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Christoph Böhringer

Xaquin Garcia-Muros

Ignacio Cazcarro

Iñaki Arto

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Department of Economics
University of Oldenburg, D-26111 Oldenburg

The Efficiency Cost of Protective Measures in Climate Policy

A Computable General Equilibrium Analysis for the United States

Christoph Böhringer [a,], Xaquin Garcia-Muros[b], Ignacio Cazcarro[b], Iñaki Arto[b]*

Abstract: Despite recent achievements towards a global climate agreement, climate action to reduce greenhouse gas emissions remains quite heterogeneous across countries. Energy-intensive and trade-exposed (EITE) industries in industrialized countries are particularly concerned on stringent domestic emission pricing that may put them at a competitive disadvantage with respect to producers of similar goods in other countries without or only quite lenient emission regulation. This paper focuses on climate policy analysis for the United States of America (US) and compares the economic implications of four alternative protective measures for US EITE industries: (i) output-based rebates, (ii) exemptions from emission pricing, (iii) energy intensity standards, and (iv) carbon intensity standards. Based on simulations with a large-scale computable general equilibrium model for the global economy we quantify how these protective measures affect competitiveness of US EITE industries. We find that while protective measures can attenuate adverse competitiveness impacts measured in terms of common sector-specific competitiveness indicators, they run the risk of making US emission reduction much more costly than uniform emission pricing stand-alone. In fact, the cost increase is associated with negative income effects such that the gains of protective measures for EITE exports may be more than compensated through losses in domestic EITE demand.

JEL classification: D21, H23, D58

Key words: Unilateral climate policy; competitiveness; computable general equilibrium

* Corresponding Author. Email: boehringer@uni-oldenburg.de

[a] Department of Economics, University of Oldenburg, Germany.

[b] Basque Centre for Climate Change (BC3), Bilbao, Spain.

1. INTRODUCTION

The 21st Conference of Parties (COP21) to the United Nations Framework Convention on Climate Change in Paris in December 2015 set an important milestone in international climate policy. The so-called Paris Agreement (UNFCCC, 2015) achieved global consensus on keeping the global mean surface temperature increase below 2 degrees Celsius compared to pre-industrial levels. In line with this temperature target not only industrialized countries but also developing countries signalled their willingness to reduce greenhouse gas (GHG) emissions. According to the Paris Agreement, future climate negotiations and emission reduction efforts should be planned in global coordination; however, opposite to the Kyoto Protocol with its legally binding reduction targets for signatory industrialized countries, the Paris Agreement builds only on voluntary pledges of individual countries - the so-called intended nationally determined contributions (INDCs) - to reduce GHG emissions.

Under the Paris Agreement, the United States of America (US) has committed itself to cut domestic emissions by 26% - 28% by 2025 as compared to 2005 emission levels. One contentious issue in domestic US climate policy is the threat of competitiveness losses for US emission-intensive and trade-exposed (EITE) industries if facing more stringent regulation than international rivals abroad.

Reflecting such competitiveness concerns, the present paper investigates the economic impacts of four alternative protective measures for US EITE industries: (i) output-based rebates, (ii) exemptions from emission pricing, (iii) energy intensity standards (instead of emission pricing), and (iv) carbon intensity standards (instead of emission pricing). Based on simulations with a large-scale computable general equilibrium model (CGE) for the global economy we quantify how these protective measures affect competitiveness of US EITE industries for alternative degrees of climate policy stringency in other OECD countries. We find that while protective measures can substantially attenuate adverse competitiveness impacts, they run the risk of making US climate policy much more costly than uniform emission pricing stand-alone. In fact, the cost increase is associated with negative income effects such that the gains of protective measures for EITE exports may be more than compensated through losses in domestic EITE demand.

The remainder of this paper is organised as follows. Section 2 summarizes the literature on climate policy design in the context of competitiveness concerns. Section 3 adopts a simple analytical framework to investigate the competitiveness impacts of alternative protective measures. Section 4 provides a description of the CGE model and data underlying our quantitative analysis, presents the policy scenarios and discusses the simulation results. Section 5 concludes.

2. LITERATURE REVIEW

Concerns on adverse competitiveness effects of asymmetric emission pricing are at the fore of the climate policy debate in many industrialized countries. Energy-intensive and trade-exposed (EITE) industries in countries with stringent emission regulation fear shifts in competitive advantage in favour of other international producers (which could occur under certain conditions). Cost disadvantages would incentivize the relocation of EITE production from domestic sites to abroad thereby amplifying adverse domestic production and employment effects for these industries. In this context, opponents to unilateral emission pricing also point to the risk of counterproductive emission leakage – i.e. the partial offsetting of domestic emission reduction through increases of emissions abroad.

