Peterson, Everett B.; Schleich, Joachim

Working Paper

Economic and environmental effects of border tax adjustments

Working paper sustainability and innovation, No. S1/2007

Provided in cooperation with:
Fraunhofer-Institut für System- und Innovationsforschung (ISI)

Working Paper Sustainability and Innovation
No. S 1/2007 (Revised Version October 2007)

Everett B. Peterson
Joachim Schleich

Economic and Environmental Effects of Border Tax Adjustments

Fraunhofer Institute
Systems and
Innovation Research

Abstract

Taxing imports from regions which are not subject to climate policy and subsidizing exports into these regions have recently been proposed to address presumed negative effects of the EU Emissions Trading Scheme (EU ETS) on industry competitiveness and carbon leakage. This paper analyzes the economic and environmental effects of alternative border tax adjustment (BTA) mechanisms using an extended version of the GTAP-E model that explicitly includes domestic trade and transport margins. The BTAs are imposed on regions which have not committed to emission targets under the Kyoto Protocol or which failed to ratify the Kyoto Protocol. The analyses distinguish between effects of the BTAs on the EU15 countries and on the rest of the EU (REU). Likewise, the analyses single out the effects of climate policy with and without BTAs on domestic output changes which are due to changes in import competition and export competitiveness. Implementing a BTA whose power is equal to the percentage change in production costs in the energy-intensive sectors in the EU has different impacts for those sectors in the EU15 countries compared with the REU countries. In the EU15, the BTA effectively neutralizes import competition in the energy-intensive sectors while enhancing the export competitiveness of these sectors. Conversely, in the REU, the BTA is not effective in neutralizing increased import competition or decreased export competitiveness because the majority of trade by the REU is with countries/regions that are not included in the BTA. Overall, implementing a BTA has little effect on the marginal abatement costs of achieving the emission reductions in the Kyoto Protocol and does little in reducing carbon leakage.

Table of Contents

Page

Figures

Tables

1 Introduction

Partial implementation of environmental policies in some regions will not lead to a cost-efficient outcome in case of transnational externalities. Yet such policies are observed in the context of international climate policy. In particular, in the Kyoto Protocol only so called Annex B countries have committed to reduce greenhouse gases by approximately 5.2% from the 1990/1995 base year levels during the first commitment period of 2008-2012. Even though the United States and Australia refused to ratify the Kyoto Protocol, adopting members implemented the agreement in 2005. In the same year, the European Union launched an EU-wide trading scheme (EU ETS) for CO_2-emissions generated by companies in the energy industry and other carbon-intensive industry sectors as its key climate change policy instrument. Approximately 12,000 installations are currently covered by the EU ETS and account for nearly 45% of total CO_2-emissions, and about 30% of all greenhouse gases in the EU (CEC 2005). The purpose of the EU ETS is to allow EU Member States to achieve their Kyoto greenhouse gas emission targets at minimum cost. However, this partial implementation of emissions trading may result in competitive distortions for carbon-intensive companies like producers of cement or steel in the EU. Since participating in the EU ETS increases the marginal production costs, depending on the carbon intensity of the production process and the price for EU allowances, companies from these sectors which export to regions that have not implemented climate policy would be disadvantaged since the additional (opportunity) costs may generally not be passed on. Likewise, EU companies that face import competition from companies in regions that have not implemented climate change policies would also be at a competitive disadvantage.[1] Because of these changes in competitiveness, the production of energy-intensive products may shift to regions without climate change policies. This would lead to carbon leakage and a smaller reduction in global CO_2 emissions if firms in these countries employ less carbon efficient production processes. As a consequence, BTAs may also allow regions to take leadership in terms of climate policy. For example, the EU has committed to reduce greenhouse gas emissions by 2020 by 20%, even if there was no Post-Kyoto agreement.

---

1 Since in the EU ETS at least 90% of allowances have to be allocated for free for the period 2008-2012, actual costs to companies would be lower than the opportunity costs. However, competitiveness is determined by the marginal costs, which under ideal conditions do not depend on whether allowances are allocated for free or auctioned off.

