Navigating various flexibility mechanisms under European burden-sharing

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Abstract

In July 2016, the European Commission presented its proposal for a regulation to reduce greenhouse gases emissions in sectors not covered by the emissions trading system with regard to post-2020 binding targets. The proposal extends the burden-sharing framework designed in 2008, and called the Effort Sharing Decision. This burden-sharing is based on a GDP per capita rule and aims to reflect the economic capacity of each European Member State on the basis of its relative wealth. However, several papers have pointed out that this way of allocating emissions can result in great cost-inefficiencies, as the allocations do not take Member State abatement costs into account. The proposal acknowledges this issue and proposes a range of flexibility instruments (i.e., more than 15 flexibility options) that intend to enhance cost-effectiveness. This paper evaluates the proposal and analyzes the economic impacts of each flexibility option with respect to fairness and cost-effectiveness using a computable general equilibrium model. The performed analysis demonstrates that flexibility mechanisms that allow "inter-Member state flexibility" constitute the most efficient options. Specifically, they reduce compliance costs and, simultaneously, increase fairness between low-income Member States and high-income Member States.

Keywords: Effort Sharing Decision, European Union, Climate policy, Computable general equilibrium model

Highlights

- I evaluate the new EU effort sharing decision with regard to 2030 European

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GHG emissions commitments for each European Member State.

- The economic impacts of 12 flexibility options listed by the European Commission are analyzed with respect to fairness and cost-effectiveness.
- In term of overall efficiency, i.e., aggregated EU welfare cost, the most promising mechanism is the one that allows "inter-Member state flexibility".
- If we are concerned about fairness among Member States and their economic capacities to implement decarbonization policies, the "inter-Member state flexibility" mechanism is also the most attractive one.

1. Introduction

In July 2016, the European Commission (EC) presented its proposal for a regulation to reduce greenhouse gases (GHG) emissions in sectors not covered by the emissions trading system (ETS) with regard to post-2020 binding targets (European Commission, 2016b). The proposal extends the burden-sharing framework designed in 2008 (Commission of the European Communities, 2008) and called the Effort Sharing Decision (ESD). The text proposes several new features of the European framework aimed at limiting GHG emissions for the period 2021-2030. As pointed out by Sartor et al. (2015), the proposal raises a new and critical challenge because it will be more difficult to comply with the 2030 targets than it was in 2020. This is mainly because the overall emissions cuts required are deeper in 2030 (-30% with respect to 2005 levels) than they were in 2020 (-10%). Moreover, the ESD, based on GDP per capita and not on abatement potentials, leads to the risk that a number of Member States (MS) may simply fail to meet their targets (see, for example, the analysis performed at the MS level by Sartor et al. (2015)). If the EC still wants to use a GDP per capita rule for allocating a GHG budget across MSs, it requires the implementation of flexibility mechanisms to achieve the GHG abatement at a lower cost. The EC proposal acknowledges this issue and proposes a range of flexibility instruments (i.e., more than 15 flexibility options) that intend to augment cost-effectiveness. The aim of this paper is to evaluate the 2030 ESD and analyze the economic impacts of each of these flexibility options with respect to fairness and cost-effectiveness. I use the GEMINI-E3 model, which has been involved in the evaluation of the 2020 ESD (Bernard and Vielle, 2009; Böhringer et al., 2009), and more recently used in the assessment of the ESD 2030 within the context of the United Kingdom decision to leave the European Union (EU) (Babonneau et al., 2018).

The remainder of this paper is structured as follows. Section 2 presents the ESD proposal and details the flexibility mechanisms. Section 3 provides an overview of the computable general equilibrium model used to perform the simulations, and explains how the welfare cost is computed. Section 4 presents the scenario results. Section 5 concludes.

2. The Effort Sharing Decision

2.1. Overview

The "Energy–Climate" directive adopted in 2008 divided the European economy into two parts (Böhringer, 2014; Böhringer et al., 2009): (i) sectors subject to the European ETS were chosen from those most energy-intensive (primarily electricity generation); and (ii) all other sectors (non-ETS), including the fossil energy consumption of households. The ETS constitutes an exchange-tradable permits market for firms, characterized by one CO_2 price (Venmans, 2012). The allocation of allowances is primarily based on free allowances with some auctioning. However, in the future, it is planned that auctioning will become the default method (Hepburn et al., 2006). For the non-ETS market, CO_2 abatement objectives are based on the so-called "Effort Sharing Decision".

The ESD sets GHG emission targets for MSs according to their economic capacity, evaluated on the basis of their relative wealth measured by GDP per capita. Two rounds of ESD were already defined, one for the year 2020 adopted in 2007 and the other one recently proposed for the year 2030 (European Commission, 2016b). Table 1 shows these two ESDs.

2.2. Flexibility options

The EC proposal lists 19 flexibility options that are organized into five categories. The present paper adds two additional options (called F6 and F7) that extend the coverage of some EC options. All of these flexibility mechanisms are described in Table 2.

The first category is related to what the EC calls the "target adjustment", which is not, in a proper sense, a flexibility mechanism. Option T1 is the baseline option computed from GDP per capita and presented in Table 1. The European Council decided that these targets should be adjusted for high-income MSs, taking into account cost-effective reduction potential. The adjustment is related to MSs having a GDP per capita above the EU average in 2013 (see Table 1). It represents 11 countries, called "high-income MSs" in the proposal as namely: Luxembourg, Denmark, Sweden, Ireland, Netherlands, Austria, Finland, Belgium, Germany,

Table 1: Effort Sharing Decision (source: European Commission (2016b))

	GDP per capita in € 2013	ESD target 2020 in % of 2005 levels	ESD target 2030 in % of 2005 levels
Bulgaria (BGR)	5'800	20%	0%
Romania (ROU)	7'200	19%	-2%
Croatia (HRV)	10'200	11%	-7%
Hungary (HUN)	10'200	10%	-7%
Poland (POL)	10'200	14%	-7%
Latvia (LAT)	11'300	17%	-6%
Lithuania (LIT)	11'800	15%	-9%
Slovakia (SVK)	13'600	13%	-12%
Estonia (EST)	14'400	11%	-13%
Czech Republic (CZE)	14'900	9%	-14%
Portugal (POR)	16'300	1%	-17%
Greece (GRE)	16'500	-4%	-16%
Slovenia (SVN)	17'400	4%	-15%
Malta (MLT)	18'100	5%	-19%
Cyprus (CYP)	21'000	-5%	-24%
Spain (SPN)	22'100	-10%	-26%
Italy (ITA)	26'500	-13%	-33%
United Kingdom (GBR)	31'900	-16%	-36%
France (FRA)	32'100	-14%	-36%
Germany (DEU)	35'000	-14%	-37%
Belgium (BEL)	35'400	-15%	-38%
Finland (FIN)	37'400	-16%	-39%
Austria (AUT)	38'100	-16%	-39%
Netherlands (NLD)	38'700	-16%	-39%
Ireland (IRL)	39'000	-20%	-39%
Sweden (SWE)	45'400	-17%	-40%
Denmark (DNK)	45'500	-20%	-40%
Luxembourg (LUX)	85'600	-20%	-40%
European Union	26'700	-10%	-30%

Table 2: Flexibility options

Name	Definition	Source
Target adjustment		
T1	Baseline option	EC
T2	Limited target adjustment for high-income MSs	EC
T3	High target adjustment for high-income MSs	EC
T4a	50% based on T1 and 50% based on a cost-effective emission reduction for high-income MSs (GHG40)	EC
T4b	50% based on T1 and 50% based on a cost-effective emission reduction for high-income MSs (EUCO30)	EC
One-off flexibility between ETS and non-ETS		
O1	Baseline option, no flexibility between ETS and non-ETS	EC
O2	One-off flexibility for eligible MSs with low access limits (from 2% to 4% of 2005 emissions per annum)	EC
O3	One-off flexibility for eligible MSs with high access limits (from 2% to 4% of 2005 emissions per annum)	EC
O2b	Same as option O2 with additional MSs eligibility	EC
O3b	Same as option O3 with additional MSs eligibility	EC
Options including LULUCF flexibility		
L1	No use of LULUCF credits for compliance	EC
L2	Use of up to 280 million tons of LULUCF credits for compliance	EC
Options enhancing existing flexibility instruments		
F1	Baseline option	EC
F2	Increased permitted borrowing within the commitment period to 10%	EC
F3	Central information site	EC
F4	Central market place for AEA transfers	EC
F5	Mandatory auctioning	EC
F6	Increased inter-Member to 10%	own
F7	Fully fungible ESD allocations	own
Options enhancing existing flexibility instruments		
C1	Baseline option	EC
C2	Biennial compliance checks	EC
C3	Compliance checks every fifth year	EC

France, and United Kingdom. These countries are together responsible for approximately 60% of GHG ESD emissions. This adjustment is computed from simulations performed with the PRIMES and GAINS models, in which the GHG abatements are implemented in a cost-effective manner. Their analysis lead to the definition of the following four groups:

- Group 1: Germany, United Kingdom and France, where the gap between option 1 and the results from the simulations assuming a cost-effective implementation is below or around 5%;
- Group 2: Sweden and Finland, with a positive gap, but with some uncertainties around it;
- Group 3: Austria, Denmark, Belgium and Netherlands, with a significant gap below 15%;
- Group 4: Luxembourg and Ireland, with a gap above 15%.

The adjustments must leave the total abatement of high-income MSs unchanged; which means that, if some MSs have to do less abatement, some others would have to mitigate more. Option T2 increases the ambition of group 1 by 1 percentage point, and decreases the ambition of group 3 and 4, respectively, by 3 and 9 percentage points. Group 2, however, remains unchanged. Option T3 sees high adjustments, in which the target of group 1 is increased by 2 percentage points, and 1 percentage point for group 2. In contrast, the target is decreased in group 3 and 4 by, respectively, 7 and 13 percentage points. Option T4 was suggested by Belgium, and assumes that the targets are based for 50% on option T1 and 50% on a target based on a cost-effective emission reduction computed from model runs. Two simulations were utilized to compute this latter target, the GHG40 projection (based on the 2013 reference scenario (European Commission, 2013)) and the EUCO30 projection (based on the EU 2016 reference scenario (European Commission, 2016b)), resulting in two options T4b and T4a, respectively.

Options O assume some flexibilities between ETS emissions and non-ETS emissions. Option O1 is the current situation, in which emission reductions under the ETS cannot be used for compliance in the non-ETS. However, the EC established a new possibility, in which allowances from ETS can be transferred to ESD allocations. These options are conditioned to the following two design parameters: (i) *eligibility*, i.e., which MS can use this one-off mechanism; and (ii) *limit of access*, i.e., the amount of ETS allowances that can be transferred to ESD allocations.

