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The Impacts of the European Emissions Trading Scheme on Competitiveness and Employment in Europe – a Literature Review

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Structure of Report:

Executive Summary

In 2005, the European Emissions Trading Scheme (EU ETS) came into force. This scheme is the cornerstone of the EU member states' efforts to fulfil their emission reduction targets of the Kyoto Protocol. The protocol requires European countries to reduce their greenhouse gas emissions by eight per cent until between 2008 and 2012. Our paper analyses the future impacts of the EU ETS on competitiveness and employment. To achieve this we identify the key determinants and characteristics of efficient emission trading systems, and review the literature dealing with the impacts such schemes can have on competitiveness and employment.

We have identified the choice of the reference scenario as the most critical issue for an appropriate analysis of the relevant literature. The results from all theoretical and simulation studies analysing environmental regulation depend substantially on the reference scenario, i.e. whether the impacts of the EU ETS are compared to a business as usual-scenario (BAU) with no regulation in place at all, or whether the impacts are compared with the impacts of another instrument such as Command and Control regulation (CaC). Given the legally binding framework of the Kyoto Protocol, the EU has no alternative but to engage in environmental regulation to reduce CO2 emissions.

Apart from this important qualification regarding the reference scenario, our paper puts the ETS related costs and impacts as derived from the models analysed into a wider context. Costs of climate protection – for instance - have to be compared with the costs of inaction, i.e. the external costs caused by global warming. Further, other cost factors such as labour costs have to be taken into account for a realistic assessment of ETS impacts. A certain innovation potential of ETSs also needs to be considered. The EU ETS could significantly be optimised and also grow in scope and scale, especially geographically over time, resulting in a global policy diffusion and corresponding demand. In this case first mover advantages can be expected for the EU.

If the reference scenario and other key assumptions of the models are identified and analysed, it is possible to obtain a relatively clear picture of how the introduction of the EU ETS influences Europe's competitiveness and employment. With regard to competitiveness, most of the studies model the EU ETS and compare it with other regulation scenarios. The reference point is often Kyoto compliance without allowance trading. It makes sense to choose this scenario as it clearly demonstrates the efficiency or cost effects of emissions trading in relation to given environmental objectives. The alternative BAU scenario without emission reductions is used in single cases.

The competitiveness record of the EU ETS is mixed, with emission trading coming out as the cheapest option, if we accept a reality with climate change and Kyoto compliance. Simulation studies suggest that the system offers major cost benefits when compared with Kyoto-based non-trading scenarios. Possible positive innovation effects must also be taken into account, depending on the actual design of the scheme. Winners and losers at the firm and sector level are produced, particularly in comparison with the BAU scenario, but even here the results of the studies analysed suggest only modest costs.

Studies dealing with the power sector disagree on whether the system enables the sector to boost its gains. One thing appears to be clear, however, and that is that the sector is not among the major losers produced by this mechanism. The main reasons for potential negative impacts on Europe's competitiveness found by some studies are the heterogeneous National Allocation Plans and the limitation of emissions trading to a handful of sectors. This means that the mechanism is by no means optimal from an economic point of view. Improvements in the system with significantly lower costs whilst retaining the same ecological goals are certainly possible. The potential this represents for the instrument should not, however, obscure just how much has already been achieved with the EU ETS. If countries were required to comply with their Kyoto commitments without engaging in any trading at all, this would result in a substantial increase in costs. A well designed EU ETS is found to clearly be the cheapest option.

With regard to ETS impacts on employment, evidence is found for both positive and negative impacts of environmental regulation and ETSs. However, we have to be very careful in deriving robust conclusions from the studies analysed. Only two out of the six available studies are focusing on the EU ETS, and one of the two has been criticised for flaws in the methodology. Further, it is crucial not to ignore the choice of the reference scenario in the studies evaluating employment effects. Almost all studies use BAU scenarios as a reference rather than alternative regulation. Comparing the impacts of ETSs with the impacts of BAU, it is simple to assume a moderate reduction in employment. However, even compared to BAU neither economic theory nor the simulation studies reviewed suggest high employment reductions. If ETS employment effects are compared to impacts of alternative regulation methods accepting the need to reach the Kyoto targets, the arrangement of the EU ETS is certainly among the better choices. Because of its flexibility and the innovation incentives induced, an ETS should be preferred to non-market instruments.

To conclude, the employment effects of the EU ETS will be smaller than many representatives of the sectors concerned fear. Aggregated job losses will barely be visible, even if BAU is used as a reference. This is due to the choice of an ETS to achieve the target defined in the Kyoto-Protocol as well as the specific design of the EU ETS. A variation of the mechanism intended to improve its labour market impact would therefore appear to be problematic. The mechanism should not, however, be expected to create jobs. At the firm or even sector level, there will be winners and losers. Some firms and sectors will lay off workers while others will recruit.

However, on the basis of the scientific research available to date one cannot draw solid conclusions regarding the sector-specific ETS impacts on employment. Even if the overall effect for the EU turns out to be negative, our analysis finds that it will certainly be of minor importance.

Summing up, the impacts of the EU ETS on competitiveness and employment are modest, and they are smaller than the impacts of alternative regulation scenarios. Compared to these other regulation methods ETSs can have positive competitiveness effects. However, the EU ETS is not designed to boost Europe’s economy. Its prime purpose and justification is to ensure that Europe’s CO_2 emissions are brought down and Kyoto targets are reached at minimal costs.

The EU ETS should be justified on environmental grounds. It is especially important that modifications to the system due to economic considerations do not undermine the environmental goals associated with this policy instrument. The EU ETS will not be responsible for a significant reduction of EU competitiveness. Consequently the scheme will also not be a job killer.

1. Introduction

In 2005, the European Union Emissions Trading Scheme (EU ETS) came into force. This scheme is a crucial cornerstone of the efforts being made by the EU member states to fulfil the emissions reduction targets of the Kyoto Protocol. The protocol requires European countries to reduce their greenhouse gas emissions by eight per cent until 2008. The baseline is the level of emissions in 1990. The ETS does not apply to all emissions generated in the EU, however. It is confined only to CO_2 emissions of installations in the four sectors of energy (e.g. electric power, direct emissions from oil refineries), production and processing of ferrous metals, minerals (e.g. cement, glass) and pulp and paper. The ETS will cover almost half (46 per cent) of total CO_2 emissions in the EU countries and almost a third of the EU's total greenhouse gas emissions. In the scheme’s first phase (2005 to 2007) the emission allowances are grandfathered according to National Allocation Plans (NAPs) of the member states, in the second phase (2008 to 2012) up to 10 per cent can be auctioned. European firms may partly fulfil their emissions reduction obligations outside of the EU by using flexible instruments such as Joint Implementation (JI) and Clean Development Mechanism (CDM) (for a general description of the EU ETS see for example Böhringer et al., 2005a, or Kruger and Pizer, 2004). However, the relevant European Directive demands member states to restrict the use of these credits, suggesting a review in case a 6 per cent limit for the use of JI and CDM is exceeded. Basically, member states are free in defining the limits, but such a review is likely to limit the official cap to somewhere around 10 per cent.

The current design of the EU ETS has been heavily criticised by the scientific community for its lack of environmental effectiveness and economic efficiency. With respect to the ETS’s ecological effectiveness, Kyoto and national targets were not considered sufficiently in setting caps (over-allocation), such that only few countries are actually on a path to achieve their Kyoto targets. To meet these, serious reductions will need to be made in phase two by most countries. Many countries shifted reduction obligations to the non-trading sectors (Böhringer et al., 2005b), further weakening the efficiency of the system in relaxing the reduction obligations without having a clear mechanism to ensure reductions in the non-trading sectors.

Phase one NAPs did not reflect the burden sharing agreement as reduction obligations did not reflect the objectives under the burden sharing agreement. Economic efficiency suffered from a lack of transparency, simplicity and harmonisation. As a result of the scheme’s implementation in January 2005, companies in energy intensive industries have criticised an anticipated loss of competitiveness partially due to increasing energy prices. However, regarding its role as an innovation-driver, the EU ETS has the potential to stimulate energy efficiency at the same time and bring about positive effects on competitiveness.

Our paper attempts to analyse the future impacts of the EU ETS on competitiveness and employment. To achieve this we aim at identifying the key determinants and characteristics of efficient emission trading systems, and review the literature on the impacts ETSs have on competitiveness and employment.

However, to begin with we need to make two qualifications. First, it is not at all clear how the EU ETS will develop subsequent to the planned trading period from 2008 to 2012. Therefore, the long term effects on competitiveness and employment are highly uncertain. Furthermore, due to a lack of data – in particular with respect to the EU ETS presently installed – the empirical literature does not refer to ex-post econometric analysis. The literature review consequently focuses on economic theory and simulation studies. Naturally, using econometrics for an ex-post analysis of economic consequences of the EU ETS might offer intriguing new insights into the topic. This type of analysis remains to be done as soon as the EU ETS produces sufficient data.

The paper is structured as follows: Section 2 discusses the methodolody of the study: What do we understand by an ETS and what are the guiding principles? Is there a global trend towards the diffusion of ETSs? What is the reference case analysed in the simulation studies? How did we select our reviewed studies? How did we deal with the costs of inaction, i.e. the external costs of climate change? And finally: What are the other drivers for competitiveness and employment? Section 3 analyses the competitiveness effects of the system. In a first step the relevance of the famous Porter hypothesis and the US trading schemes are examined. Secondly, the EU ETS itself is introduced by presenting a theoretical background discussing the existing simulation studies. Furthermore we briefly examine EU ETS evidence for the power sector. The section concludes with a summary of our main findings on competitiveness effects. Section 4 investigates employment impacts. This section begins with a discussion of the Porter hypothesis and its relevance for employment. The relevance of the double dividend approach to the employment issue is also discussed. This general discussion then serves as the starting point for a specific analysis of the potential labour market impacts of the EU ETS taking into account theoretical analysis as well as existing simulation studies. Literature dealing with alternative national or international ETSs is explored as well since only two simulation studies analysing employment effects of the EU ETS exist. The section concludes in summing up the main findings. Section 5 provides an overview of the general findings of this paper.

2. Methodology

There is growing consensus amongst the scientific community that global warming is a fact. The main cause for the rise in temperatures is the build-up of atmospheric greenhouse gases (GHG), in particular CO_2, which alone accounts for over 80 per cent of the total amount of GHGs. Science also suggests that the need for deep emission cuts is urgent: to keep the consequences from climate change to an acceptable level, CO_2 emissions in industrialised countries will have to be reduced by 60 to 80 per cent until 2050 (Hohmeyer and Rennings, 1999).

The EU has chosen the instrument of emissions trading to fulfil its 8 per cent GHG reduction commitment compared to 1990 under the Kyoto Protocol. The EU ETS as the key political measure to help achieve this target will have to be judged against this background, as opposed to a comparison with business as usual scenarios. Given the legally binding framework of the Kyoto Protocol, Europe has to fulfil its commitments and business as usual scenarios simply are no real options. Any discussion of economic advantages and disadvantages of the EU ETS have to reflect that. Simple inaction on GHG emissions do not serve as appropriate evaluation alternatives, the potential impacts of the EU ETS have to be compared to other instruments like Command and Control regulation (CaC).

Costs of climate protection have to be compared with the costs of inaction, i.e. the external costs caused by global warming. Although quantifying potential external costs from climate change is subject to a high level of uncertainty, this has to be considered as the actual alternative. Further, other cost factors such as labour costs have to be taken into account for a realistic assessment of the impacts of the EU ETS. The context given in this chapter and the following subsections is important to properly assess the ETS impacts as derived from the simulation studies analysed below.

2.1. ETS: Guiding principles and controversial discussions

The idea of emissions trading means that environmental targets are met at minimal costs for the economy (SRU, 2006). While emissions are free in a system without emissions trading, and thus firms do not take them into account, an ETS creates a market price for emissions. Furthermore, it defines an absolute cap on total emissions. In doing so, the state only defines the reduction target, not the costs involved. The “rights to pollute” are allocated among the participants of the system by auctioning or grandfathering.

In theory the market mechanism decentrally ensures the right allocation of emissions as opposed to an otherwise required centrally formulated and monitored process. In an ETS every firm has the possibility to use emission permits or to sell them on the market. It is profitable for firms to sell or to buy emissions rights until the marginal abatement costs of all involved firms are equal. This ensures the cost efficiency of the system (static efficiency). Cost efficiency can not be ensured by other instruments of environmental policy due to a lack of information.

In a trading system emissions are taken into account by each firm as a cost factor. By assigning CO_2 emissions a price the EU ETS introduces the "polluter pays principle". For the first time, businesses have to factor their impact on the climate into their commercial activities. The more they pollute, the more they pay – and investments in carbon-intense technologies can become a financial risk. The ETS has the potential to stimulate companies to reduce energy consumption or even to switch from carbon-rich technologies to cleaner and more efficient alternatives. If abatement technologies are cheaper compared to emission rights available on the market, firms will invest in abatement technologies. This permanent incentive to look for new, emission reducing technologies ensures the innovation efficiency of the system (dynamic efficiency).

When looking at the impacts on competitiveness and employment, two central questions regarding an ETS have to be addressed:

1) Is grandfathering or auctioning the applied method to allocate emission allowances?
2) How far can emission reductions from outside the system, e.g. JI/CDM, compensate emission reductions at home?

The design of the current EU ETS includes a free initial allocation of emissions allowances, i.e. grandfathering. This can be justified by political feasibility, i.e. by ameliorating adverse production and employment effects in dirty industries (Böhringer and Lange, 2005). For the second phase (2008 to 2012) the scheme allows auctioning of up to 10 per cent of the total amount of allowances. In the long run, auctioning is more appropriate to find the cheapest emission reductions in the economy, to stimulate technological progress and to separate emissions trading from questions of distribution and energy policy which may undermine the efficiency of the trading system. It may also help reducing tax distortions (Cramton and Kerr, 2002).

