Project logo: TAXBEN

Project no. SCS8-CT-2004-502639

Project acronym TAXBEN

Project title: Tax/benefit systems and growth potential of the EU

Instrument: Specific Targeted Research Project

Thematic Priority: SSP Priority 8 Topic 3.1 Task 4

Deliverable reference number and title 20 (20a)

Taxes and tradable permits in the EU to curb CO_2 emissions:

Efficiency Losses from Overlapping Instruments in European Carbon Emissions Regulation

Actual submission date: September 2006

Project co-funded by the European Commission within the Sixth Framework Programme		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Efficiency Losses from Overlapping Economic Instruments

in

European Carbon Emissions Regulation

Christoph Böhringer[a,b], Henrike Koschel[a], Ulf Moslener[a],

[a] Centre for European Economic Research (ZEW), Mannheim

[b] Faculty of Economics and Social Studies, University of Heidelberg

Abstract: In order to achieve their climate policy targets EU member states apply various regulatory instruments. We analyse the potential efficiency losses arising from the co-existence of emission taxes and emissions trading within a partial equilibrium framework for the EU carbon market. Our analysis indicates substantial excess cost of overlapping regulation. We show that firms subject to the EU Emissions Trading Scheme (EU ETS) which in addition face domestic energy or carbon taxes will abate too much while other firms within the EU ETS will benefit from lower international emission permit prices. In essence, unilateral emission taxes within the EU ETS are ecologically ineffective and subsidise net permit buyers.

JEL Classifications: D61; H21; H22; Q58

Keywords: Regulation; emission taxes; emissions trading

1. Introduction

From 2005 onwards, the EU Emissions Trading Scheme (EU ETS) sets an aggregate carbon emission cap for specific energy-intensive industrial and energy installations across the EU. Each EU member state allocates CO_2 allowances to these installations amounting to the EU wide cap which can be traded.[1] In the first trading period 2005-2007, Germany has the biggest share in EU allowances (23%), followed by the United Kingdom, Poland and Italy (around 11%) (EU 2005).

For each member state the allocated amount of allowances represents a share in the national emission budget fixed in the EU Burden Sharing Agreement of 1998. The partitioning of national emission budgets between sectors covered by the EU ETS and the rest of the economy is laid out in the National Allocation Plans which are developed by each member state and approved by the Commission. For overall compliance, the EU member states must apply complementary regulatory measures to those sectors that are not covered by the EU ETS. This segmented CO_2 regulation runs the risk of producing substantial excess cost since marginal abatement costs are not equalized across emission sources (see Böhringer et al., 2005).[2] In Germany – as in almost all other member states – the allocation to energy-intensive industries has been rather generous at the expense of sectors outside the EU ETS (e.g. Betz et al., 2004). The burden has been shifted from energy-intensive industries with rather low marginal abatement costs to sectors with potentially high abatement costs.

[1] Five main sectors are covered by the EU ETS. As the power and heat sector accounts for 55% of all (EU-wide) allowances, the EU ETS particularly depends on activities within this sector (see Point Carbon, 2006).

[2] The pending trade-offs between different objectives of the EU ETS – i.e. efficiency, compensation, and competition integrity – are discussed in Böhringer and Lange (2005).

In several EU countries, industrial installations which have to hold emission permits are also affected by national energy tax regimes (see Johnstone (2003) or Sorrell and Sijm (2005) for an overview of climate policy regulations). In contrast to the EU emissions trading directive that clearly prescribes which installations are affected by the emissions trading scheme, the EU energy tax directive allows the member states great latitude as to whether EU ETS sectors are taxed or not (EU, 2003a,b). Reflecting basic economic principles, "the use of a mix of policies" in order to pursue a single policy objective "will be at best redundant and at worst counterproductive" (Johnstone, 2003): If there is one efficient instrument to implement an environmental target, it makes little sense to introduce an additional one. Nevertheless, it is in the nature of policy design within a federal system such as the EU that instruments introduced on a European level are complemented by instruments of the member states.

From a more subtle theoretical point, there are several reasons why a mix of policy instruments might even be preferable to a single instrument. Differentiated instruments can be justified if there are multiple policy objectives, such as social or technology-related criteria that may conflict with pure efficiency considerations. Second-best regimes, which are characterised by initial market distortions or imperfections provide a general argument for differentiated regulation. Such regimes include situations with uncertainty, external knowledge spillovers, initial tax distortions, market power, or transaction costs. In climate policy design, sector-specific differences in transaction costs have, e.g., been used as an argument for applying different climate policy instruments to different economic sectors.

In the policy debate we find arguments against and in favour of additional energy or carbon taxes on residual CO_2 emissions from the ETS sectors. While the antagonists refer to the double burden which has to be borne by the energy-intensive sectors, the proponents of an overlapping regulation, in contrast, argue that (1) an energy or carbon tax in the energy-intensive ETS sectors would give an additional incentive for CO_2 emission reductions and thus would help to reach the overall emission target laid down in the EU Burden Sharing

Agreement, (2) a tax would bring the marginal abatement costs in the emissions trading sectors closer to the efficient level. The tax could therefore be considered as a second-best instrument to increase the efficiency of the national or EU-wide abatement. The latter argument is based on the assumption that due to a very generous allocation of permits to the ETS sectors the marginal abatement costs of the ETS sectors can be expected to be lower than under the assumption of socially optimal abatement.[3]

In this paper, we disprove the economic rationale of these arguments. The following analysis abstracts to a large extent from market distortions and focuses on the static efficiency implications of emission taxes imposed on energy-intensive sectors that are in addition subject to the EU ETS. We show that overlapping regulation may induce substantial excess costs: Firms under the EU ETS which – at the same time – face domestic energy or carbon taxes will abate inefficiently much while other firms within the EU ETS will benefit from lower international emission permit prices. In essence, unilateral emission taxes within the EU ETS are ecologically ineffective and subsidise net permit buyers.

The paper is structured as follows: Chapter 2 introduces a simple stylized model designated to investigate the efficiency implications of overlapping economic instruments in climate policy. Chapter 3 presents numerical simulations based on empirical data for the EU in order to quantify the policy relevance of our theoretical analysis. Chapter 4 provides conclusions.

2. Stylized Analysis of Overlapping Emission Regulation

We illustrate the effects of possible overlaps of existing CO_2 emissions regulations with the EU ETS using a simple emission market model. Each member state is characterized by an

---

[3] Likewise, the arguments of interest groups such as the European Wind Energy Association are based on this argument: "The price of a CO_2 allowance is unlikely to ever reflect the external costs associated with […] emissions. […] Thus emissions trading can never replace other [initiatives] aiming at internalizing external costs, e.g. energy taxation."

(aggregate) marginal abatement cost function of the sectors that are subject to the EU ETS, including the power sector, oil refining, several energy-intensive industries, and by an (aggregate) marginal abatement cost function for the rest of the economy (covering all sectors outside the scope of the EU ETS including private households, transport, trade). The ETS sectors in each member state receive an emission budget according to the National Allocation Plans and can trade the permits thereafter. In contrast, the rest of the economy does not participate in trade. The member states, however, are required to take complementary action. We assume that the emission reductions in the rest of the economy are prescribed by the National Allocation Plans and implemented cost efficiently by carbon taxes.[4]

Our discussion of efficiency implications from an overlap of ETS with carbon taxation starts with an analysis of the interaction of permits and carbon taxes within the European trading scheme. This analysis is presented both for identical scope of tax and permit regulation in all EU member states as well as for the case that a non-uniform carbon tax is applied in only one EU country.

2.1. Interaction of a uniform carbon tax with EU ETS

We begin with the assumption that the ETS sectors in all EU member states are subject to both EU ETS and an additional uniform carbon tax. The associated first-order conditions are straightforward and result from the minimization of aggregate (EU-wide) marginal abatement costs of the ETS sectors subject to an aggregate emission constraint: $C_{ETS}^{i'}(e_{ETS}^{i}) = p + \tau \ \forall \ i$, where $C_{ETS}^{i'}(e_{ETS}^{i})$ represent marginal abatement costs of ETS sectors in EU member state i at emission level e_{ETS}^{i}, p is the EU-wide permit price and τ the EU-wide uniform carbon

---

[4] For reasons of simplicity, revenue recycling issues will be ignored in the following. However, the way tax revenues are recycled can have an impact on the overall costs of a regulation (see, e.g. Goulder (1995) or Bovenberg, 1999).

tax. Since marginal abatement costs are equalized across all emitters of the ETS sectors, abatement is cost efficient.