To avoid excessive (and potentially inefficient) structural change against domestic EITE industries, various protective measures for EITE industries which are at risk of carbon leakage are discussed. Principal among these measures are border carbon adjustment, where emissions embodied in imports from non-regulating regions are taxed at the emission price of the regulating region (i.e. "taxing products at the border on their carbon content") and emission payments for exports to non-regulating countries are rebated. From a global efficiency perspective such a combination qualifies as a second-best measure complementing (unilateral) uniform emission pricing (Markusen, 1975; Hoel, 1991; Copeland, 1996). However, border carbon adjustments are quite controversial from the perspective of international trade agreements and their political feasibility (Cendra, 2006; Ismer et al., 2007). When border measures are unavailable, differential emission pricing in favour of domestic EITE industries including full exemptions may serve as an alternative protective measure (Hoel, 1996; Böhringer et al., 2014a). Another important strategy for protecting EITE industries involves the allocation of free emission allowances conditional on production (i.e. output-based allocation Fischer, 2001). Contrary to auctioning of emission allowances or unconditional free allowance allocation, an output-based grandfathering system effectively works as a subsidy to production to recover (part) of losses in comparative advantage (Böhringer et al., 1998). A further potential candidate for protection of EITE industries are intensity standards. Instead of being subjected to emission pricing, EITE industries could adopt intensity standards to reduce their emissions as compared to business-as-usual levels. Holland (2012) shows that emission pricing via an emission tax or an emission cap-and-trade system may be an inferior instrument to standards if accounting for emission leakage.

As protective measures for EITE industries are predominantly discussed in the context of competitiveness, there is a need for concepts on the definition and measurement of competitiveness at the sector level. The economic literature provides a broad variety of competitiveness concepts (Oberndorfer and Rennings, 2007; Alexeeva-Talebi and Böhringer, 2012). Among indicators to quantify sector-specific competitiveness effects most common are metrics to measure international trade performance such as relative world trade shares (RWS – see e.g. Balassa, 1962; Ballance et al., 1987; Gorton et al., 2000; Fertö and Hubbard, 2003; Abidin and Loke, 2008) or revealed comparative advantage (RCA – see e.g. Kravis and Lipsey, 1992; Carlin et al., 2001).

The economic impacts of protective measures for EITE industries in unilateral climate policy design have been quantified by numerous simulation studies predominantly based on multi-sector multi-region CGE analysis. The bulk of these studies investigates border carbon adjustments (e.g., Babiker and Rutherford, 2005; Mattoo et al., 2009; McKibben and Wilcoxen, 2009; Dissou and Eyland, 2011; Winchester et al., 2010; Böhringer et al., 2010) and report impacts on EITE industries in terms of change in production output. The general finding is that border carbon adjustment attenuate negative output effects for EITE industries in unilaterally regulated countries (see Böhringer et al., 2012a for a meta-analysis) while, providing only limited gains in global cost-effectiveness of unilateral action and enhancing negative terms-of-trade spillover effects to countries without emission regulation. Output-based allocation or preferential emission pricing for EITE sectors can also help to dampen adverse output effects (Fischer and Fox, 2012) significantly. To date, there are only a few studies which cross-compare alternative protective measures: Böhringer et al. (2014b) show that – as the coalition of unilaterally abating countries increases – border carbon adjustments are consistently more effective than output-based rebates in mitigating relocation of EITE output; Böhringer et al. (2012b) extend the comparison to include also tax exemptions for EITE industries and find that the negative repercussions on domestic EITE production can be strongly reduced for border carbon adjustments whereas tax exemptions and output-based rebates can only achieve a fraction of this alleviation.

This paper sheds further light on the relative performance of alternative policy measures to protect competitiveness of EITE industries. In our cross-comparison, we deliberately drop border carbon adjustments since their appeal for practical climate policy is limited given international trade law; instead, we include standards on emissions or energy as a potentially attractive measure beyond output-based rebates or tax exemptions. Furthermore, we quantify sector-specific impacts not only in terms of output changes but also adopt more common metrics for competitiveness such as RWS and RCA. Our simulation analysis for US climate policy design provides insights on how protective measures for EITE industries trade-off with other policy objective such as minimizing economy-wide adjustment cost to national GHG emission targets.

3. STYLIZED THEORETICAL ANALYSIS

We simplify the partial equilibrium model by Böhringer et al. (2014b) to illustrate the basic idea of protective measures in unilateral climate policy. Consider two countries (regions) which differ only with respect to potential regulatory action: country M with emission regulation and country N without emission regulation. Demand q_{ik} in country i for the good produced in country k exhibits constant elasticities with respect to prices. We measure competitiveness as the ratio of exports over imports in the regulated region M where export demand and import supply can be stated as:

$$Exports\ of\ \ region\ M\!:\ \ q_{NM} = a p_{NM}^{-\eta_o} p_{NN}^{\eta_x}$$

$$Imports\ of\ region\ \ M\!:\ \ q_{MN} = a p_{MN}^{-\eta_o} p_{MM}^{\eta_x}$$

with:

- a denoting benchmark quantities (as initial prices are normalized to unity),
- η_o referring to the own-price elasticity, and
- η_x referring to the cross-price elasticity.

As both economies are symmetric, a competitiveness loss will occur when a policy regulation involves lower exports than imports. We thus measure competitiveness φ as the ratio of exports over imports in the regulated country:

$$\varphi = {}^{q_{NM}}\!/_{q_{MN}}$$

We assume competitive markets, so prices equal marginal costs plus potential taxes. The emission intensity in country i is denoted by μ_i. Marginal production cost $c(\mu)$ is constant with respect to output and increasing as the intensity of emissions μ decreases (i.e. c'<0). Let $\mu(t)$ denote the cost-minimising emission intensity at emission tax t. Furthermore, given any positive carbon price, t>0, producers decrease their emission intensity to lower compliance costs, so $1 + t\mu_0 > c\big(\mu(t)\big) + t\mu(t)$.