To address these concerns, border tax adjustments (BTA) have recently been proposed by academics (e.g. Ismer and Neuhoff 2004, Grubb and Neuhoff 2006, Stiglitz 2006), industry associations (e.g. CEMBUREAU), and politicians. The proposed border adjustments would tax imports from regions that have not implemented climate change policies and subsidize exports to those regions. The tax and subsidy rates would correspond to the additional (opportunity) costs imposed on like commodities produced in the EU. Thus, the higher the carbon tax (implied through emission trading), the higher will be the tax burden on imported commodities and the higher the subsidy on EU exports.[2] Current proposals for a US national greenhouse gas trading system include provisions which are similar to a BTA and are meant to induce participation of those countries in a global effort to reduce greenhouse gas emissions which failed to take appropriate measures. According to the Lieberman-Warner America's Climate Security Act of 2007, importers of greenhouse-gas-intensive manufactured products from such countries would have to submit emissions allowances of a value that matches that of the allowances domestic manufacturers pay under the US system.[3]

In practice, at least three types of problems may arise with the implementation of a BTA mechanism. First, because of information costs and information asymmetry, it may be difficult to determine the appropriate level of the import tariffs and export subsidies that offset the loss of competitiveness. Ideally, the power of the BTA would be set equal to the percentage change in costs from implementing climate change policies. However, this may be difficult to measure and there would be incentives for firms to include cost increases not associated with climate change policies to obtain larger tariffs and export subsidies. Second, the set of commodities which would be subject to the BTA have to be defined. Annex 1 of the EU Emissions Trading Directive lists the types of installations which are directly covered by the EU ETS. However, since the EU ETS not only increases prices of final commodities, but also of intermediate commodities such as electricity, the competitiveness of companies which do not participate in the EU ETS but intensively use these intermediates, may also be affected negatively. Sectors indirectly affected by the EU ETS include, in particular, the aluminum and large parts of the chemical industry. Third, it is doubtful whether

2 Other remedies discussed to address incomplete regulatory coverage include output-based allocation of allowances or rebate systems (see Demailly and Quirion 2006, Demailly and Quirion 2007b, Fischer (forthcoming), or Bernard et al. 2007).

3 See http://lieberman.senate.gov/documents/acsa.pdf

BTA would be compatible with current WTO/GATT rules (e.g., van Asselt and Biermann 2007). Notably, Ismer and Neuhoff (2004) argue that a BTA would be allowed under WTA rules if it is based on emissions of best-available technologies (BAT).

In this paper we analyze the economic and environmental effects of the EU implementing a BTA policy employing a static version of the GTAP-E model that also includes domestic trade and transport margins. Such margins are particularly relevant for some of the sectors included in the EU ETS such as cement or lime producers. Peterson and Lee (2005) have shown that the impact of energy taxes on prices and emissions may be significantly overstated if the domestic trade and transport margins are not explicitly modeled. The power of the BTA is set equal to the percentage change in costs for sectors that are subject to the BTA, with the BTA being imposed on two alternative sets of industries: those industries directly participating in the EU ETS and those industries directly or indirectly affected by the EU ETS.

This paper extends existing applied general equilibrium (AGE) based analyses of the EU ETS (including Klepper and Peterson 2006, or Kemfert et al. 2006) which do not allow for BTAs (and not for transport margins), and do not distinguish between effects on the EU15 and the REU countries. It complements existing analyses on BTAs for selected sectors such as steel and cement based on partial-equilibrium models (including Demailly and Quirion forthcoming, Demailly and Quirion 2007, and Mathiesen and Mæstad 2004). Finally, the paper distinguishes the effects on domestic output which result from changes in import and export competitiveness.

2 Model Description

The model employed is an extended version of the static GTAP-E Model (Burniaux and Truong 2002). This model is based on the perfectly competitive, multi-region, multi-sector GTAP model (Hertel and Tsiagas 1997). Because the GTAP-E explicitly models substitution possibilities between energy inputs and between energy and capital; and also tracks CO_2 emissions, it has been frequently used in the analysis of climate change policies (e.g. Kremers et al. 2002, Nijkamp et al. 2005 or Kemfert et al. 2006). Our model extends the GTAP-E model by including domestic trade and transport margins.

