Distributional effects of climate policies

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6. Distribution of climate change mitigation costs across European Member States in both a CO_2-only and a Multigas strategy[21]

Abstract Concerns about inequitable distributions of mitigation costs across regions are a serious barrier for international climate policies. It is, therefore, important to have insight into such distributional effects. This chapter analyzes the cost distribution across European Member States in both a CO_2-only and a Multigas strategy in 2020 by means of the GAINS (GHG and Air Pollution INteractions and Synergies) model. By equalizing marginal abatement costs across countries and relevant sectors, the model selects the cost-optimal mitigation measures for achieving a given set of environmental targets in Europe. Results of the GAINS model show that including non-CO_2 GHGs in the mitigation strategy shifts costs from Western to Eastern Europe. This will lead to an increase in the inequity between Eastern and Western Europe according to per capita GDP. These findings can be relevant for policy-makers when they consider the extension of ETS with non-CO_2 GHG.

6.1. Introduction

The European Emissions Trading Scheme (ETS) stimulates reduction of greenhouse gas (GHG) emissions, thus helping the European Union and its Member States to meet their emission commitments under the Kyoto Protocol. While emissions trading has the potential to involve many economic sectors and all greenhouse gases controlled by the Kyoto Protocol (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6), the scope of the ETS is initially limited to gain experience with emissions trading. In the first trading period, the ETS covers only CO_2 emissions from large emitters in the power and heat generation industry and in selected energy-intensive industrial sectors (European Commission, 2005). For the second trading period (2008-2012), extension of the ETS with non-CO_2 GHG is considered (European Commission, 2007, European Climate Change Programme, 2007). Such an extension will very likely change the cost distribution across economic sectors, because non-CO_2 GHG originate from other sources than CO_2 emissions. Since countries have different economic structures, this may influence the cost distribution across countries. Concerns about inequitable distributions of mitigation costs across countries may complicate the extension of ETS with non-CO_2 GHG, and it is, therefore, highly relevant for policy-makers to have insight into such distributional effects. Yet, there is still no insight into the change in cost distribution across countries when extending ETS with non-CO_2 GHG.

The scientific interest for non-CO_2 GHG has been increasing over the last few years because it is expected that a policy which takes account of non-CO_2 GHG as well as CO_2 can mitigate climate change with lower costs than a CO_2-only policy can (Reilly et al., 1999; Manne and Richels, 2001; Weyant et al., 2006). A few studies also analyzed the way

[21] The research in this chapter has been carried out during participation in the Young Scientists Summer Program 2007 at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria.

in which mitigation costs might be shared across countries when including non-CO_2 GHG in the mitigation strategy. Bernard et al. (2006) discussed the distribution of welfare costs across various world regions in a CO_2-only strategy and a Multigas strategy. They conclude that the introduction of non-CO_2 GHGs in the mitigation strategy reduces significantly the welfare costs of a long term emissions stabilization policy but that benefits vary across regions. This analysis is carried out at the global level in the 1990-2020 period.

The aim of this chapter is to examine and compare the distribution, across European Member States, of the mitigation costs of greenhouse gas emissions in a cost-optimal way in both a CO_2-only strategy and a Multigas strategy in 2020. The analysis includes all economic sectors and the greenhouse gases CO_2, CH_4 and N_2O. Additionally, the study compares the equity of the cost distribution of both strategies. The analysis may provide insight into the possible distributional effects of including non-CO_2 GHG in the European ETS. This chapter describes the GAINS model in Section 6.2. Then, Section 6.3 presents the results regarding the distribution of mitigation costs across European Member States. Finally, the results are discussed and conclusions are drawn in Section 6.4.

6.2. GAINS model

The GAINS (GHG and Air Pollution INteractions and Synergies) model was used to determine the cost distribution of climate change mitigation across European Member States in both a CO_2-only strategy and a Multigas strategy. The model assesses, for any exogenously supplied projection of future economic activities (1990-2030), the resulting emissions of GHG and conventional air pollutants, the technical potential for emission controls and the costs of such measures, as well as the interactions between emission controls of various pollutants (Klaassen et al., 2005). By equalizing marginal abatement costs across countries and relevant sectors, the model selects the cost-optimal mitigation measures for achieving a given set of environmental targets in Europe. This cost-optimal solution results in a certain distribution of mitigation costs across countries.

