The Cost of Greenhouse Gas Mitigation in Europe – Kyoto and Beyond

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Introduction

The Intergovernmental Panel on Climate Change (IPCC) has currently finalized its Fourth Assessment Report (AR4). AR4 consists of three working groups and Working Group III assesses options for limiting greenhouse gas emissions (GHG) and otherwise mitigating climate change (IPCC, 2007).

Chapter 11 in the report from Working Group III presents issues of mitigation from a cross-sectoral perspective, among them the macroeconomic costs. As there is substantial literature on these issues, the review necessarily had to be relatively short. Therefore, this paper provides some more information on the costs of abating GHG emissions in Europe based on studies assessed in chapter 11. We focus on how these costs vary across countries, how they depend on U.S. rejection of the Kyoto Protocol and how they vary under different emissions trading schemes. Our review is based on macroeconomic studies (top-down approaches), and gives costs in the short and medium term, i.e., for the Kyoto period (2008-12) and beyond (up to 2030). Note that we do not focus on induced technological change, pre-tax levels or double dividend in this survey, but we refer to AR4 for such considerations.

While the Third Assessment Report (TAR) of the IPCC (IPCC, 2001) also gave cost estimates for Europe, there have been several developments in mitigation studies since then. Modeling of events such as the U.S. and Australian rejection of the Kyoto Protocol are included, and there has also been an evolution of models and modeling leading to more refined estimates of mitigation costs.

Abatement Costs

An important development since TAR has been additional detailed studies of abatement costs for individual countries in Europe within consistent models. Viguier et al. (2003) provides a comparison of four model estimates of the costs of meeting Kyoto targets without trading based on the 1998 burden sharing agreement. Two of the models, EPPA and GTEM, are CGE models, while the two others, POLES and PRIMES, are partial equilibrium models with considerable energy sector detail. In EPPA, the Scandinavian countries and Netherlands have the highest domestic permit prices, ranging from 385US$/tC to 217US$/tC. Italy and France have permit prices of about 140US$/tC, while the lowest prices are in Germany and the United Kingdom, 119US$/tC and 91US$/tC. The domestic carbon price and costs of abatement vary across the models. Viguier et al. (2003) explain differences among model results in terms of baseline forecasts and estimates of abatement costs. Germany, for example, has lower baseline emission forecasts in both POLES and PRIMES, but at the same time higher abatement costs. The net effect is that domestic carbon prices are estimated to be lowest in Germany in POLES and PRIMES while EPPA and GTEM find lower costs in the United Kingdom. Overall, the two general equilibrium models find similar EU-wide costs, in between the estimates of POLES and PRIMES.

Viguier et al. (2003) continue to discuss the differential consequences across European countries. They find that other measures of cost—welfare and GDP losses—generally follow the pattern of domestic carbon prices. The welfare effects of meeting Kyoto are lowest for Germany and highest for Netherlands. Terms of trade generally improve for European countries, except for the United Kingdom and Denmark, the former owing to its position as a net exporter of oil and the latter owing to its very low share of fuels and energy-intensive goods in its basket of imports. The results presented are for no trade, and, therefore, gives some indication on which country may sell or buy permits in a system of tradable permits.

While the former study did not focus on permit trading, tradable permits and costs of CO_2 abatement are studied in Böhringer and Löschel (2002). They use a large-scale static CGE model of the world economy to analyse the costs of Kyoto in different scenarios. Emission reductions in 2010, compared to a baseline scenario, is found to be 16.6 % for the EUR region (EU15+EFTA). For the CEA region (Eastern Europe without former Soviet Union) it is -4.21%. With no emission trading, the welfare change for EUR is -0.18% relative to the baseline. The CEA experiences a significant increase in welfare, of 0.29%, due to improvements in terms of trade. Welfare improves when trade in emission rights are introduced between Annex B countries; for EUR to -0.11%, for CEA to 0.87%. However, welfare in both regions goes down if the U.S. does not participate and there is no trade in emission

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rights. Higher fossil fuel demand in the U.S. due to non-participation has important implications for spillovers from international energy markets, leading to a worsening of the terms of trade for energy importing countries. In this case - without trade in emissions - the welfare change relative to the baseline is -0.22% for EUR and 0.16% for CEA.

