Climate Policy and Competitiveness: An Economic Impact Assessment of EU Leadership in Emission Regulations

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Abstract. The European Council has recently endorsed to achieve unilaterally at least a 20 percent reduction of greenhouse gas emissions by 2020 compared to 1990 level. Using a multi-sector, multi-region CGE model framework and implementing selected competitiveness indicators, we investigate implications of alternative emission reduction targets and tax differentiation regimes on leakage rates, economy-wide and sectoral competitiveness, and efficiency. For a given emission reduction target, tax differentiation towards energy-intensive industries is a matter of priorities for improving EU-wide international competitiveness (terms of trade) or efficiency. Our results indicate also that competitiveness effects at the sectoral level are highly sensitive to the particular indicator chosen and strongly responding to the level of tax differentiation. In contrast, leakage rates are much more robust with respect to alternative tax differentiation regimes.

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1 Introduction

Recent studies on climate change have contributed to a growing awareness of the long-term consequences and have stressed the need for decisive actions to mitigate global warming (IPCC, 2007; Stern, 2007). In order to limit the global average temperature increase to a maximum of 2°C compared to the pre-industrial level, the European Union (EU) has agreed to take the leading role in international climate protection: In March 2007, the Spring European Council has endorsed to achieve *unilaterally* at least a 20% reduction of greenhouse gas emissions by 2020 compared to 1990 level. Provided that other industrializes countries commit themselves to comparable emission reduction targets, the European Council has supported an EU objective of a 30% reduction in greenhouse gas emissions by 2020 (EU, 2007a).

Since the adoption of the first EU Sustainable Development Strategy (SDS) at the Gothenburg summit in 2001, ambitious environmental policy forms the core of the EU sustainable development approach (EU, 2001a,b). In the renewed EU SDS, the focus on environmental sustainability – as set up in the first EU SDS – has been complemented by economic and social dimensions through the integration of the Lisbon Strategy: The Lisbon Strategy makes an essential contribution to the overarching objective of sustainable development focusing primarily on increasing competitiveness, economic growth and enhancing job creation (EU, 2006). As a consequence, the drive for competitiveness has had repercussions within and beyond the EU SDS, while the term "competitiveness" has turned into a catchword in virtually every political debate on new regulatory proposals.

Obviously, more stringent environmental policies raise concerns on competitiveness, particularly to those sectors that are energy- intensive, export-oriented and not covered by globally harmonized policies but subject to unilateral actions. Policy debate on these issues has been, however, exacerbated by an extraordinary variety of competitiveness concepts and measures, while competitiveness impacts have been often discussed in a quite narrow (partial) perspective with a focus on those industries which have been directly affected by a respective regulation. Instead, thorough analysis of competitiveness implications requires a clear-cut notion of competitiveness and precise specification of appropriate indicators: An issue that can not be clearly measured will be difficult to improve. It is also inevitable to apply methodologies which allow for an appropriate systematic and consistent quantification of competitiveness implications associated with alternative regulatory options.

The most recent CGE-related literature has focused on assessing competitiveness effects associated with the implementation of the EU ETS (Bollen et al., 2003; Klepper and Peterson, 2004; COWI, 2004; Reinaud, 2005; Peterson, 2006). Standard macroeconomic indicators such as output and welfare have been typically applied as proxies to measure the competitiveness implications. The effectiveness of domestic policies – including exemptions of energy-intensive sectors and border adjustment measures – to mitigate the negative competitiveness effects and to reduce the leakage rate associated with the implementation of (unilateral) environmental regulations has, however, not yet been widely analyzed (Böhringer and Rutherford, 1997; Babiker et al. 2003; Babiker and Rutherford, 2005).

Our analysis complements recent research in a threefold manner: First, we review the most recent literature on competitiveness concepts, identify key dimensions of competitiveness notions and specify appropriate indicators at sectoral and economy-wide level. Second, we implement selected competitiveness indicators into the multi-sector, multi-region computable general equilibrium (CGE) model. In order to demonstrate how such indicators can be operated within an economy-wide quantitative framework and to test the consistency of the indicators, we perform an illustrative policy analysis on EU leadership in climate policy: The EU is assumed to adopting stricter carbon emission regulation in accordance with the declaration of the Spring European Council in 2007. At hand of this model framework, we investigate implications of alternative emission reduction targets and tax differentiation regimes on leakage rates, economy-wide and sectoral competitiveness, and efficiency. Therefore, our study assesses a broader range of EU unilateral policy options going beyond the commitment of the Kyoto protocol. Third, we conquer purely descriptive assessment of competitiveness through an *explicit* link to the normative concept of welfare.

General insights from our analysis support the careful and complementary use of alternative macroeconomic and competitiveness indicators. Our key finding is that tax differentiation towards energy-intensive industries is a matter of priorities for improving EU-wide international competitiveness or efficiency: For a given emission reduction target, tax differentiation may improve the EU terms of trade but will inevitably induce increasing excess costs compared to the uniform taxation. Moreover, our results indicate that the leakage rate is much less volatile to the level of the tax differentiation than sectoral and economy-wide competitiveness effects

The remainder of this paper is structured as follows: Section 2 reviews competitiveness concepts and discusses selected competitiveness indicators that are subsequently implemented into a computable general equilibrium model framework. Section 3 provides a model-based policy assessment of the EU unilateral climate policies. Section 4 concludes.