The GAINS model has been developed by the Atmospheric Pollution and Economic Development program of IIASA by extending and revising the well-know RAINS (Regional Air Pollution Information and Simulation) model. The RAINS model was not only extended with greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6), but the optimization problem was revised too. GAINS takes account of the interactions between emission control options of multiple pollutants and their effects on multiple environmental impacts. Additionally, changes in underlying economic activities, such as energy efficiency improvements and fuel substitution, were incorporated as abatement options into the model. For a more detailed description of the method see the GAINS 1.0 documentation (Klaassen et al., 2005; Höglund-Isaksson and Mechler, 2005; Winiwarter, 2005; Tohka, 2005) and the report about the GAINS Optimization Module Version 0.986 (IIASA, 2006).

With the GAINS model we ran a scenario of 10 percent reduction of total GHG emissions in the EU27 in 2020 as compared to the baseline (including current air pollution legislation) in 2020. Total GHG emissions are 5100 Mton CO_2 equivalents in the baseline of 2020. Thus, a reduction of GHG emissions by 10 percent implies an emission reduction of 510 Mton CO_2 equivalents. Both strategies reduce the same absolute amount of GHG emissions. In the Multigas strategy, the reductions of emissions of CO_2, CH_4 and N_2O are interchangeable for achieving the reduction target. In the CO_2-only strategy, however, the target can be achieved with a reduction of CO_2 emissions only.

6.3. Results

6.3.1. Regional cost distribution

The results from the model run show that a reduction target of 510 Mton CO_2 eq. in 2020 as compared to the baseline scenario (including current air pollution legislation) in 2020 can be achieved with an emission price of 64 €/t CO_2 eq. in a Multigas strategy and with an emission price of 146 €/t CO_2 eq. in a CO_2-only strategy. This implies that a Multigas strategy can achieve the same target with marginal costs that are 56 percent lower than in the CO_2-only strategy. The EU27 as a whole can save 10,36 billion €/year for climate change mitigation when implementing a Multigas strategy instead of a CO_2-only strategy. This is a cost saving of 42 percent as compared to a CO_2-only strategy.

The shift from a CO_2-only strategy to a Multigas strategy will not only lead to lower total costs to achieve the same reduction target for Europe, but will also change the distribution of mitigation costs across countries. Figure 6.1 shows the change in total mitigation costs in each country of the EU27[22] when shifting from a CO_2-only to a Multigas strategy (see Appendix 6.A for the total costs and emission reduction per country). The results show that most countries experience a decrease in total mitigation costs. For example, the total mitigation costs of the Netherlands will decrease by 78 percent (680 million €/year). France will have a decrease of 54 percent (2226 million €/year), Germany of 41 percent (2118 million €/year) and Denmark of 39 percent (158 million €/year). However, some countries experience an increase in total mitigation costs. For example, the total mitigation costs of Poland will increase by 7 percent (123 million €/year) when shifting from a CO_2-only to a Multigas strategy. Bulgaria will have an increase of 11 percent (29 million €/year), Romania of 22 percent (65 million €/year) and Hungary of 44 percent (45 million €/year). The results show that most countries in Western Europe experience a decrease in total mitigation costs while most countries in Eastern Europe experience an increase in total mitigation costs. So, costs shift from Western Europe to Eastern Europe when non-CO_2 GHG are included in the climate change mitigation strategy.

[22] Results of Malta are not discussed.

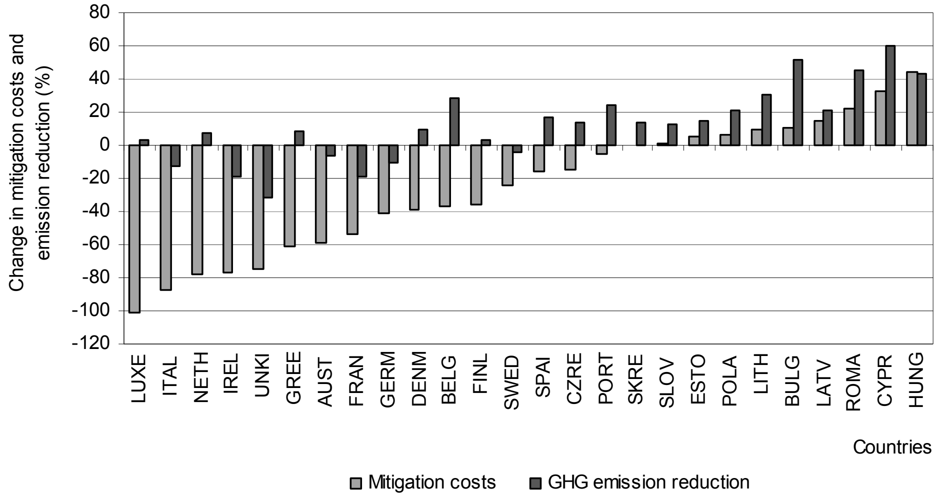

Figure 6.1. Change in total mitigation costs and emission reduction in 2020 when shifting from a CO_2-only to a Multigas strategy.