This regime does not differ from the case where (i) only permits are issued or (ii) only a tax is levied such that the given level of emissions is achieved. In the latter case – as the tax is sufficiently high to make the permit constraint non-binding – the permit price would be zero and the emissions would be below the level targeted by the number of permits. However, double-regulation is likely to be more complicated, thereby increasing overall transaction costs. Furthermore, it has no additional ecological effect since the tax is compensated by a lower permit price unless the permit price falls to zero and the permit scheme becomes dispensable.

2.2. Interaction of a non-uniform carbon tax with EU ETS

Next we assume that the carbon tax is not introduced EU-wide but in the ETS sectors of only one or several EU countries. As a matter of fact, several EU countries have already introduced energy or carbon taxes during the last years. In Germany, for example, an energy tax with reduced tax rates for energy-intensive industries has been implemented in 1999 (see BMU, 2003).

We argue again that an additional carbon tax levied on the sectors of the ETS has no ecological effect itself, disproving the wide-spread argument that "an energy or carbon tax in the energy-intensive ETS sectors would give an additional incentive for CO_2 emission reductions and thus would help to reach the overall emission target laid down in the EU Burden Sharing Agreement" (see Section 1). Once the National Allocation Plans are established, the emission budget is fixed for the ETS sectors across all EU member states. Any price-based mechanism *within* the quantity-based emissions trading regime will not alter the ecological effectiveness. Additional taxes in some countries within the trading scheme will lead to permit export to other regions of the trading scheme where no tax is applied. The overall ecological effect will be zero, unless the tax is high enough and applied in a sufficiently large number of countries such that the permit price is driven down to zero and the trading scheme is no longer binding. The tax acts as a lower bound to the abatement expenditures of the regulated firms.

Starting from an EU wide efficient allocation of emission permits with equalized marginal abatement costs, it is obvious that introducing an additional emission tax in the ETS sectors in a single country would typically produce inefficiencies as the first-order conditions of equalized marginal abatement costs no longer hold. The tax drives marginal abatement costs apart and introduces inefficiencies on both the member state as well as the aggregate EU level.

The open question is whether our basic results may change if the country that levies an additional carbon tax on ETS sectors is characterised by two specific features: over-allocation of permits to ETS sectors and market power.

2.2.1. Over-allocation

Let us assume an over-allocation of emission permits to the ETS sectors in a country. Over-allocation is defined by an inefficient allocation of emission reductions between the ETS sectors and the rest of the economy, implying lower marginal abatement costs for the ETS sectors (the latter are expressed by the ex-post permit price) than for the rest of the economy. In the policy debate, this rather realistic constellation has given rise to claims for overlapping regulation: For the case of over-allocation of emission permits to ETS sectors, "a tax would bring the marginal abatement costs in the ETS sectors closer to the efficient level. The tax could therefore be considered as a second-best instrument increasing the efficiency of the national or EU-wide abatement" (see Section 1).

Figure 1 illustrates why this argument is misleading. We consider a (small) open economy represented by the marginal abatement cost function of ETS sectors and the rest of the economy (ROE). Mirroring the assumption of permit over-allocation to ETS sectors the marginal abatement costs in the ROE sectors, C'_{ROE} (associated with emissions e_{ROE}), exceed the permit price on the international emissions trading market, *p*, which applies to the ETS sectors.

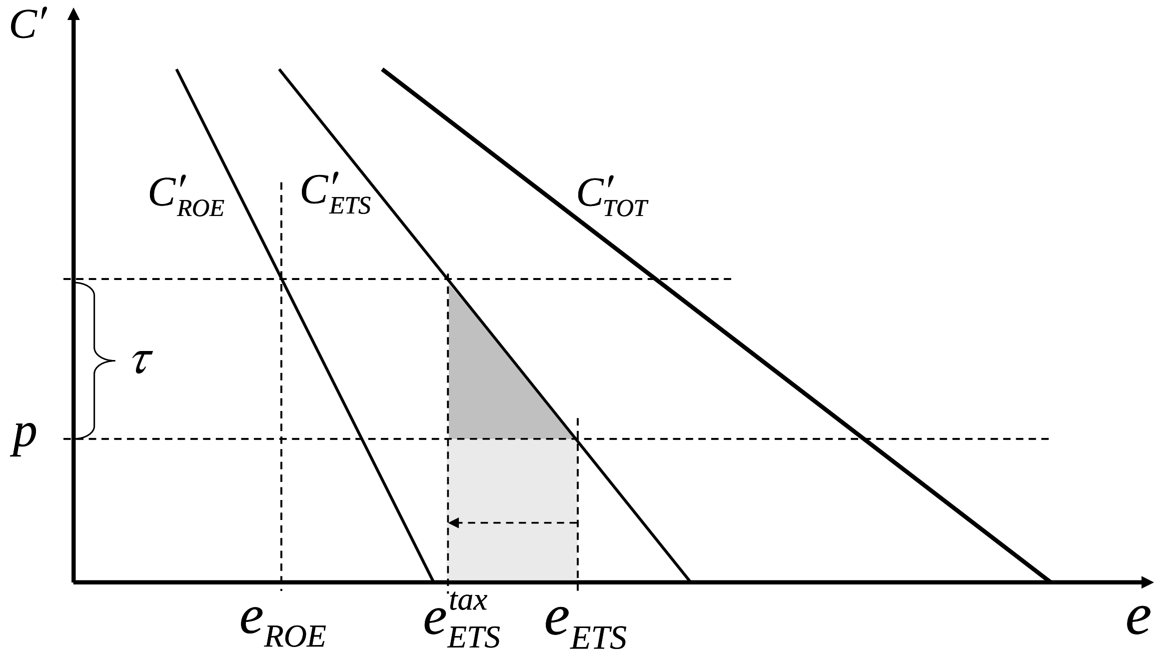

Figure 1: Unilateral emission tax in the ETS sector

Under double-regulation, the ETS sectors face an emission tax τ in addition to the permit regime. The tax increases the incentive to reduce emissions within the taxed region such that the marginal abatement costs of the ETS sectors will equal $p+\tau$. For a small open economy these additional abatement efforts will leave the international permit price unchanged.

The shaded areas in Figure 1 visualize the tax-induced efficiency effects. On the one hand, reducing emissions from e_{ETS} to e_{ETS}^{tax} will lead to a surplus due to the sale of permits (lighter shaded rectangular area).[5] On the other hand, the additional abatement costs are given by

[5] For reasons of simplicity, we assume that the use of revenues at the firm level does not have any efficiency implications.

the area under the marginal abatement cost curve (darker shaded triangle plus lighter shaded rectangle). Per saldo, the tax leads to excess costs, represented by the darker shaded triangle.

The EU ETS implements any given EU-wide target for the ETS sectors at minimum costs – independent of whether the country-specific National Allocation Plan implies an over-allocation or not. An additional tax within the trading scheme cannot change the distribution between the ETS and ROE sectors ex post. It brings the marginal costs closer to what would have been the optimal level across all emitters in the EU given that the National Allocation Plans had been designed in a cost-efficient manner, but only in the region where the tax is applied. Due to the segmentation of the economy into ETS and ROE sectors, however, taxes do not act as an instrument to implement a second-best solution: A unilateral emission tax drives apart the marginal abatement costs *within* the ETS sectors of the different regions and leads to efficiency losses.

To conclude: An additional carbon tax on firms of the ETS sectors in a single member state – which does not have any market power on the EU permit market – is costly for the member state, increases the EU overall implementation costs of the emissions target and has no ecological effect.

2.2.2. Market power

We relax the small country assumption and suppose that the EU member state that imposes a carbon tax has the capacity to influence the EU-wide permit price. This means that the tax-induced increase of net permit supply on the EU permit market will lower the EU-wide permit price. As in the case of a small open economy, the additional tax will drive apart the marginal abatement costs within the ETS sectors of the different countries and therefore generate a cost burden for the EU as a whole. A large open economy, however, may ─ under specific assumptions ─ achieve a net gain from the introduction of a carbon tax. If the member state imposing the tax (i) is a net permit importer (before and after implementing the tax), (ii) has relatively flat marginal abatement costs in the ETS sectors and (iii) can generate a sufficiently large drop of the market price for permits, then the lower import price for permits and the reduced amount of permits to be imported can compensate for the increased abatement efforts (thereby generating net profits).