In the benchmark without emission regulation t=0, with μ_0=μ(0) indicating the initial emissions intensity and normalising p_0=$c(\mu_0)$=1; obviously, benchmark competitiveness $\varphi = 1$.

When an emission tax (t>0) is set (subscript T), the regulated country adjusts emission intensity and prices are equal to marginal costs plus taxes. Thus, $p_{MM}=p_{NM}=c_T+t\mu_T$, where $c_T=c(\mu_T)$ and $\mu_T=\mu(t)$. Exports and imports in the regulated country are given by:

$$q_{NM} = a(c_T + t\mu_T)^{-\eta_0}; \qquad q_{MN} = a(c_T + t\mu_T)^{\eta_x}.$$

Compared to a situation without emission regulation, exports in the unilaterally regulated country decrease while imports increase:

$$q_{NM} = a(c_T + t\mu_T)^{-\eta_0} < 1; \qquad q_{MN} = a(c_T + t\mu_T)^{\eta_x} > 1.$$

Competitiveness for the region with a unilateral emission tax will decrease:

$$\varphi_T = (c_T + t\mu_T)^{-\eta_0-\eta_x} < 1.$$

We now consider protective measures to restore at least partially competitiveness in the regulated country. In our simple partial equilibrium setting with one commodity produced by each region, it is trivial to see that tax exemptions restores competitiveness – in the extreme case of a full exemption, we are back to the benchmark situation. More interesting is the case of output-based rebates or intensity standards. Output-based rebating suppresses the cost increase for domestic producers, so that the playing field does not tilt toward imports or competitors in export markets. Specifically, a rebate is offered to domestic producers in proportion to their production, based on a benchmark that we assume is equal to the average emissions intensity of the sector, multiplied by the emissions tax. As this allocation is updated according to production, the rebate works de facto as a per-unit subsidy $t\mu_T$. The producer price in the regulated country then no longer includes the cost of the remaining embodied emissions, but the emissions intensities (and corresponding production costs) respond to the emission tax so the production cost with output-based rebating equal the production cost for the case of emission taxing stand-alone. Meanwhile in the non-regulated country, $p_{MN}=p_{NN}=c_0=1$.

Holland et al. (2009) show analytically that intensity standards work as implicit emission taxes on the input side where the fictitious tax revenues are recycled as implicit subsidies on the output side. If we set the implicit tax for the case of standards equal to the exogenous emission tax t, the effects of intensity standards and output-based rebating are identical in our simple model framework where we do not have multiple multiple products that differ in emission intensity.[1]

[1] With multiple products that differ in emission intensity, output-based rebating is no longer equivalent with intensity standards even if the latter are made tradable since effective output subsidies across sectors in general differ.

We then can derive exports and imports in the regulated country for the case of protective rebates or standards (subscript *RS*) as:

$$q_{NM} = a(c_{RS})^{-\eta_o} < 1; \qquad q_{MN} = a(c_{rS})^{+\eta_x} > 1$$

and competitiveness as:

$$\varphi_T = (c_{RS})^{-\eta_o - \eta_x} < 1$$

With the exogenous emission tax t, $c_T = c_{RS}$ and $\mu_T = \mu_{RS}$ so we can readily compare the competitiveness performance of protective measures against our reference case of an emission tax:

$$\varphi_{RS}/\varphi_T = \frac{(c_T + t\mu_T)^{\eta_o + \eta_x}}{(c_T)^{\eta_o + \eta_x}} > 1$$

Hence, we can see that output-based rebates like intensity standards attenuate the competitiveness losses as compared to emission taxing stand-alone.

4. COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

The stylized theoretical analysis provides qualitative insights into the competitiveness effects of different measures for protecting EITE industries under unilateral emission regulation. For an empirical quantitative assessment it is however imperative to account for real-world complexities that are no longer tractable in theoretical analysis. Economic adjustment to emission regulation is driven through complex substitution, output and income effects across multiple markets following changes in relative prices. In this context, computable general equilibrium (CGE) models represent an important complement to theoretical analysis of policy regulation since they allow researchers to conduct counterfactual experiments that are grounded in microeconomic theory and have quantitative content based on empirical data. We therefore undertake numerical simulations with a large-scale CGE model of global trade to quantify the economic impacts of US climate policy design where alternative protective measures for EITE industries are still under debate.[2] We first provide a non-technical summary of the CGE model and describe the data sources used for parameterization. Next, we lay out the criteria for industries to qualify as EITE sectors and recall the definitions of sector-specific competitiveness

[2] The EU as a forerunner in climate policy legislation has adopted output-based rebates to protect EITE industries (EU, 2008).

indicators. We then follow up with a characterization of counterfactual climate policy scenarios and discuss simulation results.

4.1. Non-technical model summary

We use a multi-region, multi-sector CGE model of global trade and energy use destined for the impact assessment of climate policies (see Böhringer and Rutherford, 2010 or Böhringer et al., 2014b for recent applications and the detailed algebraic formulation of the core model).