Figure 6.1 also represents the change in emission reduction per country when shifting from a CO_2-only to a Multigas strategy. Countries in Eastern Europe reduce more GHG emissions (up to 50 percent) in the Multigas strategy than in the CO_2-only strategy. Due to the availability of inexpensive abatement measures these countries reduce more emissions, which results in higher total mitigation costs. Many Western European countries, e.g. Germany, France and the UK, reduce less GHG emissions in the Multigas strategy than in the CO_2-only strategy due to cheaper abatement options available in other countries. However, a number of countries in Western Europe remain the same emission reduction level or even reduce more GHG emissions with lower total mitigation costs, e.g. the Netherlands. So, there seems to be three categories of countries: (1) countries with increasing mitigation costs and emission reduction, (2) countries with decreasing costs and emission reduction, and (3) countries with decreasing costs and increasing emission reduction.

More detailed information about the emission reduction in both strategies can give insight into these differences across countries. Therefore, a few representative countries are considered in detail. Figure 6.2 shows reductions of CO_2, CH_4 and N_2O emissions of Poland (category 1), Germany (category 2) and The Netherlands (category 3) in a CO_2-only and Multigas strategy. All three countries reduce higher amounts of non-CO_2 GHG in the Multigas strategy, because non-CO_2 GHG emissions can be reduced in this strategy in contrast to the CO_2-only strategy[23]. Poland reduces approximately the same amount of CO_2 emissions in both strategies. In the Multigas strategy, non-CO_2 GHGs are reduced on top of the CO_2 emissions. In contrast, Germany reduces less CO_2 emissions in the Multigas

[23] Small amounts of non-CO2 GHG are reduced in the CO2-only strategy due to implementation of multi-pollutant mitigation measures.

strategy than in the CO_2-only strategy. Apparently, expensive CO_2 measures of Germany can be replaced by inexpensive non-CO_2 GHG measures in Germany itself and in other European countries. As a result, Germany reduces less GHG emissions than in the CO_2-only strategy. Just as Germany, the Netherlands reduces less CO_2 emissions in the Multigas strategy than in the CO_2-only strategy. However, the high reduction of non-CO_2 GHG in the Multigas strategy results in a higher total GHG emission reduction than in the CO_2-only strategy. The Netherlands has many inexpensive measures for the reduction of non-CO_2 GHG. For example, CH_4 emissions of liquid slurry systems (of pigs and bovine animals) can be cheaply reduced by anaerobic digestion plants at the farm.

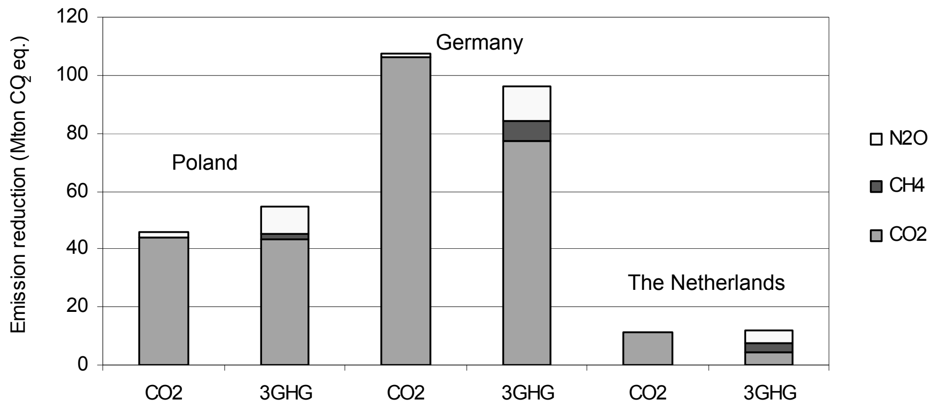

Figure 6.2. Emission reduction in CO_2-only and Multigas strategy: Poland, Germany and The Netherlands.