2 Competitiveness Indicators

2.1 Notions of Competitiveness

When dealing with competitiveness, the first major methodological problem refers to the lack of well-defined conceptual framework and theoretical background. Despite an increased attention over the past decades and an abundance of literature on this issue, the notion of sectoral and national competitiveness remains susceptible for ambiguities. Scott and Lodge (1985) emphasized at the beginning of the scientific discourse that competitiveness is a multidimensional concept and being competitive requires superiority in several aspects. In principle, remarkable diversity of concepts, elaborated during the last two decades in economic literature, reflects the multidimensional nature of competitiveness.

The second major methodological problem refers to the operationalization of the competitiveness concept(s) for a quantitative policy analysis. A review of existing literature yields an impressive array of alternative measurement concepts. However, the choice of competitiveness indicators is often insufficiently transparent or even arbitrary. Competitiveness determinants are frequently labeled as competitiveness indicators – therefore just purporting to measure competitiveness.[1] More recently, several studies stressed the importance of distinguishing between competitiveness indicators – which describe the outcome of competitiveness – and competitiveness determinants – which govern the ability to compete (Reichel, 2002; Aiginger, 2006).

In order to adequately address this requirement, we briefly elaborate on its conceptual underpinning: A variety of factors – determinants (D) – govern the competitiveness (C) which is obviously an unobservable variable.[2] In principle, all relevant factors determining competitiveness need to be considered. But ultimately, the choice of determinants will depend on theory specifying the relationship between observable determinants and competitiveness. The outcome of competitiveness is, however, reflected in the observable output (outcome) variables (O) involving e.g. international trade performance or profit. These outcome variables may be used to construct a variety of competitiveness indicators (I). Thus, although competitiveness appears not to be precisely measurable, the underlying assumption is that competitiveness indicators may be used to disclose the corresponding ability to compete.

Based on the most recent literature review, the next sections 2.1.1 and 2.1.2 identify key dimensions in the outcome-based competitiveness notion(s) at sectoral and national level and specify appropriate measurement concepts (competitiveness indicators). The purpose of these sections is to detect what is the consensus in the literature on competitiveness rather than to cover all relevant dimensions and indicators.

2.1.1 Competitiveness at the sectoral level

While there is an increasing interest in analyzing competitiveness from a sectoral perspective, the search for an appropriate notion occurs to be rather challenging. However, much agreement in the literature exists on the key dimensions of the sectoral competitiveness.

The most widely accepted definition of sectoral competitiveness refers to the ability of an industry or a sector to succeed in international markets (Priewe, 1996; Jenkins, 1998; Klepper and Peterson, 2003; EU, 2005; Grilo and Koopman, 2006; Demailly et al. 2007). Competitiveness, defined in terms of foreign trade performance, is therefore deeply encroached with the theories of international trade in general and comparative advantage in particular. The additional dimension in the outcome-based notion of sectoral competitiveness has been proposed by Havlik et al. (2001), Sell (2003), and applied by Demailly et al. (2007) in their

[1] The contribution of the EU on sectoral competitiveness indicators (EU, 2005) is an example of studies which are quite comprehensive but less structured in terms of mixing up input- and output-based approaches.

[2] Otherwise, we would exactly know what competitiveness is.

study on the EU ETS. This dimension refers to the sectoral “ability to earn”, i.e. the capacity to sell profitably in national and international markets. In sum, sectoral competitiveness as a multidimensional outcome-based concept encompasses the ability of an industry to compete in international markets and to be profitable.

Table 1 provides a selection of competitiveness indicators that can be used to quantify specific aspects of competitiveness presented above. Obviously, a relatively narrow range of indicators appears to be directly relevant when competitiveness indicators (and not competitiveness determinants) are considered.

Table 1: List of competitiveness indicators at the sectoral level

International trade performance	Profitability performance
• Export (import) ratio	• Accounting profit
• World trade matrices	• Economic profit (opportunity costs)
• Indexes of revealed comparative advantage	• Gross operating rate
• Relative trade balance	• Return on assets
• Intra-industry trade index (Grubel-Lloyd)	• Value-added
• Constant market share index	

There is no consensus in literature on an appropriate measurement concept: Critical assessment of selected sectoral indicators and normalization procedures is provided by e.g. Balance et al. (1987, 1990), Vollrath, (1991) and more recently by De Benedictis and Tamberi (2002, 2004) and Reichel (2002). The overall conclusion from this research is that it is not yet possible to identify a valid measure of sectoral competitiveness from a theoretical perspective as each indicator exhibits its own advantages and disadvantages.

2.1.2 Competitiveness at the national level

For more than two decades, concept of competitiveness at the national level has been discussed rather controversially: Paul Krugman, one of the most prominent members of the scientific community, argues that „competitiveness is a meaningless word when applied to national economies” (Krugman, 1994). In contrary to such fundamental criticism, alternative concepts of competitiveness at the national level are widely used in scientific and non-scientific contributions.

Despite an impressive diversity of notions, common interpretation of national competitiveness as an outcome-based concept is much in line with its counterpart at the sectoral level: While one strand of the literature draws on “ability to earn”, i.e the ability to create wealth (high standard of living), as a central dimension of national competitiveness (e.g. Auerbach, 1996; Trabold 1995; Reichel, 2002; Sell, 2003; EU, 2004; Grilo and Koopman, 2006), other studies identify international trade performance of a nation (“ability to sell”) as a second crucial dimension (Balassa 1962; Dollar and Wolff, 1993; Trabold 1995, Nielsen et al. , 1995; Löbbe et al., 1997).

