86 (0.80)	4.2	17.0
Estonia	12.62	8.08	19.0 (1.51)	12.72 (1.01)	8.88 (1.10)		
Finland	33.1	36.2	45.5 (1.37)	37.6 (1.14)	29.74 (0.82)	2.4	10.0
France	131.3	422.1	156.5 (1.19)	132.8 (1.01)	354.48 (0.84)		
Germany	474	527.5	499.0 (1.05)	453.1 (0.96)	438.91 (0.83)		22.0
Greece	71.3	67.9	74.4 (1.04)	69.1 (0.97)	64.05 (0.94)		
Hungary	26	54.5	31.3 (1.20)	26.9 (1.03)	58.02 (1.06)		
Ireland	22.4	47.5	22.3 (1.00)	22.3 (1.00)	37.91 (0.80)	3.6	10.0
Italy	225.5	356.7	223.1 (0.99)	195.8 (0.87)	305.31 (0.86)	19.0	15.0
Latvia	2.9	8	4.6 (1.59)	3.43 (1.18)	9.38 (1.17)		
Lithuania	6.6	16	12.3 (1.86)	8.8 (1.33)	18.42 (1.15)		
Luxembourg	2.6	10.1	3.4 (1.31)	2.5 (0.96)	8.52 (0.84)	4.7	10.0
Malta	1.98	1.42	2.9 (1.46)	2.1 (1.06)	1.53 (1.08)		
Netherlands	80.35	131.75	95.3 (1.19)	85.8(1.07)	107.3 80.81)	20.0	10.0
Poland	203.1	195.9	239.1 (1.18)	208.5 (1.03)	216.59 (1.11)		
Portugal	36.4	49.1	38.9 (1.07)	34.8 (0.96)	48.42 (0.99)	5.8	10.0
Romania	70.8	82.9	74.8 (1.06)	75.9 (1.07)	98.47 (1.19)		
Slovakia	25.2	23.5	30.5 (1.21)	30.9 (1.23)	23.55(1.00)		
Slovenia	8.7	11.6	8.8 (1.01)	8.3 (0.95)	12.13 (1.05)	0.5	15.8
Spain	182.9	257.7	174.4 (0.95)	152.3 (0.83)	219.01 (0.85)	31.8	20.0
Sweden	19.3	47.7	22.9 (1.19)	22.8 (1.18)	37.26 (0.78)	1.2	10.0
UK	242.4	415	245.3 (1.01)	246.2 (1.02)	310.38 (0.75)		

Sources: CME (2007), EEA(2007)

B A non-technical description of the DART model

In order to quantify the competitiveness effects of the EU climate package at the sectoral and economy-wide level, it is crucial to account for detailed production structure and intersectoral and international linkages. For the numerical analysis in this paper we adopt the DART model to capture the most recent EU emission targets for the ETS and non-ETS sectors.

The DART **D**ynamic **A**pplied **R**egional **T**rade Model is a multi-region, multi-sector recursive dynamic CGE model of the world economy covering in this aggregation 22 regions, 11 sectors including the main energy sectors and the production factors labor, capital and land. The economic structure is fully specified for each region and covers production and final consumption. Each market is perfectly competitive. Output and factor prices are fully flexible. For each region the model incorporates two types of agents: producers, distinguished by production sector and the final consumer (representative agent) which comprises a representative household and the government.

The static model

Figure A-1 provides a diagrammatic structure of the generic open-economy model that is the heart of DART. The **representative agent** RA(r) in each model region r is endowed with the four primary factors capital K(r), labor L(r), Land Ld(r) and fossil-fuel resources FF(r) and receives all income generated by providing primary factors to the production process. A fixed share of income is saved in each time period and invested in the production sectors. The disposable income (net of savings and taxes) is then used for maximizing utility by purchasing goods. The expenditure function is modeled as a CES composite which combines consumption of an energy aggregate and a non-energy-bundle.

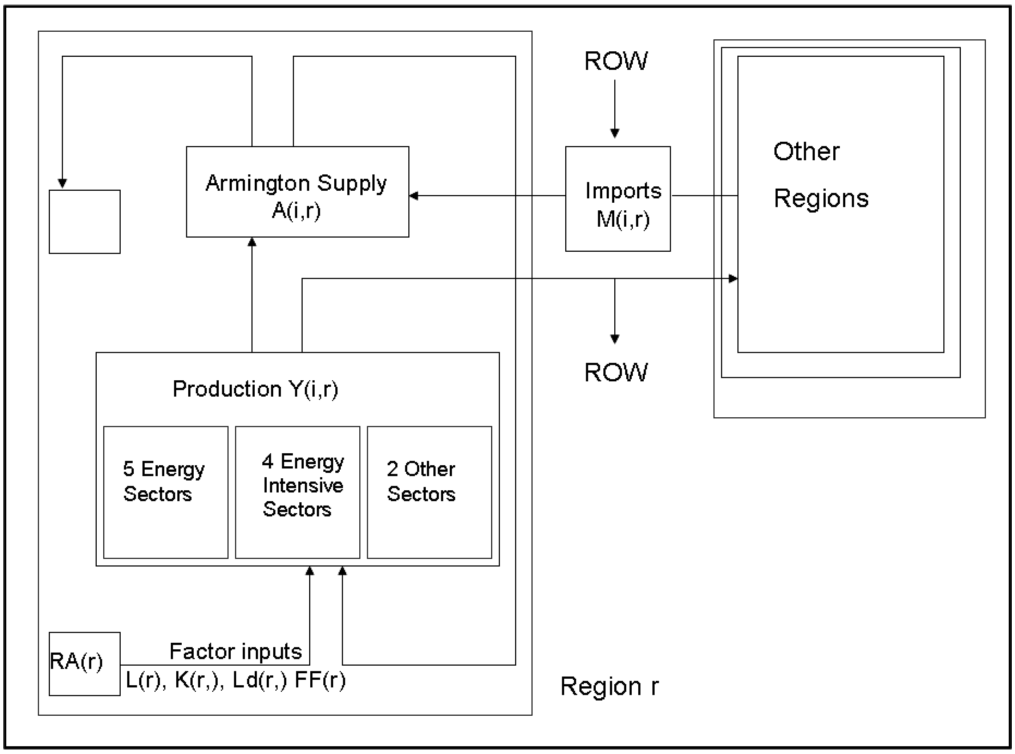

Figure A1: Diagrammatic overview over the structure of DART

Producer behavior is derived from cost minimization for a given output. Each industry i is characterized by a multi-level nested separable constant elasticity of substitution (CES) function Y(i,r) that describes the technological substitution possibilities between a value added composite of capital and labor, energy and non-energy intermediate inputs in domestic production. Figure A-2 shows the nesting structure of the non-energy production functions.