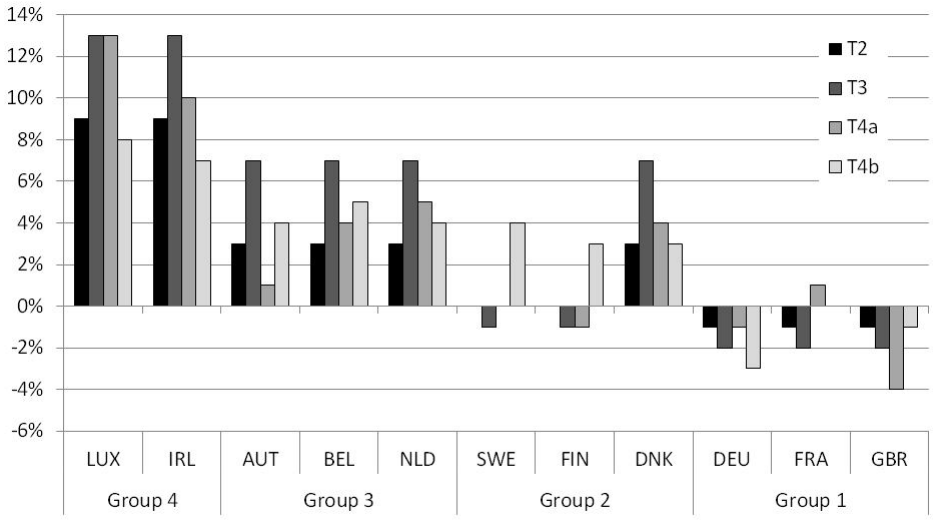

Figure 1: Change in allocations with respect to option T1 in percentage points (a positive number means more allocations)

Option O2 allows one-off flexibility for the following countries with low access limits:

- Luxembourg and Ireland (group A) have a limit equivalent to 4% of 2005 emissions per year;
- Netherlands, Belgium, Austria, Denmark, Finland, Sweden, and Malta (group B) have a limit equivalent to 2% of emissions per year.

Option O3 supposes high access limits. Luxembourg and Ireland can transfer up to 8% of 2005 emissions. The countries listed in group B have a limit equivalent of 4%. Finally, the EC also considers two other options, in which France, Germany, and United Kingdom are also included in this mechanism with a 2% limit (option O2b) and a 4% limit (option O3b).

At present, credit generated in the land use, land-use change, and forestry (LULUCF) sector cannot be used in the ESD for compliance (option L1) (Ellison et al., 2014). Option L2 includes a limited use of credit coming from the LULUCF sector that is equal to a maximum of 280 million over the period 2021-2030. This amount is distributed to MSs on the basis of their share of agriculture non-CO_2 emissions in the ESD. Table 3 shows this repartition.

Table 3: Distribution of LULUCF credit (source: European Commission (2016b)) - option L2

	Total limit credit in Mt CO_2 (2021-2030)	Average annual limit as % of annual 2005 ESD
Austria	2.5	0.4%
Belgium	3.8	0.5%
Bulgaria	4.1	1.5%
Croatia	0.9	0.5%
Cyprus	0.6	1.3%
Czech Republic	2.6	0.4%
Denmark	14.6	4.0%
Estonia	0.9	1.7%
Finland	4.5	1.3%
France	58.2	1.5%
Germany	22.3	0.5%
Greece	6.7	1.1%
Hungary	2.1	0.5%
Ireland	26.8	5.6%
Italy	11.5	0.3%
Latvia	3.1	3.8%
Lithuania	6.5	5.0%
Luxembourg	0.25	0.2%
Malta	0.03	0.3%
Netherlands	13.4	1.1%
Poland	21.7	1.2%
Portugal	5.2	1.0%
Romania	13.2	1.7%
Slovakia	1.2	0.5%
Slovenia	1.3	1.1%
Spain	29.1	1.3%
Sweden	4.9	1.1%
United Kingdom	17.8	0.4%
European Union	280	1.0%

Options F aim at enhancing flexibility within ESD emissions through "inter-temporal flexibility" and "inter-Member state flexibility". The extant rules already allow such a flexibility, with a maximum of 5% of their annual emission allocations (option F1). Option F2 increases permit borrowing to 10%, but only from the years 2021-2025. Options F3, F4, and F5 create new administrative tools or institutions that intend to facilite flexibilities within ESD emissions. Option F3 creates a central information site that should record transfers. Option F4 involves establishing a central market place for inter-Member state transfers. Option F5 creates mandatory auctioning. In the current paper, two other options, F6 and F7 are added, which are detailed in section 4.

Finally, options C consider compliance checks and periodicity of reporting. Option C1 assumes annual compliance checks, C2 biennial compliance checks, and C3 reports every fifth year.

3. The GEMINI-E3 model

3.1. Overview

GEMINI-E3 is a multi-country, multi-sector, recursive computable general equilibrium (CGE) model (Bernard and Vielle, 2008) comparable to other CGE models (EPPA, OECD-Env-Linkage, etc.), built and implemented by other modeling teams and institutions, and sharing the same long experience in the design of this class of economic models. The standard model is based on the assumption of total flexibility in all markets, i.e., both macroeconomic markets, such as capital and international trade markets (with associated prices being the real rate of interest and the real exchange rate, which are then endogenous), and microeconomic or sector markets (goods, factors of production, etc.).

The current version is built on the GTAP 9 data base (Aguiar et al., 2016), and the reference year is 2011. The industrial classification used in this study comprises 11 sectors. We describe five energy goods and sectors: coal, oil, natural gas, petroleum products, and electricity. Transport is described through three sectors: land transport, sea transport and air transport. Agriculture, energy-intensive industries, and other goods and services constitute the remaining three sectors. Sectors participating in the ETS market are petroleum products, electricity generation, and energy-intensive industries. Regarding spatial decomposition, this version of GEMINI-E3 describes the 28 EU MSs, China, and the rest of the world.

International trade is represented through the Armington assumption (Armington, 1969), which assumes that domestic and imported goods are not perfectly homogenous.

It is worth noting that, in the present European version of GEMINI-E3, we only considers CO_2 emissions from energy combustion[1].

3.2. Assessing welfare cost

Like other CGE models, GEMINI-E3 assesses the welfare cost of policies through compensating variation of income (CVI). It is commonly acknowledged that CVI is preferable to change in GDP or change in households' final consumption because these aggregates are measured at constant prices according to the methods of national accounting and do not capture the change in the structure of prices, which is a main effect of climate change policies. Moreover, it is informative to split the welfare cost between its two components, the domestic component or deadweight loss of taxation (DWL) and the imported component or gains from terms of trade (GTT). The GTT represent spill-over effects due to changes in international prices. In a climate change policy, these GTTs come mainly from the drop in fossil energy prices that results from the decrease of world energy demand.

Decomposition of the welfare cost into components is a complex issue that has been addressed in the literature, mainly by Böhringer and Rutherford (2002) in the case of climate change policy, and by Harrison et al. (2000) in a more general framework. Here, the aim is an approximate decomposition between domestic and imported cost, in order to obtain a general idea of their relative importance. This approach is justified by the fact that the change in prices, in particular the prices of foreign trade, is fairly small. In practice, CVI is first calculated from the results of the model, and the specification and coefficients of the demand function. GTT are then calculated based on the results of the involved scenario using the following equation:

$$GTT = \sum_i \Delta Pexp_i \cdot Export_i - \sum_i \Delta Pimp_i \cdot Import_i \tag{1}$$

where $\Delta Pexp_i$ and $\Delta Pimp_i$ represent changes in the exports and imports prices (for product i), with respect to the reference scenario; and $Export_i$ and $Import_i$ represent the levels of exports and imports, respectively, in the reference scenario. Finally, DWL is the difference between CVI and GTT.

[1]Other non-CO_2 GHG emissions are not taken into account. However according to UNFCCC inventory (United Nations Framework Convention on Climate Change, 2018), these emissions account for 19% of EU28 GHG emissions in 2016.

4. Numerical implementation

4.1. Reference scenario

The GEMINI-E3 reference scenario is built on the time period of 2011-2030 with yearly timesteps; all prices given in this paper are in €$_{2017}$. Assumptions about population, GDP, and international energy prices are based on the EU reference scenario 2016 (European Commission, 2016a). This projection supposes that European GDP will grow by 1.4% per year between 2015-2030. MS GDP growth rates are based on projections performed by DG ECFIN (European Commission, 2015).

The model is calibrated in order to reproduce energy consumption and related CO_2 emissions from 2011 to 2015. It thus considers all previous policies implemented since 2015, and especially those related to energy and climate fields.

4.2. EU architecture scenario

First, a scenario is simulated called the "EU architecture scenario". After 2015, the targets defined in the ESD proposal and also the ones related to the ETS market are implemented through carbon prices. Regarding the flexibility options listed in Table 2, this scenario uses options T1, O1, L1, and C1. However, option F1 is not taken into account in this scenario. Indeed, to be consistent with the other options "1" that consider no flexibility mechanism, no flexibility is assumed between ETS market and ESD emissions. However, option F1 is analyzed in the next section. The present scenario assumes that ETS sectors participate in a CO_2 tradable market in which allowances are auctioned. The revenue from ETS allowances are collected by EC and redistributed to MSs according to their ETS emissions. In this market, the CO_2 target consists of a 21% (43%) reduction in 2020 (in 2030) with respect to 2005 levels. Non-ETS sectors and households pay a domestic CO_2 tax on fossil energy consumption that is based on the ESD targets presented in Table 1. The number of CO_2 prices in EU is then one plus the number of MSs (i.e., 29=1+28).

Table 4 presents the results of this scenario for the year 2030. First, it is found that the ETS price is equal to 46 € in 2030, which is higher than the one computed by the European Commission (2016a), which is equal to 33 €. In non-ETS sectors, the average European CO_2 price is equal to 209 €, but with significant gaps among MSs. Regarding some low-income countries (e.g., Czech Republic, Greece, Hungary, Portugal, Slovakia, Bulgaria, Romania, and Croatia), the burden-sharing proposal does not require any abatement for ESD sectors, and thus the CO_2 taxes are equal to zero. These overallocations may result in "hot