Figure 2 illustrates our reasoning for a large economy with market power. The ex-ante permit allocation to the ETS sectors is denoted by e_{ETS}^{alloc}. Prior to the introduction of the carbon tax the emission level e_{ETS} is such that the marginal abatement costs of the ETS sectors equal the permit market price p. The introduction of a carbon tax τ will act as an additional reduction incentive on top of the permit price, the emissions fall to e_{ETS}^{tax} and the lower permit demand causes the permit price to fall to the after-tax level p_{tax}.

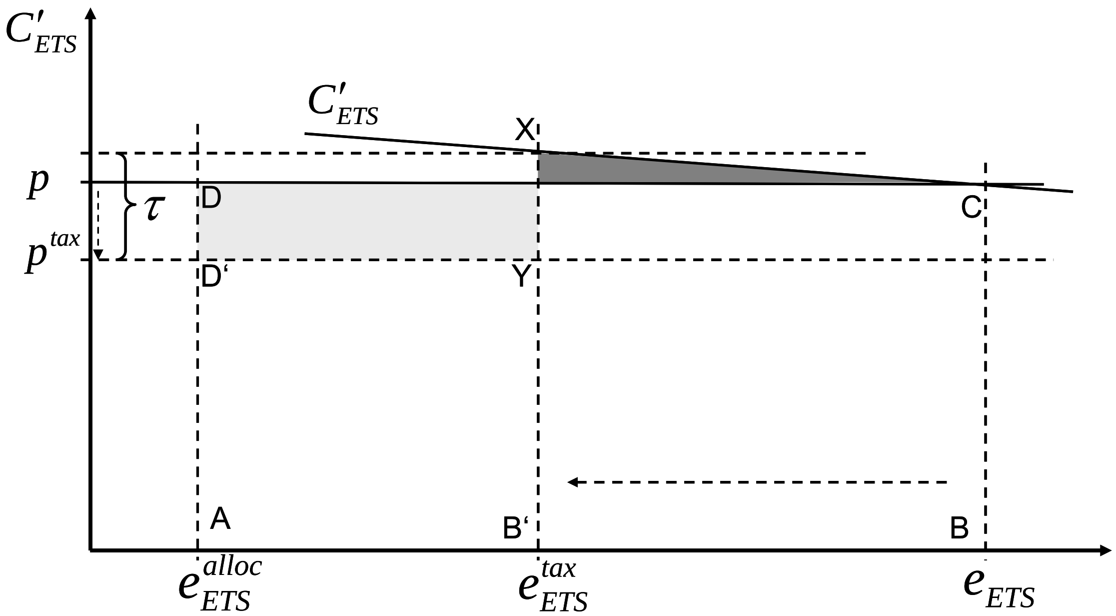

Figure 2: A large net permit importer may benefit from a unilateral emission tax

Comparison of the before-tax and the after-tax situation renders the efficiency implications for a large open economy: Before, the import expenditures of the country are given by the rectangular area *ABCD*. The increased reduction effort and the lower permit price of the after-tax regime are associated with abatement costs for the ETS sectors equal to the area *B'BCX*. On the other hand, the import expenditures are reduced, and after-tax expenditures are given by the area *AB'YD'*. Whether the country benefits from the tax is determined by the relative size of the darker and the lighter shaded areas. If the lighter shaded rectangular area exceeds the darker shaded triangular area – as is the case in Figure 2 – then the country benefits from the emission tax imposed on the ETS sectors.

It is a matter of quantitative analysis whether the conditions for beggar-thy-neighbour-policies from overlapping emission regulation are met by any EU member state. Prima facie, the conditions appear restrictive since countries with flat (marginal) abatement cost functions will – ceteris paribus – export rather than import emission permits. Moreover, it is questionable whether any of the EU member states has a sufficient market share to substantially drive down the permit price by unilateral action.

3. Quantitative analysis

We can transform our simple analytical framework into a numerical partial equilibrium model of the EU carbon market. Marginal abatement cost curves for ETS sectors of EU regions are calibrated to empirical data. Moreover, the effective emission reduction requirements for ETS sectors are based on the implementation of actual National Allocation Plans and official emission inventories. Following a brief description of the model's structure and parameterization (see Appendix A for a short algebraic model summary), we present simulation results to ascertain the policy relevance of overlapping regulation.

As to the interpretation of simulation results one has to keep in mind that the quantitative figures depend on the parameterization of the (marginal) abatement cost curves together with the climate policy prescriptions which – in our case – reflect the actual implementation of the EU ETS. For this reason, Appendix B provides the computer code[6] as well as the data underlying our simulations such that the interested reader can replicate our simulation results and alter the parameterization of marginal abatement cost functions as well as the climate policy specifications.

3.1. Permit market model

Marginal costs of emission abatement may vary considerably across EU ETS sectors of EU countries due to differences in carbon intensity, initial energy price levels, or carbon substitution possibilities. The derivation of continuous marginal abatement cost curves requires a sufficiently large number of discrete joint observations for marginal abatement costs and the associated emission reductions. These data may be generated by technology-oriented partial equilibrium models of the energy system (such as the POLES model by Criqui and Mima (2001) or the PRIMES model by Capros et al., 1998) or by computable general equilibrium (CGE) models (see e.g., Eyckmans et al., 2001). Here, we make use of the second option:[7] Marginal abatement cost curves for the ETS and ROE sectors across EU countries are derived from the PACE model - a multi-region, multi-sector CGE model for the EU economy (for a detailed algebraic exposition see Böhringer, 2002).[8] PACE is based on most recent consistent accounts of EU member states' production and consumption, bilateral trade and energy flows (as provided by the GTAP6 database – see Dimaranan and McDougall, 2002). With respect to the analysis of carbon abatement policies, the sectors in the model have been carefully selected to keep the most carbon-intensive sectors in the available data as separate as possible. The energy goods identified in the model include primary carriers (coal, natural gas, crude oil) and secondary energy carriers (refined oil products and electricity). Furthermore, the model features three additional energy-intensive

---

[6] The numerical model is implemented using the GAMS programming language (Brooke et al., 1997).

[7] Note that readers disposing of multi-sector, multi-region energy system models or macroeconomic models can readily update the parameterization of our reduced form permit market model.

non-energy sectors (iron and steel, paper, pulp and printing, non-ferrous metals) whose installations – in addition to the secondary energy branches (refined oil products and electricity) – are subject to the EU ETS. The remaining manufacturers and services are aggregated to a composite industry that produces a non-energy-intensive macro good, which together with final demand captures the activities (ROE segments) which are not included in the EU trading system. To generate the reduced form marginal abatement costs curves, a sequence of carbon tax scenarios for each region is performed where uniform carbon taxes (starting from 0 € to 100 € per ton of carbon in steps of 1 €) are imposed and the associated emission reductions in ETS as well as ROE sectors are computed. Then a simple least-square fit by a polynomial of third degree is applied (see Table *mac_coef* in Appendix B for the derived coefficients).

3.2. Policy simulations

For our numerical analysis of overlapping regulation we refer to the implementation of the EU ETS as our policy benchmark. The economic effects of a "pure" cap-and-trade regulation under the EU ETS are then compared to an overlapping regulation where the EU ETS is supplemented with an additional unilateral carbon tax in one of the EU member states. More specifically, we impose a unilateral carbon tax on the ETS sectors in Germany which increases stepwise from 0 to 5 € per ton of CO_2 emissions.[9]

The benchmark EU ETS regime is characterized by the regional emission allowances to ETS sectors which translate into specific emission reduction requirements against the business-as-usual situation. For the latter, we employ official EU projections (EU (2003c)) on carbon emissions of ETS sectors in 2010 – the central year for meeting the EU climate policy targets

---

[8] Klepper and Peterson (2006) demonstrate that marginal abatements cost functions generated by a computable general equilibrium framework are in general a useful approximation. They also examine the robustness of the cost functions with respect to world energy prices.

under the Burden Sharing Agreement. In our central case simulations, the allocation of emission allowances to ETS sectors is based on information by Gilbert et al. (2004) for the initial trading period 2005-2007 complemented by the assumption that in the subsequent EU ETS period allowances are uniformly scaled down by 6 %. Table 1 summarizes the EU ETS policy data underlying our simulations.