Generally speaking, the allocation method used represents an impact on costs companies face. Free allocation is often referred to as minimising the cost impact while auctioning strengthens the economic effciency in that the true price will at least in theory be paid. Grandfathering on the other hand is based on a controlled process of allocating allowances to individual sites, hence there is considerable effort required in measuring and monitoring for the emissions. Further the entire distribution process needs to be organised while with auctioning there is maximum flexibility and minimum effort since a cap would be the only restriction to determine.

How far the current system of grandfathering can be transferred into a system of auctioning will also depend on the global regulation trend. If other countries follow the European regulation, there are good arguments for a transition towards an auctioning system. As long as other countries such as the United Stated do not follow, the European Union may not be able to install a very strict EU ETS due to the problems of free riding. As will be shown in the next paragraph below, there are currently positive signals of a worldwirde regulation trend towards ETSs.

JI/CDM measures in theory are efficient since climate change is a global problem, and looked at from a global perspective, it does not matter where emission reduction takes place. This is the so-called “where flexibility” of the emissions trading instrument. Governments have however committed themselves to reduce domestic emissions, thus the use of JI/CDM is restricted in the EU ETS. The relevant European Directive suggests a review in case a 6 per cent limit for the use of JI and CDM is exceeded. While JI/CDM could to some extend be efficient instruments for reducing the costs of compliance within the EU ETS, the responsibility of the EU has to be considered for CO_2-reductions at home. The EU ETS is designed to help member states to comply with their Kyoto commitments, these commitments include domestic emission reductions of a significant amount. The EU ETS allows only restricted use of JI/CDM to achieve compliance, hence theoretically stimulating incentives to cut domestic emissions. As long as emission reductions abroad stay cheaper than in Europe there will always be the tendency to fulfil parts of the reduction obligation via such credits.

2.2. Perspectives for a global ETS

Impacts of an ETS on competitiveness and employment occur due to increasing prices, and because the system is not implemented on a worldwide scale but only in a certain region, in our case the EU. Thus it makes sense to look into other regions as to whether countries can be expected to follow or not. If they can be expected to follow, problems of leakage and negative impacts on competitiveness and employment can be expected to take place only temporarily. In the long run, the EU could even benefit from first mover advantages being the first to collect experiences and expertise in dealing with such a system.

The EU ETS can in fact be seen as a pioneer and as a first important step towards a global ETS. Developments of extra-EU ETS have made great progress in Norway and Switzerland who are designing schemes closely related to the EU system. Since discussions on linking the systems are already underway, these countries could be linked to the EU ETS as soon as 2010. In the medium-term perspective up to 2020, however, further candidates for linking to the EU ETS have to be considered: First, Canada is promoting the Large Final Emitter System which plans to cover energy-intensive companies which account for almost 50 per cent of total Canadian greenhouse gas emissions (CEPA Environmental Registry, 2005). However, the scheme is intended to be based on intensity targets and to include a "Price Assurance Mechanism" capping allowance costs at 15 Canadian dollars. This would lead to a very different ETS compared to the European one, which makes a direct linking of the two systems rather difficult. Second, Japan has started the Pilot Project of a Domestic Emissions Trading Scheme on a voluntary basis, with about 30 private companies participating in the program (Japanese Ministry of the Environment, 2004). Third, Russia – having ratified the Kyoto Protocol – would have good reasons to develop a domestic emissions trading system in order to be linked to the European scheme and exploit a larger market for the sale of excess permits.

Although Australia and the United States have not proceeded to ratify the Kyoto Protocol, individual states in both countries are promoting sub-national trading schemes to be established: in Australia the New South Wales (NSW) Greenhouse Gas Abatement Scheme is already operating (NSW government, 2006), in the U.S. the Regional Greenhouse Gas Initiative is promoted by nine Northeast and Mid-Atlantic states (RGGI, 2006). As a consequence, there are strong signs for future ETSs to be established in non-EU countries and potentially linked with the European scheme by 2020. Following the European ETS, emerging schemes can – like the Canadian or Japanese systems – be expected to include mainly energy-intensive industries.

The examples show that there are signals of a global regulation trend towards ETSs. This is important since further steps of an EU ETS will likely depend on the question of whether climate regulation is diffusing to other parts of the world. Secondly, a regulation trend towards ETS can be interpreted as a forecast for a demand trend towards carbon-efficient technologies, and thus towards first mover advantages for the pioneering country (Beise-Zee and Rennings, 2005).

2.3. Selection of studies

Due to the early state of our review no empirical data is available on how emissions trading affects competitivness and employment. Thus empirical literature in terms of econometric studies is not available. Our literature review consequently focuses on economic theory and simulation studies, the so-called "theory with numbers".

Using econometrics for an ex-post analysis of economic consequences of the EU ETS might offer intriguing new insights into the topic. This type of analysis remains to be done as soon as the EU ETS produces sufficient data.

We did not have to select studies for our literature review. Due to the limited number of studies we have considered all existing studies for our analysis dealing with (European) emissions trading, competitiveness and employment.

It has to be noted that the assumptions the different studies are based on and the emission trading systems described in them do not always match the EU ETS reality. The EU ETS as we currently know it differs from some of the schemes outlined in the studies analysed below, e.g. regarding peculiarities of the specific national allocation of allowances. But there are also similarities in some cases (e.g. PRIMES, POLES, SIMAC).

This means that the studies are not analysing the real EU ETS, but emission trading schemes of a more or less comparable type. As a consequence, the results of the studies analysed do not necessarily hold true for the EU ETS. But in tendency the findings regarding impacts on employment and competitiveness should apply.

Furthermore it has to be noted that not all models in the section on ETS and employment deal with a European ETS. Four out of the six models look at national or international emission trading schemes, therefore the relevance of results derived from these models might be limited. Two simulation studies are analysed that focus on the EU ETS. However, as one of them only looks at Germany and the other has received rather widespread criticisms, the results from these studies also have to be handled with care.

All reviewed models belong to three groups of models and have different strengths and weaknesses: CGE models, partial models (which are in nearly all cases energy models) and macroeconometric models. These model types and their advantages and disadvantges should be introduced briefly:

Computable General Equilibrium (CGE) models

CGE models calculate a vector of prices such that all the markets of the economy are in equilibrium, implying that resources are allocated efficiently. They are based on economic theory and theoretical coherence (i.e. the Walrasian representations of the economy). Therefore, parameters and coefficients are calibrated with mathematical methods and not estimated as in econometric modelling. They can be static - comparing the situation at one or more dates - or dynamic, showing developments from one period to another. CGE models require a Social Accounting Matrix that is built by combining Input-Output-tables (to model interrelations between productive sectors) with national account data.

The strength of CGE models is their internal consistency; i.e. they allow for consistent comparative analysis of policy scenarios by ensuring that in all scenarios the economic system remains in general equilibrium (however, extensions to model market imperfections are possible). Thus e.g. the effects of a certain market structure in the electricity market is typically not adressed by these models.

They integrate micro-economic mechanisms and institutional features into a consistent macro-economic framework and consider feedback mechanisms between all markets. All behavioural equations (demand and supply) are derived from microeconomic principles. Since CGE models are calibrated to a base year data set, the data requirement is limited even if the degree of disaggregation is high. This allows for the evaluation of distributional effects across countries, economic sectors and agents. CGE models are advantageous for analysing general economic policies like public finance, taxation and social policy, and their impact on longer term structural change.

The weakness of CGE models is their somewhat tautological construction (all results are implicitly linked to to the assumptions and calibration made). CGE models can be used only for simulation purposes, but not for forecasts. Another disadvantage compared to sectoral models is that, following the top-down approach, CGE models typically lack a detailed bottom-up representation of the production and supply side. Since top-down models rely on the assumption that all “best available technologies” have been already installed, the calculated cost of a specific emission reduction measure is typically higher than in bottom-up studies.

Energy models

Energy models belong to the sectoral models. These models are constructed on the equilibrium of one specific sector (here the energy sector) of the economy.

The strength of sectoral models is that they focus only on one economic sector and thus enable a relatively high degree of disaggregation and a detailed representation of the specific economic and institutional factors. Partial models are an appropriate tool if the focus of policy analysis is on a specific sector and if feedbacks between the rest of the economy (e.g. via substitution and demand effects) can be ignored to a large extent. Note that the importance of these indirect feedback effects increases with the degree of regulative intensity. Sectoral models are often very detailed since they are sometimes complemented by more specific (e.g., engineering-economic) bottom-up models. The latter are advantageous since they, for example, are able to handle nonlinearities.

The most important drawback of sectoral models is their incapacity to capture the effects on other markets and the feedbacks into the specific market under consideration.

Macroeconometric models

These models are empirical and are therefore developed using coherent datasets. The parameters of the equations are estimated with econometric methods. They are fundamentally designed to evaluate macro-sectoral impacts of economic policies, although they have been extended to incorporate environmental dimensions.

The strength of macroeconometric models relies on the validation of the equations of the model with statistical methods and on the model's ability to provide short-to-medium term forecasting and to evaluate the impact of policies. Moreover, these models ensure a coherent framework for analysing inter-linkages between variables. The weakness of such models is their difficulty to catch longer run phenomena, since the equations on which they are based are linked to a given time framework. Besides, due to the extensive need of data the degree of sectoral disaggregation is usually smaller than in calibrated CGE models. Frequently, behavioural assumptions do not rely on microeconomic theory.

With respect to our application of the models in the context of an impact assessment of the EU ETS on competitiveness and employment, this means we should not expect specific insights into the market structure of single markets such as the power market from CGE models. However, CGE models give an orientation regarding the magnitude of indirect effects. On the other hand, energy models do not say anything on indirect effects, which are especially important for a simulation of the employment effects.

Generally, all studies contribute to the questions addressed in this paper. As expected, all models generate the same qualitative results, i.e. that trading systems are superior to non-trading systems, and that unrestricted trading is more efficient than restricted trading. Due to the nature of the models and the year of the study, the question of the design of NAPs is not addressed in detail. One exception is the SIMAC model which addresses the question of how allowances were allocated at the national level, and how this affects costs.

We will describe how competitiveness and employment effects were addressed in the studies, and in single cases clearly state critical applications of models (e.g. models being combined in a non-transparent way). We did not describe in detail how labour and energy markets, the substitutability of labour and energy, and foreign trade are modelled in the different studies. This would go beyond the scope of this study, and the models are not very well documented in this regard. As far as the modelling of the labour market is concerned, we have described the way of modelling in the description of the studies in the Annex as far as information was available.

Thus, our approach consists of looking at the results across different types of models, all based on the methodological approaches described at the beginning of each chapter, in order to draw conclusions regarding the magnitude of effects that can be expected from emissions trading.

2.4. Business as usual vs. alternative instruments as reference case

Against this background, we have identified the choice of the reference scenario as the most critical issue of the study. This is crucial in all theoretical and simulation studies analysing environmental regulation since the results depend substantially on the chosen reference standard, i.e. whether the impacts of the EU ETS are compared to a business as usual scenario (BAU) with no regulation in place at all, or whether the impacts are compared with the impacts of another instrument such as Command and Control regulation (CaC).

This question is highly relevant for the analysis of an EU ETS since the BAU is hardly a realistic reference scenario for policymakers. The EU ETS is the key approach Europe takes to achieve compliance with the emission reduction targets defined in the Kyoto Protocol. Given the existence of this agreement, the EU has no alternative but to engage in environmental regulation. Inaction is not an option.

It appears reasonable to assume that regulation will have at least initially some negative economic consequences. We will argue below, however, that regulation does not only imply additional burdens and costs for the relevant economic agents. Experience and science agree that it can also result in concrete benefits. Priorities of environmental regulation have to be clearly understood, though. The (main) purpose of environmental regulation is not to deliver economic benefits but to protect and improve the environment. In cases where ecological progress is no “free lunch”, we should always aim at minimising any potential economic damage. If an environmental target has been set, we should choose the regulation instrument which imposes the lowest possible burden on domestic firms.

This paper therefore concentrates on the competition and employment performance of different instruments designed to help Europe meet the Kyoto targets. It however also makes transparent which studies use the BAU as the reference case. This is of particular importance in the section on ETSs and employment, as none of the models analysed there uses alternative regulation as reference scenario. Instead, five out of six models use BAU. In the section on ETSs and competitiveness the distribution is more balanced, with four models using BAU and six models using alternative regulation as reference scenario.

2.5. External costs of climate change

When discussing the potential costs of climate protection measures like an emission trading scheme, one should not ignore the growing damage costs from climate impacts. If it is intended to carry out a full cost benefit analysis of climate protection, the problem is that only the costs can be easily observed and measured. In contrast, the benefits of climate protection – or, in other words: the marginal costs of damages that would appear if no action is taken - are uncertain and occur in the future (Rennings and Hohmeyer, 1999).

In several contributions, damage cost calculations of climate change like that of Nordhaus (1991), Cline (1991) and Fankhauser (1995) were criticised especially from an ecological perspective. It had been argued that mere neoclassical optimisation concepts tend to ignore the ecological, ethical and social dimension of the greenhouse effect, especially issues of an equitable distribution and a sustainable use of non-substitutable, essential functions of ecosystems (IPPC, 1995). Due to methodological and empirical problems, the major valuation studies estimating external costs in the energy sector refused to integrate damage costs of climate change into their results.

As an alternative option, abatement costs (for specific CO_2-reduction targets) have been calculated instead. Most advocates of an ecological paradigm of sustainable development prefer the use of abatement costs because they are normally related to CO_2-reduction targets leading to sustainable future emission paths. Others do not quantify anything.