Table 4: EU architecture scenario - year 2030

	Components of welfare cost[a]			CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	DWL	ETS	ESD	Total	ESD sectors
Austria	-0.41%	-2.05%	1.64%	-23.3%	-25.7%	-24.9%	434
Belgium	-0.81%	-2.06%	1.26%	-22.2%	-25.8%	-24.6%	357
Bulgaria	0.34%	-0.23%	0.58%	-38.9%	1.6%	-28.8%	0
Croatia	-0.09%	-0.29%	0.20%	-32.0%	0.9%	-12.4%	0
Cyprus	-0.48%	-0.91%	0.43%	-9.9%	-9.3%	-9.6%	71
Czech Republic	0.79%	0.05%	0.74%	-46.9%	1.1%	-32.4%	0
Denmark	-0.13%	-1.84%	1.72%	-44.3%	-26.0%	-33.6%	399
Estonia	-3.28%	-5.80%	2.51%	-10.5%	-19.1%	-13.9%	225
Finland	0.63%	-0.46%	1.09%	-31.2%	-14.2%	-24.2%	217
France	0.17%	-0.60%	0.78%	-23.4%	-20.0%	-20.9%	226
Germany	0.39%	-1.56%	1.96%	-38.1%	-29.5%	-34.3%	555
Greece	-0.25%	-0.33%	0.08%	-30.2%	2.7%	-15.1%	0
Hungary	0.29%	0.09%	0.21%	-28.6%	0.7%	-10.8%	0
Ireland	-0.14%	-2.39%	2.25%	-33.8%	-28.4%	-30.5%	275
Italy	0.17%	-0.15%	0.32%	-27.5%	-7.3%	-16.2%	74
Latvia	0.48%	0.46%	0.02%	-17.3%	0.8%	-5.6%	0
Lithuania	-0.92%	-1.11%	0.19%	-15.0%	-16.7%	-15.9%	140
Luxembourg	-2.31%	-4.44%	2.12%	-19.3%	-37.1%	-33.9%	409
Malta	0.45%	-3.96%	4.40%	-10.9%	-44.5%	-30.5%	315
Netherlands	-1.11%	-3.23%	2.12%	-26.4%	-26.2%	-26.3%	390
Poland	0.81%	0.03%	0.78%	-47.7%	-16.0%	-36.6%	41
Portugal	0.00%	-0.06%	0.06%	-34.2%	1.6%	-13.5%	0
Romania	0.86%	0.43%	0.43%	-37.0%	-1.2%	-23.6%	0
Slovakia	0.83%	0.45%	0.38%	-28.4%	0.4%	-15.9%	0
Slovenia	0.37%	0.13%	0.23%	-33.5%	-2.5%	-16.4%	25
Spain	-0.04%	-0.11%	0.07%	-31.9%	-0.4%	-15.7%	10
Sweden	0.18%	-1.25%	1.42%	-23.3%	-22.1%	-22.5%	455
United Kingdom	0.32%	-0.18%	0.50%	-37.6%	-17.5%	-26.3%	158
European Union	0.15%	-0.80%	0.95%	-35.4%	-16.8%	-25.8%	209
ETS price[c]				45			

[a] in % of households consumption.
[b] change in % with respect to the reference scenario.
[c] in €$_{2017}$ per ton of CO_2.

air"[2] that could be sold to other MSs. Table 5 shows that other studies find similar overallocations. These studies converge on the countries that are concerned, but differ on the amount of "hot air". However, these overallocations highlight the weakness of the per capita rule to take into consideration existing situations (regarding current CO_2 emissions) and also cost-effective abatement potential. Oppositely, "old" MSs (e.g., Austria, Denmark, Germany, Luxembourg, Netherlands and Sweden) with high-income levels have to implement significant abatements that require CO_2 taxes that are higher than 300 €. The other countries are in a middle position, for example, France with a CO_2 that tax equals 226 €, Ireland with a CO_2 tax that equals 275 € (Chiodi et al., 2013), and United Kingdom with a CO_2 tax that equals 158 €.

Table 5: "Hot air" within ESD emissions in 2030

Study	Countries with "hot air"	Emissions covered	Amount in Mt CO_2-eq
European Commission (2016a)	Bugaria, Croatia, Czech Republic, Greece, Hungary, Latvia, Lithuania Portugal, Romania, Slovakia, Slovenia	GHG	50.8
Sartor et al. (2015)	Bulgaria, Croatia, Greece, Hungary, Portugal, Romania	GHG	24.5
GEMINI-E3	Bulgaria, Croatia, Czech Republic, Greece, Hungary, Latvia, Portugal, Romania Slovakia	CO_2 from energy combustion	29.8

The burden-sharing proposal results in an important disparity of effective CO_2 emission reductions that range from -44.5% to +2.4%. In contrast, effective abatements in the ETS sectors are more uniform and range from -44.7% and -11%. Of course, this leads to similar findings in terms of welfare costs. It is worth noting that, for some countries, GTTs counterbalance abatement costs. This is the reason why some countries are better off after the CO_2 policy. The GTT are positively correlated to trade openness and the ESD tax[3]. These positive international splillovers have been well established since the Kyoto Protocol especially for energy-importing countries such as European countries (see (Böhringer and Rutherford, 2002; Bernard and Vielle, 2003). Finally, when subtracting the GTT, all countries face a DWL.

[2]For an etymology of the word "hot air" see Victor et al. (2001).

[3]I estimate a linear regression between the GTT and these two variables. The following estimation is found: $GTT = 0.0071 \cdot Trade\ Openness + 0.00005 \cdot ESD\ tax - 0.0096$ with R^2=0.67

4.3. Target adjustments

Options T2 to T4b are simulated and compared to the EU architecture scenario. The aim of these target adjustments is to reallocate efforts within high-income MSs that take cost-efficiency and fairness into account. Allocations of MSs with a GDP per capita below 30'000 € are unchanged, and the simulations reveal that they are not impacted by these options. Therefore, I concentrate my analysis on high-income MSs[4]. Table 6 gives welfare costs for the four groups identified in the proposal. Surprisingly, in contrast to what is assumed in the proposal, I find that groups 3 and 4 have welfare improvements when the EU climate policy is implemented (see also Table 4 that details the results at the MS level). By subtracting the GTT, we obtain a ranking that matches the initial intuition: countries with a high GDP per capita and therefore a high level of effort face high DWL. Nevertheless, considering the GTT and the results coming from GEMINI-E3, it can be concluded that the options T are not required, as groups 3 and 4 are better off. It is difficult to elaborate more on these options, as the results of the simulations conducted with the GEM-E3 and the GAINS models, that have been used to justify the target adjustments, have not been published. However, it can be concluded that options T2 to T4b effectively balance the DWL. In my simulations, option T4a equalizes the DWLs in % of household consumption and leads to a fair distribution of DWL across high-income MSs.

Table 6: Target adjustments scenarios - year 2030

	EU architecture Option T1	Option T2	Option T3	Option T4a	Option T4b
Welfare cost[a]					
Group 1	0.31%	0.33%	0.37%	0.37%	0.34%
Group 2	0.34%	0.33%	0.35%	0.29%	0.34%
Group 3	-0.72%	-0.61%	-0.46%	-0.56%	-0.56%
Group 4	-0.70%	-0.65%	-0.58%	-0.66%	-0.59%
European Union	0.15%	0.17%	0.21%	0.20%	0.18%
DWL[a]					
Group 1	1.16%	1.25%	1.36%	1.34%	1.26%
Group 2	1.31%	1.30%	1.42%	1.20%	1.34%
Group 3	1.71%	1.33%	0.94%	1.21%	1.25%
Group 4	2.22%	1.14%	0.82%	1.30%	0.99%
European Union	0.95%	0.95%	0.96%	0.98%	0.94%

[a] in % of households consumption.

[4]The detailed simulation results of all scenarios presented in this paper are given in the Appendix.

4.4. One-off flexibility between ETS and non-ETS

I consider now options that link ETS markets and ESD emissions by allowing MSs to use allowances coming from the ETS market in sectors covered by the ESD. Again, only high-income MSs are allowed to use this flexibility mechanism. However, in contrast to target adjustment options, this mechanism could impact the other MSs (having a GDP per capita lower than 30'000 €) by increasing the ETS price and the compliance cost of energy-intensive industries and electricity generation sector. Table 7 presents the results of these simulations. Options O2 and O3 have very limited impacts on the results. This is not the case of option O3b, however, where the welfare cost of high-income MSs and average ESD CO_2 price are divided by two. Using ETS allowances within ESD sectors increases the ETS price (by 25% with option O3b, for example), and therefore penalizes the countries that do not participate in this flexibility mechanism. Low-income MSs are the most impacted, with a welfare cost that shifts from 0.68% of household consumption to 0.75%, because in these countries, the ETS sectors constitute a larger part of the economy (Brink et al., 2016). In contrast, regarding the overall efficiency of the EU climate change policy, option Ob3 cuts the EU welfare cost by one-third.

4.5. Land use, land-use change, and forestry

In this scenario (i.e., option L2), the credits coming from LULUCF increase ESD allocations. Starting from 2021, these credits are gradually used with the assumption that the total amount of LULUCF from 2021 to 2030 is equal to the amounts given in Table 3. The credits used in year t (>2020) are equal to $(t - 2020) \times \frac{2 \times \overline{LULUCF}}{2030-2021}$ where $\overline{LULUCF}$ is the total amount of LULUCF. No cost related to these credits is assumed, as LULUCF are not represented in this version of GEMINI-E3. Several studies (Nabuurs et al., 2017; Michetti and Rosa, 2012), however, demonstrate that the cost savings from carbon sequestration by LULUCF could be significant, up to 65% (Elofsson and Gren, 2018). For all MSs, their DWL decrease as their ESD allocations increase, and the average ESD CO_2 price drops from 209 to 173 €. The impact on the welfare cost depends on the change in GTT. For some countries, less abatement means less gains in terms of trade and an increase in the welfare cost (see, e.g., Lithuania, and Estonia). However, at the EU level, the incorporation of LULUCF credits reduces the welfare cost slightly, with a shift from 0.15% to 0.12% of household consumption. It is worth noting that this incorporation benefits only high-income MSs.

Table 7: One-off flexibility between ETS and ESD emissions scenarios - year 2030

	EU Architecture Option O1	Option O2	Option O3	Option O2b	Option O3b
Welfare cost[a]					
Austria	-0.41%	-0.38%	-0.34%	-0.36%	-0.30%
Belgium	-0.81%	-0.75%	-0.68%	-0.77%	-0.73%
Bulgaria	0.34%	0.31%	0.28%	0.29%	0.26%
Croatia	-0.09%	-0.05%	-0.02%	0.02%	0.13%
Cyprus	-0.48%	-0.47%	-0.46%	-0.43%	-0.38%
Czech Republic	0.79%	0.79%	0.79%	0.81%	0.84%
Denmark	-0.13%	-0.08%	-0.03%	-0.08%	-0.02%
Estonia	-3.28%	-3.25%	-3.22%	-3.30%	-3.31%
Finland	0.63%	0.54%	0.46%	0.53%	0.45%
France	0.17%	0.17%	0.17%	0.13%	0.09%
Germany	0.39%	0.38%	0.37%	0.30%	0.22%
Greece	-0.25%	-0.23%	-0.21%	-0.17%	-0.09%
Hungary	0.29%	0.28%	0.27%	0.29%	0.28%
Ireland	-0.14%	-0.22%	-0.25%	-0.23%	-0.27%
Italy	0.17%	0.17%	0.16%	0.17%	0.17%
Latvia	0.48%	0.46%	0.43%	0.43%	0.39%
Lithuania	-0.92%	-0.96%	-0.99%	-1.03%	-1.13%
Luxembourg	-2.31%	-2.09%	-1.84%	-2.04%	-1.74%
Malta	0.45%	0.35%	0.27%	0.42%	0.39%
Netherlands	-1.11%	-0.99%	-0.87%	-1.01%	-0.91%
Poland	0.81%	0.82%	0.84%	0.87%	0.95%
Portugal	0.00%	0.01%	0.01%	0.03%	0.05%
Romania	0.86%	0.85%	0.85%	0.86%	0.88%
Slovakia	0.83%	0.78%	0.74%	0.74%	0.65%
Slovenia	0.37%	0.34%	0.32%	0.32%	0.28%
Spain	-0.04%	-0.04%	-0.04%	-0.03%	-0.02%
Sweden	0.18%	0.14%	0.12%	0.13%	0.09%
United Kingdom	0.32%	0.31%	0.31%	0.27%	0.23%
European Union	0.15%	0.15%	0.15%	0.12%	0.11%
MSs by GDP per capita in €					
<10'000	0.68%	0.68%	0.68%	0.71%	0.75%
10'000-20'000	0.26%	0.26%	0.25%	0.27%	0.27%
20'000-30'000	0.06%	0.06%	0.06%	0.07%	0.08%
>30'000	0.13%	0.13%	0.14%	0.08%	0.05%
High-income MSs by group					
Group 1	0.31%	0.30%	0.29%	0.24%	0.19%
Group 2	0.34%	0.28%	0.24%	0.27%	0.22%
Group 3	-0.72%	-0.65%	-0.57%	-0.66%	-0.59%
Group 4	-0.70%	-0.70%	-0.66%	-0.70%	-0.65%
ETS price[b]	46	47	49	51	57
Average ESD CO_2 price[b]	209	199	190	179	152

[a] in % of households consumption.
[b] in $€_{2017}$ per ton of CO_2.