Table 1: EU ETS climate policy data

		ETS emissions in 2010 (Mt CO2)[1]	Allocation factor in 2005[2]	Adjusted allocation factor[3]	Emission cutback (Mt CO_2)	Emission cutback (% of projected emissions)
Austria	AUT	25.9	0.94	0.88	3.01	11.6
Belgium	BEL	54.5	1.04	0.98	1.12	2.1
Czech Republic	CZE	73.8	1.00	0.94	4.43	6.0
Germany	DEU	439.8	1.00	0.94	26.39	6.0
Denmark	DNK	25.5	0.85	0.80	5.13	20.1
Spain	ESP	144.6	0.94	0.88	16.83	11.6
Finland	FIN	32.0	0.98	0.92	2.52	7.9
France	FRA	142.1	1.00	0.94	9.19	6.5
U.K.	GBR	242.2	0.99	0.93	16.13	6.7
Greece	GRC	68.0	1.00	0.94	4.08	6.0
Hungary	HUN	32.9	1.00	0.94	1.97	6.0
Ireland	IRL	20.8	0.97	0.91	1.83	8.8
Italy	ITA	201.9	1.07	1.01	-1.93	-1.0
Netherlands	NLD	84.8	1.04	0.97	2.30	2.7
Poland	POL	203.8	1.00	0.94	12.23	6.0
Portugal	PRT	37.0	1.00	0.94	2.22	6.0
Slovakia	SVK	28.4	1.00	0.94	1.70	6.0
Sweden	SWE	23.3	1.00	0.94	1.40	6.0
Baltic States*	BAL	26.6	1.00	0.94	1.60	6.0
Rest of EU**	XEU	107.1	1.00	0.94	6.35	5.9
Total EU-27		2015.0	1.00	0.94	118.50	5.9

* (Estonia, Latvia, Lithuania) **(Luxembourg, Cyprus, Malta, Slovenia, Bulgaria, Romania)

[1] EU (2003c), [2] Gilbert et al. (2004), [3] Scaling of allocation factor in 2005 by 0.94

[9] The choice of Germany as the unilaterally taxing ETS region is motivated by the fact that it holds by far the largest share of emission allowance among EU member states (roughly a quarter of the initially allocated EU ETS permit volume) and thus may have the potential to exert some market power.

Figure 3 depicts the development of the marginal abatement cost for Germany and the remaining EU member states (*Rest of EU*). Whereas marginal abatement cost for remaining EU member states reflect the international permit price, Germany in addition faces the unilaterally imposed carbon tax. In the benchmark situation, i.e. the EU ETS without unilateral carbon tax, the international permit price amounts to about 3 € per ton of CO_2. The rather low permit price reflects the modest overall emission reduction requirement of 5.9% for the EU ETS (as compared to projected benchmark emissions in 2010). Imposition of a unilateral carbon tax in Germany exerts a downward pressure on the international permit price which decreases to around 2 € per ton of CO_2 for at CO_2 tax of 5 €.

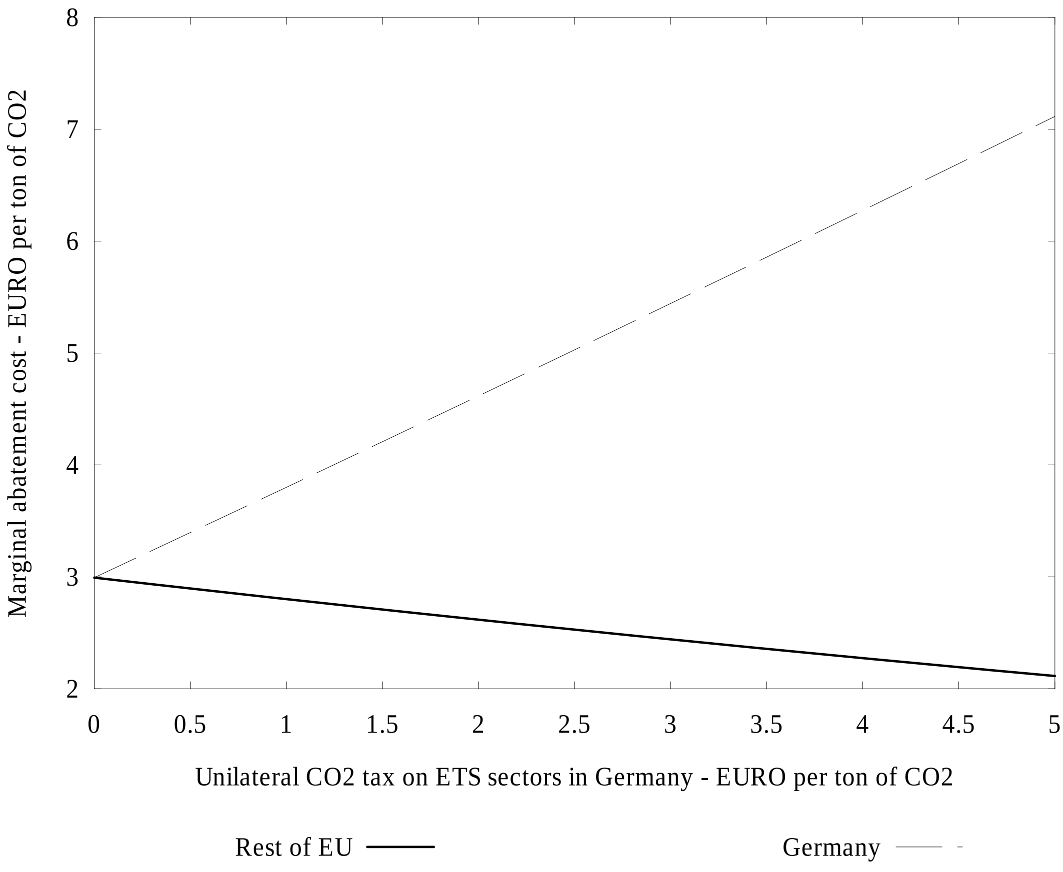

Figure 3: Marginal abatement cost for Germany and the Rest of the EU

Reflecting our theoretical analysis, overlapping regulation through the unilateral CO_2 tax in Germany induces overall excess costs for the sectors of the EU ETS. Figure 4 illustrates these excess costs in percent of the efficient no-tax EU-ETS regime. We can see that additional costs may be quite substantial (in particular as the compliance cost of the efficient no-tax EU-ETS regime are rather small).