Table 2 provides a selection of competitiveness indicators at the national level according to two key dimensions presented above. Obviously, the same indicators may be used to assess competitiveness at sectoral and economy-wide level. This is particularly true when assessment of the international trade performance is required.

Table 2: List of competitiveness indicators at the national level

International trade performance	"Ability to earn"
• Current account • Terms of trade • Real exchange rate • Constant market share index • Indexes of revealed comparative advantage • Market share indicator • Relative trade balance	• (Per capita) income • (Labor-) productivity

The most recent literature underlines the importance (i) to analyze the interdependences between both dimensions of competitiveness at the national level and (ii) to conquer purely descriptive assessment of economy-wide international trade performance through an explicit link to the normative concept of welfare (Siegel, 2006; Aiginger, 2006). In order to close the gap between a descriptive concept of competitiveness and a normative concept of welfare, we address the latter requirement in the next section in more detail.

2.2 Selected Competitiveness Indicators for CGE-Analysis

As to numerical model-based analysis, the question which of the indicators can be implemented depends on the specific modeling framework. In the extension and application of our standard multi-sector, multi-region CGE framework in section 3, we will compulsorily focus on selected indicators which are suitable to quantify *trade-based* competitiveness at the sectoral and national level.

2.2.1 Sectoral Competitiveness Indicators

In this section we briefly review three highly policy-relevant output-based indicators – "Revealed Comparative Advantages (RCA), Relative World Trade Share" (RWS) and Relative Trade Balance (RTB) – established in the broader literature on competitiveness that are directly amenable to CGE-based policy analysis.

In 1965, Ballassa has proposed a trade-based indicator, the so-called Relative World Trade Shares (RWS) indicator, being presently the most used one in empirical literature (Balassa, 1965). Letting X denote exports, P^x export prices, i the region and j the sector, the RWS index for region i in sector j can be presented as follows:

$$RWS_{ij} = \frac{P_{ij}^{x} X_{ij} / \sum_{i} P_{ij}^{x} X_{ij}}{\sum_{j} P_{ij}^{x} X_{ij} / \sum_{i} \sum_{j} P_{ij}^{x} X_{ij}} .$$

This index compares the ratio of country's exports in a certain sector over the world's exports in this sector with the ratio of country's overall exports over the world's exports in all sectors. If the sectoral export-import ratio is identical to the economy-wide ratio, the RCA index takes the neutral value of one ($RWS_{ij} = 1$). Thus, a region *i* is said to have a comparative advantage in sector *j* if the RWS index exceeds unity ($1 < RWS \leq \infty$). By contrast, a region *i* is has a comparative disadvantage in sector *j* if the RWS index takes the values between zero and one ($0 \leq RWS < 1$). Thus, the lack of symmetry between the value ranges for comparative advantage ($1 < RWS \leq \infty$) and comparative disadvantage ($0 \leq RWS < 1$) is one of the major shortages in this index definition.

We additionally consider two alternative (highly policy relevant) sectoral competitiveness indicators which stem from the report of the European Commission on sectoral competitiveness. The Revealed Comparative Advantage (the RCA) index is concerned with the competitiveness of different industries within an economy (Balassa, 1965). Letting *X* denote exports, P^{x} export prices, P^{m} import prices, *M* imports, *i* the region and *j* the sector, the index for revealed comparative advantage (RCA) for region *i* in sector *j* can be presented as follows:

$$RCA_{ij} = \frac{P_{ij}^{x} X_{ij} / P_{ij}^{m} M_{ij}}{\sum_{j} P_{ij}^{x} X_{ij} / \sum_{j} P_{ij}^{m} M_{ij}}$$

For a particular region and sector, this index compares the ratio of exports by a specific sector over its imports with the ratio of exports over imports across all sectors of the region. The RCA indicator posses the same value range as the RCA index ($0 \leq RCA_{ij} \leq \infty$) and thus may be interpreted in a similar way. Finally, we refer to Relative Trade Balance (RTB) index which compares the trade balance (exports minus imports) for a product to the total trade (exports plus imports) of that product:

$$RTB_{ij} = \frac{P_{ij}^{x} X_{ij} - P_{ij}^{m} M_{ij}}{P_{ij}^{x} X_{ij} + P_{ij}^{m} M_{ij}}$$

This index posses the neutral value of zero ($RTB_{ij} = 0$) and the value range of $-1 \leq RTB_{ij} \leq 1$.

There is a range of slightly different measures and normalization approaches for the mentioned indicators (see Reichel, 2002 for a comprehensive review). For our illustrative analysis presented in section 3, we will stick to the simple definition given above. For an appropriate interpretation of the results on sectoral competitiveness, it is important to note that alternative indicators measure competitiveness implications using a different reference point. The RWS indicator shows how the relative performance of a particular sector changes compared to the relative performance of the same sectors across the world. The RCA indicator compares the performance of a particular sector with an average performance of all sectors within the same region. Finally, changes in the RTB index indicate how the export import performance of a particular sector varies through the environmental regulation relative to the performance of the same sector in the BAU situation.

Due to the lack of the theoretical background on the selection of an appropriate indicator, the purpose of the following sections is to examine within a general equilibrium model to what extent various measures of sectoral competitiveness are consistent.