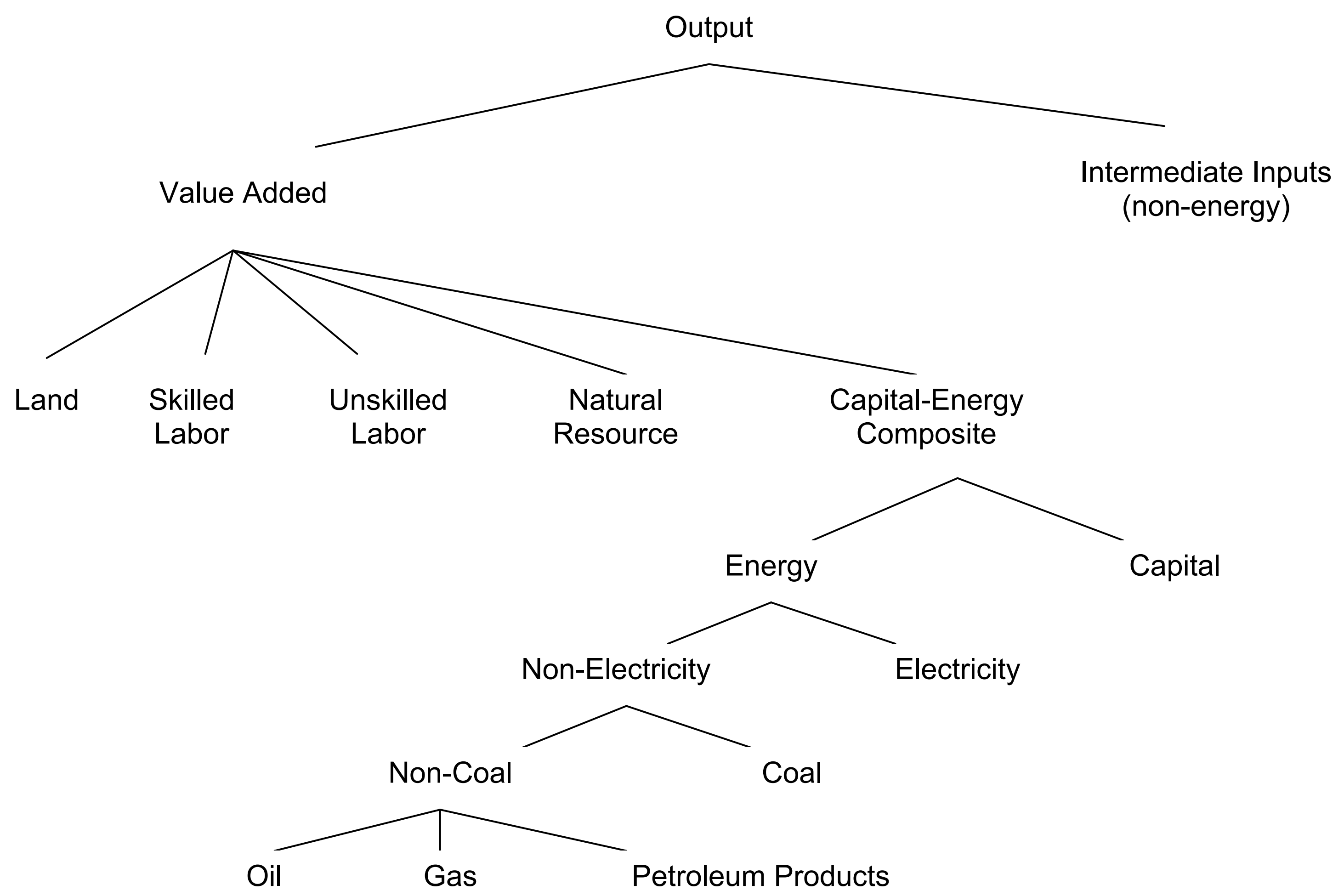
2.1 Regional Household Demand

In each region, there is a single aggregate household that represents the consumption side of the model. This regional aggregate household collects all of the factor income and tax receipts and spends this income on private consumption of goods and services, government consumption, and savings. The utility function for the aggregate regional household consists of two levels. At the top-level, a Cobb-Douglas utility function is specified such that shares of private consumption, government consumption, and savings remain constant. At the second-level, a non-homothetic Constant Difference Elasticity of substitution (CDE) utility function is used to represent preferences for private consumption. Also at the second-level, a Cobb-Douglas utility function is used to represent preferences for government consumption.

2.2 Production

Similar to the GTAP-E model, a nested Constant Elasticity of Substitution (CES) production structure, as illustrated in Figure 1, is specified in the model. Each sub-nest in the production structure represents the potential for substitution between individual or composite inputs. Each composite input is composed of the commodities at the next lower level in the tree structure of Figure 1. Beginning at the top of the production structure, firms produce output by using non-energy intermediate inputs and a primary factor composite (or value added). Typically, the elasticity of substitution between the primary factor composite and non-energy intermediate inputs (σ_T) is assumed to equal zero. This implies a constant per-unit-of-output input use of all non-energy intermediate inputs and the primary factor composite. The primary factor composite is composed of land, skilled labor, unskilled labor, natural resources, and a capital-energy composite with a constant elasticity of substitution (σ_{VA}) between them.