In the Multigas strategy, all European countries implement inexpensive non-CO_2 GHG abatement measures. These inexpensive abatement measures make the implementation of expensive CO_2 measures unnecessary. So, expensive CO_2 measures of Western Europe are no longer implemented and as a result the Western European countries experience a decrease in mitigation costs. However, the relatively inexpensive CO_2 mitigation measures in Eastern Europe are still cost-effective to be implemented for achievement of the reduction target. So, Eastern European countries still implement their CO_2 measures in a Multigas strategy and on top of that they implement non-CO_2 GHG measures, resulting in higher total mitigation costs.

6.3.2. Equity issue

The shift in mitigation costs from Western to Eastern Europe will change the burden sharing of climate change mitigation. Figure 6.3 shows total mitigation costs of countries as share of GDP and their GDP per capita. All countries with a per capita GDP below 20 thousand Euros are Eastern European countries and all countries with a per capita GDP higher than 20 thousand Euros are Western European countries. Figure 6.4 also shows regression lines fitted to the data points. This figure shows again that Western Europe benefits from inclusion of non-CO_2 GHG in the mitigation strategy while Eastern European countries benefits from a CO_2-only strategy. Additionally, the figure shows that both a CO_2-only and Multigas strategies are regressive in the total mitigation costs as share of GDP, which means that countries with a relatively low GDP (Eastern European countries) spend a larger fraction of their GDP on climate change mitigation costs than those with a relatively high GDP (Western European countries). This effect is more pronounced in the lower ranges of per capita GDP than in the higher ranges of per capita GDP. When comparing the two mitigation strategies, the results show that a Multigas strategy gives rise to a more intense regressivity than a CO_2-only strategy. This implies that inequity increases across Western and Eastern Europe when including non-CO_2 GHG in the mitigation strategy.

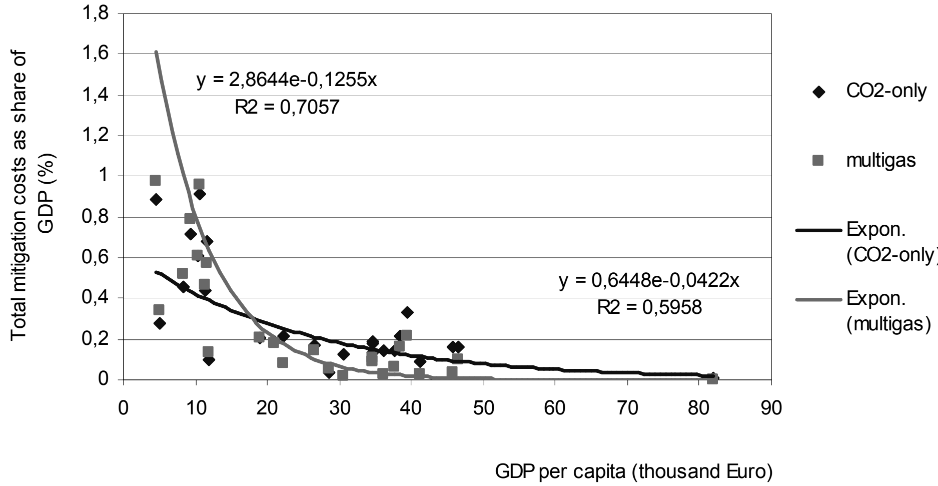

Figure 6.3. Total mitigation costs as share of GDP versus GDP per capita.

6.4. Discussion and conclusions

This chapter examined and compared the distribution, across European Member States, of the mitigation costs of greenhouse gas emissions in a cost-optimal way in both a CO_2-only strategy and a Multigas strategy in 2020. Additionally, the equity of the distributional effects of both strategies was considered. The results show that the costs shift from Western to Eastern Europe when including non-CO_2 GHG in the mitigation strategy. This will increase the inequity between Eastern and Western Europe according to per capita GDP. In this chapter, the GAINS model version 0.986 (IIASA, 2006) was used. After discussing the limitations of this version of the GAINS model, the policy implications of this study will be discussed.