The impact on compliance costs from the U.S. rejection of the Kyoto Protocol is analysed further by Manne and Richels (2004). They use the MERGE model, which is an intertemporal general equilibrium model of the world economy with endogenous technology diffusion. 2010 is the first commitment period, and it is assumed that Annex B countries reduce emissions by an additional 10% per decade starting in 2020. For the U.S., the constraint in 2020 is assumed to be the same as if it had adopted the Protocol. Emission permits are tradable. For Western Europe the percentage GDP loss of the Kyoto Protocol in 2010 is about 0.4%. Mitigation costs during the first commitment period appear to be slightly lower than they would be with U.S. ratification, due to lower permit prices, but not as low as they would be in the absence of banking. Banking means that hot air is deferred for later use, which gives a higher permit price.

The importance of alternative emissions trading schemes on macroeconomic costs is analyzed in Capros and Mantzos (2000). Costs for the EU15 are studied using the PRIMES model. The Kyoto Protocol target of 8% emissions reduction for the EU15 is implemented in 2010. Each member state has an operational domestic trading scheme and achieves individually its specific target under the Burden Sharing Agreement. Three cases considering different sets of sectors engaged in EU-wide emissions trading are analyzed; energy suppliers, energy suppliers and energy intensive industries, and all sectors. The study also includes a case with full emissions trade between Annex B countries and an international permit price of €17.7/tCO_2.

In a reference case without EU-wide trading, the total compliance costs for the EU is about €9 billion yearly in 2010 (1999 prices), or 0.075% of GDP. In the EU-wide trading cases the price of emission permits is about €33/tCO_2 and the compliance costs falls the more sectors included in the trading scheme. The lowest cost of about €4.6 billion is found in the Annex B trading case. Costs and gains from trading for individual member states vary greatly over the scenarios according to the states' specific targets and marginal abatement costs. Belgium, Finland and the Netherlands have the highest marginal abatement costs, while France and Germany have the lowest.

Emissions trade in the EU is regulated by the European Emissions Trading Scheme (ETS). Using the DART model Klepper and Peterson (2004) finds that savings from introducing the ETS can only be achieved if the cap on emissions is distributed between the ETS sectors and the rest of the economy in such a way that the different abatement costs are taken into account. This implies a relatively small allocation of the total reductions to the ETS sectors. Also, even if the accession countries do not supply hot air in the ETS market, they contribute substantially to the cost savings by offering low-cost abatement options.

The authors study this further in Klepper and Peterson (2006), and examine the implications of the current National Allocation Plan (NAP) under different assumptions about CDM and JI. There are strong distortions having the ETS exist parallel to other policy measures in the non-ETS sectors. The NAPs drive a large wedge between the allowance price in the ETS and the implicit tax necessary for reaching the Kyoto targets in the non-ETS sectors. While the use of CDM and JI drives down the allowance price in the ETS by one third and reduces the wedge between implicit tax outside the ETS and the allowance price, the distortions created by NAP cannot be eliminated. This has implications for welfare costs. Also the supplementary condition that requires that the major part of the emission reductions be realized domestically, has large implications for the efficiency of the EU climate strategy. Whereas the current policies will give a welfare loss of close to 1% in 2012 relative to "business as usual", an unrestricted trading in project credits and allowances would result in an allocation where the Kyoto target can be met with hardly any welfare costs.