Table 8: Land use, land-use change, and forestry scenarios - year 2030

	EU architecture Option L1	Option L2
Welfare cost[a]		
Austria	-0.41%	-0.40%
Belgium	-0.81%	-0.80%
Bulgaria	0.34%	0.27%
Croatia	-0.09%	-0.02%
Cyprus	-0.48%	-0.36%
Czech Republic	0.79%	0.76%
Denmark	-0.13%	0.03%
Estonia	-3.28%	-2.84%
Finland	0.63%	0.48%
France	0.17%	0.09%
Germany	0.39%	0.32%
Greece	-0.25%	-0.19%
Hungary	0.29%	0.28%
Ireland	-0.14%	-0.16%
Italy	0.17%	0.15%
Latvia	0.48%	0.45%
Lithuania	-0.92%	0.13%
Luxembourg	-2.31%	-2.23%
Malta	0.45%	0.55%
Netherlands	-1.11%	-1.00%
Poland	0.81%	0.80%
Portugal	0.00%	0.02%
Romania	0.86%	0.81%
Slovakia	0.83%	0.73%
Slovenia	0.37%	0.45%
Spain	-0.04%	-0.02%
Sweden	0.18%	0.11%
United Kingdom	0.32%	0.26%
European Union	0.15%	0.12%
<10'000	0.68%	0.72%
10'000-20'000	0.26%	0.27%
20'000-30'000	0.06%	0.06%
>30'000	0.13%	0.08%
ETS price[b]	46	46
Average ESD CO_2 price[b]	209	173

[a] in % of households consumption.
[b] in $€_{2017}$ per ton of CO_2.

4.6. Inter-Member State flexibility

I next analyse flexibility mechanisms that allow a MS to transfer allowances to another MS. In my EU architecture scenario, the existing rule, which is currently limited to 5% of allowances is not assumed. Therefore, option F1, representing the current situation, is simulated alone and compared to the EU architecture scenario in Table 9. Moreover, two other scenarios are simulated that increase the percentage of allowance to 10% and 15% (called F2 and F6, respectively). Finally, a scenario (named F7), which assumes that ESD allowances are fully fungible is also presented.

When inter-Member State flexibility is implemented, the EU abatement cost decreases significantly. Option F1 decreases the EU cost by approximately 5.7 billion €, from 0.15% to 0.10% of household consumption with respect to the EU architecture scenario. High-income MSs buy CO_2 quotas from low-income MSs, which implement CO_2 abatement measures or only sell "hot air". In 2030, quotas from "hot air" represent 8.4 Mt CO_2 sold by Greece, Portugal, Czech Republic, Hungary, Bulgaria and Croatia. Main buyers are Germany and France, which purchase respectively, 11.2 and 9.4 Mt CO_2. 26 countries reach their 5% trading constraint, and only Finland and Lithuania could buy and sell more, respectively. This option benefits mainly low-income MSs (with a GDP per capita lower than 20'000 €), who can sell quotas and therefore benefit from additional revenue. In contrast, if high-income MSs can buy cheap quotas and decrease their DWL, they suffer from less gains in terms of trade. This result confirms that emissions trading is not always beneficial, as pointed out by Babiker et al. (2004). In addition, the average ESD CO_2 price drops from 209 to 177 €, while the ETS price is unchanged.

When the trading limit is increased, the EU marginal benefit decreases. Shifting from 5% to 10% trading limit induces a 3 billion € gain at the EU level and from 10% to 15%, the EU benefit is equal to 2.5 billion €.

If I assume fully fungible allocations within ESD emissions, the EU cost equals only 3 billion €, which represents 0.02% of household consumption in 2030. For all MSs, the ESD price is equal to 145 €. This option creates significant amounts of trading. In relative terms, the top buyer is Luxembourg, which purchases 29% of its emissions allocation, and the top seller is Greece with a selling rate that equals 43% of its emissions allocation. In absolute terms, Germany is the highest buyer (53.5 Mt CO_2), and Greece is the top seller (18.8 Mt CO_2).

Table 9: Inter-Member State flexibility scenarios - year 2030

	EU Architecture	Option F1	Option F6	Option F7
Welfare cost[a]				
Austria	-0.41%	-0.22%	-0.01%	0.35%
Belgium	-0.81%	-0.59%	-0.32%	-0.05%
Bulgaria	0.34%	-0.37%	-1.00%	-4.95%
Croatia	-0.09%	-0.42%	-0.66%	-0.88%
Cyprus	-0.48%	-0.88%	-1.11%	-1.04%
Czech Republic	0.79%	0.35%	0.18%	-1.19%
Denmark	-0.13%	0.10%	0.29%	0.55%
Estonia	-3.28%	-2.19%	-2.00%	-1.88%
Finland	0.63%	0.59%	0.54%	0.47%
France	0.17%	0.25%	0.25%	0.24%
Germany	0.39%	0.37%	0.38%	0.56%
Greece	-0.25%	-0.54%	-0.76%	-2.54%
Hungary	0.29%	-0.17%	-0.42%	-1.61%
Ireland	-0.14%	-0.03%	0.11%	0.20%
Italy	0.17%	0.03%	-0.01%	0.01%
Latvia	0.48%	-0.21%	-0.75%	-1.94%
Lithuania	-0.92%	-1.21%	-1.22%	-1.27%
Luxembourg	-2.31%	-1.84%	-1.47%	-0.19%
Malta	0.45%	0.47%	0.51%	0.80%
Netherlands	-1.11%	-0.71%	-0.38%	0.06%
Poland	0.81%	0.41%	0.06%	-0.26%
Portugal	0.00%	-0.28%	-0.42%	-1.24%
Romania	0.86%	0.51%	0.07%	-0.65%
Slovakia	0.83%	0.40%	-0.03%	-0.77%
Slovenia	0.37%	-0.34%	-0.91%	-1.10%
Spain	-0.04%	-0.29%	-0.47%	-0.57%
Sweden	0.18%	0.22%	0.30%	0.40%
United Kingdom	0.32%	0.29%	0.28%	0.28%
European Union	0.15%	0.10%	0.07%	0.02%
$<$10'000	0.68%	0.27%	-0.11%	-0.81%
10'000-20'000	0.26%	-0.09%	-0.32%	-1.23%
20'000-30'000	0.06%	-0.14%	-0.25%	-0.42%
$>$30'000	0.13%	0.18%	0.23%	0.34%
ETS price[b]	46	46	46	47
Average ESD CO_2 price[b]	209	177	174	145

[a] in % of households consumption.
[b] in $€_{2017}$ per ton of CO_2.

5. Conclusion

In its new proposal, the EC has allocated an emissions target for non-ETS sectors by MSs according to GDP per capita. This proposal raises several questions, as the targets do not take into account cost-effective potentials. The EC has acknowledged this issue by proposing several flexibility mechanisms. The current article, to the best of the author's knowledge, constitutes a first assessment of these flexibility mechanisms allowed within the EU Effort Sharing Decision for the year 2030. Figure 2 summarizes my main findings.

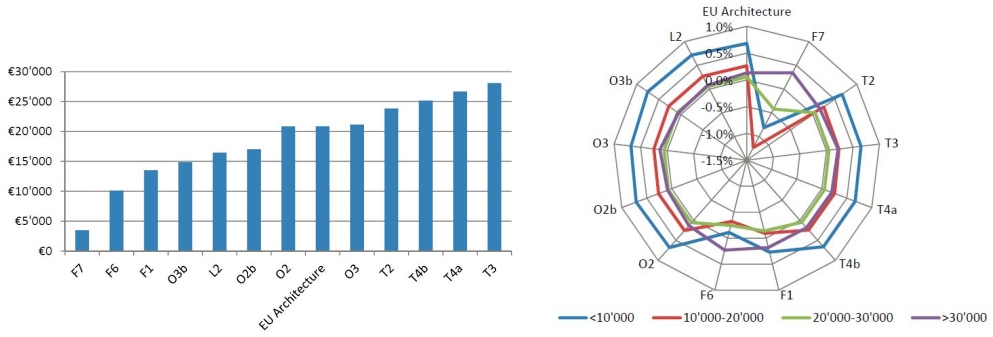

Figure 2: EU welfare cost in billion € (right) and welfare cost in % of household consumption per MS income level (left) - year 2030

In term of overall efficiency, i.e., aggregated EU welfare cost, the most promising mechanism is the one that allows "inter-Member state flexibility". Indeed, it tends to equalize CO_2 taxes, and in this way, marginal abatement costs among MSs. The downside of this mechanism is the use of "hot air" from several MSs and therefore less EU CO_2 emissions abatements in 2030. Using offsetting from LULUCF reduces the EU welfare cost slightly by 4.4 billion €. Allowing trading between ETS and non-ETS allocations also reduces the EU welfare cost if large CO_2 emitters (Germany, United Kingdom, and France) can participate in this mechanism (options Ob2 and Ob3). In contrast, the present study finds that options T increase the EU welfare cost and fail to balance the burden among high-income MSs. Unfortunately, the way that the policy options T were designed is rather non-transparent, as the scenarios used to design the options have not been published. However, the current analysis demonstrates that the design of this policy option strongly depends on baseline assumptions and abatement costs by countries. Indeed, target adjustment mechanisms open up the Pandora's Box of lobbying and bargaining powers (Viguier et al., 2006) between European actors (firms, States,

NGOs). In addition, this option cannot take into account unforeseen future events, such as economic downturns or energy price shocks, that would alter the cost hierarchy between countries and necessitate a redefinition of burden-sharing. Finally, allowing fully fungible ESD allocations (option F7) results in very low aggregated EU welfare cost, estimated at 3.5 billion €. In this scenario, the ESD CO_2 taxes are equal to 145 € with an ETS price that equals 47 €.

If we are concerned about fairness among MSs and their economic capacities to implement decarbonization policies, the "inter-Member state flexibility" mechanism is the most attractive one. With this mechanism, the welfare of low-income MSs is improving and the richest MSs bear the cost of the climate policy. As can been seen in Figure 2, the other options do not change the distribution of burden-sharing significantly.