To analyze climate policies **CO_2 emissions** are calculated for final and intermediate energy consumption.

All regions are linked by bilateral **trade** flows and all goods, except the investment good, are traded among regions. Following the Armington assumption, domestic and foreign goods are imperfect substitutes distinguished by country of origin. Thus, all goods on the domestic market in intermediate and final demand correspond to a CES composite A(i,r) that combines the domestically produced goods Y(i,r) and imports M(i,r) of the same good i from other regions.

Factor markets are perfectly competitive and full employment of all factors is assumed. Labor is assumed to be a homogenous good, mobile across industries within regions but internationally immobile. In the basic version of the DART model the same is assumed for capital.

Figure A-2 provides a diagrammatic structure of the generic, static, open-economy model at the heart of DART. The model is calibrated to the GTAP6 database that represents production and trade data for 2001 (for an introduction to GTAP data see Dimaranana & McDougall 2002).

Dynamics

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 driving exogenous factors of the model dynamics are population change, the rate of labor 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 behavior of regional households is characterized by a constant savings rate over time.

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

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

An increase of effective labor implies either growth of the human capital accumulated per physical unit of labor, gh(r), population growth gp(r) or total factor productivity g(r) or the sum of all. The basic version of the DART model assumes constant, but regionally different labor productivity improvement rates, ga(r), constant but regionally different growth rates of human capital, gh(r) and declining population growth rates over time, gp(r,t), according to current projections. Because of the lack of data for the evolution of the labor participation rate it is assumed to be constant so that the growth rate of population growth can be used.

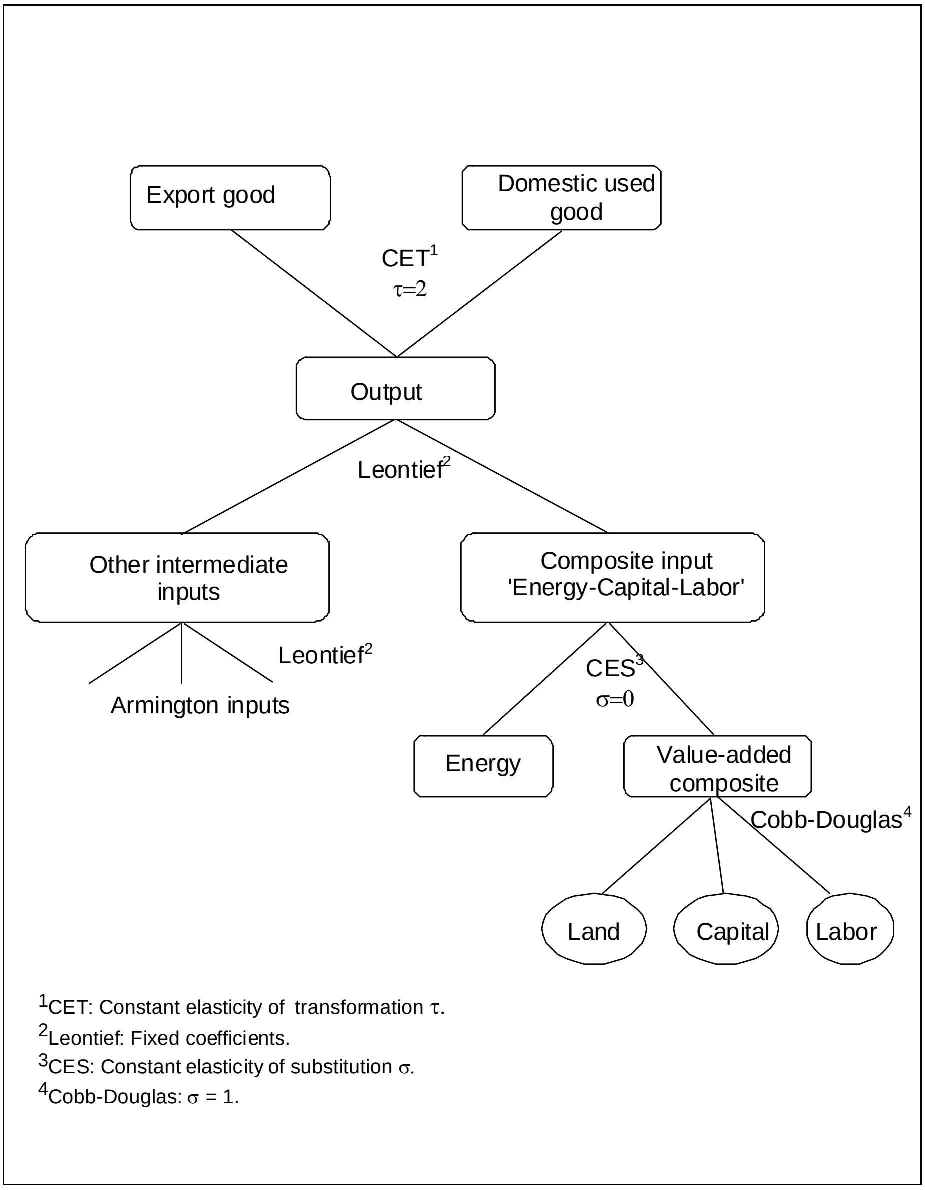

Figure A-2: Nesting structure of the non-energy production sectors.