Production of commodities except fossil fuels is captured by constant elasticity of substitution (CES) cost functions describing the price-dependent use of capital, labour, energy, and material in production. At the top level, a CES composite of material trades off with an aggregate of energy, capital, and labour at a constant elasticity of substitution. At the second level, a CES function describes the substitution possibilities between intermediate demand for the energy composite and a value-added aggregate of labor and capital. At the third level, the value-added composite is formed as a CES function of labour and capital while the energy composite is formed as a CES function of different primary and secondary energy inputs (coal, gas, refined oil, electricity). Production of fossil fuels (coal, gas, crude oil) is characterized by a single-level CES function where the fossil-fuel resource trades off with a Leontief composite of all other inputs.

Final consumption demand in each region is determined by the representative household who maximizes utility subject to a budget constraint with fixed investment and exogenous government provision of public goods and services. The household's total income consists of tax revenues and net factor income from primary factors labour, capital and fossil-fuel resources. Final consumption demand is given as a CES aggregate of composite non-energy consumption and composite energy consumption. Both – the non-energy consumption composite and the energy consumption composite – are in itself CES functions of disaggregate non-energy and energy commodities.

Labor and capital are mobile across sectors within a region but immobile between regions. Fossil-fuel resources are tied to the respective resource production sectors.

Bilateral trade follows the Armington (1969) approach of product heterogeneity where domestic and foreign goods are distinguished by origin. A balance of payment constraint incorporates the base-year trade deficit or surplus for each region. All goods used on the domestic market in intermediate and final demand correspond to a CES (Armington) composite that combines the domestically produced good and the imported good from other regions.

CO_2 emissions are linked in fixed proportions to the use of fossil fuels, with CO_2 coefficients differentiated by the specific carbon content of fuels. Restrictions to the use of CO_2 emissions in production and consumption are implemented through exogenous emission constraints or (equivalently) CO_2 taxes. CO_2 emission abatement then takes place by fuel switching (inter-fuel substitution) or energy savings (either by fuel-nonfuel substitution or by a scale reduction of production and final demand activities).

4.2. Data

As is customary in CGE analysis, base-year data and exogenous elasticities determine the free parameters of the model's functional forms that characterize production technologies and consumer preferences. The base-year data together with exogenous elasticity values calibrate the functional forms such that the Global Trade Analysis Project (GTAP) dataset is consistent with market structure assumptions and optimizing behavior of economic agents. For the calibration we use the most recent data from the GTAP which features detailed accounts of regional production and consumption, bilateral trade flows, energy flows, and CO_2 emissions for up to 140 regions and 57 sectors in the base-year 2011 (Narayanan et al. 2015). Elasticities in international trade and in sector-specific value-added are included in the GTAP database. Interfuel substitution elasticities are based on Narayanan and Steinbuks (2014). The elasticities of substitution in fossil fuel sectors are calibrated to match exogenous estimates of fossil fuel supply elasticities (Graham et al., 1999; Krichene, 2002).

The GTAP database is aggregated toward a composite dataset that accounts for the specific regional and sectoral requirements of our analysis. On the regional dimension, we have depicted important geolpolitical players and major trading partners of the US to reflect concerns about competitiveness losses induced by stringent US climate policy regulations. On the sectoral dimension, the composite dataset identifies five primary and secondary energy goods to track differences in CO_2 intensity and the degree of substitutability. We furthermore include all GTAP sectors explicitly that qualify as energy-intensive and trade-exposed (EITE) industries according to the criteria as laid out in section 4.3. All remaining sectors are condensed in a composite of “other manufactures and services”. Table 1 lists all sectors and regions included in the model (for the sectors we include acronyms in brackets with are used in Figure 1 of section 4.3.).

(INSERT TABLE 1)

4.3. Qualification criteria for EITE sectors

For the selection of EITE sectors we adopt the criteria put forward by the EU in the definition of industries at risk of carbon leakage which in turn serves as a proxy for the threat of international competitiveness losses. The EU ETS Directive, Article 10a (EU, 2003) defines that a sector or sub-sector is deemed to be exposed to a significant risk of carbon leakage using two metrics: trade intensity (T) and the additional cost (A) induced by emission regulation. These metrics are formally defined at the sector level as:

$$\text{Trade intensity } (T) = \frac{(X + V)}{(Y + V)}$$

$$\text{Additional Cost } (A) = \frac{(c * e + d) * \varepsilon}{\omega}$$

where:

X, V, Y	denote exports, imports and output,
c	are the direct emissions,
d	are the indirect emissions of CO_2 from electricity consumption,
e	is the share of emissions that are auctioned,
ε	is the expected carbon price in 2020, and
ω	denotes the gross value added at factor costs.[3]

Article 10a of the ETS Directive classifies a sector to be exposed to a significant risk of carbon leakage if at least one of the three criteria combinations listed in Table 2 is met.

(INSERT TABLE 2)

As we apply these criteria to the GTAP dataset, the sectors which qualify only contribute 13% to overall gross value-added. To correct for the fact that GTAP only features a relative broad and highly aggregated sector classification we have lowered the threshold to the third criteria from 30% to 10%. Additional sectors that meet these relaxed critieria are attributed towards two composite sectors, i.e. trade-intensive agricultural goods (TIA) and trade-intensive manufactured goods (TIM), increasing the share of

[3] Values for e and ε were taken from De Bruyn et al (2013). All other parameters are assigned based on GTAP data.

all EITE sectors in economy-wide value-added to roughly 22%. Figure 1 provides a scatter plot in trade intensity (%) and additional cost (%) for the selected EITE sectors.