6.4.1. Discussion of method

Since the GAINS model version 0.986 was finished in March 2006, very recent reduction technologies are not included in the model. Examples of reduction technologies that are not included in the model are integrated gasification and combined cycle power plants (IGCC), combined heat and power production (CHP) and carbon capture and storage (CCS). These abatement measures aim at the reduction of CO_2 emissions. The relatively limited CO_2 mitigation portfolio of this version of the model may have resulted in a higher cost saving potential of inclusion of non-CO_2 GHG in the mitigation strategy. This depends on the cost-effectiveness of IGCC, CHP and CCS, i.e. would these measures have been selected by the model to achieve the reduction target. The findings regarding cost savings are in the same range as those in the literature. This study found a marginal cost reduction of 56 percent when including non-CO_2 GHG in the mitigation strategy. This lies within the same range as the results of Weyant et al. (2006), who found a marginal cost savings of 48 percent in 2025 at the global level. Though, 56 percent marginal cost savings may be high for Europe. Moreover, the cost distribution across European countries may have been affected by the relatively limited CO_2 mitigation portfolio. This depends on the cost-effectiveness of IGCC, CHP and CCS on the one hand and the availability of these measures in certain countries on the other hand. The extent in which the relatively limited CO_2 mitigation portfolio has affected the results is difficult to determine. Most likely, the general conclusion that costs shift from Western to Eastern Europe will maintain. After all, it is very plausible that Eastern Europe will still have a higher number of cost-effective CO_2 abatement measures than Western Europe.

6.4.2. Policy implications

The analysis included all economic sectors, even though complete participation of all economic sectors is very unlikely for the second trading period of the ETS[24]. Nevertheless, the results can indicate the direction of the distributional effect of extending the scope of ETS with non-CO_2 GHG. The results demonstrate that extending a CO_2-only strategy with non-CO_2 GHG will shift costs from Western Europe to Eastern Europe when applying an allocation rule that equalizes marginal abatement costs across countries. Moreover, this shift in costs intensifies the inequity between Western and Eastern Europe regarding per capita GDP. Policy-makers can diminish the increase in inequity between Western and Eastern Europe by distributing the emission permits according to other allocation rules than equalizing marginal abatement costs. Application of allocation rules that converge the total mitigation costs as share of GDP for Western and Eastern Europe can create benefits for Eastern European countries. In that case, Eastern European countries can sell their emission rights to Western European countries. Then, a Multigas strategy would be even more beneficial to Eastern Europe than a CO_2-only strategy.

[24] The discussion about the extension of the ETS is still ongoing (European Climate Change Programme, 2007) and, therefore, it is unknown which sectors, processes and GHG will be included in the ETS in the second trading period.

6.5. Acknowledgements

The research in this chapter has been carried out during my participation in the Young Scientists Summer Program 2007 at IIASA. I would like to thank my supervisors Peter Rafaj and Fabian Wagner from the Atmospheric Pollution and Economic Development Program (APD) for their support in general and for their help with the GAINS model in particular.

Appendix 6.A

Table 6.A. Total costs and emission reduction per EU Member State to achieve a reduction target of 510 Mton CO_2 eq. in the EU27 in 2020 as compared to the baseline scenario (including current air pollution legislation) in 2020.

Countries	**CO_2-only strategy**		**Multigas strategy**	
	Total costs (mln.Euro/year)	Total emission reduction (Mton CO_2 eq.)	Total costs (mln.Euro/year)	Total emission reduction (Mton CO_2 eq.)
Austria	451.4	9.5	184.6	8.8
Belgium	498.2	9.8	312.7	12.6
Bulgaria	268.5	6.0	297.1	9.1
Cyprus	7.6	0.3	10.2	0.5
Czech Republic	787.2	14.5	668.1	16.6
Denmark	408.5	8.2	250.0	8.9
Estonia	107.5	2.5	113.2	2.8
Finland	686.4	12.8	440.6	13.3
France	4154.9	75.0	1928.0	60.6
Germany	5116.8	106.8	2998.5	96.0
Greece	528.5	9.2	206.0	10.0
Hungary	101.2	5.8	145.8	8.3
Ireland	337.4	5.0	77.8	4.0
Italy	2109.9	45.2	263.3	39.5
Latvia	80.6	1.9	92.6	2.3
Lithuania	219.8	4.3	241.2	5.6
Luxembourg	5.2	0.4	-0.1	0.4
Netherlands	875.5	11.4	195.3	12.2
Poland	1874.5	45.0	1997.4	54.7
Portugal	411.8	9.2	389.9	11.4
Romania	293.4	13.3	358.0	19.4
Slovakia	335.3	7.6	334.9	8.7
Slovenia	72.4	2.2	73.0	2.5
Spain	1889.0	41.2	1587.4	48.2
Sweden	742.1	18.8	565.5	18.1
UK	2312.4	51.4	583.5	35.3