The ExternE project funded by the European Commission (EC 1994) describes the problems concerning the valuation of damages. The main results have been that:

- the impacts of global warming are complex, scenario dependent, very uncertain, long term and potentially very large,
- the regional variation of climatic change is poorly understood,
- the most comprehensive impact assessments (IPCC) are largely qualitative,

- the results are very sensitive to scenarios considering secondary effects, especially starvation in developing countries,
- serious ethical questions are touched which go beyond mere allocation questions of welfare theory and
- there is no consensus about these fundamental ethical questions.

In their latest methodology update (Bickel and Friedrich, 2005), the ExternE project refers to damage costs of 9€/tC for a medium discount rate. This value is seen as conservative since only damages with a reasonable certainty are included. The risks of extended floods and more frequent hurricanes are for example not included. Thus they propose to use the avoidance cost approach and estimate a value between 5 and 20€/tC for meeting the Kyoto targets.

Similar conclusions have been drawn by the Intergovernmental Panel on Climate Change (IPCC) in its Second Assessment Report (IPPC, 1995). The Working Group III of the IPCC has given special attention to the assessment of cost-benefit analysis and the incorporation of intra- and intergenerational equity aspects. It has identified some key problems being not adequately addressed by applying traditional cost-benefit-analysis to climate change (IPCC, 1995, Arrow et al., 1996):

- large uncertainties,
- long time horizons,
- global, regional and intergenerational nature of the problem,
- wide variations of the cost estimates of potential physical damages due to climate change,
- wide variations of the cost estimates of mitigation options,
- low confidence in monetary estimates for important consequences (especially non-market impacts),
- possible catastrophes with very small probabilities and
- issues of intragenerational equity (especially lower values for statistical lives of people in developing countries than those in developed countries).

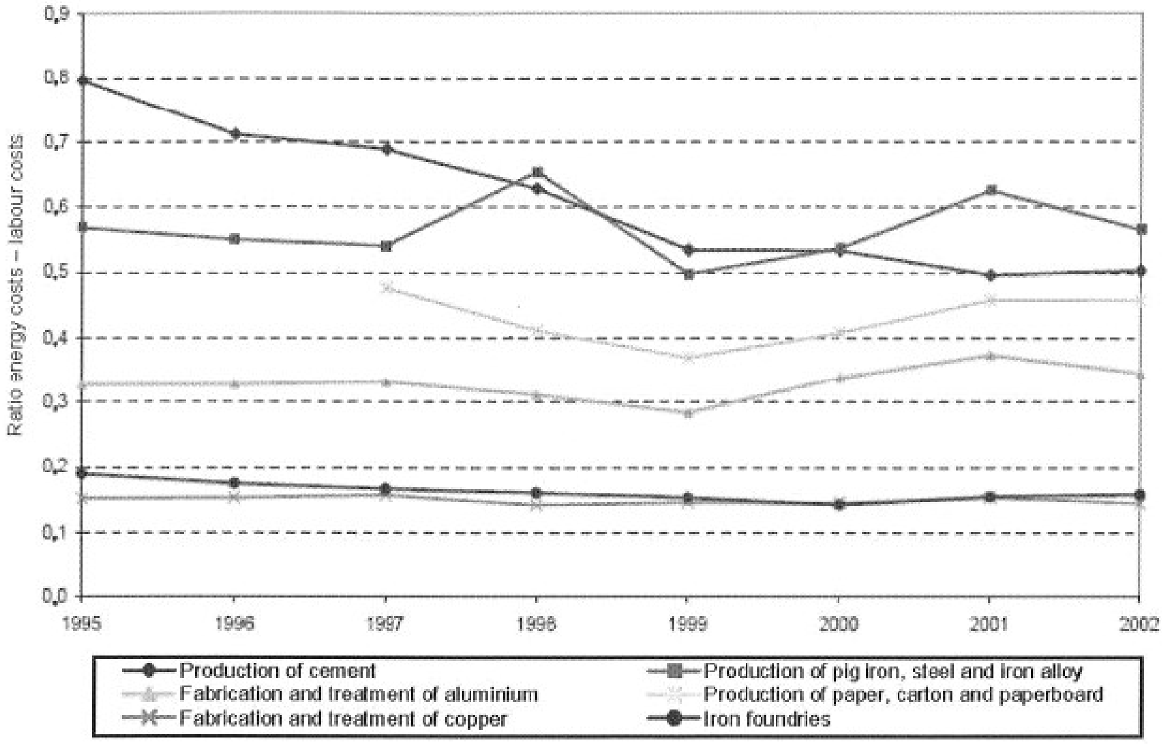
Until these substantial problems are solved, no serious value for damage costs of climate change is to be agreed upon. This conclusion does not say that damages from climate change are zero, but that precise estimates of these damages do not have a sound scientific basis because of great uncertainty. It should be considered that significant damage costs of climate change exist, and that these costs have to be weighed against potential costs of climate policy.

2.6. *The role of energy compared to labour costs*

Finally, we should generally discuss the question of how relevant emission trading is for competitiveness and employment, and how much impact the costs resulting from emissions trading have in comparison with other factors such as labour costs.

Increasing energy prices lead to increased prices of products. If all other factors remain constant, profitability will decrease. A firm has three options to react: first it can increase prices, secondly it can reduce other costs. Finally it can reduce the energy input, for example by implementing efficiency measures. In the long run the firm can also decide to change the used technology or even to relocate. However, energy prices have to be seen in the context of other cost components. Increasing energy prices only matter if they contribute to or even dominate the overall costs. Figure 1 shows the development of the ratio of energy costs compared to labour costs (including social costs) for selected sectors in Germany until 2002.

Figure 1: Development of the ratio energy to labour costs in selected sectors



Source: Eikmeier et al. (2005).

In the figure only energy intensive sectors are selected. Figure 1 shows that the ratio is relatively constant over time (except in the cement industry showing a decreasing importance of energy costs). In this German example labour costs dominate in all cases even in the energy intensive sectors. In the iron foundries and copper sector labour costs are six times as high as energy costs. This means that a 1 per cent increase of labour costs will have the same effect as a 6 per cent increase of energy costs. If the relation of labour and energy costs is extended to sectors being more representative for the whole economy, the average value is a relatively constant relation of 0.8 for labour costs and 0.2 for energy costs (Eikmeier et al., 2005).

Summing up it can be concluded that labour costs are the dominating factor for costs and competitiveness, even in the energy intensive industries. There are costs involved with emission trading and they should not be ignored, but this example shows that ETS-related costs have to be put in a relevant context and perspective to understand their dimensions.

3. EU ETS and competitiveness

3.1. The Porter hypothesis and early US ETS experience

The Porter hypothesis

The view that environmental regulation like an emission trading scheme is merely a source of costs and thus entails competitive disadvantages for the affected firms and companies is controversial. The key argument against this view – i.e. that environmental action can actually generate competitive advantages – is based on what is referred to as the 'Porter hypothesis'. This hypothesis postulates that, in the long term, the objectives of environmental protection and commercial competitiveness are congruent with each other (cf. for example Porter and van der Linde, 1995). Specifically, Porter argues that a pioneering environmental policy role can create technological first mover advantages and make companies more innovative (Taistra, 2000). This is based on the assumption that other countries follow in the footsteps of the pioneering country and adopt environmental regulations at some later point in time (e.g. extension of the EU ETS to other parts of the world). If this does actually happen, the regulation imposed on domestic industry at an earlier point in time will give the pioneering country an adjustment head start. It enables providers of environmental technologies to export their solutions to other countries and the greater (ecological) efficiency of consumers of such technology on the domestic market will place them at an advantage vis-à-vis their foreign competitors.

The empirical evidence for the Porter hypothesis is mixed. Most studies tend at least to demonstrate that stricter environmental regulations do not result in a significant deterioration in competitiveness (refer to Rennings et al. 2004). An example of the validity of the hypothesis is provided by Albrecht (1998). In relation to the 1978 Montreal Ozone Protocol Albrecht identifies the USA and Denmark as pioneers and, with the help of econometric analyses, is able to demonstrate that the competitive position of the relevant companies in these countries improved.

It would seem therefore that, ideally, strict environmental regulations can have a positive impact on innovation and competitiveness. However, if the conditions are not right – if other countries do not follow suit, or to a much lesser extent, Porter's case for enhanced competitiveness ceases to be quite so persuasive. In the case of climate protection it is quite possible that other regions outside the EU might "follow suit" and that, as the lead market, the EU could profit from a first mover advantage. As discussed in Section 2, there are some developments indicating that the EU ETS is a first step towards a global diffusion of emissions trading systems. This is by no means certain, however, as it would – at least theoretically – be worthwhile for other countries to adopt a free rider position with regard to public goods such as climate protection (cf. for example Hoel, 1991).

What is more, the ETS can only establish the EU as a lead market for CO_2 reducing innovations if the mechanism delivers sufficient incentives to innovate. All in all this would appear plausible. However, in its present form the system is not particularly demanding with regard to CO_2 reductions and this could lessen its innovation incentives. The main reason for this is the design of the NAPs. For example, the German NAP is less demanding compared to the earlier voluntary agreement of the German industry. The German Council of Environmental Advisors concludes that the German design of the EU ETS is not at all ambitious and thus increases the costs of climate protection (SRU, 2006).

Initial evidence from the EU ETS does, however, suggest that the system could trigger compensatory innovations in the relevant industries. In a survey conducted by the European Commission DG Environment, McKinsey and Ecofys (2005), half of the surveyed companies stated that the mechanism had a strong or medium influence on their innovation decisions. Time will tell if these statements will be reflected in real innovations and efforts by companies to increase energy efficiency and to reduce energy demand. After the European Commission has published emission data for 2005, we know that there is serious over-allocation in phase one in a number of member states. This makes significant innovation efforts rather unlikely, as CO_2 permits are relatively cheap in comparison to abatement measures.

US ETS Experience

The most comprehensive and best known practical examples of permit-based solutions are the US Acid Rain and RECLAIM (Regional Clean Air Incentives Market) programmes. An analysis of these programmes – which were launched in the 1990s – shows that permit trading may offer an efficient market-based solution. The average cost savings achieved by

RECLAIM compared with a regulative policy solution amount to 57.9 million dollars annually (Fromm and Hansjürgens, 1994). The reason for these savings is that output-oriented control via permits generates a wide range of varying internal company adjustment options and related cost savings (Fromm and Hansjürgens, 1998). The innovation effects of the American systems are limited, however (Gagelmann, 2004). The reasons for this are mainly to be found in the overly weakening design of flexible mechanisms.

The mistakes in the US systems do not, however, appear to have been rectified in the EU ETS. The EU ETS is a permit system on a supranational and thus much greater scale. Very few insights into competitive impacts are thus provided by experiences of the US system. However, it would appear plausible to assume that the conclusions regarding efficiency and innovative impact will apply in a very similar way to the European system. In comparison with CaC approaches, the efficiency performance of the EU ETS as we currently know it is positive, but its impact on innovations and modernisation is minor. This is due to the fact that the system in its present form is not very demanding with regard to CO_2 reductions, in particular because of the weak design of the NAPs. As outlined in chapter 2, more auctioning rather than grandfathering of emission allowances could result in additional costs for companies falling under the scheme, but appears at the same time more likely to fully disentangle the EU ETS innovation potential.

3.2. EU ETS and competitiveness

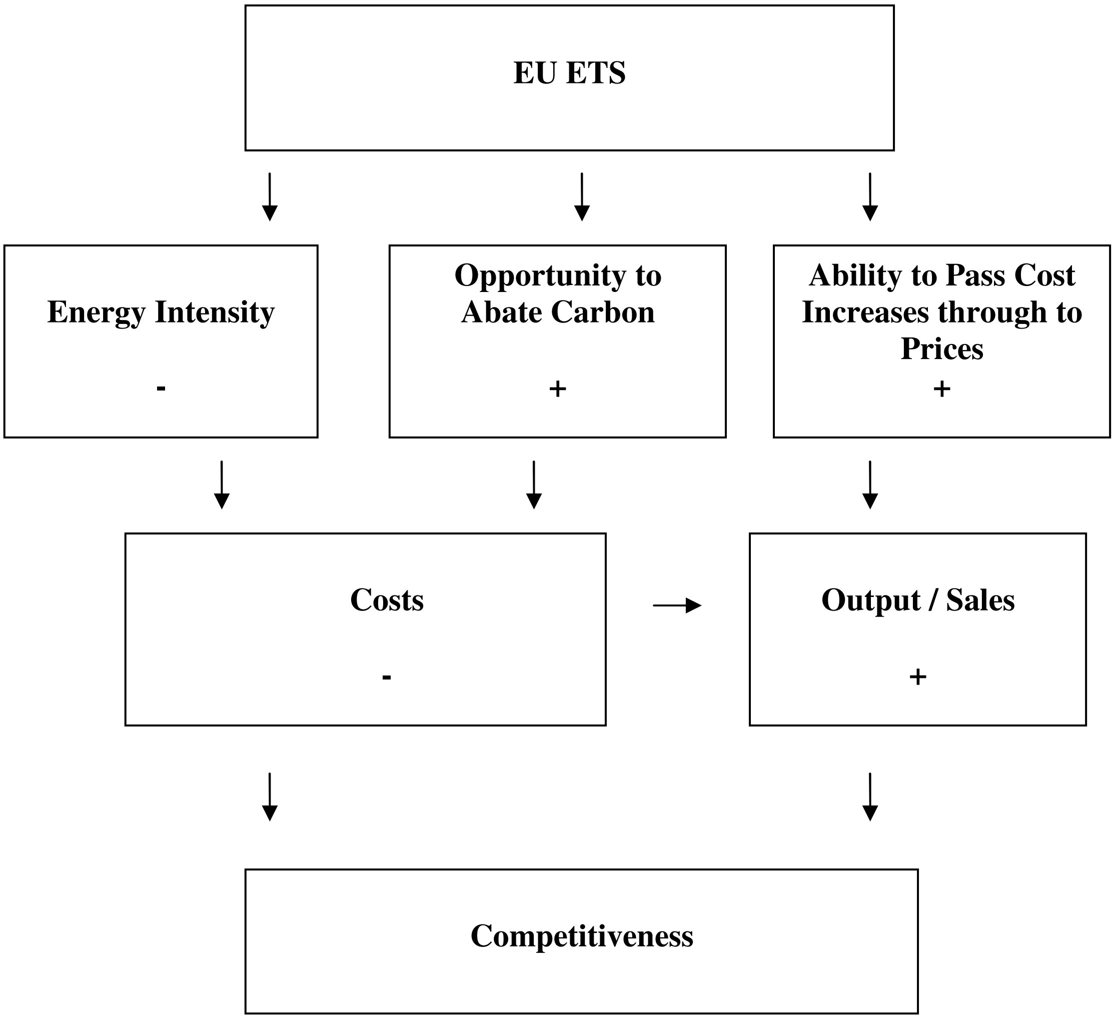
3.2.1. Impacts of EU ETS on competitiveness

The term competitiveness must be defined before the impact of the EU ETS can be studied. There are not only a number of different definitions of competitiveness, various aspects of competitiveness can also be measured in completely different ways. In this paper competitiveness is understood to mean the economic performance of producers. There are various means of measuring this economic performance, such as a company's sales or productivity. Studies of the EU ETS usually only provide information about the costs of the emissions trading system, in other words about the possible increases or reductions in costs induced by the introduction of the ETS or in comparison with other regulations. Considering the lack of any better measures, they can be used here as a measure of companies' competitiveness as these costs are part of the productivity of companies. As outlined in Section 2.6, the costs resulting from an ETS are only one cost factor among others. In general, however, one can say that increasing costs result in falling corporate productivity. An alternative measure is the change in output or GDP. These are also indicators of the competitiveness or economic performance of companies, sectors or entire economies.