(INSERT FIGURE 1)

4.4. Sector-specific competitiveness indicators

In order to assess the competitiveness effects on EITE sectors induced by emission regulation we draw on two widely used competitiveness indicators: relative world trade shares (RWS) and revealed comparative advantage (RCA). These indicators are defined as follows:

$$RCA_{ir} = \frac{X_{ir}/V_{ir}}{\sum_i X_{ir}/\sum_i V_{ir}} \qquad RWS_{ir} = \frac{X_{ir}/\sum_r X_{ir}}{\sum_i X_{ir}/\sum_i \sum_r X_{ir}}$$

where:

X_{ir} denotes the exports of sector *i* in region *r*, and

V_{ir} denotes the imports of sector *i* in region *r*.

4.5. Policy scenarios

Our research interest is in the economic impact assessment of protective measures for EITE industries as a potentially important element of US climate policy design. We distinguish four different protective measures: (i) output-based rebates (*obr*), (ii) exemptions from emission pricing (*exe*), (iii) energy intensity standards instead of emission pricing (*eis*), and (iv) carbon intensity standards instead of emission pricing (*cis*). The reference policy (*ref*) without any protective measures for EITE industries involves a uniform emission pricing across all segments of the US economy. Table 3 summarizes the characteristics across the five climate policy designs underlying our simulation analysis.

(INSERT TABLE 3)

In our central case simulations we assume that the US is committed to a CO_2 emission reduction of 30% compared to business-as-usual emission levels which are provided by the 2011 base year. This emission reduction target is roughly in line with the voluntary pledges to reduce GHG emissions submitted by US under the Paris Agreement. In the reference scenario the emission reduction target is achieved through uniform CO_2 emission pricing across all segments of the economy. The CO_2 price is either determined as the emission allowance price within a domestic emission trading system where the cap is set at 70% of the base-year emissions; alternatively, the CO_2 emission price equals a CO_2 emission tax set sufficiently high to achieve the 30% reduction in domestic emissions.[4]

Despite the Paris Agreement on the need of globally coordinated action to achieve the 2°C temperature target, a common global emission price is unlikely in the foreseeable future. The realistic assumption remains that industrialized countries lead the way with stringent emission controls while developing countries refrain from rigorous measures to curb GHG emissions. We reflect international asymmetries in climate action by assuming that non-OECD countries have negligible emission prices while we impose a series of increasingly emission taxes on OECD economies other than the US ranging from $0 per ton to $70 per ton of CO_2 with intermediate tax steps of $10. Across all scenarios, we keep the US emission reduction at 30% from base-year emission levels. When we replace explicit emission pricing in EITE sectors by intensity targets, we set EITE standards at the level achieved in the *ref* scenario while emission pricing for all other segments of the US economy are adjusted endogenously to warrant the economy-wide US emission reduction.[5]

4.6. Simulation results

In the exposition of simulation results we quantify the effects of alternative US climate policy designs in percentage change from the business-as-usual (BaU) without climate policy. We start the discussion of simulation results with policy-induced changes in EITE competitiveness which reflects the primary research interest of our analysis.

(INSERT FIGURE 2)

Figure 2 shows the competitiveness impacts for US EITE sectors measured in terms of widely spread competitiveness indicators RCA and RWS. These metrics indicate, EITE competitiveness concerns stand-alone would provide a strong rationale for protective measures. As can be expected, the international cost disadvantages for US EITE industries and thus the argument in favour of protective EITE measures are weakened as OECD trading partners adopt increasingly stringent emission pricing.

Among protective measures, full exemptions (*exe*) are – unsurprisingly – most effective to preserve competitiveness of US EITE industries followed by output-based rebates (*obr*) and standards (*cis*, *eis*). With full exemptions, US EITE sectors might even gain in competitiveness vis-à-vis the BaU provided

[4] Revenues from auctioning emission allowances or taxing emissions are recycled lump-sum to the representative US household.

[5] In our central case simulations, we do not impose a global emission constraint to keep global emission for all US climate policy scenarios constant (given a specific emission price in other OECD countries). The interest of our simulation analysis is on how alternative protective measures in US climate policy design affect the performance of US EITE industries and domestic US welfare rather than investigating global cost-effectiveness.

international OECD rivals adopt sufficiently high economy-wide emission taxes. Although standards are set to in scenarios *eis* and *cis* at the energy/carbon intensities obtained in scenario *ref*, the implicit subsidization of output inherent to standards leads to lower competitiveness losses as compared to the *ref* scenario. Overall, the competitiveness metrics RCA and RWS show the same trend with respect to competitiveness losses being lowest for scenario *exe*, followed by *obr*, *eis*, *cis*, and finally *ref*.