To conclude, with respect to efficiency and equity, it is essential to promote trading between MS ESD emissions. The existing limit of 5% trading is too small and must be increased. My simulations show that a 15% limit can significantly reduce the EU's mitigation cost and capture most of the gain from allowances trading. This conclusion is in line with further assessments of EU burden-sharing (Böhringer et al., 2016, 2009; Cara and Jayet, 2011; Capros et al., 2011; Tol, 2009; Bernard and Vielle, 2009). However, as the required GHG emissions abatements increase (from 10% in 2020 to 30% in 2030), some MSs may not be able to meet their targets or may bear welfare costs that are too high. As pointed out by Sartor et al. (2015), such a failure would throw into question the credibility of the European Effort Sharing Decision.

Finally, I compare my results with other models (i.e., macro-economic ones) and find similar carbon prices. Indeed, Capros et al. (2014) report a CO_2 price ranging from 91 (GEM-E3 model) to 60 $€_{2005}$ (NEMESIS model) in a "basic decarbonisation scenario" assuming that all technological decarbonisation options are available and used according to cost optimality. With GEMINI-E3, this scenario means that a uniform carbon price is implemented across MSs and emissions (ETS and ESD). In this case[5], I find a CO_2 price that equals 70 $€_{2017}$.

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[5]See Table 22 in the Appendix.

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7. Appendix: Scenario detailed results

Table 10: Scenario Option T2 - year 2030

	Components of welfare cost[a]			CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	DWL	ETS	ESD	Total	ESD sectors
Austria	-0.39%	-1.67%	1.28%	-22.8%	-22.1%	-22.3%	343
Belgium	-0.71%	-1.68%	0.97%	-21.8%	-22.3%	-22.2%	282
Bulgaria	0.32%	-0.25%	0.57%	-38.9%	1.6%	-28.8%	0
Croatia	-0.08%	-0.29%	0.21%	-31.9%	0.9%	-12.5%	0
Cyprus	-0.49%	-0.93%	0.44%	-9.9%	-9.4%	-9.6%	72
Czech Republic	0.78%	0.04%	0.74%	-46.8%	1.1%	-32.4%	0
Denmark	-0.07%	-1.47%	1.39%	-44.2%	-22.4%	-31.4%	314
Estonia	-3.30%	-5.83%	2.53%	-10.5%	-19.2%	-13.9%	226
Finland	0.62%	-0.47%	1.09%	-31.2%	-14.3%	-24.2%	219
France	0.20%	-0.66%	0.86%	-23.6%	-21.3%	-21.9%	249
Germany	0.43%	-1.67%	2.10%	-38.2%	-30.7%	-34.9%	597
Greece	-0.26%	-0.34%	0.08%	-30.2%	2.7%	-15.1%	0
Hungary	0.28%	0.08%	0.20%	-28.5%	0.7%	-10.8%	0
Ireland	-0.23%	-1.41%	1.18%	-33.2%	-17.9%	-23.8%	139
Italy	0.17%	-0.15%	0.32%	-27.4%	-7.4%	-16.2%	75
Latvia	0.46%	0.44%	0.02%	-17.3%	0.8%	-5.6%	0
Lithuania	-0.93%	-1.13%	0.19%	-15.0%	-16.8%	-16.0%	141
Luxembourg	-1.88%	-2.94%	1.06%	-19.0%	-27.8%	-26.2%	252
Malta	0.45%	-3.97%	4.42%	-10.9%	-44.6%	-30.5%	315
Netherlands	-0.94%	-2.62%	1.68%	-26.1%	-22.7%	-24.1%	309
Poland	0.80%	0.02%	0.78%	-47.7%	-16.1%	-36.6%	41
Portugal	0.00%	-0.06%	0.06%	-34.2%	1.6%	-13.5%	0
Romania	0.85%	0.42%	0.43%	-37.0%	-1.2%	-23.6%	0
Slovakia	0.79%	0.43%	0.37%	-28.3%	0.4%	-15.9%	0
Slovenia	0.35%	0.11%	0.24%	-33.4%	-2.6%	-16.4%	26
Spain	-0.04%	-0.11%	0.07%	-31.9%	-0.5%	-15.8%	11
Sweden	0.17%	-1.25%	1.43%	-23.3%	-22.2%	-22.5%	454
United Kingdom	0.34%	-0.22%	0.56%	-37.8%	-18.9%	-27.2%	177
European Union	0.17%	-0.77%	0.95%	-35.4%	-16.8%	-25.8%	209
ETS price[c]				45			

[a] in % of households consumption.

[b] change in % with respect to the reference scenario.

[c] in €$_{2017}$ per ton of CO_2.

Table 11: Scenario Option T3 - year 2030

	Components of welfare cost[a]			CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	DWL	ETS	ESD	Total	ESD sectors
Austria	-0.33%	-1.22%	0.89%	-22.2%	-17.3%	-19.0%	242
Belgium	-0.55%	-1.22%	0.67%	-21.4%	-17.7%	-19.0%	199
Bulgaria	0.29%	-0.28%	0.57%	-38.9%	1.6%	-28.8%	0
Croatia	-0.06%	-0.28%	0.22%	-31.9%	0.8%	-12.5%	0
Cyprus	-0.51%	-0.95%	0.44%	-9.9%	-9.5%	-9.7%	73
Czech Republic	0.77%	0.04%	0.73%	-46.8%	1.0%	-32.3%	0
Denmark	0.03%	-1.03%	1.05%	-44.1%	-17.6%	-28.5%	221
Estonia	-3.35%	-5.90%	2.54%	-10.4%	-19.3%	-13.9%	227
Finland	0.66%	-0.54%	1.20%	-31.3%	-15.8%	-24.8%	249
France	0.23%	-0.72%	0.95%	-23.7%	-22.6%	-22.9%	273
Germany	0.47%	-1.78%	2.25%	-38.3%	-31.9%	-35.4%	641
Greece	-0.28%	-0.35%	0.08%	-30.1%	2.7%	-15.0%	0
Hungary	0.26%	0.07%	0.20%	-28.5%	0.7%	-10.8%	0
Ireland	-0.21%	-1.08%	0.86%	-33.0%	-13.3%	-20.9%	96
Italy	0.16%	-0.16%	0.32%	-27.4%	-7.5%	-16.3%	76
Latvia	0.44%	0.43%	0.02%	-17.2%	0.8%	-5.6%	0
Lithuania	-0.95%	-1.14%	0.19%	-15.0%	-16.9%	-16.0%	141
Luxembourg	-1.65%	-2.40%	0.74%	-18.9%	-23.7%	-22.8%	199
Malta	0.43%	-4.00%	4.43%	-10.8%	-44.6%	-30.5%	315
Netherlands	-0.71%	-1.91%	1.20%	-25.8%	-17.9%	-21.2%	219
Poland	0.79%	0.01%	0.78%	-47.6%	-16.2%	-36.6%	42
Portugal	-0.01%	-0.07%	0.06%	-34.2%	1.6%	-13.5%	0
Romania	0.83%	0.41%	0.43%	-37.0%	-1.1%	-23.6%	0
Slovakia	0.75%	0.40%	0.35%	-28.2%	0.4%	-15.8%	0
Slovenia	0.33%	0.10%	0.24%	-33.4%	-2.7%	-16.5%	26
Spain	-0.05%	-0.12%	0.07%	-31.9%	-0.6%	-15.8%	11
Sweden	0.18%	-1.37%	1.55%	-23.5%	-23.6%	-23.5%	495
United Kingdom	0.36%	-0.26%	0.62%	-37.9%	-20.3%	-28.0%	198
European Union	0.21%	-0.76%	0.96%	-35.4%	-16.8%	-25.8%	210
ETS price[c]				45			

[a] in % of households consumption.
[b] change in % with respect to the reference scenario.
[c] in €$_{2017}$ per ton of CO_2.

Table 12: Scenario Option T4a - year 2030

	Components of welfare cost[a]			CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	DWL	ETS	ESD	Total	ESD sectors
Austria	-0.38%	-1.55%	1.17%	-22.7%	-20.8%	-21.4%	314
Belgium	-0.61%	-1.43%	0.81%	-21.6%	-19.9%	-20.5%	235
Bulgaria	0.32%	-0.25%	0.57%	-38.9%	1.7%	-28.7%	0
Croatia	-0.09%	-0.29%	0.21%	-31.9%	0.9%	-12.4%	0
Cyprus	-0.51%	-0.94%	0.43%	-9.9%	-9.3%	-9.6%	72
Czech Republic	0.79%	0.05%	0.74%	-46.8%	1.1%	-32.3%	0
Denmark	-0.07%	-1.46%	1.39%	-44.2%	-22.3%	-31.3%	312
Estonia	-3.21%	-5.74%	2.52%	-10.5%	-19.1%	-13.9%	222
Finland	0.52%	-0.29%	0.81%	-30.9%	-10.0%	-22.2%	141
France	0.18%	-0.60%	0.78%	-23.4%	-20.0%	-20.9%	225
Germany	0.53%	-1.86%	2.39%	-38.4%	-32.9%	-35.9%	680
Greece	-0.28%	-0.35%	0.07%	-30.1%	2.7%	-15.0%	0
Hungary	0.28%	0.08%	0.20%	-28.5%	0.7%	-10.8%	0
Ireland	-0.23%	-1.60%	1.37%	-33.3%	-20.2%	-25.2%	163
Italy	0.17%	-0.15%	0.32%	-27.4%	-7.3%	-16.2%	74
Latvia	0.47%	0.45%	0.02%	-17.3%	0.8%	-5.6%	0
Lithuania	-0.91%	-1.11%	0.19%	-15.0%	-16.7%	-15.9%	139
Luxembourg	-1.92%	-3.07%	1.15%	-19.0%	-28.8%	-27.0%	264
Malta	0.43%	-3.98%	4.41%	-10.8%	-44.5%	-30.5%	314
Netherlands	-0.88%	-2.42%	1.54%	-26.1%	-21.4%	-23.3%	282
Poland	0.80%	0.02%	0.78%	-47.6%	-16.0%	-36.6%	41
Portugal	0.00%	-0.06%	0.06%	-34.2%	1.6%	-13.5%	0
Romania	0.85%	0.42%	0.43%	-37.0%	-1.1%	-23.6%	0
Slovakia	0.80%	0.44%	0.37%	-28.3%	0.4%	-15.9%	0
Slovenia	0.36%	0.13%	0.23%	-33.4%	-2.6%	-16.4%	25
Spain	-0.04%	-0.11%	0.07%	-31.9%	-0.4%	-15.7%	10
Sweden	0.17%	-1.25%	1.42%	-23.3%	-22.1%	-22.5%	451
United Kingdom	0.34%	-0.22%	0.56%	-37.7%	-18.8%	-27.1%	175
European Union	0.20%	-0.79%	0.98%	-35.4%	-16.8%	-25.8%	212
ETS price[c]				45			

[a] in % of households consumption.
[b] change in % with respect to the reference scenario.
[c] in €$_{2017}$ per ton of CO_2.