3 Policy Application: EU Leadership in Climate Policy

3.1 Analytical framework

To investigate the implications of EU leadership in climate policy on sectoral competitiveness, gross economic welfare (abstracting from benefits of changes in environmental quality), and global carbon emissions we make use of the static multi-sector, multi-region model PACE for the world economy (for a detailed algebraic exposition see Böhringer, 2002). The model is based on most recent consistent accounts of production, consumption, bilateral trade and energy flows for 87 countries and 57 sectors provided by the GTAP 6 data base for the base year 2001 (Dimaranan and McDougall, 2006).

For the sake of compactness, the GTAP countries have been aggregated to 3 major regions: European Union (EUR), Non-EU OECD (OEC), and Rest of World (ROW). The sectoral aggregation in the model has been chosen to distinguish carbon-intensive sectors from the rest of the economy. It captures key dimensions in the analysis of greenhouse gas abatement, such as differences in carbon intensities and the degree of substitutability across carbon-intensive goods. The primary and secondary energy goods identified in the model are coal, natural gas, crude oil, refined oil products, and electricity. Important carbon-intensive and energy-intensive non-energy industries that are potentially most affected by carbon abatement policies are aggregated within a composite energy-intensive sector. The remaining manufacturers and services are aggregated to a composite industry that produces a non-energy-intensive macro good. The primary factors in the model include labor, physical capital, and fossil-fuel resources. Table 4 summarizes the regional, sectoral, and factor aggregation of the model.

Table 4: Model dimensions

Production sectors	Regions and primary factors
Energy	*Regions*
Coal	European Union (EUR)
Crude oil	Non-EU OECD (OEC)
Natural gas	Rest of World (ROW)
Refined oil products (OIL)	
Electricity	
Non-Energy	*Primary factors*
Energy-intensive sectors (EIS)	Labor
Rest of industry and services (OTH)	Capital
Savings good	Fixed factor resources for coal, oil and gas

3.2 Scenarios and Results

The EU is presently endorsing an ambiguous environmental policy which goes beyond the commitment under the Kyoto Protocol: The Spring European Council has endorsed to achieve *unilaterally* at least a 20% reduction of greenhouse gas emissions by 2020 compared to 1990 level. Simultaneously, the concerns about the repercussions of more stringent commitments on the European competitiveness keep rising. Addressing these issues, the Green Paper has recently underlined the potential of alternative environmental tax designs, particularly if they are closely-coordinated at the Community level, to alleviate possible adverse competitiveness impacts (EU, 2007b).

In order to illustrate the consequences of the European Union moving forward in terms of global climate policy we first assume unilateral emission abatement within the EU while trading partners abstain from any comparable carbon emission regulation. We differentiate the unilateral EU policy along two central dimensions: Firstly, the degree of leadership measured in terms of the unilateral reduction target of EU emissions vis-à-vis the benchmark situation where no effective emission abatement policy applies. The emission reduction target is set subsequently at 5 %, 10 %, 15 %, 20 %, 25 % and 30 % of the base year emission level to account for a wide range of possible commitments compared to the obligations under the Kyoto Protocol (8 % emission reduction). Secondly, the level of tax differentiation between carbon-intensive (non-electric) industries – EIS and OIL – and the rest of the economy is flexible: The ratio of implicit tax rates to achieve the exogenous EU emission reduction target ranges from unity (i.e. uniform carbon taxes), via factors of 2, 5, 10, and 20 to full exemption of the carbon-intensive industries. Ratios higher than one indicate that taxes are discriminated in favor of carbon-intensive industries – for example a ratio of 20 implies that the carbon tax rate in the rest of the economy is twenty times higher than for carbon-intensive industries.

We use contour plots over the unilateral emission abatement target and the tax ratio to visualize our results. Note that in the graphs we refer to the case of full tax exemptions of carbon intensive industries with a label "inf" for the associated *infinite* tax ratio.

3.2.1 Economic and environmental implications of EU carbon emission constraints

Figure 1a. reports the carbon taxes which must be levied to effect an emission cutback in the range of 5-30% vis-à-vis the BaU. Under a uniform carbon tax regime, taxes amount to approximately 45 USD/tC (125 USD/tC) for emission reduction target of 15 % (30 %). Under sectorally differentiated carbon tax regime, the associated carbon tax values for the rest of the economy are also displayed in Figure 1a. (which yields – by means of the tax ratio – the lower carbon value for carbon-intensive industries). In this case, the carbon value imposed on the rest of the economy ranges up to several hundreds of $US per ton of carbon. With full exemption of the carbon-intensive industries, the carbon taxes for the rest of economy amount to 85USD/tC (250USD/tC) to meet the emission reduction targets of 15% (30%).

Imposition of carbon taxes increase the costs of production, particularly for the energy-intensive sectors in which energy represents a significant share of (direct and indirect) costs and leads subsequently to a distinct decline in sectoral output. Figures 2a.-c. summarize the impacts of unilateral EU emission carbon policies on sectoral production for EIS, OIL, and OTH. The implications of more stringent unilateral emission reduction targets for economy-wide and sectoral production are unambiguously negative. For the case of uniform carbon taxation, the output losses for carbon-intensive industries may become drastic towards higher emission reduction targets. In particular, for the mineral oil industry output losses may amount to as much as 30% if the EU adopts emission reduction target of 30%. In turn, tax differentiation in favor of energy-intensive industries offset to a large extent adverse output effects for these industries. While tax breaks are clearly beneficial for carbon-intensive industries, they go at the expense of the energy-extensive industries (OTH) which are subject to relatively higher carbon tax rates to meet the exogenous overall emission reduction target. Output losses for these industries increase towards strong preferential tax treatment of carbon-intensive industries. However, even for emission reduction target of 30% and full exemption of energy-extensive industries output losses for these industries amount to as much as 1.2%.