Emission trading is also likely to have an impact on employment. This will be analysed separately and not as part of the following discussion of ETS impacts on competitiveness. Owing to their great importance for the issues dealt with in this study in an overall economic context, the ETS impacts on employment are examined in detail in Section 4.

A study undertaken by Carbon Trust (2004) identifies three factors which determine the impact of an ETS on competitiveness – whether at the level of the company, sector or economy as a whole. It has to be said, however, that this consideration neglects Porter-like innovation effects and is therefore more relevant for the short than for the long run. As Figure 2 shows, the first and foremost factor is energy intensity. The second factor is the ability to pass on higher costs via prices and the third is the ability to avoid CO_2 consumption during production or to replace CO_2 intensive inputs.

Figure 2: The (short-term) impact of the EU ETS on competitiveness



These three factors are particularly decisive with regard to the cost aspects of the ETS.

Indirectly, however, they affect other competitiveness indicators such as economic strength. As a result they can generally be seen as providing the theoretical basis for the analysis of the competitiveness effects of the introduction of an ETS.

The impact of energy intensity on competitiveness can be broken down into two effects. The first effect only concerns companies or sectors which participate in the system and is based on the fact that companies have to purchase additional allowances if they wish to emit more CO_2 than they are allowed to under their free permits. This gives rise to additional costs and impairs competitiveness. If the opposite case applies, however, the ETS introduction can have the opposing effect ("windfall profits" or "hot air"). The second effect, on the other hand, also affects non ETS participants and is based on the fact that the system could induce higher electricity prices[1]. If this is the case, all companies or sectors in the EU are subject to higher prices via their electricity bills. The effect on energy intensity is likely in many cases to be significantly lower under the EU ETS than under alternative regulations. Under the current EU ETS the biggest share of permits is distributed free of charge based on historic emissions, the second phase allows auctioning of up to 10 per cent of allowances. As outlined in Section 2, both allocation methods have their advantages and their disadvantages. What is more, the system is more flexible than CaC measures because the agents can purchase permits creating costs on the one hand and enabling levelling out on the other.

The more effectively prices can be passed on the less companies or sectors will suffer under an ETS. Determining factors in this context are the price elasticity of demand and the competitive situation. The less elasticity and competition the less impact the ETS will have on competitiveness.

Finally, and as mentioned previously, the ability to avoid CO_2 emissions or to substitute CO_2 intensive inputs also plays a role. An ETS will put less pressure on sectors or companies which can do this better than others. There are no fundamental differences in this respect between an ETS and any other systems of regulation. There is, however, a connection with the Porter hypothesis explained in the previous section. Abatement also depends on how strong the system-inherent incentives to abate emissions are. Permit solutions generally perform well in this respect. The advantages are particularly clear when compared with CaC instruments. However, as the current NAPs do not appear to be particularly demanding, the incentives under the specific design of the EU ETS may prove to be relatively modest. More demanding NAPs with tough caps on CO_2 and auctioning of emission allowances could induce stronger incentives.

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[1] The Carbon Trust (2004) and others consider this a plausible scenario. See below.

From a theoretical point of view there is therefore a tendency – in comparison with a BAU scenario – to assume that energy-intensive companies or sectors at least will be subject to greater burdens with the attendant effects on the economy as a whole. This is not very surprising, however (cf. Section 2). On the other hand an ETS does have competitive advantages when compared with alternative regulation scenarios. These are particularly apparent when compared with CaC instruments, although the differences when compared with other market conform regulation approaches are much more modest. The advantage of the EU ETS with grandfathering is the comparatively lower costs imposed by the system. At the same time, of course, this also means that it offers fewer incentives to innovate[2].

3.2.2. Simulation studies on the EU ETS

PRIMES

A partial equilibrium model of the energy market is the PRIMES model applied by Capros and Mantzos (2000). It analyses the economic impact of variants of the EU ETS. Compliance with the Kyoto targets in each country is analysed and used as reference scenario (alternatively, within individual sectors of individual countries). The modelled scenarios are (1) an EU-wide trading system between power utilities, (2) an EU-wide trading system which includes power utilities and energy-intensive industries, (3) an EU-wide trading system which includes all sectors and industries and (4) an international trading system within all Annex B countries taking account of all sectors.

The simulations reveal that emission trading substantially reduces the costs of the Kyoto protocol. The savings are dependent on the implied scenarios and, in the case of alternative reference frameworks, are between 20.7 and 48.6 per cent. The savings increase as emission trading expands. While savings remain relatively modest when emissions are traded by power utilities, they are highest in the system with the Annex B countries. Scenarios two and three generate savings of 24 and 34 per cent respectively.

The results imply that the highest marginal abatement costs borne by EU member countries are incurred in Belgium, Finland, and the Netherlands. These countries are thus among the net purchasers in the system while France and Germany are the largest seller countries. However, if the system welfare gains weighted with the gross domestic product of each country are considered, the net sellers turn out not to be the major winners. Owing to the greater economic strength of France and Germany the gains accruing to these countries prove to be relatively small while the Netherlands, Greece and Belgium are ahead.

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[2] For a discussion see chapter 2.1.

The PRIMES model consequently demonstrates that all participants gain from emissions trading. Trading also proves to be all the more beneficial the more prevalent and widespread trading is. There are large differences between the countries, however, in terms of the distribution of savings and gains. The EU ETS actually introduced is to some extent comparable with the scenario two in the model. One interpretation of these results is therefore that while the EU system is more beneficial than the no trading scenario, it is by no means optimal when compared with alternative scenarios including emissions reduction commitments by additional countries (see Section 2.2. on the latest developments regarding emission trading schemes outside Europe and the likelihood of linking them with the EU ETS).

POLES

The POLES partial equilibrium model of energy systems (IPTS 2000) compares EU-wide trading with a reference scenario up to 2010 in which no trading takes place. In this reference scenario, each country or region must meet the Kyoto obligations without European-wide trading. The study encompasses six EU countries/regions – Germany, France, Italy, the United Kingdom and the remaining southern EU countries in a single group (Spain, Portugal, Greece) as well as northern EU states (Austria, Belgium, Denmark, Finland, Ireland, Luxembourg, the Netherlands, Sweden). The model measures the impact of the EU ETS on the basis of an aggregated study up to the year 2010. Whether one particular country comes out better or not depends on the extent to which the country has managed to reduce its costs by trading permits compared with a non-trading scenario.

The results of the study reveal that the northern European countries bear the highest Kyoto costs as a share of their respective GDP. In the trading scenario, costs of 0.48 per cent of GDP are incurred. In comparison, the costs incurred in other regions do not exceed 0.17 per cent (Italy). However, almost all countries benefit from trading compared with the reference case. Only France remains unaffected by the EU ETS. Gains are highest in the southern European countries (savings of 62 per cent), with Germany (50 per cent) and Italy (20 per cent) also doing particularly well. The biggest net sellers are Germany and the United Kingdom.

GETS 3

The GETS 3 (ERM/Eurelectric 2002) energy market model is similar to the PRIMES model in that it attempts to capture the overall costs and incidence of costs on the basis of a number of different design variants of the ETS. The study encompasses the electricity industry and another nine sectors of the manufacturing industry in 20 countries (EU 15 and five other potential trading partners). The study focuses on a pre-compliance period 2005-2007 and two compliance periods 2008-2012 and 2013-2017. The study analyses three base scenarios: a "no-trading" scenario in which no trading and no JI/CDM is licensed, the "latest guess" scenario which reflects the scope of trading proposed in the publication on the EU directive on the ETS of March 2002, and the "perfect trading" scenario. This implies unlimited trading between all the countries and sectors studied from the year 2005 onwards.

The aggregated abatement costs are lowest in the perfect trading scenario. Limited trading of the type in the latest guess scenario increases overall costs by 1.6 billion euros. Separate compliance with the reduction commitments of each single country, in other words the no trading scenario results in an increase in overall costs compared with the perfect trading scenario of 80.5 billion euros. This is mainly due to the fact that companies do not achieve their reduction goals and must consequently pay penalties.

The results of the study also show that the choice of reference year is decisive for the allocation of emission credit purchaser and seller roles. The electricity industry is particularly sensitive to variations in the reference year.

The inclusion of additional greenhouse gases (in addition to CO_2) only has a minor impact on overall costs. This is because the study only covers industrial sectors while other greenhouse gases are mainly produced in other sectors. According to the study, a sector-based allocation of reduction goals leads to substantial distributional effects and favours sectors with lower rates of growth. An allocation variant of this type has no impact on the total compliance costs of the favoured sectors, however. Auctioning of allowances on the other hand triggers redistribution between the sectors depending on the precise recycling route.

The study confirms the positive impact of an ETS on the lowering of costs if Kyoto compliance without trading is used as the reference scenario. As in the PRIMES model, the study also shows that the existing EU ETS leaves potentials for improved competitive effects. These potentials are caused by restricting trading to a few sectors. While some of these potentials can be tapped through improving the scheme in the second phase, the debate about an extension to other sectors and gases will be part of the revision of the relevant ETS Directive, scheduled for start this year and to become binding ahead of Phase 3 (post 2012).

SIMET

The SIMET energy system model (Matthes et al. 2003) analyses the impact of emissions trading on Germany and, amongst other things, determines the resulting costs borne by various sectors. The study designs 25 different variations of emissions trading systems. One important result of the various simulations is that an allocation on the basis of selected basis years has a major influence on the level of additional costs and gains. The study reveals, for example, a gain of 135.4 million euros for the German chemical industry compared with a non-trading scenario if 1990 is selected as the base year, and of 5.5 million euros for the base year 2000. Regulations with a similar impact (e.g. early action) also have a major influence on the volume of distribution effects. The inclusion of specific aspects such as non-energy related CO_2 emissions or the abandonment of nuclear energy, in contrast, has no impact on the distribution of costs. The partial auctioning of 15 per cent of total allowances and the orientation towards anticipated costs reduce the divide between ETS winners and losers.

All in all the study reveals that, compared with compliance with the Kyoto goals by individual sectors in Germany, the use of emissions trading induces cost benefits worth between 230 and 545 million euros. The degree of fluctuation in this figure is partly due to the uncertainty inherent in the assumed figures for future growth in the sectors considered. The allocation options form a relatively reliable pattern for the structure of distribution effects, while the volume of additional costs and gains is highly dependent on the underlying allocation variations. As a result, Germany only acts as a net seller in the ETS if specific assumptions apply. The study also supports the results of the PRIMES and GETS3 models which imply cost savings as a result of emissions trading compared with the no-trading scenarios if the Kyoto goals are pursued.

Carbon Trust

The Carbon Trust (2004) uses a Cournot oligopoly model to deliver a sector by sector analysis of the effects of the EU ETS on competitiveness. Three scenarios are modelled: A short-run scenario for the first EU ETS phase based on an allowance price of 5€tCO_2, a medium-term scenario (up to around 2008, 10€/allowance) and a long-run scenario (from 2012, of 25€/allowance). The interpretation focuses primarily on medium-term projections. The reference scenario, in contrast to the studies discussed thus far, is BAU (rather than comparing the EU ETS with alternative regulation, which would take into account that Europe has to reduce CO_2 emissions in order to comply with the Kyoto targets).

The study investigates the electricity, cement, newsprint, steel and aluminium sectors. The study results demonstrate that allowance trading probably only has a minor influence on the productivity of the relevant sectors. Only the aluminium sector may prove to be a loser of the EU ETS. Under the medium-term scenario sector profits collapse by at least 30 per cent although the branch is not participating in emissions trading. This is due to the projected increase in electricity prices which increases production costs as well as the intensive global competition to which the sector is subject.

On the other hand, the study shows that the electricity, cement and print markets would be able to increase their profits somewhat over the BAU scenario. Except in the case of the long-term scenario, this is also possible for steel producers. Increased profits would entail raising prices even further than required to cover the additional costs imposed by the ETS. It is hard to tell whether this will be the case or not. However, for companies operating in these sectors very small price increases would be sufficient to compensate for the additional financial burden of emissions trading. This would not lead to a drop in sales in the oligopolistic market modelled. The study does concede that the ETS could produce losers as well as winners on subsector and company levels in all sectors, though.