Reduction in emissions beyond the Kyoto Protocol is analyzed in Bollen et al. (2004). They assess possible macroeconomic consequences of a 30% reduction in GHG emissions for industrialized nations in 2020, compared to 1990 levels, using an applied general equilibrium model called WorldScan. It is assumed that in 2010 all countries form a global policy coalition. The emission quota allocation is initially based on 2010 levels, but converges to equal emission levels per capita in 2025. This gives a joint emissions-reduction target for the industrialized nations of 30% in 2020. Compared to no climate agreements this gives emission reductions for the industrialized nations of just over 50% from 2020 levels. A global unrestricted emission trading system is used to achieve the targets. In the post-Kyoto scenario the reduction in national income for EU25 is 0.6% compared to the baseline in 2020. The majority of this loss is due to imports of emission permits with a price of €17/tCO_2. The costs of implementing the Kyoto Protocol in 2010 are found to be a 0.3% reduction in national income for the EU25. The reason that the costs in the two scenarios do not differ more is that in the Kyoto Protocol scenario Russia uses its market power as a major supplier of emission rights, while in the post-Kyoto scenario emissions trading is assumed to be competitive. The costs of the post-Kyoto scenario depend heavily on the size of the coalition. In two alternative scenarios, one without the participation of Africa and Asia, and one with only Annex I countries, the national income reductions are 1.8% and 3.1%, respectively.

Marginal Abatement Costs and Permit Prices

There have been several studies calibrating a permit price in a European market for tradable permits. This price will be the same as the equalised marginal abatement cost for the trading countries if there are no restrictions on trade. An early study is IPTS (2000), which calculates the clearing price in the EU market in 2010 to be 49 €/tCO_2 using the POLES model. Trading reduces the EU abatement costs by 25%, or 0.05% of the Union's 2010 GDP, however, the authors note that this is an underestimation of the gains because the non-trading case already assumes that the countries/regions (six in the model) already have reduction in greenhouse gas emissions in an optimal manner. All countries/regions gain from trading, and the main sellers of quotas are Germany and the UK, while the region "Rest of EU North" (Austria, Belgium, Denmark, Finland, Ireland. Luxemburg, Netherlands, and Sweden) is the major buyer.

A more recent study using the POLES model is Criqui and Kitous (2003) who analyse the effect of the ETS on costs of meeting the Kyoto Protocol for Europe, given that the U.S. stays out of the Protocol. Given the Kyoto targets and no emission trading within Europe, marginal abatement costs (MAC) vary substantially between countries, from $4 to $253, with the highest MAC in Sweden, Denmark and Austria, and with the lowest MAC in Germany, UK, Belgium, Luxemburg and Finland. With trading, the MAC's equalize and there is an allowance price of 26 €/tCO_2, and the total compliance costs are reduced by almost 60%. Including JI and CDM credits in the European trading scheme reduces the allowance price. The lower the level of competition for JI and CDM credits from other countries, the greater is the volume of credits purchased by the trading European countries and the lower is the price of the corresponding allowances. Without any competition from non trading European countries and the other Annex B countries on the JI and CDM credits market, the allowance price collapses from 26 €/tCO_2 to less than 5 €/tCO_2, and the annual compliance costs are reduced by another 60%. If other participating Annex B countries carry out JI and CDM projects, the allowance price increases to 10.5 €/tCO_2, and the compliance costs doubles.

Holtsmark and Mæstad (2002) study permit prices for GHG emissions under three alternative trading regimes with a static partial equilibrium model, given a U.S. ratification of the Kyoto Protocol. Particular attention is devoted to the EU proposal on how much hot air a country can sell and on how much of the abatement a country must conduct domestically. In 2010 the Annex B countries meet the Kyoto Protocol, implementing national tradable permit systems. With free trade, marginal abatement costs across regions are equal to the international permit price of 16US$/tC. With limits to trade, the price rises to 26US$/tC. For most countries this is the marginal abatement cost, as they are not restricted by the trading limits. Countries that are restricted on the export (import) side will have lower (higher) marginal abatement costs. Most Eastern European countries, as well as Greece and Spain, have zero marginal abatement costs. When there are no emissions trading, marginal abatement costs differ substantially among countries. Countries with zero abatement cost in the limits to trade case also have zero costs with no trade. Net importers, such as USA, Canada, Japan and most countries in Western Europe, experience marginal abatement costs above 26US$/tC, while countries like Germany and France face costs around 18-19US$/tC.