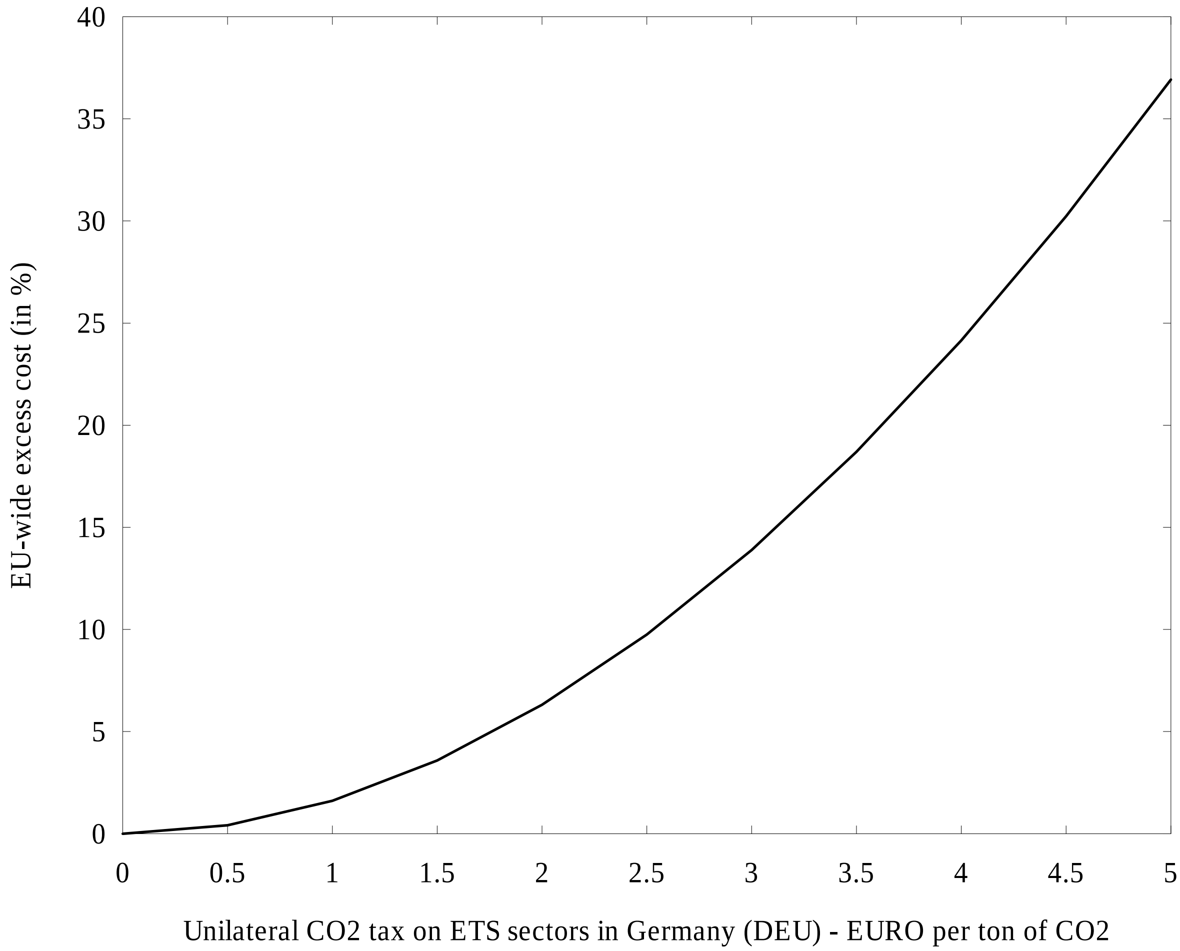

Figure 4: EU-wide excess cost for EU ETS sectors of unilateral CO_2 tax in Germany

While the aggregate efficiency implications are unambiguous, individual EU member states may benefit or lose from the unilateral carbon tax in Germany. The basic reasoning behind the regional effects are linked to the initial trade patterns: Since the international permit price decreases with a rising unilateral carbon tax, regions that are net exporters of emission allowances can initially be expected to lose with the permit price and their exports falling, whereas permit importers can be expected to win. Some countries – a net permit exporter if there is no tax – may even switch to importing permits if the unilateral emissions tax is high. Germany is not able to achieve a net profit from unilateral CO_2 taxation: Based on our empirical parameterization, the three conditions for a country to benefit from a unilateral tax are obviously not fulfilled. Instead, Germany suffers substantial cost increases. Tables A1 and A2 in the Appendix report the trade flows and costs in more detail.

In order to perform some sensitivity analysis of our results with respect to the stringency of environmental regulation, we have calculated the excess cost of double regulation as both, a function for the unilateral carbon tax as well as a function of the allocation factor. Whereas the central case simulation assumes a scaling of 2005 allocation factors by 0.94, the sensitivity analysis investigates more ambitious emission reduction requirements up to a scaling factor of 0.8. Figure 5 reports the results of the sensitivity analysis. We see that overall relative excess cost for the sectors of the EU ETS of the unilateral carbon tax decreases with increased stringency of the emission cap. As the marginal and inframarginal costs of the no-tax EU ETS regime increase, the imposition of the unilateral carbon tax (here: in Germany) induces relatively smaller distortions.

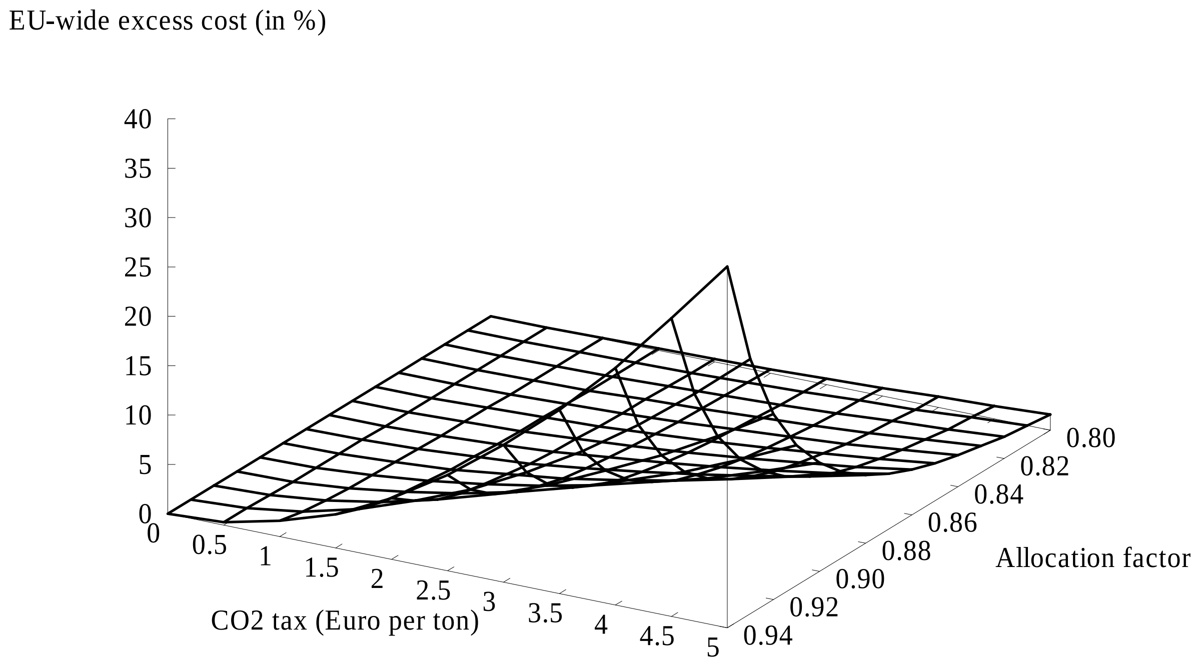

Figure 5: EU-wide excess cost of unilateral CO_2 tax in Germany

4. Concluding remarks

In this paper, we shed some light on the debate of the appropriate instrument mix in climate policy. In particular we analyse whether carbon emissions of the EU ETS sectors in one or several countries should be additionally regulated by a unilateral carbon tax. It turns out that overlapping regulation of a quantity-based instrument – such as a permit trading scheme – with a price based-instrument – such as a CO_2 tax – does not contribute to overall emission reduction, but increases overall compliance costs.

Emission taxes are typically a matter of the EU member states' legislation. Any additional regulation within the sectors covered by the EU ETS, however, has to consider that it will act within an “ecologically effective” regime, meaning that the overall emissions are determined by the amount of permits on the market. Once the initial allocation of the permits is fixed, additional regulation within the trading sectors can have distributional effects or it can alter the permit price, but it will not change the EU wide emission reduction. The only exception would be a permit price driven down to zero in case of comprehensive and sufficiently high emission taxes.

A carbon tax is a cost efficient instrument to regulate CO_2 emissions in the sectors that are not covered by the EU ETS. When applied within the trading sectors, however, unilateral carbon taxes increase the EU overall costs of implementing a given emissions constraint. Typically, a unilateral carbon tax also leads to excess costs in the country that introduces the tax since the additional abatement expenditures exceed the revenues from permit sales, or from less spending for permit purchases, respectively. The taxing country may gain at the expense of overall cost effectiveness only if rather restrictive conditions are met: The country has a large share in the permit market, features comparatively flat marginal abatement costs in the sectors subject to emissions trading, and is at the same time a net permit importer. In this case, the reduced domestic permit demand may lower the EU-wide market price for permits and thereby cause an extra reduction of the country’s expenditures for permit imports.

We have performed empirical simulations for the EU ETS where Germany levies an additional unilateral carbon tax on its EU ETS sectors. Our results confirm that the cost implication of overlapping regulation can be substantial.

To conclude, energy or carbon taxes within the part of the EU economy that is regulated by the emissions trading system should be handled with great care and justified by other reasons than implementing the commitments under the Burden Sharing Agreement in a cost-efficient manner. Our results suggest that the EU member states should make use of the legislative scope left by the EU energy tax directive, thereby exempting installations subject to the EU ETS from (additional) fossil fuel taxation.

References

Betz, R., W. Eichhammer, and J. Schleich. 2004. "Designing National Allocation Plans for EU Emissions Trading - A First Analysis of the Outcome." *Energy and Environment* 15 (3): 375-423.

BMU. 2003. "Die Ökologische Steuerreform: Einstieg, Fortführung und Fortentwicklung zur ökologischen Finanzreform." German Federal Ministry for the Environment, Berlin.