Table 13: Scenario Option T4b - year 2030

	Components of welfare cost[a]			CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	DWL	ETS	ESD	Total	ESD sectors
Austria	-0.41%	-1.92%	1.51%	-23.1%	-24.5%	-24.0%	402
Belgium	-0.67%	-1.55%	0.88%	-21.7%	-21.1%	-21.3%	257
Bulgaria	0.30%	-0.27%	0.57%	-38.9%	1.7%	-28.7%	0
Croatia	-0.08%	-0.29%	0.21%	-31.9%	0.9%	-12.4%	0
Cyprus	-0.50%	-0.94%	0.44%	-9.9%	-9.3%	-9.6%	72
Czech Republic	0.78%	0.04%	0.74%	-46.8%	1.1%	-32.3%	0
Denmark	-0.05%	-1.34%	1.29%	-44.2%	-21.1%	-30.6%	287
Estonia	-3.32%	-5.84%	2.51%	-10.4%	-19.1%	-13.8%	225
Finland	0.66%	-0.53%	1.19%	-31.3%	-15.6%	-24.8%	246
France	0.15%	-0.56%	0.70%	-23.2%	-18.8%	-20.0%	205
Germany	0.42%	-1.67%	2.09%	-38.2%	-30.7%	-34.8%	595
Greece	-0.27%	-0.34%	0.08%	-30.1%	2.6%	-15.1%	0
Hungary	0.28%	0.07%	0.20%	-28.5%	0.7%	-10.8%	0
Ireland	-0.24%	-1.33%	1.09%	-33.1%	-16.7%	-23.0%	128
Italy	0.16%	-0.16%	0.32%	-27.4%	-7.3%	-16.2%	75
Latvia	0.45%	0.43%	0.02%	-17.3%	0.8%	-5.6%	0
Lithuania	-0.94%	-1.13%	0.19%	-14.9%	-16.7%	-15.9%	140
Luxembourg	-1.64%	-2.37%	0.73%	-18.9%	-23.5%	-22.7%	197
Malta	0.39%	-4.01%	4.41%	-10.8%	-44.5%	-30.4%	316
Netherlands	-0.81%	-2.22%	1.41%	-25.9%	-20.2%	-22.6%	260
Poland	0.79%	0.01%	0.78%	-47.6%	-16.0%	-36.6%	41
Portugal	-0.01%	-0.07%	0.06%	-34.2%	1.6%	-13.5%	0
Romania	0.84%	0.41%	0.43%	-37.0%	-1.1%	-23.6%	0
Slovakia	0.79%	0.42%	0.37%	-28.3%	0.4%	-15.9%	0
Slovenia	0.34%	0.11%	0.23%	-33.4%	-2.6%	-16.4%	25
Spain	-0.05%	-0.12%	0.07%	-31.9%	-0.4%	-15.7%	10
Sweden	0.17%	-1.25%	1.42%	-23.3%	-22.1%	-22.5%	452
United Kingdom	0.43%	-0.32%	0.76%	-38.2%	-22.7%	-29.5%	239
European Union	0.18%	-0.76%	0.94%	-35.4%	-16.8%	-25.8%	209
ETS price[c]				45			

[a] in % of households consumption.
[b] change in % with respect to the reference scenario.
[c] in €$_{2017}$ per ton of CO_2.

Table 14: Scenario Option O2 - year 2030

	Components of welfare cost[a]			CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	DWL	ETS	ESD	Total	ESD sectors
Austria	-0.38%	-1.78%	1.40%	-23.4%	-23.3%	-23.3%	370
Belgium	-0.75%	-1.81%	1.06%	-22.3%	-23.5%	-23.1%	305
Bulgaria	0.31%	-0.29%	0.60%	-39.5%	1.6%	-29.3%	0
Croatia	-0.05%	-0.29%	0.23%	-32.4%	0.8%	-12.7%	0
Cyprus	-0.47%	-0.90%	0.43%	-10.2%	-9.3%	-9.7%	71
Czech Republic	0.79%	0.03%	0.76%	-47.5%	1.0%	-32.8%	0
Denmark	-0.08%	-1.58%	1.50%	-44.8%	-23.6%	-32.3%	339
Estonia	-3.25%	-5.77%	2.52%	-10.8%	-19.1%	-14.0%	222
Finland	0.54%	-0.36%	0.90%	-31.5%	-11.4%	-23.2%	165
France	0.17%	-0.61%	0.78%	-23.8%	-20.0%	-21.0%	225
Germany	0.38%	-1.58%	1.96%	-38.7%	-29.5%	-34.6%	553
Greece	-0.23%	-0.32%	0.09%	-30.8%	2.5%	-15.4%	0
Hungary	0.28%	0.07%	0.21%	-29.0%	0.6%	-11.0%	0
Ireland	-0.22%	-1.93%	1.71%	-34.0%	-23.7%	-27.7%	207
Italy	0.17%	-0.16%	0.32%	-27.9%	-7.3%	-16.4%	74
Latvia	0.46%	0.44%	0.02%	-17.7%	0.8%	-5.8%	0
Lithuania	-0.96%	-1.14%	0.19%	-15.2%	-16.7%	-16.0%	139
Luxembourg	-2.09%	-3.67%	1.58%	-19.6%	-33.0%	-30.5%	331
Malta	0.35%	-3.74%	4.09%	-11.1%	-43.2%	-29.8%	296
Netherlands	-0.99%	-2.80%	1.81%	-26.5%	-23.8%	-24.9%	333
Poland	0.82%	0.02%	0.81%	-48.3%	-16.0%	-37.0%	41
Portugal	0.01%	-0.06%	0.07%	-34.7%	1.5%	-13.8%	0
Romania	0.85%	0.41%	0.44%	-37.6%	-1.2%	-24.0%	0
Slovakia	0.78%	0.40%	0.38%	-28.8%	0.4%	-16.2%	0
Slovenia	0.34%	0.10%	0.24%	-34.1%	-2.5%	-16.6%	25
Spain	-0.04%	-0.11%	0.07%	-32.4%	-0.4%	-15.9%	9
Sweden	0.14%	-1.05%	1.20%	-23.3%	-19.5%	-20.7%	379
United Kingdom	0.31%	-0.19%	0.50%	-38.1%	-17.5%	-26.6%	157
European Union	0.15%	-0.76%	0.91%	-35.9%	-16.4%	-25.8%	199
ETS price[c]				47			

[a] in % of households consumption.
[b] change in % with respect to the reference scenario.
[c] in €$_{2017}$ per ton of CO_2.

Table 15: Scenario Option O3 - year 2030

	Components of welfare cost[a]			CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	DWL	ETS	ESD	Total	ESD sectors
Austria	-0.34%	-1.52%	1.18%	-23.5%	-20.8%	-21.7%	313
Belgium	-0.68%	-1.57%	0.89%	-22.5%	-21.1%	-21.6%	258
Bulgaria	0.28%	-0.34%	0.62%	-40.1%	1.5%	-29.7%	0
Croatia	-0.02%	-0.28%	0.26%	-32.9%	0.6%	-13.0%	0
Cyprus	-0.46%	-0.89%	0.44%	-10.5%	-9.3%	-9.8%	70
Czech Republic	0.79%	0.01%	0.78%	-48.1%	1.0%	-33.2%	0
Denmark	-0.03%	-1.34%	1.31%	-45.3%	-21.1%	-31.1%	285
Estonia	-3.22%	-5.75%	2.53%	-11.1%	-19.1%	-14.2%	220
Finland	0.46%	-0.27%	0.73%	-31.8%	-8.6%	-22.2%	118
France	0.17%	-0.61%	0.78%	-24.1%	-20.0%	-21.1%	224
Germany	0.37%	-1.59%	1.96%	-39.3%	-29.5%	-35.0%	552
Greece	-0.21%	-0.31%	0.10%	-31.3%	2.4%	-15.8%	0
Hungary	0.27%	0.05%	0.22%	-29.4%	0.5%	-11.2%	0
Ireland	-0.25%	-1.53%	1.28%	-34.2%	-19.1%	-24.9%	151
Italy	0.16%	-0.16%	0.33%	-28.3%	-7.3%	-16.5%	73
Latvia	0.43%	0.41%	0.02%	-18.0%	0.7%	-5.9%	0
Lithuania	-0.99%	-1.18%	0.18%	-15.4%	-16.7%	-16.1%	139
Luxembourg	-1.84%	-2.99%	1.15%	-19.9%	-28.8%	-27.2%	266
Malta	0.27%	-3.53%	3.80%	-11.4%	-41.8%	-29.1%	278
Netherlands	-0.87%	-2.41%	1.54%	-26.7%	-21.4%	-23.6%	283
Poland	0.84%	0.01%	0.83%	-49.0%	-16.0%	-37.4%	41
Portugal	0.01%	-0.06%	0.08%	-35.2%	1.3%	-14.1%	0
Romania	0.85%	0.40%	0.45%	-38.1%	-1.3%	-24.4%	0
Slovakia	0.74%	0.36%	0.38%	-29.2%	0.4%	-16.4%	0
Slovenia	0.32%	0.08%	0.24%	-34.7%	-2.5%	-16.9%	24
Spain	-0.04%	-0.12%	0.08%	-32.8%	-0.4%	-16.1%	9
Sweden	0.12%	-0.87%	0.99%	-23.4%	-17.0%	-19.0%	311
United Kingdom	0.31%	-0.20%	0.50%	-38.7%	-17.5%	-26.8%	156
European Union	0.15%	-0.72%	0.88%	-36.4%	-15.9%	-25.8%	190
ETS price[c]				49			

[a] in % of households consumption.
[b] change in % with respect to the reference scenario.
[c] in €$_{2017}$ per ton of CO_2.

Table 16: Scenario Option O2b - year 2030

	Components of welfare cost[a]			CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	DWL	ETS	ESD	Total	ESD sectors
Austria	-0.36%	-1.76%	1.40%	-24.3%	-23.3%	-23.6%	367
Belgium	-0.77%	-1.83%	1.06%	-23.3%	-23.5%	-23.4%	304
Bulgaria	0.29%	-0.37%	0.67%	-41.0%	1.4%	-30.4%	0
Croatia	0.02%	-0.28%	0.29%	-33.5%	0.5%	-13.3%	0
Cyprus	-0.43%	-0.87%	0.44%	-11.0%	-9.3%	-10.0%	69
Czech Republic	0.81%	-0.01%	0.82%	-48.9%	0.9%	-33.8%	0
Denmark	-0.08%	-1.59%	1.52%	-46.1%	-23.6%	-32.8%	337
Estonia	-3.30%	-5.83%	2.54%	-11.6%	-19.1%	-14.5%	222
Finland	0.53%	-0.38%	0.91%	-32.7%	-11.4%	-23.9%	164
France	0.13%	-0.51%	0.64%	-24.4%	-17.5%	-19.4%	185
Germany	0.30%	-1.42%	1.72%	-40.0%	-27.3%	-34.3%	479
Greece	-0.17%	-0.29%	0.12%	-32.1%	2.2%	-16.3%	0
Hungary	0.29%	0.05%	0.24%	-30.0%	0.5%	-11.5%	0
Ireland	-0.23%	-1.94%	1.70%	-35.1%	-23.7%	-28.1%	205
Italy	0.17%	-0.17%	0.34%	-28.9%	-7.3%	-16.8%	72
Latvia	0.43%	0.41%	0.02%	-18.6%	0.7%	-6.2%	0
Lithuania	-1.03%	-1.21%	0.18%	-15.8%	-16.7%	-16.3%	139
Luxembourg	-2.04%	-3.62%	1.58%	-20.6%	-33.0%	-30.7%	329
Malta	0.42%	-3.66%	4.08%	-11.9%	-43.2%	-30.1%	293
Netherlands	-1.01%	-2.83%	1.81%	-27.3%	-23.8%	-25.3%	332
Poland	0.87%	0.01%	0.87%	-49.9%	-16.0%	-38.0%	41
Portugal	0.03%	-0.06%	0.09%	-35.8%	1.1%	-14.4%	0
Romania	0.86%	0.39%	0.47%	-38.9%	-1.4%	-24.9%	0
Slovakia	0.74%	0.34%	0.39%	-29.8%	0.3%	-16.8%	0
Slovenia	0.32%	0.07%	0.25%	-35.5%	-2.5%	-17.3%	24
Spain	-0.03%	-0.12%	0.09%	-33.4%	-0.4%	-16.4%	8
Sweden	0.13%	-1.07%	1.19%	-24.1%	-19.5%	-21.0%	378
United Kingdom	0.27%	-0.14%	0.41%	-39.1%	-15.0%	-25.6%	123
European Union	0.12%	-0.71%	0.83%	-37.1%	-15.3%	-25.8%	179
ETS price[c]				51			

[a] in % of households consumption.
[b] change in % with respect to the reference scenario.
[c] in €$_{2017}$ per ton of CO_2.