(INSERT FIGURE 3)

Figure 3 reports how alternative US climate policy designs affect composite output of US EITE industries. The striking insight is that protective measures rather decrease than increase output as compared to the ref scenario. The reason behind is that protective measures increase overall compliance cost for the US economy (see Figure 4 below) which translates into lower real income and lower domestic demand for US products. EITE sectors are trade-intensive, but their output still depends mainly on domestic demand. With protective measures, the gains in export compared to the ref scenario are more than compensated through reductions in domestic demand.

Comparison of Figures 2 and 3 also highlights that the use of international competitiveness indicators might be quite misleading as a proxy on output performance: While EITE competitiveness measured in terms of RCA or RWA increase with protective measures vis-á-vis scenario *ref*, domestic EITE output nevertheless is more adversely affected under seemingly protective measures.

We finally turn to the discussion of welfare impacts for the US economy. Welfare is measured in terms of Hicksian equivalent variation in income as a percentage of the BaU level. Figure 4 indicates that none of the protective measures yield welfare gains compared to the *ref* policy. Cost-effective reduction of domestic emissions is warranted by uniform emission pricing stand-alone. Subsidies to EITE industries – be it explicit in terms of exemptions and output-based rebates or implicit via standards – induce a deviation from the cost-effective pattern of CO_2-abating substitution and output effects. Most costly is scenario *exe* where EITE industries which typically dispose of relatively cheap emission abatement options do not face any emission price – abatement efforts are shifted to the remaining segments of the US economy which must undertake more costly emission reduction measures.

(INSERT FIGURE 4)

5. CONCLUSION AND POLICY IMPLICATIONS

Future international climate policy will continue to be characterized by disparate ambition levels in greenhouse gas abatement where industrialized countries most likely lead the way with more ambitious emission reduction targets while developing countries stick to rather lenient emission controls. Against this background energy-intensive and trade-exposed (EITE) sectors in industrialized countries are concerned on competitiveness losses and call for protective measures. The EU has already opted for output-based rebates to EITE industries that are regulated under the EU Emissions Trading System. In other OECD countries such as the US the debate on industry-specific protective measures is still ongoing.

In this paper we have analysed the economic implications of US climate policy design considering alternative protective measures for US EITE industries: (i) output-based rebates, (ii) exemptions from emission pricing, (iii) energy intensity standards, and (iv) carbon intensity standards. We have compared how these measures perform against a climate policy reference where the US relies solely on economy-wide uniform emission pricing to reduce domestic CO_2 emissions by 30%.

Based on simulations with a large-scale CGE model of global trade and energy use calibrated to most recent GTAP data, we find that protective measures can significantly attenuate adverse competitiveness effects measured in terms of common indicators such as relative world trade shares (RWS) or revealed comparative advantage (RCA). However, protection of domestic US EITE industries comes along with substantial welfare losses in particular for the case of exempting EITE industries from emission payments. The induced real income losses – compared to the reference policy without protective measures – depress domestic demand for EITE production. As a consequence, composite EITE output under protective measures might rather decrease than increase: Output of US EITE industries hinges predominantly on domestic demand – the gains of protective measures in US EITE exports may be more than compensated through losses in domestic EITE demand. Our results warrant caution against an embracement of protective measures even from the perspective of EITE lobbyists.

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TABLES

Table 1: Model sectors and regions

Sectors and commodities	Regions
Primary and secondary energy goods:	United States of America
Coal (COL)	
Crude oil (CRU)	*Other OECD regions:*
Natural gas (GAS)	EU-28+ EFTA
Refined oil products (OIL)*	Japan
Electricity (ELE)	Canada (CAN)
	Other OECD countries (ROE)
Energy-intensive and trade-exposed (EITE) industries:*	
Air transport (ATP)	*Other geopolitical players:*
Chemical rubber plastic products (CRP)	China (CHN)
Electronic equipment (EEQ)	Russian Federation (RUS)
Fishing (FSH)	Organization of the Petroleum Exporting Countries (OPEC)
Leather products (LEA)	Rest of the World (ROW)
Motor vehicles and parts (MVH)	
Metals (NFM)	
Crops (OCR)	
Machinery and equipment (OME)	
Manufactures (OMF)	
Minerals (OMN)	
Oil seeds (OSD)	
Transport equipment (OTN)	
Transport (OTP)	
Processed rice (PCR)	
Paddy rice (PDR)	
Plant based fibers (PFB)	
Other manufactures and services (ROI)	
Sugar (SGR)	
Vegetable oils and fats (VOL)	
Vegetables fruit nuts (V_F)	
Wearing apparel (WAP)	
Wheat (WHT)	
Trade-intensive agricultural products (TIA)	
Trade-intensive manufactured products (TIM)	
Remaining industries and services:	
Other manufactures and services (ROI)	

*Refined oil products are included in EITE

Table 2: Criteria to qualify as sector at significant risk of carbon leakage (EU 2003)

	Additional costs (A)	Trade intensity (T)
Criteria combination #1	>5%	>10%
Criteria combination #2	>30%	-
Criteria combination #3	-	>30%

Table 3: Summary of policy scenarios (scenario acronyms in parenthesis)

Reference scenario	**Scenarios with protective measures for EITE industries**
Uniform CO_2 emission pricing across all segments of the economy (*ref*)	Output-based rebates (*obr*)
	Full exemption (*exe*)
	Energy intensity standard (*eis*)
	Carbon intensity standard (*cis*)