Figure 1: Structure of Production in GTAP-E Model

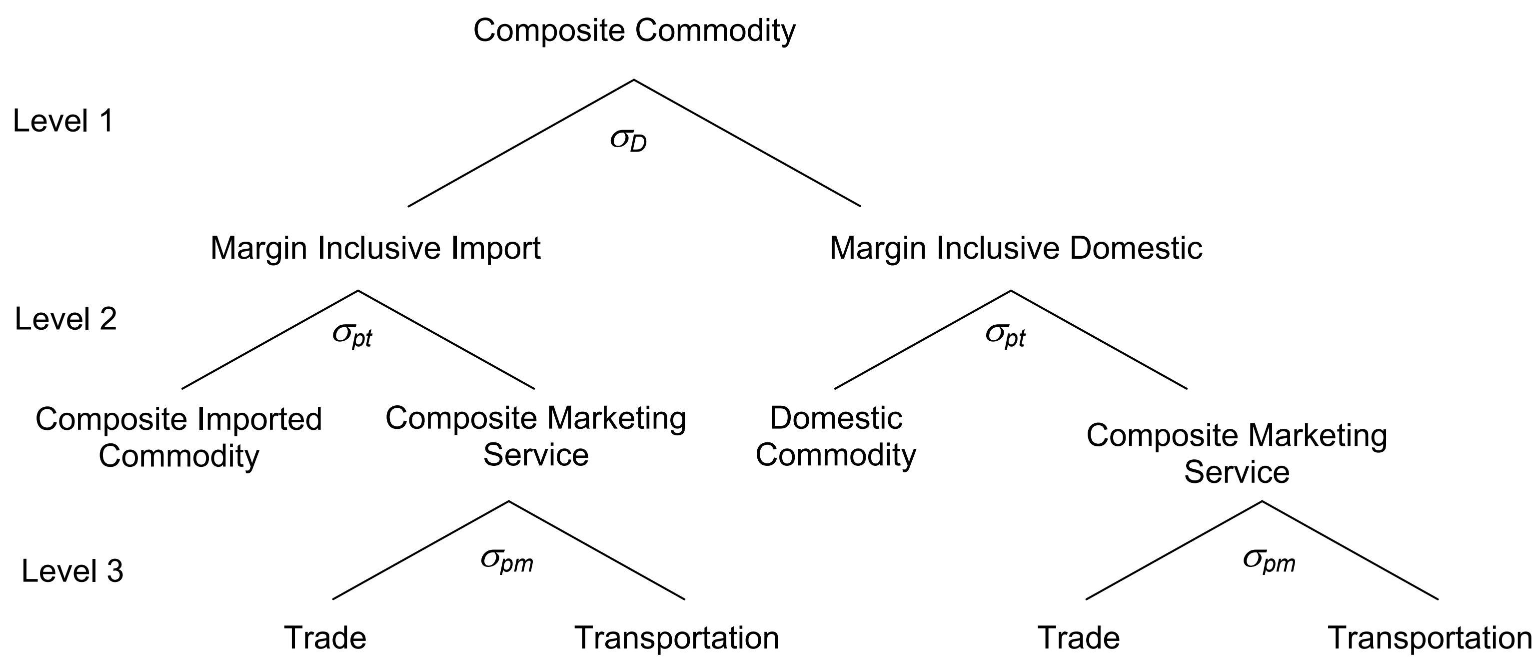


Within the capital-energy composite, there are three inter-fuel substitution possibilities: (a) electricity versus non-electricity composite (σ_{ELY}); (b) coal versus non-coal composite (σ_{COAL}); and (c) between oil, gas, and petroleum products (σ_{FU}). For example, producers may substitute coal for non-coal fuel (a composite of oil, gas and petroleum products) when coal becomes more expensive than non-coal fuels. Firms may also substitute the energy composite (σ_{KE}) for capital when the aggregate energy price decreases relative to the capital rental rate. As pointed out by Burniaux and Truong (2002), the advantages to this specification is that it allows for substitution between fuels and the potential for capital and energy to be either substitutes or complements, depending on the values of the elasticities of substitution chosen.

2.3 Incorporating Domestic Margins

Domestic margins, which drive a wedge between producer and purchaser prices, have been incorporated into AGE models in a variety of ways. In this paper, we follow the specification of domestic margins used by Bradford and Gohin (2006), and Peterson (2006). This approach specifies a nested CES structure shown in Figure 2. At the top of this structure is a composite commodity that is purchased by the private household, government household, or firms. Similar to the GTAP-E model, the composite commodity is a combination of the margin inclusive composite imported commodity and a margin inclusive domestic commodity (see Level 3 of Figure 2), where σ_D is the elasticity of substitution between the composite import and the composite domestic commodity. Note that the composite commodities include domestic trade and transportation margins. At Level 2, the composite