DART

In contrast to the studies described so far, the DART model (Klepper and Peterson 2004) analyses competitiveness on the basis of a computable general equilibrium (CGE) model. The study analyses 16 regions, including nine EU countries or groups of countries and seven regions outside Europe, and subdivides the economies of each region into twelve sectors of which four in each case participate in the ETS. The results relate to the year 2012. The model uses the BAU as the reference scenario.

In the competitiveness analysis the authors model the allocation of allowances on the basis of a least cost approach, abatement costs and potentials, including the sectors outside the ETS. The change in output is used as an indicator for competitiveness. Alongside the BAU use is made of a unilateral policy scenario (UNI) in which the individual regions comply with the Kyoto goals without interstate trading.

The simulation generates negative competitive effects for the EU ETS when the BAU case is taken as the reference. If all the sectors are studied in aggregate, the reduction in output of 0.3 per cent is very low, however. Individual sectors suffer more dramatic drops. Compared with UNI, all sectors gain from the ETS, including sectors which do not take part in the ETS. If the drop in output in comparison with the BAU in the least cost scenario for the participating energy sector (oil products, electricity) is two per cent, it is more than double as high under UNI. The results for the remaining sectors are similar, only that part of the energy sector which does not take part in the ETS (coal, gas) has high losses in the least cost scenario (ten per cent), although these are two per cent point higher in the UNI case.

Overall, the DART model thus shows significant reductions in output to some extent and consequently loss of competitiveness if the EU ETS is compared as a least cost scenario with the BAU. If, on the other hand, one applies Kyoto measures, emissions trading generates positive competitive effects including in sectors which do not take part in emissions trading. In some sectors, this ameliorates the negative Kyoto effects by over 50 per cent.

REINAUD

Reinaud (2005) also projects modest competitiveness losses of European firms in comparison with the business as usual case. Reinaud uses rising CO_2 emissions and thus the BAU according to the World Energy Outlook as the reference and models two emissions trading scenarios: The 10 per cent scenario in which the industry is allocated allowances under the EU ETS covering 90 per cent of its emission needs and the 20 per cent scenario in which the industry is allocated allowances to cover 80 per cent of its emission needs.

Loss of competitiveness is defined as loss in output – whether as a reduction in demand or the displacement of production from one country to another (leakage). Reinaud, like the Carbon Trust (2004), identifies the aluminium sector as the industry which would be most seriously affected by the scheme. As a result of a cost increase of 3.7 per cent in both scenarios and an allowance price of 10€/tCO_2 the study calculates a fall in demand, at an unchanged margin, of 2.9 per cent. The drop is more modest for the other industries studied and does not exceed half a per cent for cement and steel, for example. Reductions in operational earnings are only predicted to be more significant if the authors make the extreme assumption of perfect competition on the observed markets.

GTAP-E

With GTAP-E, Kemfert et al. (2005) use a modified version of the general equilibrium model GTAP. The authors perform three experiments, focusing primarily on the competitive factor of marginal abatement costs. The study is based on data provided by the NAPs of the EU ETS. In experiment 1 the marginal abatement costs are estimated for a case in which every national sector is required to comply with NAP targets without engaging in trading. Experiment 2 allows national trading. Experiment 3 also provides for trading between EU countries. GTAP includes 17 European and four international regions. 57 different sectors can be distinguished.

In contrast to experiment 1, experiment 2 leads to major efficiency gains because, under the non-trading scenario, large differences in abatement costs are calculated. Enormous costs are calculated for national oil refining sectors with Greece, the Netherlands and Sweden gaining in particular. As of the transition to experiment 3, all countries gain although cost reductions are more moderate between the second and third experiments. Altogether, the GTAP calculates major reductions in costs via emissions trading compared to non-trading scenarios under Kyoto. The broader based a trading system is, the more countries and sectors stand to gain from it. A good example is provided by the extreme savings made by the oil refining sector in Sweden where marginal abatement costs in $/t$CO_2$ drop from 163 (experiment 1) to 8.4 (generally for Sweden, experiment 2) and finally to 2 (for the entire EU, experiment 3).

GTAP-ECAT

COWI (2004) use GTAP-ECAT (European Carbon Allowance Trading) to assess impacts of the EU ETS on competitiveness. They model two different ETS scenarios – long-term adaptation as well as sluggish shorter-term adaptation. As a reference scenario, BAU is used. GTAP-ECAT results suggest that competitiveness is affected in Europe due to the ETS introduction. It calculates a loss of productivity inducing a reduction of the overall production value of -0.36 per cent (-0.48 per cent with sluggish adaptation). These are comparable to other models like DART using BAU as a reference. The estimated allowance price is 17 €/tCO_2 (26.5 €/tCO_2). The authors stress that JI/CDM, which are taken into account in the calculations, may be an important element for cost-efficiency of EU ETS[3]. Furthermore, it is assumed that the EU implements an optimal split between trading and non-trading sectors. A non-optimal split, however, would increase costs of the trading scheme.

SIMAC

Böhringer et al. (2005b) use the partial model SIMAC to evaluate the actually implemented emissions trading system for Europe. The model consists of marginal abatement cost curves for the European countries participating in the system. They analyse three different scenarios: Besides a no trading – Kyoto commitment without interstate trading – and a perfect trading scenario including all European sectors[4] and countries, the actually implemented EU ETS (scenario *NAP*) is modelled. The authors find two main conclusions: First, the hybrid emissions regulation implying that only few sectors participate in the ETS leads to substantial excess costs. Second, it induces politically delicate burden shifting between sectors participating and not participating in the ETS.

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[3] For a discussion see chapter 2.1.

[4] Among these, households and transport are the most important sectors regarding CO_2 emissions.

The results suggest that compliance costs under *NAP* are eight times higher than under perfect trading and still five times higher than for purely domestic – but efficient – abatement action. This is in contrast to the other studies reviewed which generally show that the actually implemented EU ETS implies at least better competitiveness effects than domestic action. The SIMAC results are mainly due to the assumption that the generous NAPs shift abatement to sectors not participating at the ETS where, in this case, domestic action applies. Furthermore, the generous compensations to ETS sectors are at the expense of sectors not participating who suffer from costs induced by domestic policies which are a direct consequence of the NAPs. Therefore, results provided by the SIMAC model suggest – in line with other simulation studies – that restrictions to the EU ETS induce additional costs and therefore harm competitiveness. The actually implemented *NAP* scenario is shown to be inefficient, as it shifts the whole abatement obligation from the traded to the non-trading sectors, which is not at all intended in the theory of emission trading. Therefore, the results calculated by Böhringer el al. suggest that an extension of the EU ETS to other sectors would improve competitiveness in Europe. This is in line with other studies, e.g. Kemfert et al. (2005). Additionally, SIMAC produces markedly less important negative effects if JI/CDM is introduced[5].

3.2.3. Simulation studies with a focus on the power sector

As the single biggest emitter of CO_2 in Europe and in the world, the power sector is of special interest in the framework of the EU ETS. This is partly due to the heavy reliance on solid fossil fuels in power production (the power sector is responsible for 39% of Europe's CO_2 emissions) even if actual intensity depends on power production technology. Utilities could benefit from the innovation triggering effects that could result from an improved EU ETS. Given that utilities operate mostly in not fully liberalised markets and elasticity of demand for electricity is almost zero, utilities are also in a relatively comfortable position to pass costs on to their customers.

What is more, power is also an important input factor for all sectors of the economy and fluctuations in its price can have enormous effects. For this reason we concentrate in particular in this section on the impact of the EU ETS on the competitiveness and costs of the power sector.

Martinez and Neuhoff (2004) argue that the energy producing sector may well gain from emissions trading. The reason for this is the grandfathering approach adopted by the EU ETS. Energy producers are thus allocated free allowances in this simulation while, in the view of

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[5] For a discussion see chapter 2.1.

the authors, opportunity costs can be priced in if demand falls slightly. This results in gains which exceed the business as usual case. The analysis by the Carbon Trust (2004) also shows that the sector is able to boost its profits. In the view of the authors, this would be possible as an increase in prices by more than the costs induced by the ETS would appear feasible. However, a profit-neutral price increase in the study's focal 10 dollar scenario already makes up five per cent of the BAU prices.

The PRIMES model does not allow for any fundamental increase in the competitiveness of the power sector. Only utilities in Austria, Germany, France, Spain and the United Kingdom can be identified in this case as net sellers of emission allowances as long as the trading system is restricted to power utilities[6]. The simulations in the GETS3 model also identify the electricity industry as a net seller in most countries. This only applies under certain conditions, however, such as if 1995 is modelled as the base year. In the GTAP model the sector efficiency gains arising from emissions trading are slightly above average compared with the non-trading scenario. The effect varies, however, over the regions and experiments included in the simulation.

Overall, the impact of emissions trading on the power sector thus depends on the model used. An improvement in the competitiveness of industries as a result of the introduction of an allowance system is only found in some of the literature. There is, however, a large degree of consensus in the literature that, compared with BAU, other sectors would suffer greater losses. The main reason for this is probably the fact that demand elasticity in the power sector is much lower than in other industries.

3.3. Conclusion

Section 3 of this paper analyses the link between the introduction of the EU ETS and competitiveness in Europe on the basis of a literature review with a focus on simulation studies. The choice of the reference scenario was identified to be of fundamental importance for the results; in other words, whether the introduction of an EU ETS is compared with BAU or with a no trading system is crucial. Given Europe’s Kyoto commitment to an 8 per cent reduction of 1990 emission levels, only comparing with alternative regulation refers to realistic options in today’s political context. What is more, the results are also dependent on other assumptions, mainly the inclusion of flexible instruments and the modelling of (partial) auctioning. If these factors are identified and analysed it is possible to obtain a relatively clear

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[6] As PRIMES does not model recent NAPs, these results giving distributional effects on a national level may imply discrepancies in comparison with actual developments.

picture of how the introduction of the EU ETS influences Europe's competitiveness. Table 1 provides an overview of the most important results of the studies analysed above.

Table 1: Impacts of the EU Emissions Trading System on competitiveness in Europe – Simulation studies results

Model	**Reference Scenario**	**Effects on Competitiveness**
Reference Scenario: Business As Usual		
Carbon Trust (2004)	BAU	**Positive effects:** Electricity, Cement, Printing: Positive effect on profits possible **Negative effects:** Aluminium industry: -30 % profits
Reinaud (2005)	BAU	Most sectors: Very small and diverse effects **Negative effects:** Aluminium industry: Costs +3.7 %, demand -2,9 %
DART (2004)	BAU	**Negative effects:** Effects overall: Output -0.3 % **Negative effects:** Energy sector: Output -2 %
GTAP-ECAT (2005)	BAU	**Negative effects:** Effects overall: Output -0.36 % (-0.48 % with sluggish technology adaptation)
Reference Scenario: No Trade		
POLES (2000)	No Trade	**Positive effects:** Abatement Costs -25 % on average
PRIMES (2000)	No Trade	**Positive effects:** Abatement Costs -25 % on average
GETS 3 (2002)	No Trade	**Positive effects:** Abatement Costs -80.5 billion € (maximum)
DART (2004)	No Trade	**Positive effects:** Effects overall: Small output growth **Positive effects:** Energy sector: Output +3%
GTAP (2005)	No Trade	**Positive effects:** Abatement Costs -98 % (maximum)
SIMAC (2005)	No Trade	**Negative effects:** Compliance Costs +400 % (actual NAPs, costs accrue mainly in non-participating sectors)

Most of the studies model the EU ETS and compare it with other regulation scenarios. As a rule studies assume the need to comply with the Kyoto commitments of individual countries or sectors. The reference point is often Kyoto compliance without allowance trading. It makes sense to choose this scenario as it clearly demonstrates the efficiency or cost effects of emissions trading in relation to given environmental objectives. The alternative BAU scenario is used in the Carbon Trust (2004) study, in Klepper and Peterson (2004), COWI (2005) and in Reinaud (2005). All the effects calculated by these studies are interesting given that every new policy measure must be compared with the alternative no policy option at some time or other. However, as argued in Section 2 on reference scenarios in the EU ETS analysis, this comparison is unrealistic as it ignores the basic commitment made by European countries to climate protection.

The market conform allowance solution would, theoretically, enable ecological objectives such as emission reductions to be met at minimum cost. However, there is massive room for improvement since the scheme is far from perfect in terms of its efficiency. According to the models analysed above, heterogeneous NAPs and the limitation of emissions trading to a handful of sectors are among the major flaws. Although this may be seen as a first step towards (efficient) emissions reduction, the mechanism is by no means at its optimum from an economic point of view. Improvements at significantly lower costs whilst retaining the ecological goals are possible. Empirical evidence for this is provided by the PRIMES, GETS3 and SIMET models. GETS3, for example, estimates possible savings at 1.6 billion euros.

Highlighting the potential improvements of the instrument should not, however, obscure just how much has already been achieved with the EU ETS. If countries were required to comply with their Kyoto commitments without engaging in any trading at all, this would result in a substantial increase in costs to reach their obligatory emission reduction targets. A well designed EU ETS is a by far cheaper option. Again the GETS3 demonstrates cost savings in the EU ETS-related scenario compared with a non-trading scenario of around 79 billion euros. In this respect the otherwise very different simulation models come to fairly similar conclusions.