Böhringer, C. 2002. "Industry-level Emission Trading between Power Producers in the EU." *Applied Economics* 34 (4): 523-533.

Böhringer, C. and A. Lange. 2005. "Mission Impossible!? – On the Harmonization of National Allocation Plans under the EU Emissions Trading Directive." *Journal of Regulatory Economics* 27 (1): 51-71.

Böhringer, C., T. Hoffmann, A. Lange, A. Löschel, and Ulf Moslener. 2005. "Assessing Emission Allocation in Europe: An Interactive Simulation Approach." *The Energy Journal* 26 (4): 1-22.

Brooke, A., D. Kendrick and A. Meeraus. 1987. "GAMS: A User's Guide." Scientific Press, San Francisco.

Bovenberg, A.L. 1999. "Green Tax Reforms and the Double Dividend: An Updated Reader's Guide." *International Tax and Public Finance* 6: 421-443.

Capros, P., L. Mantzos, D. Kolokotsas, N. Ioannou, T. Georgakopoulos, A. Filippopoulitis, and Y. Antoniou. 1998. "The PRIMES Energy System Model – Reference Manual."

National Technical University of Athens. Document as peer reviewed by the European Commission, Directorate General for Research.

Criqui, P. and S. Mima. 2001. "The European Greenhouse Gas Tradable Emission Permit System: Some Policy Issues Identified with the POLES-ASPEN Model." *ENER Bulletin* 23: 51-55.

Dimaranan, B. and R.A. McDougall. 2002. "*Global Trade, Assistance and Production: The GTAP 5 Data Base*." West Lafayette, Center for Global Trade Analysis. Purdue University.

EU. 2003a. Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003, Establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community and Amending Council Directive 96/61/EC. *Official Journal of the European Union* L 275/32, Brussels.

EU. 2003b. Council Directive 2003/96/EC of 27 October 2003, Restructuring the Community Framework for the Taxation of Energy Products and Electricity. *Official Journal of the European Union* L 283/51, Brussels.

EU. 2003c. "European Energy and Transport Trends to 2030." European Commission, Brussels.

EU. 2005. "EU Action Against Climate Change." European Commission, Brussels.

Eyckmans, J., D. van Regemorter, and V. van Steenberghe. 2001. "Is Kyoto Fatally Flawed? – An Analysis with MacGEM." Working Paper Series – Faculty of Economics, No. 2001-18, Catholic University of Leuven, Leuven.

Gilbert, A., J.-W. Bode, and D. Phylipsen. 2004. "Analysis of the National Allocation Plans for the EU Emissions Trading Scheme." Ecofys Interim Report, Utrecht, The Netherlands.

http://www.ecofys.com/com/publications/documents/Interim_Report_NAP_Evaluation_180804.pdf.

Goulder, L.H. 1995. “Environmental Taxation and the Double Dividend: A Reader's Guide.” *International Tax and Public Finance* 2: 157-183.

Johnstone, N. 2003. “The Use of Tradable Permits in Combination with Other Environmental Policy Instruments.” Report ENV/EPOC/WPNEP(2002)28/Final, OECD, Paris.

Klepper, G. and S. Peterson. 2002. “Marginal Abatement Cost Curves in General Equilibrium: The influence of World Energy Prices.” *Resource and Energy Economics* (28)1: 1-23.

Point Carbon. 2006. “Carbon 2006.” edited by Hasselknippe, H. and K. Røine.

Sorrell, S. and J. Sijm. 2003. “Carbon Trading in the Policy Mix.” *Oxford Review of Economic Policy* 19 (3): 420-437.

Appendix A: Algebraic Model Summary

The partial equilibrium model of the EU ETS is based on region-specific marginal abatement cost curves which characterize emission reduction possibilities in the ETS sector of each EU member state. Marginal abatement cost curves are denoted by cost functions $C_r(e_r)$ (decreasing, convex, differentiable) where e_r are the actual emissions of ETS sectors in EU member state *r*. Emission limits for the ETS sectors in each member state are provided by the initial allocation of emission allowances $\overline{E}_r$. The emissions trading scheme reflects the decentralized solution to the central planner problem which seeks for the cost minimum of EU-wide abatement cost subject to the overall EU-wide emission constraint:

$$\min_{e_r} \sum_r C_r\left(e_r\right)$$

$$\text{s.t.} \qquad \sum_r e_r \leq \sum_r \overline{E}_r \ ,$$

The first-order conditions for the cost minimization problem are given by:

$$C_r^{'}\left(e_r\right) = \tau \quad \forall r \ .$$

where τ denotes the shadow price of the aggregate emission constraint which can be readily interpreted as international permit price. In the cost minimum, the price taking EU member states abate emissions in the EU ETS up to a level where their marginal abatement costs ($C_i^{'}$) are equalized. Total costs of reducing emissions to the overall target level are minimized, since all opportunities for exploiting cost differences in abatement across the ETS sectors of EU member states are taken.

Imposition of a unilateral carbon tax by region *r'* implies the modified optimization problem:

$$\min_{e_r} \sum_{r \neq r'} C_r\left(e_r\right) + C_{r'}(e_{r'}) - \bar{t}_{r'} e_{r'}$$

$$\text{s.t.} \qquad \sum_r e_r \leq \sum_r \overline{E}_r$$

where $\bar{t}_{r'}$ denotes the exogenous tax imposed on carbon emissions of the ETS sectors in region *r'*. First-order conditions can be summarized as:

$$C_r^{'}\left(e_r\right)=\tau \quad \forall r \text{ and } C_{r'}^{'}\left(e_{r'}\right)=\tau+\bar{t}_{r'}$$

Obviously, imposition of a unilateral carbon tax in region *r'* violates the conditions of the overall social cost minimum as marginal abatement cost in region *r'* deviates from marginal abatement cost in other regions *r* by the exogenous carbon tax.