FIGURES:

Figure 1: EITE Sectors in the US – trade intensity (%) and additional costs (% of value added)

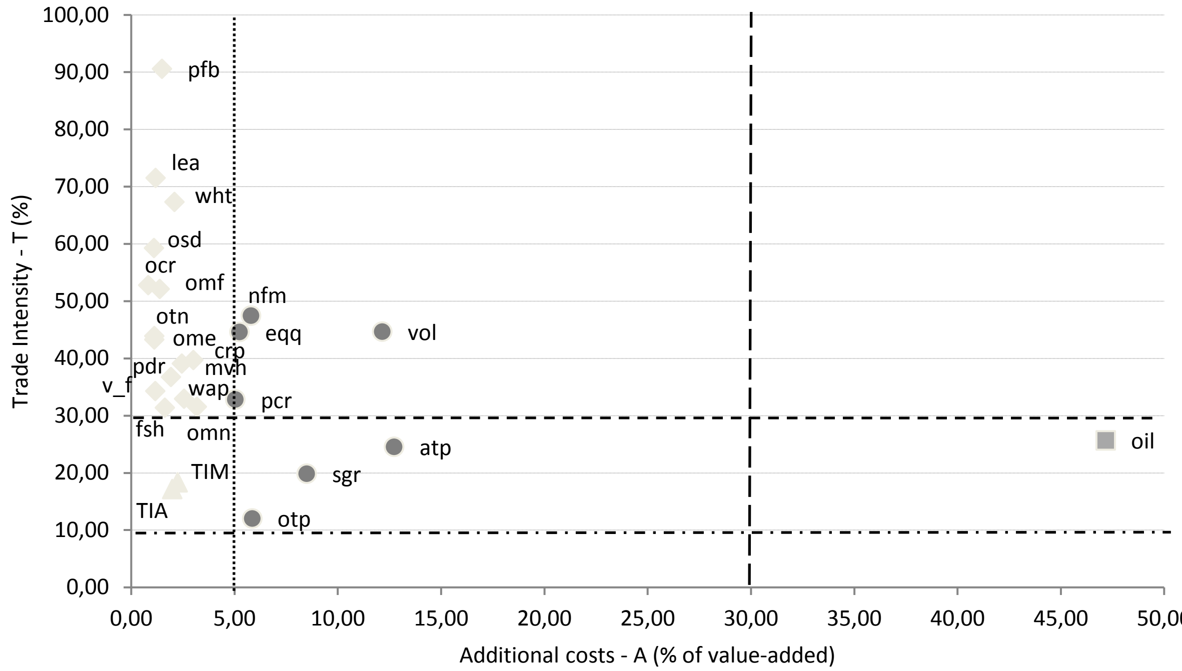


Figure 2: Competitiveness effects on EITE industries (% from BaU) – RCA and RWS

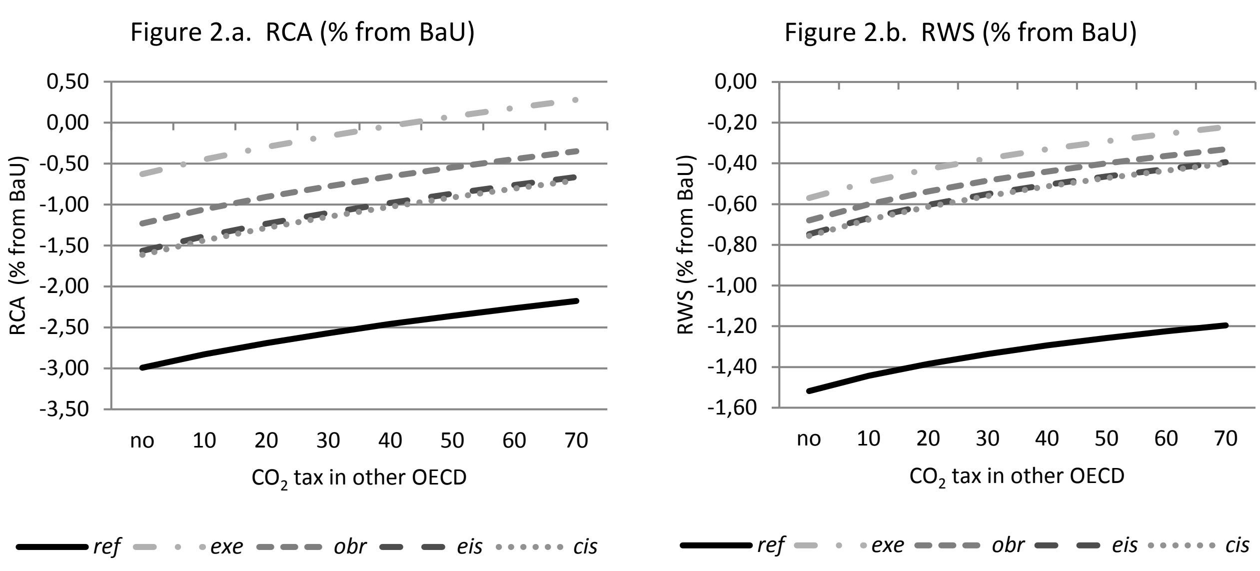


Figure 3: Output effects in US EITE industries (% from BaU)