As argued in Section 2, a comparison of the competitiveness effects with the BAU scenario largely makes sense but is not particularly relevant against the background of real reduction commitments under the Kyoto Protocol. What is interesting, however, is that even when compared with business as usual the losses in most sectors are modest. With emission trading the EU has implemented an instrument that will have two positive effects for a relatively cheap price: it may significantly contribute to CO_2 emission reduction to tackle climate change while triggering the necessary structural change in the power sector and other industries to make Europe ready for the future. While most sectors analysed in the literature are only subject to these very modest costs, the aluminium sector is an exception from the rather positive trend, with its particular competitive situation, little options to reduce the electricity dependency of the production process and hence profits highly dependent on energy prices. Studies of the power sector disagree on whether the system enables the sector to boost its gains. It seems to be clear, however, that the sector is not among the major losers produced by this mechanism.

Compared with BAU the system indisputably generates higher costs, as demonstrated by a recent survey conducted by the European Commission DG Environment, McKinsey and Ecofys (2005). The survey shows that around 50 percent of the interviewed companies already build system costs into their prices. 70 percent state that this will continue to be the case in the future. The results of the same study also suggest that the EU ETS has a more powerful innovative impact than economic theory would expect given the not very demanding NAPs and lack of incentives for clean investments. While an allowance system undoubtedly offers major advantages compared with other forms of regulation such as CaC measures, the less stringent design of the current scheme and experiences with trading systems in the USA counter indicate a quick surge in innovation. Innovative progress is only likely to take place in the long term and depends on a significant devaluation in currently rather generous allocations of emission allowances.

Summing up, the competitive record of the EU ETS is mixed, with emission trading coming out as the cheapest option, if we accept a reality with climate change and Kyoto compliance. Simulation studies suggest that the system offers major cost benefits when compared with Kyoto-based non-trading scenarios. Possible positive innovation effects must also be taken into account, depending on the actual design of NAPs and scarcity of CO_2 permits. Winners and losers are produced, particularly in comparison with a BAU scenario, but even here the results suggest only modest costs. The clean development mechanism may offer a way out of this dilemma which allows domestic reduction commitments to be met internationally[7].

4. ETS and employment

4.1. The Porter hypothesis and the double dividend discussion

The Porter hypothesis

The Porter hypothesis has already been discussed in Section 3.1 of this paper, and is certainly more central to the issue of competitiveness than to the employment impact of the EU ETS. However, innovations generated by environmental regulation may also create jobs. According to Jaffe et al. (2002), market based instruments such as the ETS can provide powerful incentives for companies to develop and adopt innovations. If countries outside the EU intensify the attention they pay to climate change or become themselves subject to such

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[7] For a discussion see chapter 2.1.

regulation, regulative competition may foster a European lead market e.g. for low carbon technologies (Beise-Zee and Rennings, 2005). The demand for energy-efficient innovations could also be boosted by the recent development of energy prices. As argued by the German Council of Environmental Advisors, for example, there is an increasing economic interest in efficient energy technologies (see SRU, 2005).

According to empirical investigations, e.g. Rennings and Zwick (2002), innovations generated by environmental regulation may have a small but positive net effect on employment at the firm level. Indeed, the rise of a European lead market for low carbon technologies may even entail the creation of a higher number of jobs. Despite this, the net effect may be small as employment diminishes in "old" or carbon-intensive sectors.

Innovation effects are, however, dependent on regulations which are strict enough to stimulate the development of new technologies. The EU ETS as we see it today has not been very restrictive as far as the overall cap or the structure of the allocation of emissions allowances is concerned. In its present form the EU ETS is unlikely to have the strong innovation effects described by the Porter hypothesis. Furthermore, given the case of a tightened EU ETS, additional jobs linked to low-carbon technologies could be expected to be generated, while clearly jobs in the old industries would be impacted.

Double dividend

While the employment effects of emissions trading schemes have not been extensively investigated by economists to date, there is an extensive literature which analyses green tax reforms. The discussion is relevant in our context since it deals with the question in general of how market based instruments affect the economy. And, in principle, a tax has the same effect on the economy as auctioned emission permits, thus the results can, within limits, be transferred to the emissions trading discussion. Strictly speaking taxes are not as clearly a marked based instrument; exposure to it could only be reduced and limited, there is no way to optimise ones operations and benefit from for instance selling of surplus allowances like in an emissions trading system. However, given the state of the literature, carbon taxes are the closest to emission trading to evaluate the hypothesis.

The central hypothesis dealt with by the existing literature is the double dividend approach. This states that, on the one hand, the introduction of a green tax will improve environmental quality. This *first dividend* is straightforward as an eco-tax renders pollution more costly. This may result in less pollution and therefore better environmental quality. On the other hand, as a *second dividend* revenues generated from the tax may be used to improve the economic situation of the respective country, e.g. to lower distortionary taxes. This is not really disputed. A stronger version of the double dividend hypothesis, as Goulder (1995) puts it, states that jobs are created by the introduction of a green tax. This effect is relevant here and should apply theoretically if revenues lead to the reduction of labour costs. This approach, however, is discussed controversely in economic theory and in empirical studies.

Bovenberg and van der Ploeg (1994) show that labour supply falls as a result of the introduction of an eco-tax. However, in a different contribution, the same authors argue that due to a substitution effect from resources to labour a green tax reform may increase employment (see Bovenberg and van der Ploeg, 1996). A similar result is arrived at by Koskela and Schöb (1999). Their theoretical model follows the central economic characteristics of many European countries. The authors assume unemployment in equilibrium, endogenous wages, and take various institutional arrangements into account. According to Koskela and Schöb, a revenue neutral green tax reform lowers unemployment if and only if unemployment benefits are nominally fixed and taxed at a lower rate than labour income. Under different circumstances, however, employment may also fall. An extensive, but unfortunately not very recent theoretical overview of the double dividend hypothesis with a focus on employment is provided by Bovenberg (1995). He concludes that by introducing eco-taxes, it is very difficult to shift the tax burden away from labour. Policymakers should therefore not expect environmental taxes to significantly contribute to lowering unemployment.

The effects of the recent German environmental tax reform are analysed by Bach et al. (2002) who use both an econometric input-output-model and a dynamic computable general equilibrium model to identify a small increase in employment. The empirical evidence for a small double dividend-hypothesis goes hand in hand with the results of many simulation studies, e.g. Jansen and Klaassen (2000) who analyse EU-wide energy taxation. In their model, the tax revenues are used to reduce social security contributions paid by employers. While the energy sector is expected to face negative impacts, there are positive EU-wide effects which can also be observed in practically all member states. Modest negative effects are calculated for example by Welsch and Ehrenheim (2004) using a dynamic CGE-approach for Germany and assuming that wages rise with employment.

In summary, there is no consensus on the double dividend hypothesis in either the theoretical or the empirical literature. Several conditions have to be met for the existence of a double dividend. Crucially, tax revenues must be used to lower labour taxes, the eco-tax itself must not lead to job losses[8] and wages must not increase in response to the green tax reform. Even if these conditions are met, the magnitude of the effects remains low. However, it is also implausible that a green tax reform has strongly negative impacts.

In the existing EU ETS scenario, a double dividend cannot arise as emission allowances are grandfathered with no revenues being generated. As mentioned in Section 2, a system of auctioned emission allowances would generate results which are more similar to the discussion of green taxes. Nevertheless, the prime objective of introducing emission trading and where it has to deliver on is its ecological effectiveness, although clearly its economic efficiency plays an important role and part of this is the labour market impact.

The double dividend literature may, then, offer insights on the impacts of environmental regulation as a whole. The conclusion may be drawn that environmental taxes have a limited impact on the labour market, even being slightly positive if certain criteria are fulfilled as described. It is also important to bear in mind that the double dividend literature models effects in comparison with the BAU case. As argued in Section 2.4., for this study investigations using other reference scenarios than BAU are more relevant, i.e. scenarios that take Kyoto compliance into account.

4.2. EU ETS and employment

4.2.1. The impact of the EU ETS on employment

There are different approaches to the systematic classification of the theoretical impacts of emissions trading systems on employment. As Figure 3 shows, this paper distinguishes between direct and indirect effects.

Direct effects are based on the direct implications of the system, such as job creation in monitoring and administrating agencies, in the sector of private consultants, or additional financial experts in the firms involved within the sphere of the ETS. The direct effects of the implementation of an emissions trading system such as the EU ETS on employment are positive. These effects only apply in an ETS case, only partly for alternative regulation strategies and not at all for BAU. Their positive impact on aggregated labour demand, however, will be rather low. According to Anger et al. (2005), even in big EU countries like Germany it is unlikely that more than a few thousand jobs will be created as a direct result of the mechanism.

Indirect effects are defined here as the consequences of changes in factor price relations and in energy demand and supply. This means e.g. the effects of rising energy prices or the effects

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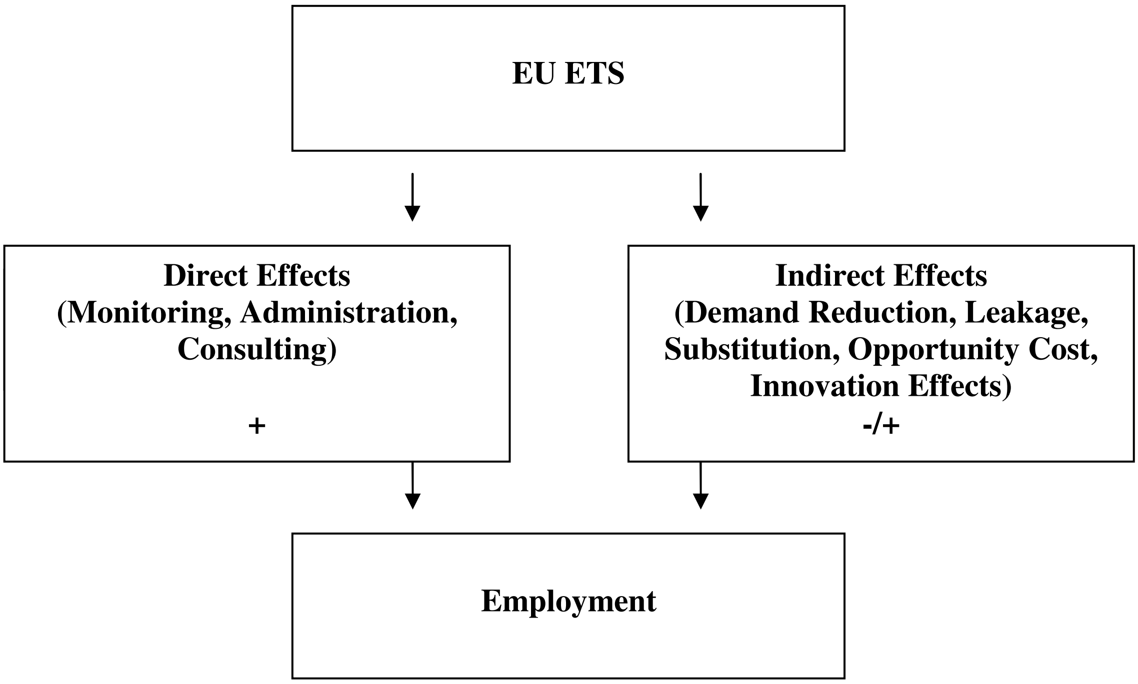
[8] This point is analysed extensively for the introduction of an ETS. Most theoretical arguments apply analogously. See section 4.2.1.

of lower available income. The indirect employment effects are more important than the direct ones. In the EU ETS case, they comprise aspects such as demand reduction, leakage, substitution, opportunity cost, and innovation effects.

Figure 3: Employment effects of the EU ETS



The most traditional concern expressed by economists is that decreasing demand may lead to job losses. This is seen as a potential effect of environmental policy in general, not only of the EU ETS in particular. If increased production costs caused by the ETS are passed on to the consumers, demand is supposed to decrease all other things being equal. Employment reduction would be the logical consequence. The extent of this effect depends on the cost increase induced by regulation and the elasticity of demand (Morgenstern et al., 2002). It could be extraordinarily strong if costs induced by the EU ETS were very high and if the elasticity of demand was high. The impact occurs unless demand is totally price-inelastic.

A further issue for any regulation which is not implemented globally is leakage. This is also the case for the EU ETS which only covers member countries of the EU. Leakage effects occur if non-participants of the mechanism increase their carbon emissions as a result of the carbon emission reductions of the participants. The background consists of changes in relative prices. Due to the EU ETS, the production costs of carbon intensive goods in participant countries rise. As a consequence, production in countries not subject to the regulation becomes relatively cheap. Therefore, firms producing in countries not participating may gain market share, again all other things equal, leading to negative employment effects in the EU. Furthermore, even a shift of employment by companies from participant to non-participant countries is possible. With global climate regulation expected to embrace more and more countries in the future and emissions trading the instrument of choice, the EU ETS can be expected to grow over time. A first mover advantage for European companies in this field could be possible, e.g. in terms of export potentials for low carbon technologies.

The impact of substitution effects on employment may work in both directions. Producers could react in substituting carbon intensive products or production by less intensive ones. The employment effect of that shift depends on its extent as well as on the labour intensity of the different production methods. The sign of the labour intensity change determines the direction of the employment impact.

Furthermore, opportunity costs may cause job losses in the EU. Investment in emission allowances employs capital that can not be invested otherwise. Therefore, the EU ETS may create opportunity costs that hinder new or even reduce actual employment. However, the current ETS distributes allowances without costs under grandfathering, hence opportunity costs should in theory not apply. Firms can also benefit from selling excess permits.

The four impacts – demand reduction, leakage, substitution and opportunity cost effects – do not seem to differ significantly if an ETS is compared to eco-taxes. Non market-based regulation is supposed to amplify the negative effects as it gives less flexibility to the firms concerned. This is one of the obvious advantages of emission trading if compared with alternative instruments. Another potential benefit from an ETS is to trigger off innovations within European industries. However, it is unclear whether the current EU ETS design can foster innovation in a way that would create lead markets in Europe involving higher employment. The scheme will have to become much more demanding in order to fully unfold its innovation potential. Employment gains due to ETS and of the type demonstrated by the Porter hypothesis would probably remain small in scale, though.