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.

For a dynamic calibration, 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 (2006).

C Assumptions to implement EU climate policy

- Since DART only includes CO_2-emissions, we used official emission data from the EEA to calculate the Kyoto targets as the CO_2 target that has to be achieved after planned reductions (see below) in non-CO_2 GHG are taken into account. The resulting CO_2 target is calculated relative to 2004 emissions, the last year before the EU ETS started and also implemented in DART relative to 2004.
- We used official emission data from the EEA to calculate the Kyoto and Burden Sharing targets. National emissions are reduced linearly from 2005 on to reach this target in 2012.
- The absolute allocation and the reported historical ETS-emissions were used to derive for each country for the NAPs1 (2005 – 2007) and the NAPs2 (2008 – 2012) the ETS targets relative to 2004, the last year before the EU ETS started. These targets where implemented in DART.
- For the years 2005 – 2012 the targets for the non-ETS sectors were derived as the difference to the overall national emission target.
- From 2012 on the targets of the non-ETS sectors are determined according to the EU proposal (EU 2008b). The ETS targets are derived as the difference to the overall national target. For the national targets it is assumed that each countries Kyoto target is reduced by the same percentage to reach the EU 20% target in 2020.
- Since DART only includes CO_2 emissions, we implicitly assume that the non-CO_2 gases are reduced by the same percentage as the CO_2 emissions in the non-ETS sectors.
- For the purchase of governmental CDM we use until 2012 EEA (2007) p. 86. From 2013 on, each member country is allowed to buy 3% of non-ETS emissions in 2005 as stated in the EU proposal (EU 2008). For the limits of CDM purchases into the ETS we take the maximum percentage share of the NAPs2.
- The purchase of CDM/JI credits is associated with transaction costs of 3$ per tCO_2.

All relevant data are summarized in Tables A1 and A2 in Appendix A.

Overview over targets and limits

<table>
<tr><td rowspan="2"></td><td colspan="3">Emission Targets</td><td colspan="2">CDM/JI limits</td></tr>
<tr><td>(1) National</td><td>(2) ETS</td><td>(3) non-ETS</td><td>(4) ETS</td><td>(5) non-ETS</td></tr>
<tr><td>2005 - 07</td><td>Linear annual reductions to reach target for 2008 – 12</td><td>NAPS1</td><td>(1) – (2)</td><td rowspan="3">Percentage share of ETS targets as summarized in CME (2007)</td><td rowspan="2">gov. plans as summarized in CME (2007)</td></tr>
<tr><td>2008 - 12</td><td>Kyoto/Burden sharing</td><td>NAPs2</td><td>(1) – (2)</td></tr>
<tr><td>2013 - 20</td><td>(1) + (2)</td><td>x% of NAP2 target such that EU 20% target is reached</td><td>Targets from climate package</td><td>3% of non-ETS emissions in 2005</td></tr>
</table>

D - Detailed Results on Sectoral Competitiveness

Table D1: Production in billion USD in the benchmark and in scenario [ETS] in 2020

		AUT	BEN	DEU	ESP	FRA	GBR	IRL	ITA	MED	NLD	PRT	SCA	POL	BAL	EEU	USA	OAB	FSU	LAM	CPA	IND	ROW
BAU	AGR	36	58	294	187	275	251	34	209	66	111	48	99	93	14	177	1608	934	461	918	1441	426	1673
	COL	0	0	5	1	0	2	0	0	1	0	0	0	5	0	2	41	17	12	3	18	5	19
	CRU	0	0	1	0	0	21	0	1	0	0	0	3	0	0	1	53	51	65	79	28	6	268
	GAS	0	0	0	0	0	4	0	0	0	6	0	0	0	0	0	9	29	54	11	1	4	52
	PPP	14	12	82	30	92	100	4	64	6	31	9	71	16	2	23	631	340	38	122	204	23	197
	OIL	2	10	25	14	18	24	1	20	4	24	3	8	6	2	11	169	118	56	76	158	36	244
	CRP	21	53	264	72	195	185	100	176	11	26	16	63	31	3	58	1188	623	104	311	750	129	553
	IMS	31	46	299	100	214	177	14	224	15	51	21	69	39	5	92	1046	781	215	344	1202	169	645
	EGW	12	12	78	41	63	54	4	36	6	15	12	32	17	7	39	428	343	116	98	196	96	322
	MOB	33	43	165	91	158	236	8	142	28	49	15	96	38	12	59	1038	878	141	439	637	183	708
	OTH	403	521	3676	1359	2708	2900	273	2122	253	863	332	891	371	58	542	22124	10437	964	3906	6462	1193	7959
ETS	AGR	36	58	295	185	274	251	32	207	66	108	48	97	94	14	177	1609	935	461	918	1441	427	1672
	COL	0	0	5	1	0	1	0	0	1	0	0	0	4	0	2	41	16	12	3	18	5	19
	CRU	0	0	1	0	0	21	0	1	0	0	0	3	0	0	1	52	51	64	79	28	5	267
	GAS	0	0	0	0	0	4	0	0	0	6	0	0	0	0	0	9	29	54	11	1	4	51
	PPP	13	12	82	29	92	100	5	63	6	31	9	71	16	2	23	631	340	38	122	203	23	197
	OIL	2	9	24	12	17	23	1	18	4	18	3	7	6	2	10	172	120	56	77	158	37	249
	CRP	21	50	261	70	193	183	101	172	11	23	16	64	31	3	57	1190	626	105	311	750	129	560
	IMS	31	45	297	99	214	176	14	222	14	51	21	69	38	5	90	1047	782	216	344	1200	168	649
	EGW	12	11	76	40	64	53	4	35	6	15	11	32	16	7	37	429	344	116	98	195	95	324
	MOB	31	41	162	83	148	232	5	136	28	47	14	86	38	12	59	1049	885	142	442	641	183	721
	OTH	403	523	3676	1357	2708	2902	273	2123	253	866	331	893	370	58	542	22116	10431	962	3903	6454	1192	7942