Appendix B: GAMS Code of Numerical Model

```
$TITLE Analysis of Excess Cost from Overlapping Carbon Regulation in the EU

$ontext
==================================================================================
GAMS source code to replicate results of manuscript:

       Efficiency Losses from Overlapping Economic Instruments in
                  European Carbon Emissions Regulation

Christoph Böhringer, Henrike Koschel, and Ulf Moslener
Centre for European Economic Research (ZEW), Mannheim

Correspondence: boehringer@zew.de

Mannheim ---  August, 2006
==================================================================================
$offtext

SET    r      EU regions represented in the model
       / AUT  Austria,
         BAL  Baltic States,
         BEL  Belgium,
         CZE  Czech Republic,
         DEU  Germany,
         DNK  Denmark,
         ESP  Spain,
         FIN  Finland,
         FRA  France,
         GBR  United Kingdom,
         GRC  Greece,
         HUN  Hungary,
         IRL  Ireland,
         ITA  Italy,
         NLD  Netherlands,
         POL  Poland,
         PRT  Portugal,
         SVK  Slovakia,
         SWE  Sweden,
         XEU  Rest of EU
       /;

SET    allr   All EU member states
       /AUT, BEL, DEU, DNK, ESP, FIN, FRA, GBR, GRC, IRL, ITA, LUX, NLD,
        PRT, SWE, HUN, POL, CYP, CZE, MLT, SVK, SVN, EST, LVA, LTU, BGR, ROM/;

SET mapit(allr,r) Mapping of EU member states to EU model regions
       /AUT.AUT, BEL.BEL, DEU.DEU, DNK.DNK, ESP.ESP, FIN.FIN, FRA.FRA, GBR.GBR,
        GRC.GRC, IRL.IRL, ITA.ITA, NLD.NLD, PRT.PRT, SWE.SWE, LUX.XEU, HUN.HUN,
        POL.POL, CYP.XEU, CZE.CZE, MLT.XEU, SVK.SVK, SVN.XEU, EST.BAL, LVA.BAL,
        LTU.BAL, BGR.XEU, ROM.XEU/;
```

```
TABLE data(*,*)     Carbon emission inventories for EU Member States (in Mt of C)
* Data sources:
* European Energy and Transport - Trends to 2030, European Commission, Brussels
* http://europa.eu.int/comm/dgs/energy_transport/figures/trends_2030/index_en.htm
* Gilbert et al. (2004), Analysis of the National Allocation Plans for the EU
* Emissions Trading Scheme, Ecofys Interim Report, Utrecht, The Netherlands,
* http://www.ecofys.com/com/publications/documents/Interim_Report_NAP_Evaluation_
* 180804.pdf.
*
* Key:
* C_ETS_05:  Total carbon emissions of ETS sectors in 2005 by region
* C_ETS_10:  Projected total carbon emissions of ETS sectors in 2005 by region
*-------------------------------------------------------------------------------
* Lambda:    Fulfillment factor for ETS sectors by region as ratio of allocated
*             emission allowances over business-as-usual emissions

*      Source:

       C_ETS_05     C_ETS_10     Lambda
AUT    26.6         25.9         0.940
BEL    56.3         54.5         1.042
DEU    444.1        439.8        1.000
DNK    27.5         25.5         0.850
ESP    147.1        144.6        0.940
FIN    36.6         32.0         0.980
FRA    132.8        142.1        0.995
GBR    258.6        242.2        0.993
GRC    63.1         68.0         1.000
IRL    20.7         20.8         0.970
ITA    204.3        201.9        1.074
LUX    2.7          3.3          1.030
NLD    78.9         84.8         1.035
PRT    33.8         37.0         1.000
SWE    22.0         23.3         1.000
HUN    31.0         32.9         1.000
POL    199.0        203.8        1.000
CYP    4.2          4.5          1.000
CZE    75.4         73.8         1.000
MLT    1.7          2.1          1.000
SVK    26.2         28.4         1.000
SVN    7.4          7.2          1.000
EST    12.7         11.2         1.000
LVA    4.3          4.6          1.000
LTU    8.5          10.8         1.000
BGR    33.3         32.9         1.000
ROM    56.9         57.1         1.000;


SCALAR CO2inC Conversion factor from carbon to carbon dioxide ;

CO2inC = 12/44;
```

```
*      Assign data to aggregate model regions:
*      Emission reduction requirements are based on projected
*      emission data for 2010 which is used as the reference
*      year for compliance within the model simulations.

PARAMETER    carbonstat(*,*)     Emission data by model region,
             ffactor(r)          ETS fulfillment factor by model region;

carbonstat(r,"ETS") = SUM(allr$mapit(allr,r), data(allr,"C_ETS_10")*CO2inC);

*      Regarding the fulfillment factors which are used for the model
*      compliance period in 2010 it is assumed that the fulfillment
*      factors as of 2005 are cut by 6 % (factor: 0.94) according
*      to internal EU Commission communication

SCALAR nap_scale  Uniform scaling of emission allowances to ETS sectors /0.94/;


ffactor(r)$SUM(allr$mapit(allr,r), data(allr,"C_ETS_05")) =
      SUM(allr$mapit(allr,r), data(allr,"Lambda")*nap_scale*data(allr,"C_ETS_05"))
             /SUM(allr$mapit(allr,r), data(allr,"C_ETS_05"));

DISPLAY carbonstat, ffactor;

TABLE   mac_coef(r,*)  Exogenous coefficients for MAC function approximation
*      (here: polynomial of third degree)
* Units:  Euro per ton of carbon
* Source: Own calculations based on European CGE model
*        (Boehringer 2002:  Applied Economics, 34, 523-533)
*         Economic data for CGE model is based on 2001 GTAP6 data
*        (Dimaranan and McDougall 2002, Purdue University)
*         available at: http://www.gtap.agecon.purdue.edu/


         a1                a2              a3

AUT    31.792798    11.404881    7.6574059
BEL    12.525735    1.3631822    0.83551358
DNK    16.815408    2.2750154    2.2515957
FIN    28.630794    5.0711964    1.0307786
fra    12.195939    1.5427418    0.5759482
DEU    1.6106427    0.0192323    0.00044646
GBR    2.6584576    0.06894563   0.00365619
GRC    13.948536    -0.53775863  0.15444644
IRL    23.029636    6.8247019    7.8718684
ITA    4.5824262    0.2904227    0.01431379
NLD    6.9398464    0.47487886   0.05661485
PRT    85.224805    20.01391     28.23715
ESP    3.8660081    0.12586864   0.02242585
SWE    56.792634    45.884037    54.739798
BAL    28.538172    -9.3137061   8.1172545
XEU    2.7068989    0.04599646   0.00385902
CZE    3.8816768    -0.01813968  0.03491031
HUN    13.588239    1.6882308    1.5992551
```

```
POL    2.6225261     0.02984338   0.0034039
SVK    19.856852     2.8059284    4.8509275 ;


*      Compute effective reduction targets w.r.t 1990 and 2010
PARAMETER target(r) Reduction targets in Mt of carbon;
target(r) =  carbonstat(r,"ETS") - ffactor(r) * carbonstat(r,"ETS");
DISPLAY target;

*      Assignment of MAC curve coefficients
*      Approximations of MACs: MAC = a1*e + a2*e**2 + a3*e**3

PARAMETER a1, a2, a3;
a1(r)   =mac_coef(r,"a1");
a2(r)   =mac_coef(r,"a2");
a3(r)   =mac_coef(r,"a3");

*      Specification of carbon tax regime for selected regions (tax_r)
SET
  tsc      Tax scenarios /T0, T05, T10, T15, T20, T25, T30, T35, T40, T45, T50/,
  tax_r(r)  Regions with additional carbon tax in ETS sectors;

PARAMETER
  taxlevel(tsc)     Carbon tax rate by scenario (in Euro per ton of CO2)
             /T0 0, T05  0.5, T10 1, T15 1.5, T20 2, T25 2.5, T30 3,
              T35 3.5, T40 4, T45 4.5, T50 5/,
  tax(*)     Carbon tax;


*      Definition of multi-regional emission market model
FREE VARIABLE
       tcost        Aggregate cost of carbon mitigation;

POSITIVE VARIABLE
       d(r)         Abatement by ETS sectors in region r

EQUATIONS
       totalcost    Total compliance cost for model regions
       ceiling      Total emission ceiling for model regions;

totalcost..   tcost =e= SUM(r, (1/2)*a1(r)*d(r)**2 + (1/3)*a2(r)*d(r)**3
                     + (1/4)*a3(r)*d(r)**4) - SUM(r, tax(r)*d(r));

ceiling..     SUM(r, d(r)) =g= SUM(r, target(r));

MODEL nlp_model     Emission market model in NLP formulations
             / totalcost, ceiling/;

*      Scenario runs and reporting

PARAMETER
       cost         Summary - total compliance costs (in millions of Euros)
       mac          Summary - marginal abatement costs (in Euros per ton of CO2)
       trade        Permit imports (in Mt of CO2)
```

```
      Fig_3        Marginal abatement cost in Euro per ton of CO2
      Fig_4        EU-wide excess cost of unilateral CO2 tax(in %)
      Fig_5        Sensitivity analysis of EU-wide excess cost (in %)

      Table_1      Benchmark emission data
      Table_A1     Permit imports (in Mt of CO2)
      Table_A2     Regional cost implication (in millions of EUROs);


Table_1(r,"emissions_2010")        = 1/CO2inC*carbonstat(r,"ETS");
Table_1("EU-27","emissions_2010")  = SUM(r,1/CO2inC*carbonstat(r,"ETS"));
Table_1(r, "ffactor2005")          = ffactor(r)/0.94;
Table_1("EU-27","ffactor2005")     = SUM(r,ffactor(r)/0.94*carbonstat(r,"ETS"))
                                        /SUM(r, carbonstat(r,"ETS"));
Table_1(r, "ffactor2010")         = ffactor(r);
Table_1("EU-27","ffactor2010")     = SUM(r, ffactor(r)*carbonstat(r,"ETS"))
                                        /SUM(r, carbonstat(r,"ETS"));
Table_1(r, "cutback_total")        = 1/CO2inC*target(r);
Table_1("EU-27","cutback_total")   = SUM(r, 1/CO2inC*target(r));
Table_1(r, "cutback_percent")      = ROUND(100*target(r)/carbonstat(r,"ETS"), 1);
Table_1("EU-27","cutback_percent") = ROUND(100*SUM(r, target(r))
                                        /SUM(r,carbonstat(r,"ETS")), 1) ;


*      Region(s) with additional carbon taxes (here: Germany (deu))
tax_r("deu") = YES;

LOOP(tsc,

tax(r)$tax_r(r) = taxlevel(tsc)/CO2inC;
DISPLAY tax;


SOLVE nlp_model USING NLP MINIMIZING tcost;

cost("EU", tsc)     = EPS + SUM(r, ROUND(  (  (1/2)*a1(r)*d.l(r)**2
                           + (1/3)*a2(r)*d.l(r)**3
                           + (1/4)*a3(r)*d.l(r)**4), 3));

cost(r, tsc) = EPS + ROUND(((  (1/2)*a1(r)*d.l(r)**2
                           + (1/3)*a2(r)*d.l(r)**3
                           + (1/4)*a3(r)*d.l(r)**4)
                           + (target(r) - d.l(r))*ceiling.m), 3);
trade(r,tsc) = EPS + 1/CO2inC*(target(r) - d.l(r));

mac(tsc)     = EPS + ROUND(CO2inC*ceiling.m, 3);

);

*      Marginal abatement cost in ETS sectors:
Fig_3(tsc,"Rest of EU") = EPS + ROUND(mac(tsc), 1);
Fig_3(tsc,"Germany")    = EPS + ROUND(mac(tsc) + taxlevel(tsc),1) ;
```

```
*      EU-wide excess cost (in % of no-Tax case):
Fig_4(tsc,"EU-ETS") = EPS + ROUND(100*(cost("EU",tsc)/cost("EU","T0") - 1),1);


*      Regional trade flows (permit exports in Mt of CO2)
Table_A1(r,tsc)            = EPS + ROUND(trade(r,tsc),1);
*      Regional cost implications (in millions of EUROs)
Table_A2(r,tsc)            = EPS + ROUND(cost(r,tsc), 1);
Table_A2("EU-27",tsc)      = SUM(r, Table_A2(r,tsc));


*      Sensitivity analysis with respect to scaling of  emission allowances to
*      ETS sectors. The reference value is 0.94. In the sensitivity analysis we
*      cover the range from [0.94 - 0.8] in steps of 0.1.

SET    itr    Iteration steps for scaling of emission allowances /1*15/;

PARAMETER     sa_cost  Summary on total compliance cost - sensitivity analysis;

SCALAR        eu_ffactor;
eu_ffactor    = SUM(r, ffactor(r)*carbonstat(r,"ETS"))      /SUM(r,
carbonstat(r,"ETS"));
DISPLAY eu_ffactor;

LOOP(tsc,
tax(r)$tax_r(r) = taxlevel(tsc)/CO2inC;

 LOOP(itr,
   nap_scale  =  0.94 - (ord(itr)-1)/100;
   ffactor(r)$SUM(allr$mapit(allr,r), data(allr,"C_ETS_05")) =
       SUM(allr$mapit(allr,r), data(allr,"Lambda")*nap_scale*data(allr,"C_ETS_05"))
              /SUM(allr$mapit(allr,r), data(allr,"C_ETS_05"));
   target(r)  =  carbonstat(r,"ETS") - ffactor(r) * carbonstat(r,"ETS");

SOLVE nlp_model USING NLP MINIMIZING tcost;


sa_cost("EU", tsc,itr)           = EPS + SUM(r, ROUND(  (  (1/2)*a1(r)*d.l(r)**2
                                 + (1/3)*a2(r)*d.l(r)**3
                                        + (1/4)*a3(r)*d.l(r)**4), 1));
 );
);


Fig_5(tsc,itr) = ROUND(100*(sa_cost("EU", tsc,itr)/sa_cost("EU","T0",itr) - 1),1);

OPTIONS DECIMALS=1;

DISPLAY Fig_3, Fig_4, Fig_5, Table_1, Table_A1, Table_A2;
```