Neglecting environmental benefits from carbon abatement, unilateral emission constraints impose non-negligible welfare losses for the EU economy which increase towards higher reduction targets and more pronounced tax differentiation in favor of carbon-intensive industries. For the case of the uniform carbon taxation, our core simulations indicate that welfare losses – measured as reduction in real consumption (here: Hicksian equivalent variation) – increase from 0.76% to 2.1% for the emission reduction targets in the range between 15% and 30%. The welfare losses slightly increase if the EU adopts the same emission reduction targets but fully exempts carbon-intensive industries (Figure 1c).

3.2.2 Competitiveness implications of EU carbon emission constraints

To start with the economy-wide competitiveness effects, Figure 1c. reports changes in the terms of trade (ToT) index which is defined as the ratio of the price of EU's exports in terms of its imports. The terms of trade deteriorate as the ToT index falls. Our simulation results indicate that the implications of more stringent unilateral emission reduction targets for economy-wide competitiveness are unambiguously negative. Under a uniform tax implementation, negative changes in terms of trade are doubled (from 0.6% to 1.2%) for the emission reduction targets of 15% and 30%, respectively. More pronounced tax differentiation in favor of carbon-intensive industries may, however, improve the terms of trade due to the possibility of tax burden shifting via higher export prices of carbon-intensive products. For relatively high emission reduction targets and full exemption of the carbon-intensive industries, the ToT index may improve by one-third compared the uniform carbon taxation. Furthermore, our results indicate that there is a qualitative difference between the ToT index and the welfare regarding the implications of tax differentiation. While more pronounced tax differentiation in favor of carbon-intensive industries clearly induces additional consumption losses, the terms of trade may improve due to the possibility of tax burden shifting.

The competitiveness effects of the EU leadership in climate policy at the sectoral level are visualized in Figures3a.-f. in terms of changes of the RCA, the RWS and the RTB indicators for EIS and OTH sectors. With uniform (tax) treatment, sectors which are relatively carbon-intensive lose competitiveness whereas relatively carbon-extensive sectors gain in competitiveness according to all three sectoral competitiveness indicators. However, specific results on competitiveness effects are likely to be sensitive to the index used: For example, for emission reduction targets of 15 % (30%), losses in sectoral competitiveness for EIS may amount as much as 3.7% (9.1%) according to the RCA and 1.5% (3.9%) according to the RWS. In contrast to these rather moderate changes, the RTB indicator reports a loss of about 55% (135%) compared to BaU. The changes in sectoral competitiveness of OIL according to the RTB indicator appear to be even much more dramatic. On the other hand, non-energy intensive sectors may improve sectoral competitiveness according to the RCA indicator at 1.5% (3.7%) and according to the RWS indicator at 0.8% (1.9%) for an emission reduction target of 30%, respectively. The RTB indicator shows a competitiveness improvement of more than 100%. Using the normalized difference between exports and imports for a particular sector, the RTB indicator responds very strongly to the relatively small changes in (export and/or import) flows. The improvement (worsening) of more than 100% implies the change from the 'net exporter' to the 'net importer' position, and vice versa. Finally, tax differentiation in favor of carbon-intensive industries can largely "neutralize" the implications of emission constraints on sectoral competitiveness on their competitiveness, but this goes at the expense of overall efficiency and competitiveness of energy-extensive sectors.

To sum up, for a balanced view, it is important to account for changes across the various sectors of the domestic economy rather than focusing on a very narrow segment of the economy which might be most affected by policy-induced structural change. It is also crucial to take the limitations of such an assessment into consideration due to a moderate consistency between alternative competitiveness indicators. In addition, sectoral implications must be traded off with economy-wide impacts. Obviously, improvements in competitiveness for some industries may not only work at the expense of competitiveness of other industries but induce an overall loss in national competitiveness measured in terms of real income. Finally, while assessing competitiveness effects, the output measures should be complemented by the competitiveness indicators as for non-energy-intensive sectors the negative output effects are consistent with the improvement of sectoral competitiveness.

3.2.3 Cost implications of unilateral carbon restrictions for the EU

Figure 5a. illustrates finally the problems of unilateral action in climate policy regarding global environmental effectiveness. For our model parameterization, a substantial part of EU abatement – around 30 % – is offset through increased emissions of non-regulating trading partners. Leakage rates are relatively robust with respect to the level of the emission reduction target. As expected, leakage rates decline with tax discrimination of carbon- and export-intensive industries – however, the magnitude of leakage reduction turns out to be rather small.

Figures 5b. and 5c. illustrate the cost implications of tax differentiation (i) for the realistic case when leakage is not compensated and (ii) for the rather unrealistic case of leakage compensation. If we do not account for leakage, larger tax differentiation may be costly in particular for higher unilateral reduction targets (although at lower reduction targets there might be some limited scope for exploiting terms of trade effects through tax discrimination vis-à-vis uniform taxation). If leakage must be compensated for, some degree of tax discrimination in favor of carbon-intensive industries may in fact be beneficial as compared to uniform taxation.