Table D2: The RWS in the benchmark and in scenario [ETS] in 2020

		AUT	BEN	DEU	ESP	FRA	GBR	IRL	ITA	MED	NLD	PRT	SCA	POL	BAL	EEU	USA	OAB	FSU	LAM	CPA	IND	ROW
BAU	AGR	-0,47	0,09	-0,37	0,42	0,30	-0,37	-0,04	-0,25	0,48	0,82	0,06	0,05	-0,14	0,34	-0,30	0,13	-0,14	-0,05	0,64	-0,72	0,08	-0,16
	COL	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	0,95	-1,00	-0,27	-0,15	0,80	0,86	0,12	0,09	-0,95	-0,02
	CRU	-1,00	-1,00	-1,00	-1,00	-1,00	-0,16	-1,00	-1,00	-1,00	-1,00	-1,00	-0,91	-1,00	-1,00	-1,00	-1,00	-0,13	0,91	0,62	-1,00	-1,00	0,78
	GAS	-1,00	-1,00	-1,00	-1,00	-1,00	-0,58	-1,00	-1,00	-1,00	0,80	-1,00	-0,99	-1,00		-1,00	-0,97	0,67	0,99	-0,80	-1,00	-1,00	0,31
	PPP	0,59	-0,03	0,26	0,10	0,11	-0,04	-0,91	-0,03	-0,64	0,41	0,67	0,91	0,46	-0,44	0,18	0,16	0,24	-0,24	-0,18	-0,64	-0,87	-0,58
	OIL	-0,97	0,01	-0,91	-0,56	-0,61	-0,38	-1,00	-0,37	0,51	0,80	-0,75	-0,30	-0,31	0,81	-0,04	-0,42	-0,67	0,87	0,47	-0,59	0,07	0,50
	CRP	-0,10	0,46	0,28	-0,04	0,38	0,34	0,91	0,13	-0,57	-0,26	-0,44	0,05	-0,16	-0,46	-0,08	0,21	-0,01	-0,46	-0,50	-0,50	-0,01	-0,37
	IMS	0,23	0,20	0,23	0,04	0,02	-0,09	-0,80	0,26	-0,30	0,10	-0,09	-0,01	0,46	0,10	0,46	-0,35	0,13	0,72	0,10	-0,19	0,11	-0,22
	EGW	0,85	-0,56	0,25	-0,02	0,87	-1,00	-1,00	-1,00	-0,75	-0,73	0,86	0,47	0,71	0,99	0,96	-0,84	0,29	0,71	0,31	-0,87	-0,99	-0,81
	MOB	0,31	0,17	-0,37	0,33	-0,08	0,02	-0,89	-0,31	0,89	0,50	0,16	0,43	0,44	0,76	0,03	-0,03	0,10	0,11	-0,17	-0,07	-0,10	-0,09
	OTH	0,06	-0,07	0,10	-0,01	-0,02	0,02	-0,26	0,11	-0,35	-0,43	0,10	-0,13	-0,09	-0,30	0,01	0,08	-0,04	-0,87	-0,15	0,26	0,11	-0,04
ETS	AGR	-0,47	0,09	-0,37	0,43	0,30	-0,36	-0,07	-0,26	0,48	0,82	0,07	0,03	-0,13	0,34	-0,29	0,13	-0,13	-0,03	0,64	-0,72	0,08	-0,16
	COL	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	0,94	-1,00	-0,40	-0,24	0,81	0,86	0,08	0,19	-0,95	-0,05
	CRU	-1,00	-1,00	-1,00	-1,00	-1,00	-0,16	-1,00	-1,00	-1,00	-1,00	-1,00	-0,91	-1,00	-1,00	-1,00	-1,00	-0,14	0,91	0,63	-1,00	-1,00	0,78
	GAS	-1,00	-1,00	-1,00	-1,00	-1,00	-0,63	-1,00	-1,00	-1,00	0,81	-1,00	-0,99	-1,00		-1,00	-0,97	0,67	0,99	-0,80	-1,00	-1,00	0,29
	PPP	0,59	-0,02	0,25	0,11	0,11	-0,04	-0,90	-0,03	-0,65	0,43	0,67	0,91	0,46	-0,45	0,18	0,15	0,24	-0,23	-0,18	-0,65	-0,87	-0,58
	OIL	-0,97	-0,13	-0,91	-0,61	-0,65	-0,42	-1,00	-0,43	0,46	0,73	-0,77	-0,41	-0,38	0,81	-0,09	-0,40	-0,66	0,88	0,48	-0,59	0,09	0,53
	CRP	-0,10	0,44	0,27	-0,05	0,38	0,33	0,91	0,12	-0,57	-0,35	-0,43	0,07	-0,16	-0,45	-0,08	0,22	0,00	-0,44	-0,50	-0,50	-0,01	-0,36
	IMS	0,23	0,18	0,22	0,04	0,03	-0,09	-0,80	0,25	-0,34	0,13	-0,08	0,01	0,45	0,08	0,44	-0,36	0,13	0,73	0,10	-0,20	0,11	-0,22
	EGW	0,85	-0,55	0,20	-0,05	0,88	-1,00	-1,00	-1,00	-0,81	-0,73	0,85	0,49	0,64	0,99	0,95	-0,84	0,32	0,73	0,32	-0,87	-0,99	-0,80
	MOB	0,28	0,16	-0,38	0,24	-0,16	0,00	-0,96	-0,35	0,89	0,50	0,05	0,36	0,45	0,77	0,05	-0,01	0,12	0,14	-0,15	-0,05	-0,09	-0,06
	OTH	0,06	-0,06	0,10	0,00	-0,02	0,02	-0,26	0,12	-0,35	-0,40	0,11	-0,12	-0,09	-0,32	0,01	0,08	-0,04	-0,87	-0,16	0,25	0,11	-0,04