The effects on the permit market after the U.S. withdrawal from the Kyoto Protocol are followed up by Holtsmark (2003), who also studies the role of Russia. Russia is a strategic player as a dominant seller of permits. It is also a major supplier of oil and gas, and a high permit price will reduce the demand for fossil fuels. Thus Russia faces a dilemma with the respect to its two roles. The analysis applies a static partial equilibrium model that emphasizes the links between the fossil fuel market and a market for emission permits under the Kyoto Protocol. With a fully competitive permit market, excess supply over demand drives prices down to zero. Permit prices rise to 9.6€/tC when Former Soviet Union (FSU) acts as a cartel in the permit market. By including CDM the supply of permits increases and gives a price fall from 9.6 to 3.4€/tC. When the FSU maximizes its total profits by taking into consideration the effect permit price has on oil and gas prices, permit price drops from 3.4 to 2.3€/tC.

Conclusions

Even if the actual cost numbers from the policy analysis differ among the studies, due to different models and different assumptions, there are still some qualitative lessons to be learned. The costs of committing to the Kyoto Protocol may not be very high in Europe. A U.S. rejection of the Kyoto Protocol may increase the cost of commitment in Europe if there were no emissions trade or other flexible mechanisms, due to terms of trade effects. The costs will also vary across countries, with France, the United Kingdom, and Germany facing lower costs and Scandinavian countries and the Netherlands generally facing higher costs. However, with international emissions trading, the U.S. rejection may actually lower costs for Europe due to a lower permit price. However, the permit price and also the costs will depend on restrictions to trade and the possible exercise of market power in the emission permit market.

References

Böhringer, C., Löschel, A. (2002). "Economic impacts of carbon abatement strategies", in C. Böhringer, M. Finus and C. Vogt (eds), Controlling Global Warming - Perspectives from economics, game theory and public choice. Edward Elgar Publishing: 105-177.

Capros and Mantzos (2000): "The Economic Effects of EU-Wide Industry-Level Emission Trading to Reduce Greenhouse Gases – Results from PRIMES Energy Systems Model", Institute of Communication and Computer Systems of National Technical University of Athens.

Bollen, J., Ton Manders, and P. Veenendaal (2004): "How much does a 30% emission reduction cost? Macroeconomic effects of post-Kyoto climate policy in 2020", CPB Document No 64, September, Central Planning Bureau, The Netherlands.

Criqui, P. and A. Kitous (2003): "Kyoto Protocol Implementation – KPI Technical Report: Impacts of Linking JI and CDM Credits to the European Emission Allowance Trading Scheme", CNRS-IEPE and ENERDATA S.A. for Directorate General Environment.

Holtsmark, B., Mæstad, O. (2002). "Emission trading under the Kyoto Protocol - effects on fossil fuel markets under alternative regimes." Energy Policy 30: 207-218.

Holtsmark, B. (2003). "Russian behaviour in the market for permits under the Kyoto Protocol." Climate Policy 3: 399-415.

IPCC (2001), *Climate Change 2001 – Mitigation,* Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.

IPCC (2007): *Climate Change 2007- Mitigation of Climate Change*, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

IPTS (2000): "Preliminary Analysis of the Implementation of an EU-wide Permit Trading Scheme on CO_2 Emissions Abatement Costs. Results from the POLES-model", Institute for Prospective Technological Studies.

Klepper, G. and S. Peterson (2004): The EU emission trading scheme allowance proices, trade flows and copetitiveness effects, European Economics, 14: 201-218.

Klepper, G. and S. Peterson (2006): Emission trading, CDM, JI and more: The climate strategy of the EU, The Energy Journal, 27: 1-26.

Manne, A. S., Richels, R.G. (2004). "U.S. Rejection of the Kyoto Protocol: the impact on compliance costs and CO_2 emissions." Energy Policy 32: 447-454.

Viguier, L. L., Babiker, M.H., Reilly, J.M. (2003). "The costs of the Kyoto Protocol in the European Union." Energy Policy 31(5): 459-483.

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