imported commodity and the domestically produced commodity are combined with a composite marketing service. Based on the work of Holloway (1989) and Wohlgenant (1989), the potential for substitution between the composite commodity and composite marketing service is denoted as σ_{pt}. As shown in Level 1, the composite marketing service is itself a CES aggregate of all trade and transportation services needed to get the good from the producer to the purchaser. The constant elasticity of substitution σ_{pm} governs the degree of substitutability between individual marketing services, such as land and air transport, as relative prices vary. Note that levels 1 and 2 do not exist in the GTAP-E model.

Figure 2: Structure of Domestic Marketing Margins



In addition to applying domestic margins on the purchases of all agents in the model, domestic margins are also applied on all commodities that are exported. These margins represent domestic trade and transport services utilized to get the commodity from the producer to the port of departure. Similar to Figure 2, a two-level nested CES structure is utilized. At the bottom level, domestic trade and transport services are combined to create a composite marketing service. At the top level, this composite marketing service is combined with exports to create the f.o.b. export composite commodity.

2.4 CO_2 Emissions

The emission of CO_2 per unit of energy commodities used is assumed to be constant across users and regions, but varies by energy commodity (coal, oil, gas, and petroleum and coal products). Formally, the level of CO_2 emissions from energy commodity *e* in region *r* is specified as:

$$CO2(r,e)=\left[\frac{C(e)}{V(e)}\right]\left[\frac{V(e)}{Q(e)}\right]\left\{\sum_{j\in prod\_comm}\left[QFD(e,j,r)+QFM(e,j,r)\right]+QPD(e,r)+ QPM(e,r)+QGD(e,r)+QGM(e,r)\right\} \quad (1)$$