3.3 Sensitivity analysis

We have performed a sensitivity analysis assuming – in accordance with recent findings (Welsch forthcoming) – rather low value of Armington elasticity, i.e. substitution elasticity between the import aggregates and the domestic production, in the range between zero and two. As expected, our results indicate that relative low values for the Armington elasticity imply a more difficult substitution between domestic and foreign production, thus reducing the negative competitiveness effects on the energy-intensive industries but also reducing the positive competitiveness effects on non-energy-intensive industries. The impact on the competitiveness indicators is, however, not uniform: The export-import-based RCA and the RTB indicators are much more sensitive to the changes in the Armington elasticity, than the RWS indicator which is constructed with export flows only.

4 Conclusions

Since the European Council started the Lisbon process in 2000, the issue of competitiveness is an area of high and rising priority within EU policy. In this study, we investigate the implications of a more stringent unilateral carbon emission regulation – as declared by the Spring European Council in 2007 – on economy-wide and sectoral competitiveness, efficiency and leakage rate.

As a prerequisite for our study, we have reviewed the most recent literature on competitiveness concepts, identified key dimensions of competitiveness notions, specified appropriate indicators at sectoral and economy-wide level and implemented selected competitiveness indicators into the multi-sector, multi-region computable general equilibrium (CGE) model. From a methodological perspective, our analysis warrants the careful and complementary use of macroeconomic and competitiveness indicators: Regarding the latter, our results demonstrate a moderate degree of consistency among alternative indicators: Results based on any (sectoral) competitiveness indicator as a cardinal measure are highly sensitive to the particular indicator chosen. Moreover, when assessing competitiveness impacts of policy regulation at the sectoral level, it is important to trade off changes across all the sectors of the domestic economy rather than focusing on only a few branches which might be most exposed at first glance to policy measures. In addition, sectoral implications must be weighted against economy-wide competitiveness and welfare impacts. As a matter of fact, improvements in competitiveness for some industries may not only work at the expense of competitiveness of other industries but induce an overall loss in national competitiveness and welfare.

Regarding the implications of more stringent unilateral environmental policy in the EU we conclude that competitiveness effects at the sectoral level depend rather on an implementation rule for a given emission reduction target than on stringency of an emission reduction target. With an economically efficient uniform taxation, relatively carbon-intensive industries face competitiveness losses, while carbon-extensive sectors improve their ability to compete internationally. Vice versa, more pronounced tax differentiation in favor of carbon-intensive industries can largely neutralize the negative impacts on their competitiveness, but goes at the expense of overall efficiency and competitiveness of energy-extensive sectors. In contrast, leakage rates are much more robust with respect to the alternative tax differentiation regimes. From an economy-wide perspective, tax differentiation towards energy-intensive industries may be justified only if improving EU-wide international competitiveness (terms of trade) enjoys a higher priority for policy makers than reducing compliance costs of a more stringent environmental policy.

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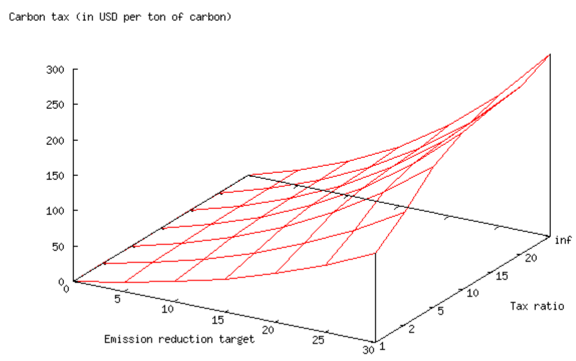
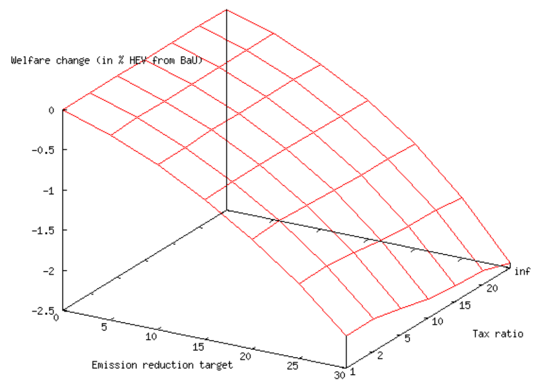
Appendix A

Figure 1: Economic implications of EU carbon emission constraints

a. Carbon tax for rest of economy ($/t of C)



b. Welfare (% HEV from BaU)



c. Terms of trade (in %)