Table 17: Scenario Option O3b - year 2030

	Components of welfare cost[a]			CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	DWL	ETS	ESD	Total	ESD sectors
Austria	-0.30%	-1.50%	1.20%	-25.4%	-20.8%	-22.4%	307
Belgium	-0.73%	-1.61%	0.88%	-24.4%	-21.1%	-22.3%	256
Bulgaria	0.26%	-0.52%	0.77%	-43.1%	1.2%	-32.0%	0
Croatia	0.13%	-0.26%	0.39%	-35.0%	0.0%	-14.2%	0
Cyprus	-0.38%	-0.83%	0.45%	-12.1%	-9.3%	-10.5%	66
Czech Republic	0.84%	-0.07%	0.91%	-50.9%	0.7%	-35.3%	0
Denmark	-0.02%	-1.37%	1.35%	-47.8%	-21.1%	-32.1%	282
Estonia	-3.31%	-5.87%	2.57%	-12.8%	-19.1%	-15.3%	218
Finland	0.45%	-0.31%	0.76%	-34.1%	-8.6%	-23.6%	115
France	0.09%	-0.43%	0.52%	-25.3%	-15.0%	-17.8%	148
Germany	0.22%	-1.29%	1.51%	-41.8%	-25.1%	-34.4%	411
Greece	-0.09%	-0.24%	0.15%	-34.1%	1.7%	-17.6%	0
Hungary	0.28%	0.01%	0.27%	-31.4%	0.2%	-12.2%	0
Ireland	-0.27%	-1.56%	1.28%	-36.4%	-19.1%	-25.8%	148
Italy	0.17%	-0.18%	0.35%	-30.3%	-7.3%	-17.4%	70
Latvia	0.39%	0.36%	0.03%	-19.9%	0.5%	-6.7%	0
Lithuania	-1.13%	-1.30%	0.18%	-16.6%	-16.7%	-16.6%	138
Luxembourg	-1.74%	-2.89%	1.14%	-22.0%	-28.8%	-27.6%	262
Malta	0.39%	-3.38%	3.77%	-13.0%	-41.8%	-29.8%	273
Netherlands	-0.91%	-2.46%	1.54%	-28.3%	-21.4%	-24.3%	280
Poland	0.95%	-0.01%	0.95%	-52.0%	-16.0%	-39.4%	40
Portugal	0.05%	-0.07%	0.12%	-37.3%	0.7%	-15.3%	0
Romania	0.88%	0.36%	0.52%	-40.8%	-1.6%	-26.1%	0
Slovakia	0.65%	0.24%	0.41%	-31.3%	0.3%	-17.6%	0
Slovenia	0.28%	0.01%	0.27%	-37.6%	-2.5%	-18.2%	22
Spain	-0.02%	-0.13%	0.10%	-34.8%	-0.4%	-17.1%	6
Sweden	0.09%	-0.90%	0.99%	-24.9%	-17.0%	-19.5%	309
United Kingdom	0.23%	-0.11%	0.34%	-40.7%	-12.4%	-24.8%	93
European Union	0.11%	-0.63%	0.74%	-38.7%	-13.8%	-25.9%	152
ETS price[c]				57			

[a] in % of households consumption.
[b] change in % with respect to the reference scenario.
[c] in €$_{2017}$ per ton of CO_2.

Table 18: Scenario Option L2 - year 2030

	Components of welfare cost[a]			CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	DWL	ETS	ESD	Total	ESD sectors
Austria	-0.40%	-1.91%	1.51%	-23.3%	-24.5%	-24.1%	400
Belgium	-0.80%	-1.94%	1.14%	-22.2%	-24.7%	-23.8%	327
Bulgaria	0.27%	-0.30%	0.57%	-39.1%	1.4%	-29.0%	0
Croatia	-0.02%	-0.27%	0.25%	-32.1%	0.6%	-12.7%	0
Cyprus	-0.36%	-0.68%	0.32%	-10.1%	-6.7%	-8.1%	52
Czech Republic	0.76%	0.02%	0.74%	-47.0%	0.9%	-32.5%	0
Denmark	0.03%	-0.96%	0.99%	-44.2%	-16.7%	-28.0%	203
Estonia	-2.84%	-4.85%	2.01%	-10.6%	-16.6%	-13.0%	185
Finland	0.48%	-0.32%	0.80%	-31.0%	-10.1%	-22.4%	142
France	0.09%	-0.43%	0.53%	-23.0%	-15.5%	-17.5%	155
Germany	0.32%	-1.48%	1.80%	-38.2%	-28.2%	-33.7%	509
Greece	-0.19%	-0.28%	0.09%	-30.4%	2.2%	-15.4%	0
Hungary	0.28%	0.06%	0.22%	-28.7%	0.5%	-11.0%	0
Ireland	-0.16%	-0.72%	0.57%	-33.0%	-7.9%	-17.6%	53
Italy	0.15%	-0.14%	0.29%	-27.5%	-6.2%	-15.6%	61
Latvia	0.45%	0.43%	0.02%	-17.4%	0.5%	-5.8%	0
Lithuania	0.13%	0.10%	0.03%	-13.8%	0.3%	-6.0%	0
Luxembourg	-2.23%	-4.27%	2.04%	-19.4%	-36.6%	-33.5%	394
Malta	0.55%	-3.81%	4.36%	-11.0%	-44.3%	-30.4%	307
Netherlands	-1.00%	-2.75%	1.76%	-26.2%	-23.5%	-24.6%	324
Poland	0.80%	0.07%	0.73%	-47.8%	-12.5%	-35.5%	28
Portugal	0.02%	-0.05%	0.08%	-34.4%	1.1%	-13.9%	0
Romania	0.81%	0.38%	0.42%	-37.2%	-1.2%	-23.7%	0
Slovakia	0.73%	0.36%	0.37%	-28.5%	0.3%	-16.0%	0
Slovenia	0.45%	0.28%	0.17%	-33.6%	0.5%	-14.8%	2
Spain	-0.02%	-0.08%	0.06%	-32.0%	0.9%	-15.1%	0
Sweden	0.11%	-1.04%	1.16%	-23.1%	-19.3%	-20.5%	367
United Kingdom	0.26%	-0.18%	0.44%	-37.6%	-16.2%	-25.6%	138
European Union	0.12%	-0.68%	0.80%	-35.4%	-14.5%	-24.7%	173
ETS price[c]				46			

[a] in % of households consumption.
[b] change in % with respect to the reference scenario.
[c] in €$_{2017}$ per ton of CO_2.

Table 19: Scenario Option F1 - year 2030

	Components of welfare cost[a]				CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	CO_2 Trade	DWL	ETS	ESD	Total	ESD sectors
Austria	-0.22%	-1.61%	0.10%	1.28%	-22.9%	-21.9%	-22.3%	311
Belgium	-0.59%	-1.66%	0.11%	0.97%	-21.7%	-22.1%	-22.0%	269
Bulgaria	-0.37%	-0.50%	-0.33%	0.46%	-38.5%	1.7%	-28.5%	0
Croatia	-0.42%	-0.40%	-0.26%	0.24%	-31.9%	0.9%	-12.4%	0
Cyprus	-0.88%	-1.39%	-0.16%	0.66%	-9.8%	-13.8%	-12.1%	65
Czech Republic	0.35%	-0.08%	-0.23%	0.67%	-46.9%	1.2%	-32.4%	0
Denmark	0.10%	-1.43%	0.10%	1.43%	-44.5%	-22.3%	-31.4%	281
Estonia	-2.19%	-4.30%	0.31%	1.81%	-10.7%	-15.0%	-12.4%	163
Finland	0.59%	-0.35%	0.07%	0.88%	-31.3%	-11.1%	-22.9%	159
France	0.25%	-0.42%	0.09%	0.58%	-23.2%	-16.0%	-17.9%	162
Germany	0.37%	-1.28%	0.08%	1.57%	-37.9%	-26.0%	-32.6%	363
Greece	-0.54%	-0.41%	-0.18%	0.05%	-30.0%	2.2%	-15.2%	0
Hungary	-0.17%	-0.04%	-0.26%	0.13%	-28.6%	0.9%	-10.7%	0
Ireland	-0.03%	-2.02%	0.14%	1.84%	-33.7%	-24.8%	-28.2%	199
Italy	0.03%	-0.34%	-0.11%	0.47%	-28.0%	-11.9%	-19.0%	132
Latvia	-0.21%	-0.03%	-0.17%	-0.01%	-16.8%	-3.6%	-8.3%	75
Lithuania	-1.21%	-1.38%	-0.04%	0.20%	-14.5%	-17.8%	-16.4%	159
Luxembourg	-1.84%	-3.69%	0.14%	1.71%	-19.5%	-34.0%	-31.3%	336
Malta	0.47%	-3.47%	0.12%	3.82%	-11.0%	-41.7%	-28.9%	241
Netherlands	-0.71%	-2.51%	0.14%	1.66%	-25.9%	-22.5%	-23.9%	277
Poland	0.41%	-0.21%	-0.21%	0.83%	-47.7%	-20.2%	-38.1%	107
Portugal	-0.28%	-0.14%	-0.17%	0.02%	-34.3%	1.5%	-13.6%	0
Romania	0.51%	0.29%	-0.19%	0.41%	-37.1%	-2.5%	-24.2%	72
Slovakia	0.40%	0.23%	-0.17%	0.34%	-28.3%	-2.2%	-17.0%	83
Slovenia	-0.34%	-0.48%	-0.19%	0.33%	-33.6%	-7.4%	-19.1%	69
Spain	-0.29%	-0.33%	-0.11%	0.16%	-32.4%	-5.4%	-18.5%	71
Sweden	0.22%	-0.94%	0.07%	1.09%	-22.9%	-18.2%	-19.7%	293
United Kingdom	0.29%	-0.21%	0.00%	0.50%	-37.8%	-17.5%	-26.4%	159
European Union	0.10%	-0.71%	0.00%	0.81%	-35.4%	-16.2%	-25.5%	177
ETS price[c]					46			
ESD quota price[c]						159		

[a] in % of households consumption.
[b] change in % with respect to the reference scenario.
[c] in €$_{2017}$ per ton of CO_2.