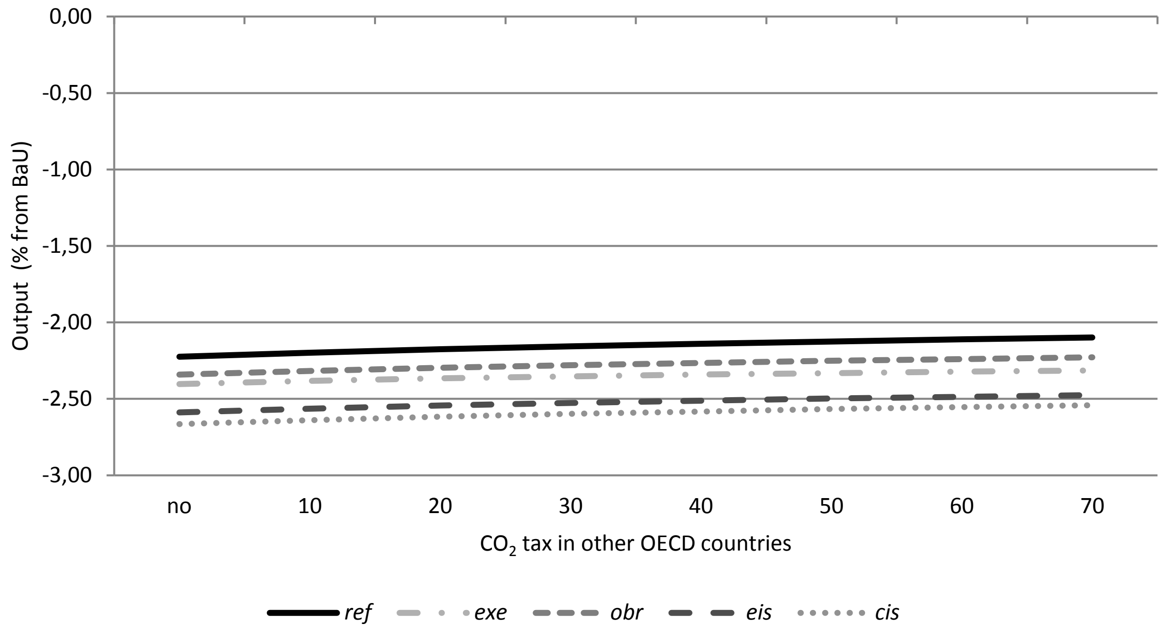
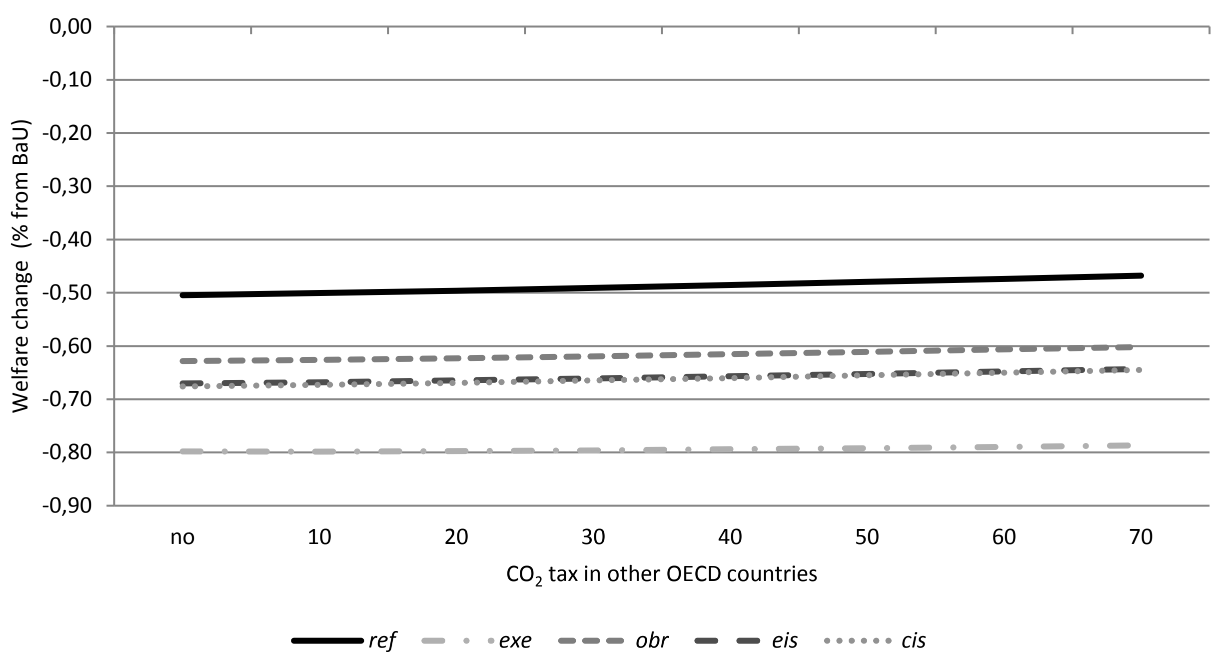


Figure 4: US welfare impacts (% Hicksian equivalent variation (HEV) in income)



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