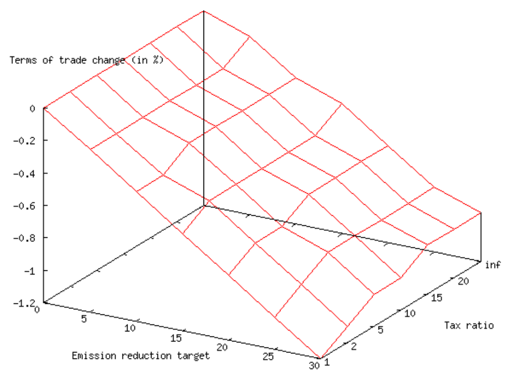
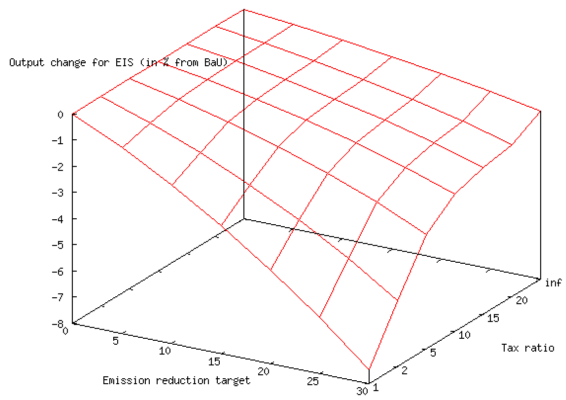
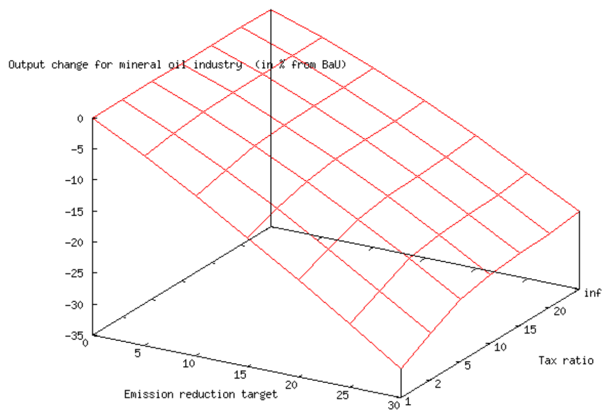


Figure 2: Changes in sectoral production of EU industries

a. Energy-intensive industries (EIS)



b. Mineral oil industries (OIL)



c. Other industries and services (OTH)

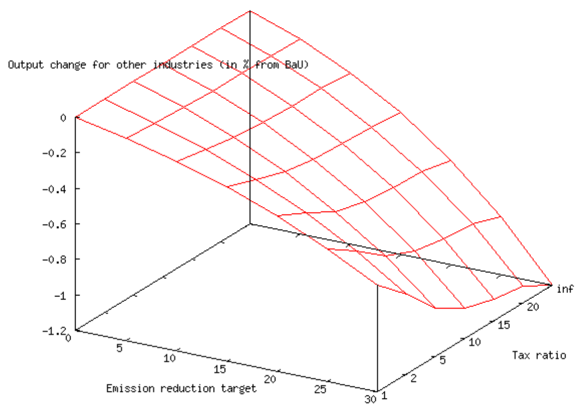
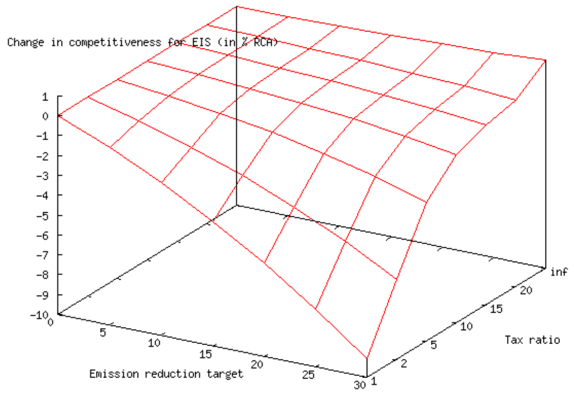
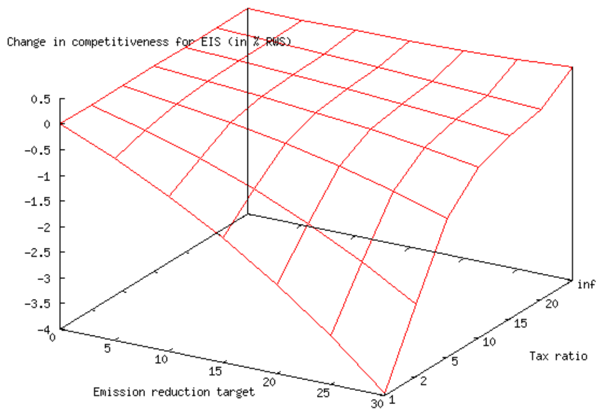


Figure 3: Changes in sectoral competitiveness for Energy-intensive industries (EIS)

a. RCA indicator (in % from Bau)



b. RWS indicator (in % from Bau)



c. RTB indicator (in % from Bau)