Table D3: The RTB in the benchmark and in scenario [ETS] in 2020

		AUT	BEN	DEU	ESP	FRA	GBR	IRL	ITA	MED	NLD	PRT	SCA	POL	BAL	EEU	USA	OAB	FSU	LAM	CPA	IND	ROW
BAU	AGR	-0,17	-0,08	-0,12	0,05	0,14	-0,28	0,25	-0,24	-0,04	0,30	-0,43	0,12	-0,27	-0,14	-0,11	0,17	-0,14	-0,26	0,24	-0,51	-0,45	-0,26
	COL	-1,00	-0,99	-0,96	-1,00	-1,00	-0,98	-1,00	-1,00	-0,93	-1,00	-1,00	-1,00	0,84	-0,87	-0,34	0,69	0,26	0,33	0,17	0,32	-0,97	-0,30
	CRU	-1,00	-1,00	-1,00	-1,00	-1,00	0,52	-1,00	-1,00	-1,00	-1,00	-1,00	-0,40	-1,00	-0,99	-1,00	-1,00	-0,08	0,83	0,55	-0,96	-1,00	0,44
	GAS	-0,98	-1,00	-0,97	-1,00	-1,00	0,66	-1,00	-1,00	-1,00	0,61	-1,00	-0,76	-1,00	0,00	-1,00	-0,87	0,40	0,38	-0,21	-1,00	-0,96	0,22
	PPP	0,11	-0,17	0,05	-0,08	-0,12	-0,23	-0,56	-0,05	-0,56	-0,07	0,12	0,66	-0,13	-0,52	-0,11	-0,07	0,17	-0,10	-0,26	-0,28	-0,54	-0,21
	OIL	-0,70	0,10	-0,57	-0,44	-0,23	0,14	-0,92	-0,12	-0,01	0,40	-0,65	0,12	-0,23	0,19	-0,05	-0,33	-0,19	0,77	-0,01	-0,31	-0,37	0,07
	CRP	-0,07	-0,03	0,18	-0,19	0,10	0,13	0,65	0,00	-0,42	-0,29	-0,47	0,13	-0,40	-0,46	-0,19	0,07	0,10	-0,23	-0,44	-0,24	-0,23	-0,21
	IMS	-0,01	0,01	0,10	-0,11	-0,04	-0,11	-0,16	0,02	-0,35	0,03	-0,33	0,05	-0,06	-0,17	0,03	-0,33	0,15	0,39	0,03	0,01	-0,16	-0,21
	EGW	0,22	-0,46	0,06	0,12	0,94	-0,94	0,71	-0,98	-0,69	-0,66	0,43	0,11	0,29	0,48	0,41	-0,15	0,49	-0,37	-0,15	-0,02	-0,70	-0,39
	MOB	0,42	0,56	0,01	0,45	0,14	0,01	-0,04	0,10	0,30	0,35	0,24	0,46	0,65	0,76	0,59	0,02	0,33	0,33	0,27	0,70	0,31	0,38
	OTH	-0,05	-0,02	0,08	-0,02	0,02	-0,11	-0,15	0,12	-0,30	-0,17	-0,06	-0,01	-0,10	-0,12	-0,02	-0,28	0,01	-0,46	-0,11	0,19	0,24	0,02
ETS	AGR	-0,17	-0,08	-0,12	0,05	0,14	-0,28	0,23	-0,25	-0,04	0,29	-0,43	0,09	-0,26	-0,14	-0,11	0,17	-0,13	-0,25	0,24	-0,51	-0,45	-0,26
	COL	-1,00	-0,99	-0,90	-1,00	-1,00	-0,96	-0,99	-1,00	-0,78	-1,00	-1,00	-1,00	0,90	-0,65	-0,01	0,56	0,20	0,29	0,12	0,48	-0,97	-0,39
	CRU	-1,00	-1,00	-1,00	-1,00	-1,00	0,56	-1,00	-1,00	-1,00	-1,00	-1,00	-0,33	-1,00	-0,99	-1,00	-1,00	-0,10	0,82	0,54	-0,96	-1,00	0,43
	GAS	-0,97	-1,00	-0,97	-1,00	-1,00	0,78	-1,00	-1,00	-1,00	0,65	-1,00	-0,72	-1,00	0,00	-1,00	-0,87	0,38	0,36	-0,22	-1,00	-0,96	0,17
	PPP	0,11	-0,17	0,04	-0,08	-0,12	-0,23	-0,55	-0,06	-0,57	-0,06	0,11	0,66	-0,13	-0,52	-0,12	-0,07	0,17	-0,09	-0,26	-0,28	-0,55	-0,20
	OIL	-0,72	0,01	-0,59	-0,46	-0,24	0,10	-0,91	-0,17	-0,07	0,31	-0,65	0,14	-0,34	0,18	-0,13	-0,31	-0,17	0,78	-0,01	-0,32	-0,36	0,09
	CRP	-0,07	-0,05	0,17	-0,20	0,09	0,12	0,65	-0,02	-0,42	-0,34	-0,47	0,13	-0,40	-0,45	-0,19	0,07	0,11	-0,22	-0,44	-0,24	-0,23	-0,20
	IMS	-0,02	-0,01	0,10	-0,12	-0,03	-0,11	-0,16	0,01	-0,37	0,04	-0,33	0,06	-0,08	-0,18	0,01	-0,33	0,15	0,40	0,03	0,01	-0,17	-0,21
	EGW	0,24	-0,46	0,00	0,06	0,94	-0,95	0,65	-0,98	-0,76	-0,67	0,39	0,11	0,08	0,44	0,33	-0,12	0,53	-0,33	-0,13	-0,01	-0,69	-0,34
	MOB	0,40	0,55	0,00	0,34	0,04	-0,01	-0,39	0,03	0,31	0,32	0,11	0,37	0,66	0,78	0,61	0,05	0,36	0,36	0,30	0,72	0,33	0,42
	OTH	-0,05	-0,02	0,08	-0,01	0,02	-0,10	-0,15	0,13	-0,30	-0,16	-0,05	0,00	-0,09	-0,13	-0,02	-0,28	0,01	-0,45	-0,12	0,19	0,23	0,02