Table A: EU ETS climate policy data

CO_2 tax in Germany (EURO/ton of CO_2)		0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
A.1 Permit imports (in Mt of CO_2)												
Austria	AUT	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.2	2.2
Belgium	BEL	-1.7	-1.7	-1.6	-1.5	-1.4	-1.3	-1.3	-1.2	-1.1	-1.0	-1.0
Czech Republic	CZE	-5.4	-5.1	-4.8	-4.6	-4.3	-4.0	-3.7	-3.5	-3.2	-3.0	-2.7
Germany	DEU	3.4	0.6	-2.2	-4.9	-7.6	-10.2	-12.8	-15.3	-17.8	-20.3	-22.7
Denmark	DNK	3.0	3.1	3.1	3.2	3.2	3.3	3.3	3.4	3.5	3.5	3.6
Spain	ESP	7.5	7.8	8.1	8.3	8.6	8.8	9.1	9.3	9.6	9.8	10.0
Finland	FIN	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.5	1.6
France	FRA	6.3	6.4	6.4	6.5	6.6	6.7	6.8	6.8	6.9	7.0	7.1
United Kingdom	GBR	2.5	2.9	3.3	3.7	4.1	4.5	4.8	5.2	5.5	5.9	6.2
Greece	GRC	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.8	1.9	2.0
Hungary	HUN	-0.6	-0.5	-0.5	-0.4	-0.3	-0.3	-0.2	-0.1	-0.1	0.0	0.1
Ireland	IRL	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.7
Italy	ITA	-9.6	-9.4	-9.2	-8.9	-8.7	-8.5	-8.3	-8.1	-7.9	-7.7	-7.5
Netherlands	NLD	-2.9	-2.8	-2.6	-2.5	-2.3	-2.2	-2.0	-1.9	-1.8	-1.6	-1.5
Poland	POL	-2.2	-1.7	-1.3	-0.9	-0.5	-0.1	0.3	0.7	1.1	1.5	1.8
Portugal	PRT	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.9
Slovakia	SVK	-0.1	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4
Sweden	SWE	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Baltic States	BAL	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5
Rest of EU	XEU	-7.4	-7.0	-6.6	-6.2	-5.8	-5.4	-5.0	-4.7	-4.3	-3.9	-3.6
A.2 Compliance cost (in million EURO)												
Austria	AUT	7.3	7.10	6.90	6.70	6.50	6.4	6.2	6	5.8	5.7	5.5
Belgium	BEL	-1.1	-0.90	-0.80	-0.60	-0.50	-0.4	-0.3	-0.2	-0.1	0	0.1
Czech Republic	CZE	-1.9	-1.40	-0.90	-0.50	-0.10	0.3	0.6	1	1.2	1.5	1.7
Germany	DEU	43.6	44.10	46.20	50.00	55.20	61.9	70	79.4	90.2	102.2	115.3
Denmark	DNK	12.0	11.70	11.40	11.10	10.80	10.6	10.3	10	9.7	9.4	9.1
Spain	ESP	35.9	35.10	34.40	33.60	32.90	32.1	31.3	30.5	29.8	29	28.2
Finland	FIN	5.5	5.40	5.30	5.20	5.10	4.9	4.8	4.7	4.6	4.4	4.3
France	FRA	23.0	22.30	21.70	21.10	20.50	20	19.4	18.8	18.2	17.7	17.1
United Kingdom	GBR	27.2	26.90	26.60	26.30	25.90	25.6	25.2	24.7	24.3	23.8	23.4
Greece	GRC	7.8	7.70	7.60	7.50	7.30	7.2	7	6.9	6.8	6.6	6.4
Hungary	HUN	1.8	1.90	1.90	2.00	2.00	2	2.1	2.1	2.1	2.1	2.1
Ireland	IRL	3.1	3.10	3.10	3.00	3.00	2.9	2.9	2.8	2.8	2.7	2.7
Italy	ITA	-17.8	-16.80	-15.90	-15.10	-14.30	-13.5	-12.8	-12.1	-11.5	-10.8	-10.2
Netherlands	NLD	-1.2	-0.90	-0.70	-0.40	-0.20	0	0.2	0.3	0.5	0.6	0.7
Poland	POL	14.5	14.70	14.90	15.00	15.00	15.1	15	15	14.9	14.8	14.7
Portugal	PRT	6.0	5.80	5.60	5.40	5.30	5.1	5	4.8	4.6	4.5	4.3
Slovakia	SVK	2.3	2.30	2.30	2.30	2.30	2.3	2.3	2.2	2.2	2.2	2.2
Sweden	SWE	3.2	3.10	3.10	3.00	2.90	2.8	2.8	2.7	2.6	2.5	2.5
Baltic States	BAL	2.5	2.50	2.50	2.50	2.50	2.4	2.4	2.4	2.3	2.3	2.3
Rest of EU	XEU	-2.1	-1.40	-0.80	-0.20	0.40	0.9	1.3	1.7	2.1	2.4	2.7
Total (EU-27)		171.6	172.30	174.40	177.90	182.50	188.6	195.7	203.7	213.1	223.6	235.1