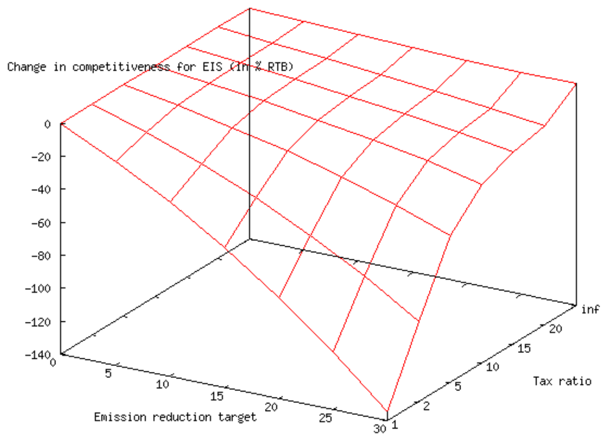
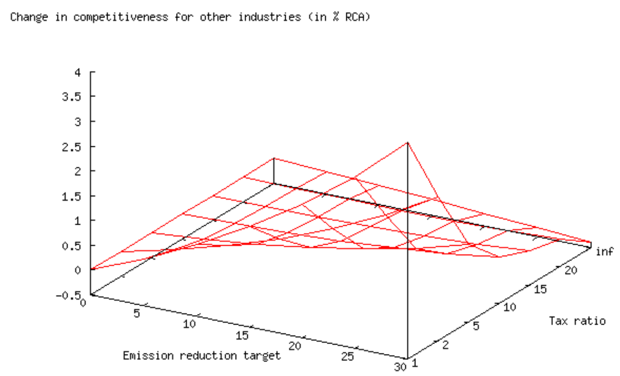
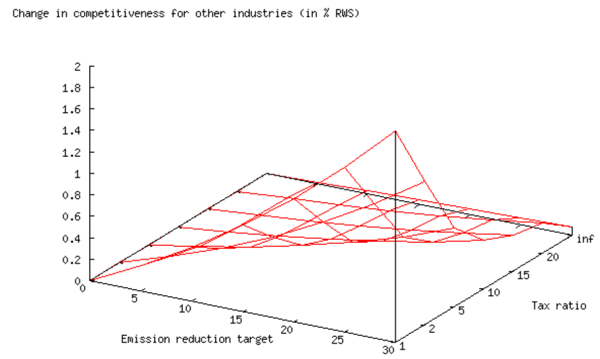


Figure 4: Changes in sectoral competitiveness for other industries (OTH)

d. RCA indicator (in % from Bau)



e. RWS indicator (in % from Bau)



f. RTB indicator (in % from Bau)

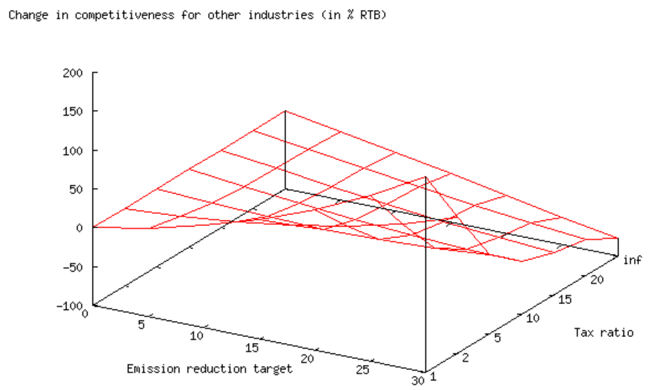
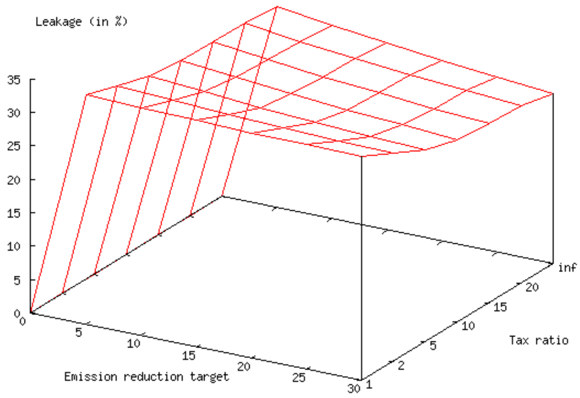
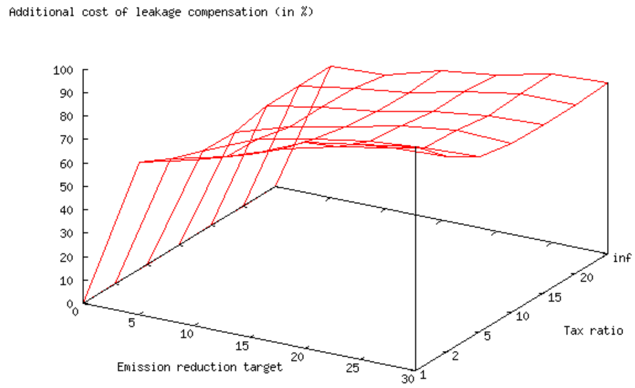


Figure 5: Leakage effects and cost implications of unilateral carbon restrictions for the EU

a. Leakage (in %)



b. Additional cost of leakage compensation (in % of cost without leakage compensation)



c. Cost of tax differentiation without leakage compensation (base: uniform taxation)

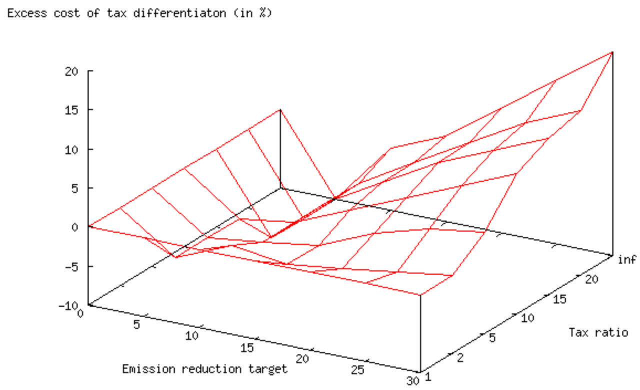


Figure 5: Leakage effects and cost implications of unilateral carbon restrictions for the EU

d. Cost of tax differentiation with leakage compensation (base: uniform taxation)