Table D4a: The RCA in the different scenarios in 2020

		AUT	BEN	DEU	ESP	FRA	GBR	IRL	ITA	MED	NLD	PRT	SCA	POL	BAL	EEU	USA	OAB	FSU	LAM	CPA	IND	ROW
BAU	AGR	-0,28	-0,13	-0,32	0,19	0,25	-0,41	0,32	-0,48	0,29	0,58	-0,52	0,05	-0,30	-0,12	-0,15	0,67	-0,36	-0,57	0,52	-0,86	-0,64	-0,51
	COL	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-0,99	-1,00	-1,00	-1,00	0,99	-0,99	-0,56	0,98	0,41	0,51	0,40	0,47	-1,00	-0,57
	CRU	-1,00	-1,00	-1,00	-1,00	-1,00	0,86	-1,00	-1,00	-1,00	-1,00	-1,00	-0,77	-1,00	-1,00	-1,00	-1,00	-0,26	0,98	0,86	-1,00	-1,00	0,73
	GAS	-1,00	-1,00	-1,00	-1,00	-1,00	0,94	-1,00	-1,00	-1,00	0,90	-1,00	-0,97	-1,00		-1,00	-0,97	0,64	0,59	-0,34	-1,00	-1,00	0,39
	PPP	0,27	-0,31	0,01	-0,08	-0,26	-0,32	-0,90	-0,14	-0,72	-0,09	0,53	0,88	-0,02	-0,75	-0,14	0,33	0,24	-0,31	-0,42	-0,63	-0,76	-0,42
	OIL	-0,93	0,22	-0,88	-0,69	-0,45	0,39	-1,00	-0,26	0,34	0,72	-0,84	0,07	-0,23	0,51	-0,03	-0,20	-0,44	0,96	0,05	-0,67	-0,51	0,11
	CRP	-0,08	-0,04	0,27	-0,28	0,17	0,37	0,87	-0,03	-0,48	-0,49	-0,58	0,08	-0,55	-0,67	-0,29	0,55	0,10	-0,53	-0,71	-0,57	-0,26	-0,43
	IMS	0,02	0,04	0,12	-0,13	-0,10	-0,08	-0,47	0,01	-0,33	0,11	-0,32	-0,08	0,12	-0,17	0,14	-0,20	0,19	0,60	0,13	-0,15	-0,11	-0,43
	EGW	0,47	-0,75	0,03	0,32	1,00	-1,00	0,92	-1,00	-0,87	-0,91	0,86	0,03	0,69	0,84	0,74	0,17	0,75	-0,71	-0,23	-0,20	-0,91	-0,69
	MOB	0,74	0,86	-0,07	0,79	0,26	0,15	-0,25	0,16	0,76	0,65	0,69	0,67	0,95	0,97	0,89	0,46	0,52	0,51	0,56	0,92	0,68	0,65
	OTH	-0,05	-0,02	0,06	0,06	0,00	-0,08	-0,45	0,22	-0,23	-0,29	0,23	-0,20	0,04	-0,08	0,04	-0,10	-0,08	-0,80	-0,15	0,22	0,60	0,01
OPT	AGR	-0,29	-0,13	-0,33	0,19	0,25	-0,41	0,32	-0,48	0,29	0,58	-0,52	0,05	-0,31	-0,12	-0,15	0,67	-0,35	-0,57	0,52	-0,86	-0,64	-0,51
	COL	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-0,99	-1,00	-1,00	-1,00	0,99	-0,97	-0,38	0,95	0,29	0,50	0,38	0,76	-1,00	-0,61
	CRU	-1,00	-1,00	-1,00	-1,00	-1,00	0,87	-1,00	-1,00	-1,00	-1,00	-1,00	-0,77	-1,00	-1,00	-1,00	-1,00	-0,28	0,98	0,86	-1,00	-1,00	0,73
	GAS	-1,00	-1,00	-1,00	-1,00	-1,00	0,95	-1,00	-1,00	-1,00	0,91	-1,00	-0,97	-1,00		-1,00	-0,98	0,63	0,59	-0,32	-1,00	-1,00	0,40
	PPP	0,27	-0,31	0,00	-0,08	-0,26	-0,32	-0,89	-0,14	-0,72	-0,09	0,53	0,88	-0,02	-0,75	-0,15	0,33	0,24	-0,31	-0,42	-0,63	-0,77	-0,42
	OIL	-0,94	0,17	-0,88	-0,70	-0,46	0,37	-1,00	-0,28	0,32	0,68	-0,84	0,06	-0,28	0,52	-0,06	-0,19	-0,42	0,96	0,05	-0,68	-0,51	0,12
	CRP	-0,08	-0,05	0,27	-0,28	0,17	0,37	0,87	-0,03	-0,48	-0,52	-0,58	0,08	-0,55	-0,67	-0,31	0,55	0,11	-0,53	-0,71	-0,57	-0,27	-0,43
	IMS	0,02	0,03	0,12	-0,14	-0,10	-0,08	-0,47	0,01	-0,34	0,12	-0,32	-0,08	0,12	-0,18	0,13	-0,20	0,20	0,60	0,13	-0,15	-0,13	-0,43
	EGW	0,48	-0,75	0,00	0,29	1,00	-1,00	0,91	-1,00	-0,89	-0,91	0,85	0,04	0,63	0,84	0,72	0,20	0,77	-0,71	-0,23	-0,22	-0,91	-0,68
	MOB	0,74	0,86	-0,09	0,78	0,25	0,15	-0,28	0,16	0,76	0,64	0,68	0,67	0,94	0,97	0,89	0,48	0,53	0,52	0,56	0,92	0,68	0,65
	OTH	-0,05	-0,02	0,06	0,06	0,00	-0,08	-0,46	0,22	-0,23	-0,29	0,23	-0,20	0,05	-0,08	0,04	-0,10	-0,08	-0,80	-0,15	0,21	0,59	0,01
LimCDM	AGR	-0,29	-0,14	-0,33	0,19	0,25	-0,41	0,31	-0,48	0,30	0,57	-0,52	0,05	-0,31	-0,12	-0,15	0,67	-0,35	-0,56	0,52	-0,86	-0,64	-0,51
	COL	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-0,98	-1,00	-1,00	-1,00	1,00	-0,93	-0,10	0,94	0,28	0,43	0,33	0,69	-1,00	-0,63
	CRU	-1,00	-1,00	-1,00	-1,00	-1,00	0,87	-1,00	-1,00	-1,00	-1,00	-1,00	-0,76	-1,00	-1,00	-1,00	-1,00	-0,28	0,98	0,86	-1,00	-1,00	0,72
	GAS	-1,00	-1,00	-1,00	-1,00	-1,00	0,95	-1,00	-1,00	-1,00	0,91	-1,00	-0,97	-1,00		-1,00	-0,98	0,62	0,58	-0,34	-1,00	-1,00	0,38
	PPP	0,27	-0,31	0,00	-0,08	-0,26	-0,32	-0,89	-0,14	-0,71	-0,08	0,52	0,88	-0,02	-0,75	-0,15	0,33	0,24	-0,31	-0,42	-0,63	-0,77	-0,42
	OIL	-0,94	0,11	-0,89	-0,71	-0,48	0,35	-1,00	-0,32	0,29	0,64	-0,84	0,04	-0,33	0,52	-0,10	-0,18	-0,41	0,96	0,06	-0,67	-0,50	0,13
	CRP	-0,08	-0,05	0,26	-0,29	0,17	0,37	0,87	-0,04	-0,47	-0,55	-0,58	0,08	-0,56	-0,68	-0,32	0,55	0,11	-0,52	-0,71	-0,57	-0,26	-0,43
	IMS	0,02	0,02	0,11	-0,15	-0,10	-0,09	-0,48	0,00	-0,35	0,12	-0,32	-0,08	0,11	-0,18	0,12	-0,20	0,20	0,61	0,13	-0,15	-0,12	-0,43
	EGW	0,49	-0,75	-0,04	0,26	1,00	-1,00	0,89	-1,00	-0,91	-0,92	0,84	0,04	0,55	0,82	0,69	0,22	0,79	-0,69	-0,20	-0,20	-0,91	-0,67
	MOB	0,73	0,85	-0,10	0,77	0,23	0,14	-0,30	0,14	0,75	0,62	0,66	0,66	0,94	0,97	0,89	0,49	0,54	0,53	0,57	0,92	0,69	0,66
	OTH	-0,05	-0,01	0,06	0,06	0,00	-0,08	-0,46	0,22	-0,22	-0,28	0,23	-0,20	0,05	-0,08	0,04	-0,10	-0,08	-0,80	-0,15	0,21	0,59	0,01