Table 20: Scenario Option F6 - year 2030

	Components of welfare cost[a]				CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	CO_2 Trade	DWL	ETS	ESD	Total	ESD sectors
Austria	-0.01%	-1.21%	0.20%	1.00%	-22.5%	-18.2%	-19.7%	239
Belgium	-0.32%	-1.27%	0.21%	0.74%	-21.5%	-18.4%	-19.5%	206
Bulgaria	-1.00%	-0.73%	-0.64%	0.38%	-38.5%	1.9%	-28.5%	0
Croatia	-0.66%	-0.47%	-0.50%	0.32%	-31.9%	0.8%	-12.5%	0
Cyprus	-1.11%	-1.75%	-0.31%	0.95%	-9.8%	-18.4%	-14.8%	102
Czech Republic	0.18%	-0.13%	-0.33%	0.64%	-46.9%	1.2%	-32.4%	155
Denmark	0.29%	-1.08%	0.19%	1.18%	-44.5%	-18.6%	-29.3%	219
Estonia	-2.00%	-4.05%	0.36%	1.68%	-10.8%	-14.3%	-12.1%	155
Finland	0.54%	-0.38%	0.07%	0.85%	-31.2%	-10.9%	-22.8%	155
France	0.25%	-0.40%	0.10%	0.55%	-23.1%	-15.5%	-17.5%	155
Germany	0.38%	-1.03%	0.16%	1.25%	-37.7%	-22.5%	-30.9%	291
Greece	-0.76%	-0.44%	-0.35%	0.03%	-30.0%	2.1%	-15.2%	0
Hungary	-0.42%	-0.11%	-0.40%	0.09%	-28.5%	0.9%	-10.7%	155
Ireland	0.11%	-1.67%	0.28%	1.50%	-33.6%	-21.2%	-26.0%	167
Italy	-0.01%	-0.40%	-0.14%	0.53%	-28.1%	-13.4%	-19.9%	155
Latvia	-0.75%	-0.42%	-0.33%	0.00%	-16.8%	-8.7%	-11.6%	108
Lithuania	-1.22%	-1.39%	-0.03%	0.19%	-14.5%	-17.6%	-16.2%	155
Luxembourg	-1.47%	-3.12%	0.27%	1.38%	-19.5%	-30.8%	-28.8%	283
Malta	0.51%	-3.03%	0.23%	3.32%	-11.0%	-39.0%	-27.3%	217
Netherlands	-0.38%	-1.94%	0.28%	1.28%	-25.8%	-18.8%	-21.7%	217
Poland	0.06%	-0.45%	-0.41%	0.92%	-47.8%	-24.4%	-39.6%	121
Portugal	-0.42%	-0.18%	-0.25%	0.01%	-34.3%	1.5%	-13.6%	155
Romania	0.07%	0.02%	-0.36%	0.40%	-37.3%	-7.7%	-26.2%	89
Slovakia	-0.03%	-0.04%	-0.32%	0.33%	-28.4%	-7.3%	-19.3%	94
Slovenia	-0.91%	-1.03%	-0.37%	0.49%	-33.7%	-12.3%	-21.8%	104
Spain	-0.47%	-0.53%	-0.22%	0.28%	-32.8%	-10.3%	-21.3%	105
Sweden	0.30%	-0.67%	0.14%	0.83%	-22.5%	-14.3%	-16.9%	223
United Kingdom	0.28%	-0.21%	0.01%	0.49%	-37.8%	-17.2%	-26.3%	155
European Union	0.07%	-0.64%	0.00%	0.72%	-35.4%	-15.9%	-25.4%	174
ETS price[c]					46			
ESD quota price[c]						155		

[a] in % of households consumption.
[b] change in % with respect to the reference scenario.
[c] in €$_{2017}$ per ton of CO_2.

Table 21: Scenario Option F7 - year 2030

	Components of welfare cost[a]				CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	CO_2 Trade	DWL	ETS	ESD	Total	ESD sectors
Austria	0.35%	-0.63%	0.33%	0.64%	-21.8%	-12.1%	-15.4%	145
Belgium	-0.05%	-0.87%	0.32%	0.51%	-21.2%	-13.9%	-16.5%	145
Bulgaria	-4.95%	-3.13%	-1.92%	0.09%	-38.9%	-20.3%	-34.2%	145
Croatia	-0.88%	-1.63%	-1.16%	1.91%	-33.4%	-11.1%	-20.2%	145
Cyprus	-1.04%	-1.73%	-0.30%	0.99%	-9.9%	-19.0%	-15.2%	145
Czech Republic	-1.19%	-1.20%	-1.03%	1.03%	-47.2%	-17.8%	-38.3%	145
Denmark	0.55%	-0.64%	0.31%	0.88%	-44.4%	-13.0%	-25.9%	145
Estonia	-1.88%	-3.83%	0.39%	1.56%	-10.9%	-13.5%	-11.9%	145
Finland	0.47%	-0.38%	0.08%	0.78%	-31.0%	-10.2%	-22.4%	145
France	0.24%	-0.37%	0.11%	0.51%	-23.0%	-14.6%	-16.9%	145
Germany	0.56%	-0.44%	0.37%	0.63%	-37.3%	-12.6%	-26.3%	145
Greece	-2.54%	-1.30%	-1.36%	0.12%	-30.4%	-12.4%	-22.1%	145
Hungary	-1.61%	-1.22%	-1.04%	0.65%	-29.7%	-15.1%	-20.8%	145
Ireland	0.20%	-1.43%	0.35%	1.28%	-33.5%	-18.5%	-24.3%	145
Italy	0.01%	-0.38%	-0.11%	0.50%	-28.1%	-12.6%	-19.5%	145
Latvia	-1.94%	-1.46%	-0.64%	0.16%	-16.9%	-20.3%	-19.1%	145
Lithuania	-1.27%	-1.43%	-0.01%	0.17%	-14.9%	-17.1%	-16.1%	145
Luxembourg	-0.19%	-1.48%	0.73%	0.55%	-19.1%	-18.9%	-18.9%	145
Malta	0.80%	-1.56%	0.67%	1.69%	-11.0%	-27.1%	-20.4%	145
Netherlands	0.06%	-1.23%	0.45%	0.84%	-25.4%	-13.2%	-18.3%	145
Poland	-0.26%	-0.77%	-0.61%	1.12%	-48.2%	-29.4%	-41.6%	145
Portugal	-1.24%	-1.17%	-0.64%	0.56%	-35.4%	-14.5%	-23.3%	145
Romania	-0.65%	-0.56%	-0.67%	0.58%	-38.2%	-18.5%	-30.8%	145
Slovakia	-0.77%	-0.71%	-0.63%	0.57%	-29.0%	-19.3%	-24.8%	145
Slovenia	-1.10%	-1.26%	-0.39%	0.55%	-33.8%	-13.8%	-22.8%	145
Spain	-0.57%	-0.71%	-0.29%	0.44%	-33.1%	-14.9%	-23.8%	145
Sweden	0.40%	-0.35%	0.21%	0.54%	-22.0%	-9.1%	-13.2%	145
United Kingdom	0.28%	-0.20%	0.03%	0.45%	-37.7%	-16.3%	-25.7%	145
European Union	0.02%	-0.55%	0.00%	0.58%	-35.4%	-15.2%	-25.0%	145
ETS price[c]					47			
ESD quota price[c]						145		

[a] in % of households consumption.
[b] change in % with respect to the reference scenario.
[c] in €$_{2017}$ per ton of CO_2.

Table 22: Uniform tax scenario - year 2030

	Components of welfare cost[a]			CO_2 emissions[b]			CO_2 tax[c]
	Total	GTT	DWL	ETS	ESD	Total	ESD sectors
Austria	0.04%	-0.37%	0.41%	-26.3%	-7.3%	-13.8%	70
Belgium	-0.38%	-0.64%	0.26%	-25.9%	-8.1%	-14.3%	70
Bulgaria	-0.71%	-1.69%	0.98%	-46.7%	-14.0%	-38.5%	70
Croatia	0.65%	-0.66%	1.31%	-38.4%	-7.9%	-20.3%	70
Cyprus	-0.30%	-0.83%	0.53%	-14.3%	-11.0%	-12.4%	70
Czech Republic	0.70%	-0.62%	1.32%	-54.2%	-11.9%	-41.4%	70
Denmark	0.28%	-0.42%	0.70%	-50.6%	-7.7%	-25.3%	70
Estonia	-1.72%	-2.54%	0.82%	-15.4%	-7.3%	-12.2%	70
Finland	0.27%	-0.36%	0.63%	-36.8%	-6.0%	-24.0%	70
France	0.03%	-0.25%	0.28%	-26.9%	-8.7%	-13.7%	70
Germany	0.01%	-0.44%	0.46%	-44.2%	-7.6%	-27.9%	70
Greece	0.08%	-0.32%	0.40%	-37.6%	-7.6%	-23.8%	70
Hungary	0.11%	-0.55%	0.67%	-34.4%	-9.8%	-19.5%	70
Ireland	-0.26%	-1.03%	0.77%	-38.9%	-11.0%	-21.8%	70
Italy	0.16%	-0.25%	0.40%	-32.9%	-7.7%	-18.8%	70
Latvia	-0.36%	-0.49%	0.13%	-22.4%	-12.9%	-16.2%	70
Lithuania	-0.98%	-1.03%	0.06%	-17.6%	-11.4%	-14.2%	70
Luxembourg	-0.56%	-0.73%	0.17%	-24.4%	-11.1%	-13.5%	70
Malta	-0.46%	-0.87%	0.41%	-14.6%	-15.8%	-15.3%	70
Netherlands	-0.35%	-0.87%	0.52%	-29.5%	-7.5%	-16.7%	70
Poland	1.08%	-0.20%	1.28%	-55.7%	-22.1%	-43.9%	70
Portugal	0.00%	-0.48%	0.48%	-40.6%	-9.0%	-22.3%	70
Romania	0.69%	-0.04%	0.73%	-44.4%	-12.4%	-32.4%	70
Slovakia	0.16%	-0.42%	0.58%	-33.9%	-13.1%	-24.9%	70
Slovenia	-0.17%	-0.63%	0.46%	-41.2%	-8.3%	-23.0%	70
Spain	-0.05%	-0.38%	0.33%	-37.8%	-9.2%	-23.1%	70
Sweden	0.05%	-0.27%	0.32%	-25.6%	-5.1%	-11.6%	70
United Kingdom	0.17%	-0.13%	0.30%	-43.6%	-10.3%	-24.9%	70
European Union	0.08%	-0.35%	0.44%	-41.4%	-9.6%	-25.0%	70
ETS price[c]				70			

[a] in % of households consumption.
[b] change in % with respect to the reference scenario.
[c] in €$_{2017}$ per ton of CO_2.