Summing up, economic theory offers arguments for both negative and positive employment impacts of the EU ETS. Using BAU as a benchmark, the former appear to outweigh the positive aspects. However, given Europe's commitment under the Kyoto Protocol, BAU can only be a theoretical reference, while other more comparable regulations like an European-wide eco-tax entail neither advantages nor disadvantages. Significant employment gains from the EU ETS should not be expected from a theoretical point of view. If the scheme unfolds its full innovation potential, small gains in specific sectors as expected from the Porter hypothesis are possible. In general, theory suggests (1) only small effects that (2) work partly in opposite directions. Consequently, ETS impacts on employment should remain modest.

4.2.2. Simulation studies on national and international ETSs

In the following analysis the available models are again taken from literature. Given the limited models available, only two of them focus on the EU ETS. Four out of the six assessed look at national or international emission trading schemes and are therefore only partially comparable in looking at the EU ETS impact on employment. Of the two studies focusing on the EU ETS, one has been criticised by peer scientists for its approach. Consequently, even these results need to be put into perspective. A major shortcoming of the models used is that none takes alternative regulation as a reference scenario. Instead, five out of six models compare against BAU, ignoring that inaction on emission reduction is no option, as Europe aims at Kyoto compliance.

Jensen and Rasmussen

Jensen and Rasmussen (2000) model the introduction of a CO_2 emissions trading scheme for Denmark. They discriminate between three different scenarios: auctioning, grandfathering and a market-share oriented distribution of allowances. The authors use a steady-state with an exogenous growth rate of two per cent as a reference. The reference point is 1998. They calculate effects for 2040 based on the assumption that Danish CO_2 emissions are reduced by 20 per cent in the period from 1999 to 2005 and subsequently remain constant. Jensen and Rasmussen use a dynamic Ramsey-type multi-sectoral general equilibrium model of the Danish economy. Compared to the reference, the only scenario not to lead to large worker displacements in energy-intensive industries is the market-share oriented allowance system which results in job losses of about one per cent. In comparison, auctioning as well as grandfathering lead to employment reductions of approximately ten per cent in the relevant sectors. These strong impacts may be due to the construction of the analysis: consideration is only given to the national ETS of one small country – Denmark – which may foster substantial leakage. This and the fact that the Danish emissions allowance market is small may lead to larger employment reductions than in an EU-wide model, limiting the relevance of this model when looking at the impacts of a European ETS on employment across the EU. Overall costs are lowest in the auctioning case as revenues are used to reduce existing distortionary taxes. There is no double dividend in the form of newly created jobs, however.

NEMS

The U.S. Energy Information Administration (EIA) (1998) analyses the effects of an international ETS according to the targets defined in the Kyoto-Protocol. The study contains the impact of this mechanism on unemployment in the U.S. For this purpose, the National Energy Modelling System (NEMS) is used. This system captures the impacts of energy market developments on macroeconomic variables. It predicts a transitory rise in unemployment if the U.S. participates in an international ETS. This boost is of short duration, however, and does not exceed two percentage points. The reference scenario is BAU. In the EIA model, unemployment variation is positively correlated with the simulated allowance prices. The highest price examined not only leads to a two per cent increase in unemployment, as referred to, but also results in a subsequent transitory reduction in unemployment of 0.5 per cent relative to the reference scenario. Scenarios which assume lower emission costs produce smaller misalignments relative to BAU, meaning maxima of one or 0.5 percentage points. Nonetheless, modelling the introduction of the mechanism in 2005, the EIA predicts no changes in unemployment as a result of the ETS after 2010 when compared with BAU. As this model looks at a global rather than European ETS, we cannot necessarily assume that its results also apply to the EU ETS as implemented.

WorldScan

The study provided by de Groot et al. (2002) identifies only small employment effects. The study uses the applied general equilibrium model WorldScan. The model was developed by the Netherlands Bureau for Economic Policy Analysis (CPB). The authors simulate the labour market impacts of an international carbon-tax assuming that the U.S. does not ratify the Kyoto Protocol and therefore does not participate. This regulative approach is equivalent to a cap-and-trade-system; effects calculated will in this study’s context be interpreted as the implications of an implemented ETS. The model reproduces sectoral employment changes for Europe and for specific countries. The reference scenario is BAU; effects are calculated for the year 2010.

The results suggest that costs and therefore employment losses in Europe are low under this scenario. This is mainly due to the assumption that countries from central and eastern Europe (CEE) offer a high number of allowances in the market so that emission costs remain modest. De Groot et al. argue that CEE countries have an excees of allowances as the collapse of their domestic industries inevitably resulted in a reduction of greenhouse emissions. This means that they exceeded the Kyoto targets even before the trading period began. This diminishes the comparability of this model since the EU directive deliberatly limits the supply of credits from CEE into the EU ETS. For Europe as a whole, the authors calculate small negative employment effects for the sector producing energy-intensive goods (-0.2) and for the trade and transport-sector (-0.3). Employment in the capital goods sector remains constant while employment in the agricultural, consumer goods and services sector even rises by 0.1 per cent. However, stronger impacts occur in the country-specific analysis of the sectors concerned: Belgium and Luxembourg, for example, suffer from a drop in employment of 0.8 per cent in both the agricultural and the trade and transport sector. The ETS also leads to a one per cent reduction in employment in the trade and transport sector in Spain, while employment in agriculture would rise by 0.3 per cent. The results must be interpreted with caution, however, as mentioned above. The authors admit that some shortcomings may have an influence on the simulated results. The most important one may be that tax revenues are neglected. Given the possibility that a double dividend exists, job losses may be overstated by the model used. The comparability to an EU ETS is substantially limited, given that only a few sectors are covered by the EU ETS, which does deliberatly not allow for unlimited transfer of CEE credits.

PACE

Böhringer and Lange (2005) use an analytical partial equilibrium and numerical general equilibrium analysis (the PACE model) to identify impacts of emissions regulation mechanisms on employment in Germany. They simulate different scenarios to show the implications of the policy choice in the CO_2 emission context. The reference scenario situation is BAU. Simulation results are provided for the scenario of an overall cutback requirement of 20 per cent. The authors use emissions in 1998 as a reference point. Besides domestic policy options, Böhringer and Lange simulate four scenarios taking into account international emissions trading. Several international options are considered: firstly, a carbon tax at the level of the international permit price, secondly an international emissions trading system with auctions, and thirdly a grandfathering system according to the output-based rule as well as to the emission-based rule. In the regulation scenarios leading to revenues, Böhringer and Lange model a lump-sum rebate to the representative agent.

The results show that ETS does not necessarily lead to high employment losses even compared to the BAU case. Grandfathering in the context of an international trading system results in small employment reductions in the energy intensive sectors (up to 4.5 per cent in the scenario of an extremely high price of 300 US-dollar per ton of CO_2) under the emission-based rule or in a rise of employment (output-based rule, two per cent given the same price of 300 dollar). If allowance prices remain more modest, impacts on employment are even smaller. Based on a price of 10\$/tCO_2, which seems to be a realistic lower bound to the current CO_2 prices, employment effects under both rules are zero. In contrast, the modelled taxation of CO_2 emissions leads to an 8.2 percent decrease in employment in the relevant sectors, auctioning to a decrease of up to 26 per cent (at again unrealistic 300 dollar per allowance). This impact is identical to the effect of a carbon tax at the level of the international permit price. However, the authors state that low emission costs imply a negative trade-off vis-à-vis economic efficiency. Regarding only employment, the EU ETS is favourable in comparison to alternative regulation strategies. Furthermore, even ignoring the targets given by the Kyoto-Protocol and therefore comparing the ETS with the BAU, Böhringer and Lange can not calculate important job losses for the German energy-intensive sectors.

4.2.3. Simulation studies on the EU ETS

E3ME

A study analysing the employment effects of an ETS for 19 European countries is provided by the Centre for Economic Studies of the Fundacion Tomillo (2000). The authors use E3ME, an energy-environment-economy model for Europe, to simulate the consequences of different policy approaches aiming at the reduction of emissions. E3ME is a sectoral, regionalised, econometric model. The endogenous variables used are determined from functions estimated on historical European data. Cointegration as well as error-correction methods apply.

The authors define BAU as a reference. Reference point is 1990, as intended by the Kyoto Protocol. Simulations are made for the year 2010. All projections assume that the EU reduction target of eight per cent is met. Besides a carbon tax and a mixed policies scenario (multilateral permit and tax scheme), two different ETS cases are simulated: the "permits + profits"- and the "permits + prices-scenario". While the former is based on the assumption that profits from allowance sales are retained by the respective firm, the latter scenario implies price reductions in case of allowance sales, which is a discrepency to the existing EU ETS. Both scenarios assume the grandfathering principle.

According to the study, carbon taxes as well as the mixed policy scenario are favourable compared to an ETS if employment effects are considered. For the Euro-19 as a whole, E3ME predicts a rise of employment of about one per cent if a carbon tax is introduced to reduce CO_2 emissions according to the Kyoto-Protocol. Emissions trading under the "permits + profits" and the "permits + prices scenario", however, leads to job losses of about 0.06 and 0.24 per cent, respectively. A mixed policy approach causes an employment boost of about 0.76 per cent against BAU. The study also offers interesting insights into the potential sectoral and country-specific effects of a European ETS. Under the “permit + profits-scenario”, western Germany, northern Italy and the United Kingdom are among the biggest losers of an ETS as far as employment effects are concerned. The biggest relative employment reductions occur in the electrical goods and the transport equipment sector. Under the “permits + prices-scenario”, besides the regions already mentioned, eastern Germany loses as well. In this case, however, the construction and the inland transport sector are highly affected by job losses.

Hillebrand et al.

Another simulation study analysing the impacts of the EU ETS on the European and German labour markets is Hillebrand et al. (2002). This study uses a combination of different partial models. Many parameters such as wage rates and international trade are thus not determined inside the model but exogenously given. This is not the only reason why this approach has been harshly criticised. Matthes et al. (2003) contains an extensive discussion of the possible shortcomings of the approach. Besides technical arguments, the main point of criticism is that several parameters used for the analysis are not published by Hillebrand et al. This makes it very difficult to interpret the results.

The labour market effects calculated by the authors are modest, but not negligible. The simulation suggests a total reduction of employment of 100,700 in the EU and of 27,600 in Germany by 2010. In the projection for 2020, the authors forecast losses of 112,700 and 34,300 jobs, respectively. The Marrakesh scenario which represents the impacts of the Marrakesh Accords serves as a reference. It suggests that non-European countries participate in the ETS in the way they are allowed to trade with EU members. For the Marrakesh scenario, allowance prices of five euros per ton of CO_2 are chosen by the authors. The job losses are based on the assumption that under the EU ETS, emission costs are 30 euros per ton of CO_2. This approximately doubles the allowance price the authors simulated in a CGE analysis conducted in the same paper. Therefore, the partial analysis may overstate the actual impact of the EU ETS on the labour market. Additionally, the calculations imply an auctioning of 20 per cent of the allowances. Besides that this might become realistic from 2013 onwards across Europe only, a serious shortcoming is that the use of the revenues is not included in the study. Given that a double dividend exists in the auctioning case, employment losses would be reduced. Furthermore, the authors calculate smaller effects given that Joint Implementation or Clean Development Mechanism apply. This is the case for the EU ETS actually implemented, although JI and CDM are introduced only gradually and current restrictions in the actual EU ETS are not as those modelled. In the analysis considering these instruments, job losses caused by an ETS are of a minor importance: Numbers calculated for the EU 15 are 15,600 (2010) and 14,600 (2020), respectively.

4.3. Conclusion

Section 4 of this paper attempts to analyse the possible impact of environmental regulation and more specifically of the EU ETS on employment. For this purpose, theoretical as well as empirical studies are reviewed. As not so much research about ETS impacts on employment has been done to date, all available studies of potential relevance were analysed above. Still we have to be very careful in deriving robust conclusions from these few studies. Only two out of the six studies analysed focus on the EU ETS, one of them has been criticised because of flaws in the methodology.

The picture we get from an analysis of what is available shows that there is no clear and unchallenged answer to the question posed. The results of all contributions critically hinge on the assumptions made. Evidence is found for the positive as well as negative employment impacts of environmental regulation and emissions trading schemes. Analysing the EU ETS, however, one can identify substantial properties of the mechanism so that labour market responses to the introduction of that mechanism can be rendered more concrete.

The choice of the reference scenario in the contributions evaluating employment effects is crucial for classifying the results of the respective analysis. As is shown in Table 2, the business as usual case is referred to as a reference scenario in the literature in five of six cases. The effect measured using this approach is definitely of interest, but a disclaimer applies here – having ratified the Kyoto-Protocol, the EU must now comply with its emissions targets. As this is very implausible under BAU, this scenario is not fully adequate. Therefore the comparison of the ETS with other mechanisms leading to a CO_2 reduction is much more relevant when looking for the “right” instrument or possible improvements of the ETS.

Table 2: Impacts of Emissions Trading on employment – Simulation studies results

Model	**Reference Scenario**	**Effects on Employment**
Jensen/Rasmussen (2000)	BAU	Large job losses if certificates are grandfathered or auctioned (applies to Denmark only under a national emission trading scheme)
NEMS (1998)	BAU	Initial job losses, partly transitory gains
WorldScan (2002)	BAU	Small effects (losses/gains)
PACE (2005)	BAU	Losses or zero impact
E3ME (2000)	BAU	Small effects (losses)
Hillebrand et al. (2002)	Marrakesh Accords	Modest job losses, small if JI/CDM considered

The Porter hypothesis predicts small job gains from environmental regulation due to offsetting innovation. Further small job gains can be expected from the direct employment effects of the EU ETS (monitoring, administration, consulting). In contrast, indirect effects (demand reduction, leakage, substitution, opportunity cost, innovation effects) may in total have a modest negative impact on employment. Consequently, only one of the six scenarios considered gives – partial – job gains. Another model shows modest job losses as a result of the implementation of an ETS partly followed by transitory gains. Depending on their choice of scenario or design of model, the other studies show modest losses or zero impact. The overall impression is that job losses caused by the mechanism should not be overestimated.