Table D4b: The RCA in the different scenarios in 2020

		AUT	BEN	DEU	ESP	FRA	GBR	IRL	ITA	MED	NLD	PRT	SCA	POL	BAL	EEU	USA	OAB	FSU	LAM	CPA	IND	ROW
ETS	AGR	-0,29	-0,14	-0,32	0,19	0,25	-0,41	0,27	-0,50	0,29	0,56	-0,52	0,00	-0,29	-0,12	-0,13	0,67	-0,35	-0,56	0,52	-0,86	-0,64	-0,51
	COL	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-0,94	-1,00	-1,00	-1,00	1,00	-0,88	0,06	0,94	0,29	0,43	0,31	0,71	-1,00	-0,69
	CRU	-1,00	-1,00	-1,00	-1,00	-1,00	0,89	-1,00	-1,00	-1,00	-1,00	-1,00	-0,70	-1,00	-1,00	-1,00	-1,00	-0,30	0,98	0,86	-1,00	-1,00	0,71
	GAS	-1,00	-1,00	-1,00	-1,00	-1,00	0,98	-1,00	-1,00	-1,00	0,92	-1,00	-0,96	-1,00		-1,00	-0,98	0,60	0,56	-0,36	-1,00	-1,00	0,31
	PPP	0,26	-0,31	-0,01	-0,07	-0,27	-0,32	-0,89	-0,14	-0,72	-0,07	0,52	0,89	-0,03	-0,76	-0,15	0,32	0,24	-0,30	-0,42	-0,63	-0,77	-0,42
	OIL	-0,94	0,05	-0,89	-0,72	-0,48	0,33	-1,00	-0,35	0,23	0,60	-0,84	0,10	-0,44	0,49	-0,18	-0,17	-0,41	0,96	0,05	-0,68	-0,50	0,14
	CRP	-0,08	-0,07	0,25	-0,31	0,16	0,36	0,88	-0,06	-0,48	-0,58	-0,58	0,09	-0,55	-0,67	-0,30	0,55	0,11	-0,51	-0,71	-0,57	-0,26	-0,41
	IMS	0,02	0,01	0,11	-0,15	-0,10	-0,09	-0,47	-0,01	-0,39	0,13	-0,32	-0,07	0,08	-0,20	0,10	-0,20	0,20	0,61	0,13	-0,15	-0,13	-0,42
	EGW	0,50	-0,75	-0,09	0,22	1,00	-1,00	0,88	-1,00	-0,93	-0,92	0,83	0,04	0,38	0,80	0,64	0,23	0,79	-0,67	-0,19	-0,19	-0,91	-0,63
	MOB	0,72	0,85	-0,10	0,67	0,06	0,11	-0,76	0,03	0,77	0,61	0,52	0,53	0,95	0,98	0,90	0,52	0,57	0,56	0,60	0,93	0,71	0,69
	OTH	-0,05	-0,01	0,06	0,08	0,01	-0,07	-0,45	0,23	-0,24	-0,27	0,25	-0,18	0,05	-0,09	0,04	-0,11	-0,08	-0,80	-0,16	0,21	0,59	0,01
ETS+	AGR	-0,28	-0,14	-0,32	0,20	0,25	-0,41	0,22	-0,48	0,32	0,56	-0,51	0,01	-0,28	-0,10	-0,13	0,67	-0,35	-0,56	0,52	-0,86	-0,64	-0,51
	COL	-1,00	-1,00	-0,99	-1,00	-1,00	-1,00	-1,00	-1,00	-0,84	-1,00	-1,00	-1,00	1,00	-0,75	0,34	0,93	0,27	0,41	0,30	0,73	-1,00	-0,71
	CRU	-1,00	-1,00	-1,00	-1,00	-1,00	0,89	-1,00	-1,00	-1,00	-1,00	-1,00	-0,74	-1,00	-1,00	-1,00	-1,00	-0,30	0,97	0,86	-1,00	-1,00	0,71
	GAS	-1,00	-1,00	-1,00	-1,00	-1,00	0,97	-1,00	-1,00	-1,00	0,93	-1,00	-0,97	-1,00		-1,00	-0,98	0,62	0,58	-0,34	-1,00	-1,00	0,34
	PPP	0,26	-0,31	-0,01	-0,08	-0,26	-0,32	-0,89	-0,15	-0,71	-0,06	0,51	0,88	-0,02	-0,75	-0,15	0,33	0,24	-0,30	-0,42	-0,63	-0,77	-0,42
	OIL	-0,95	-0,02	-0,89	-0,73	-0,51	0,30	-1,00	-0,39	0,21	0,55	-0,84	0,01	-0,49	0,52	-0,22	-0,16	-0,39	0,97	0,07	-0,67	-0,49	0,16
	CRP	-0,07	-0,08	0,24	-0,30	0,16	0,36	0,88	-0,05	-0,46	-0,61	-0,59	0,09	-0,57	-0,69	-0,35	0,55	0,12	-0,52	-0,70	-0,57	-0,26	-0,41
	IMS	0,01	0,00	0,11	-0,17	-0,10	-0,09	-0,47	-0,02	-0,38	0,13	-0,34	-0,08	0,08	-0,19	0,10	-0,20	0,20	0,61	0,13	-0,15	-0,13	-0,42
	EGW	0,51	-0,75	-0,12	0,18	1,00	-1,00	0,85	-1,00	-0,94	-0,92	0,82	0,03	0,26	0,80	0,62	0,26	0,81	-0,66	-0,16	-0,18	-0,90	-0,61
	MOB	0,72	0,84	-0,15	0,74	0,19	0,12	-0,34	0,11	0,74	0,60	0,63	0,66	0,94	0,97	0,88	0,50	0,55	0,54	0,58	0,92	0,70	0,68
	OTH	-0,05	0,00	0,07	0,07	0,00	-0,07	-0,46	0,22	-0,21	-0,26	0,24	-0,20	0,06	-0,07	0,05	-0,10	-0,08	-0,80	-0,16	0,21	0,59	0,01
30P	AGR	-0,30	-0,15	-0,32	0,18	0,25	-0,41	0,26	-0,51	0,30	0,56	-0,52	-0,01	-0,28	-0,13	-0,13	0,66	-0,36	-0,53	0,52	-0,85	-0,65	-0,51
	COL	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-1,00	-0,91	-1,00	-1,00	-1,00	1,00	-0,89	0,08	0,99	0,58	0,78	0,40	1,00	-1,00	-0,89
	CRU	-1,00	-1,00	-1,00	-1,00	-1,00	0,89	-1,00	-1,00	-1,00	-1,00	-1,00	-0,70	-1,00	-1,00	-1,00	-1,00	-0,29	0,98	0,86	-1,00	-1,00	0,65
	GAS	-1,00	-1,00	-1,00	-1,00	-1,00	0,98	-1,00	-1,00	-1,00	0,93	-1,00	-0,97	-1,00		-1,00	-0,97	0,64	0,60	-0,31	-1,00	-1,00	0,16
	PPP	0,26	-0,31	-0,02	-0,07	-0,27	-0,31	-0,89	-0,15	-0,72	-0,05	0,52	0,88	-0,03	-0,77	-0,16	0,31	0,24	-0,28	-0,42	-0,63	-0,81	-0,40
	OIL	-0,95	-0,10	-0,90	-0,72	-0,48	0,24	-1,00	-0,40	0,17	0,43	-0,82	0,10	-0,61	0,51	-0,31	-0,17	-0,53	0,97	0,09	-0,76	-0,52	0,24
	CRP	-0,08	-0,09	0,25	-0,32	0,16	0,36	0,88	-0,07	-0,47	-0,64	-0,58	0,09	-0,55	-0,65	-0,30	0,54	0,11	-0,55	-0,71	-0,59	-0,34	-0,37
	IMS	0,02	-0,01	0,11	-0,16	-0,09	-0,09	-0,47	-0,02	-0,42	0,14	-0,32	-0,06	0,06	-0,22	0,08	-0,22	0,19	0,59	0,12	-0,18	-0,23	-0,38
	EGW	0,57	-0,73	-0,15	0,18	1,00	-1,00	0,84	-1,00	-0,96	-0,92	0,82	0,12	0,03	0,81	0,57	-0,02	0,80	-0,70	-0,19	-0,33	-0,95	-0,47
	MOB	0,71	0,84	-0,13	0,61	0,00	0,13	-0,79	-0,01	0,76	0,60	0,42	0,52	0,95	0,98	0,91	0,48	0,58	0,57	0,61	0,93	0,70	0,74
	OTH	-0,05	0,00	0,06	0,09	0,01	-0,07	-0,45	0,22	-0,23	-0,25	0,25	-0,18	0,06	-0,12	0,04	-0,11	-0,08	-0,79	-0,15	0,21	0,58	0,00