Neither economic theory nor the simulation studies reviewed suggest high employment reductions in the sectors concerned if the BAU is used as a reference scenario. If employment effects of the EU ETS are compared to impacts of alternative regulation methods assuring the Kyoto targets, the arrangement of the EU ETS is among the better choices. Because of its flexibility and the innovation incentives induced, an ETS should be preferred to non-market instruments when it comes to impacts on employment. All simulation studies suggest higher job losses under an ETS with auctioning than under an ETS with grandfathering as the chosen allocation method. Therefore, the mechanism does not induce high cost pressure, although in the grandfathering case opportinity costs occur as well. However, auctioning rather than grandfathering is the allocation method of choice if Europe wants to make optimal use of the scheme's innovation potential (including incentives for the job market) and eventually optimise the schemes economic efficiency and ecological effectiveness[9].

As only two of the reviewed simulation studies model sector-specific employment effects, it would appear to be highly speculative to give an outlook concerning this issue. This is also due to the fact that these two studies (de Groot et al., 2002, and Centre for Economic Studies of the Fundacion Tomillo, 2000) make different conclusions concerning the sector-specific impacts. The results suggest, however, that there may be important differences between different sectors and between sectors in different European countries. On the basis of the scientific research available to date one cannot draw solid conclusions regarding the sector-specific ETS impacts on employment. Finally, the Clean Development Mechanism has been identified as an element in the EU ETS which is able to reduce negative employment effects. In the Hillebrand et al. study they reduce negative employment impacts, and in the WorldScan study less costly reduction options in other parts of the world are responsible for positive employment effects. Thus the conclusion can be drawn that negative effects on employment

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[9] For a discussion see chapter 2.1.

can be compensated for by the unrestricted handling of Joint Implementation and the Cleaner Development Mechanism in the EU ETS[10].

To conclude, the employment effects of the EU ETS will be smaller than many representatives of the sectors concerned fear. Aggregated job losses will barely be visible, this even holds true if BAU is used as a reference. This is due to the choice of an ETS to achieve the target defined in the Kyoto-Protocol as well as the specific design of the EU ETS. A variation of the mechanism intended to improve its labour market impact would therefore appear to be problematic. The mechanism should not, however, be expected to create jobs if the BAU is used as a reference. At the firm or even sector level, there will be winners and losers. Some firms and sectors will lay off workers while others will recruit. Even if the overall effect for the EU turns out to be negative, our analysis finds that it will certainly be of minor importance.

5. General conclusion

This paper attempts to analyse the possible impact of the EU ETS on competitiveness and employment. For this purpose, theoretical as well as empirical studies are reviewed. The results differ according to the assumptions made and especially with the scenarios used. It is, however, possible to arrive at robust results.

These results are drawn from all available simulation studies that have been carried out to date. These simulation studies are based on models for a sector (energy models) or the whole economy (general equilibrium models and macroeconometric models). Due to the nature of models they reduce reality by assuming certain market structures, behaviour etc. Thus the results of the simulation studies can not be seen as empirical evidence for the question, but they give first estimates on the magnitude of impacts to be expected.

Summing up, the impacts of EU ETS on competitiveness and employment are modest, and if losses occur, they remain generally smaller than the impacts of alternative regulation scenarios. Compared to these alternative regulation scenarios, ETSs can have positive competititveness effects. However, the ETS is not designed to boost Europe's economy, its prime purpose and justification is to ensure Europe's CO_2 emissions are brought down according to comittment levels of Kyoto in 2012 at minimal costs. Thus the most important conclusion is analogous to Parry (2002) who states with regard to the double dividend hypothesis that "environmental taxes need to be justified on environmental grounds" (p. 2). This holds true for a trading scheme like the EU ETS as well. Emissions trading should be justified on environmental grounds. It is especially important that modifications to the system

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[10] Again, see chapter 2.1. for a broader discussion.

due to economic considerations do not undermine the environmental impacts intended with this policy instrument.

It is always welcome as a side effect, but introducing environmental regulation is not designed to generally improve employment or competitiveness. Theory contradicting this claim exists – the Porter- and the double dividend hypothesis are predominant in this respect. This paper shows that they cannot be applied in unqualified form to an EU ETS. The reason is that innovation depends on strict environmental regulation. The currently deployed EU ETS does not seem to be strictly enough designed to give the necessary incentives for the technological innovation the scheme would allow. In the future, a stricter EU ETS may increase these incentives. Current developments already show a trend towards a global diffusion of emissions trading systems. As a result the expansion into truly global carbon markets appears to be likely.

The EU ETS will not be responsible for a significant reduction of EU competitiveness. Consequently the scheme will also not be a job killer. Even compared to an inappropriate BAU scenario, this paper shows that the aggregate ETS impacts are only slightly negative if at all existant. Furthermore, if more relevant reference scenarios such as alternative regulations apply, important competitiveness gains from emission trading are predominant. Given the EU's obligatory Kyoto targets, the actually implemented EU ETS is responsible for cost reductions in comparison to no trading scenarios. Neither environmental taxes nor CaC instruments are shown to have more positive employment impacts than the ETS.

There is agreement, however, that the implemented system is not optimal. According to the simulation studies analysed, competitiveness effects are superior in the case of trading schemes covering all emitting sectors. An extension of the EU ETS to additional sectors will have to be discussed during the review of the relevant directive. Furthermore, it is obvious that the mechanism will create winners and losers at the sectoral level and at the firm level. Many studies suggest that the power sector will be among the sectors benefitting from the currently applied form of the ETS. This view is not supported by all studies analysed in this paper. It seems fairly clear, however, that the system will induce important cost pressure on the heavily energy intensive aluminium sector, even though it does not participate in the ETS. Still, this paper shows that the fears of the majority of other sectors concerned about EU ETS impacts are not justified.

6. Annexes

6.1. Annex 1: Synopsis of the literature on ETSs and competitiveness

Authors	Model	Critical Assumptions	Reference Scenario, projection period (if given)	Scenarios	Results
IPTS (2000)	POLES, a partial equilibrium model for the world energy system	certificate prices of 49 € per ton of CO_2 modelled; overestimates cost reductions, as transaction costs and market failure neglected	no-trading-scenario (national compliance to Kyoto-goals) for 2010	EU-wide emissions trading scheme	profits for all participants (highest profits for EU-south, Germany and Italy); average cost reductions of 25 per cents
Capros and Mantzos (2000)	PRIMES, a sectoral model for the energy market	burden sharing; EU reduction target of eight per cents	no-trading-scenario (national compliance or alternatively compliance within national sectors to Kyoto-goals) for 2010	(1): EU-wide ETS between energy suppliers, (2): EU-wide ETS between energy suppliers and energy-intensive branches, (3) EU-wide ETS between all sectors, (4): international ETS including Annex-B countries (all sectors)	ETS induces cost reductions (alternative reference scenario: 20.7-48.6 per cents); enlargements of ETS lead to additional cost reductions
de Groot et al. (2002)	WorldScan, an applied general equilibrium model	(tax) revenues neglected	BAU; 1997-2010	international carbon tax / emissions trading	small and diverse effects

ERM / Eurelectric (2002)	GETS 3, a partial model for the energy market	covers pre-commitment-period (2005-2007) and two commitment-periods (2008-2012, 2013-2017); approximately 50 sensitivities applied to basis scenarios	see scenarios	three basis scenarios: (1): no-trading scenario, (2): latest guess-scenario (according to EU ET directive from March 2003), (3): perfect trading-scenario (all possible participants trade fully under free market rules from 2005)	constraints increase trading costs; least abatement costs under perfect trading; latest guess (no trading) leads to cost increase of 1.6 (80.5) billion €; distributional effects if auctioning applies
Matthes et al. (2003)	SIMET, a partial model for the energy market (bottom up)	simulations only for Germany; emissions trading participants according to EU ET directive; certificate prices of 10 € per ton of CO_2 modelled	no-trading-scenario (national compliance to Kyoto-goals) for 2010	25 different allocation rules modelled	cost reductions due to ETS between 230 and 545 Mio. €; auctioning of 15 per cents of the certificates reduces differences between relative “winners” and “losers” of the TS
Klepper and Peterson (2004)	DART, a computable general equilibrium model	no market failure; JI/CDM neglected	business as usual-scenario for 2012	(1): least-cost (LC)-scenario, (2): unilateral policy-scenario (UNI)	small competitiveness-effects: output loss of 0.3 per cents (LC); positive competitiveness-effects of LC in comparison with UNI
Carbon Trust (2004)	Economic Cournot model of oligopoly behaviour	Cournot-competition (oligopoly) modelled; sectoral analysis of EU ETS	business as usual	(1): first phase of EU ETS (certificate price of 5 € per ton of CO_2; (2): second phase (2008-2012; 10 €); (3) third phase (starting 2012; 25 €)	generally small competitiveness effects; aluminium sector looses from EU ETS: profit fall of 30 per cents; for the other sectors concerned, additional burden can be compensated by moderate price increases
Reinaud (2005)	Partial model	sectoral analysis of EU ETS; competitiveness effects defined as output variation; certificate	business as usual: increasing CO_2-emissions	(1): ten per cent scenario (90 per cents of certificates needed are grandfathered); (2): two per cent scenario (98	generally modest competitiveness effects; aluminium sector looses from EU ETS: cost increase of 3.7 per cents in both scenarios (demand

		price of 10 € per ton of CO_2	according to World Energy Outlook	per cents grandfathered)	decrease of 2.9 per cents)
Kemfert et al. (2005)	GTAP-E, a computable general equilibrium model		see scenarios	experiment 1: Kyoto-compliance within national sectors; experiment 2: national trade; experiment 3: additionally trade between EU-member states	cost reductions due to enlargements of ETS; higher efficiency gains under experiment 2 than under experiment 3
COWI (2004)	GTAP-ECAT, a computable general equilibrium model	JI/CDM included	business as usual	(1): EU ETS with long-term technology adaptation; (2): EU ETS with sluggish shorter-term adaptation	output reduction of -0.36 per cent (-0.48 per cent with sluggish adaptation); allowance price of 17 €/tCO_2 (26.5 €/tCO_2); JI/CDM has positive effect on competitiveness
Böhringer et al. (2005b)	SIMAC, a simple numerical partial equilibrium model of the EU carbon market	JI/CDM neglected; model assumes Kyoto commitment: if the NAPs/ETS are not sufficient in this regard, abatement is shifted to sectors not participating (domestic action)	see scenarios	(1): no trade scenario: EU member states meet the emissions reduction target through cost-efficient domestic action; (2): unrestricted emissions trading across all sectors and EU member states; (3): emissions as suggested by NAPs	lowest compliance costs under unrestricted trading (2.1 billion €); scenario (3) induces highest costs (17.6 vs. 3.4 billion € under scenario (1)); lower costs for (3) if JI/CDM considered; (3) induces burden shifting between sectors

6.2. *Annex 2: Synopsis of the literature on ETSs and employment*

Authors	**Model**	**Labour Market Modelling**	**Other Critical Assumptions**	**Reference Scenario, projection period (if given)**	**Scenarios**	**Results**
Jensen and Rasmussen (2000)	dynamic Ramsey-type multi-sectoral general equilibrium model for Denmark	auctioning revenues used to lower taxes	ETS only introduced in Denmark; 20 per cents emissions reduction until 2005	steady-state with an exogenous growth; 1999-2040	(1): auctioning, (2): grandfathering, (3): market-share oriented certificate distribution	job losses in energy-intensive industry: (1), (2): large, (3): small
U.S. Energy Information Administration (EIA) (1998)	NEMS, an energy-economy modelling system of U.S. energy markets	industry output projections, national wage rates, productivity trends and average workweek trends taken in order to project employment for the 45 NEMS industries		BAU; 2008-2012	International emissions trading	transitory significant unemployment increase
de Groot et al. (2002)	applied general equilibrium model WorldScan	(tax) revenues neglected; low and high-skilled labour modelled which allows for a better description of specialization patterns		BAU; 1997-2010	international carbon tax / emissions trading	small and diverse effects

Centre for Economic Studies of the Fundacion Tomillo (2000)	E3ME, an energy-environment-economy model for Europe: sectoral, regionalised, econometric model	Revenues lead to reduction of employers' social security contributions; demand for employment partially adjusts to output growth, costs of labour and technology index; participation rate in the labour force depend on reservation wage; wage-setting decisions are depend on union activities across different regions of Europe; unions choose wage rates to maximise utility subject to the labour-demand constraint		BAU; 2001-2010	(1): carbon tax, (2): mixed policy, (3): ETS permits + profits, (4): ETS permits + prices	(1), (2): small employment rise; (3), (4): small job losses
Böhringer and Lange (2005)	Numerical general equilibrium model	detailed description of labor market imperfections and public taxation to trace back the interaction of tax policies and involuntary unemployment (e.g. due to union-bargaining); revenue leads to lump-sum rebate	analysis of an international ETS; effects only calculated for Germany; overall cutback requirement of 20 per cents	BAU	(1): carbon tax, (2): international carbon tax, international ETS: (3): auctioning, (4): grandfathering: emission-based rule, (5): output-based rule	(1), (2), (3): large employment reduction, (4): small employment reduction, (5): small employment rise
Hillebrand et al. (2002)	Combination of different partial models	auctioning revenues neglected	high certificate prices modelled	*Marrakesh Accords; 2020*	EU ETS: grandfathering / auctioning (20 per cents)	modest job losses, smaller if JI / CDM are considered

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