where CO_2 is defined as millions of metric tons (MT) emitted; (C/V) is the amount of CO_2 emissions per mtoe (million tons of oil equivalent); (V/Q) is the mtoe per unit of energy commodity; *QFD* and *QFM* are the level of domestic and imported intermediate inputs; *QPD* and *QPM* are the level of domestic and imported energy commodities purchased by the private household; and *QGD* and *QGM* are the level of domestic and imported energy commodities purchased by the government. So the terms (C/V)(V/Q) convert the physical quantities of the energy commodity into the level of CO_2 emissions. The percentage change in CO_2 emissions is:

$$\begin{aligned} CO2(r,e)*gco2(r,e)=\sum_j\left[EDINT(e,j,r)*qfd(e,j,r)+EMINT(e,j,r)*qfm(e,j,r)\right]+\\ EDHH(e,r)*qpd(e,r)+EMHH(e,r)qpm(e,r)+\\ EDGV(e,r)*qgd(e,r)+EMGV(e,r)*qgm(e,r), \end{aligned} \quad (2)$$

where *gco2* is the percentage change in CO_2 emissions; *EDINT*, *EMINT*, *EDHH*, *EMHH*, *EDGV*, and *EMGV* are the amount of CO_2 emitted from domestic and imported intermediate energy inputs, domestic and imported energy commodities consumed by the private household, and domestic and imported energy commodities consumed by the government households; and *qfd*, *qfm*, *qpd*, *qpm*, *qgd*, *qgm*, are the percentage changes in the use of energy commodities by firms, private households, and the government.

2.5 Carbon Tax and Emission Trading

A carbon tax, both on a real and nominal basis, is used to represent the marginal abatement costs in the model. The level of the carbon tax is endogenously determined in the model and depends on the level of quantitative restrictions on CO_2 emissions in the Annex B countries. When emission trading is permitted, one may interpret the carbon tax as the value of CO_2 permits.

In levels form, the nominal carbon tax is specified as:

$$NCTAX(r) = GDPIND(r) * RCTAX(r)\,, \tag{3}$$

where *NCTAX*(r) and *RCTAX*(r) are the nominal and the real carbon tax rate for region r and *GDPIND*(r) is the GDP deflator of region *r*. The change in the nominal tax rate is specified as:

$$nctax(r) = GDPIND(r) * rctax(r) + 0.01 * NCTAX(r) * pgdp(r)\,, \tag{4}$$

where *nctax*(*r*) and *rctax*(*r*) are the changes in the nominal and the real carbon tax rates for region *r* and *pgdp*(*r*) is the percentage change in the GDP deflator in region *r*.

When a group of countries join an emissions trading scheme, the marginal abatement costs are equalized across countries through the trading of CO_2 emission permits. In terms of equations (3) and (4), this implies that *NCTAX*(r) is equalized in all participating countries. Formally, the value of traded emissions permits is specified in the model as:

$$DVCO2TRA(r) = \left[CO2Q(r) - CO2T(r)\right] * NCTAX(r) \tag{5}$$

where CO_2Q(r) is the CO_2 emissions quota for region r; CO_2T(r) is the total CO_2 emissions of region r; and DVCO2TRA(r) is the dollar value from CO_2 emissions trading of region *r*. If *DVCO2TRA*(*r*) is negative, country *r* is buying emissions permits, as it emits more than its allocated quota. If *DVCO2TRA*(*r*) is positive, country *r* is selling emissions permits, as it emits less than its allocated quota. The change in the dollar value of emissions trading is specified as:

$$dvco2tra(r) = 0.01 * NCTAX(r) * \left[CO2Q(r) * gco2q(r) - CO2T(r) * gco2t(r) \right] + nctax(r) * \left[CO2Q(r) - CO2T(r) \right], \quad (6)$$

where *dvco2tra*(*r*) is the change in dollar value from CO_2 emissions trading; *gco2q*(*r*) and *gco2t*(*r*) are the percentage changes in the CO_2 emissions quota and total CO_2 emissions.

The inclusion of domestic trade and transport margins in the model creates a wedge between producer and purchaser prices. Compared to models that do not account for domestic margins, this leads to smaller effects on the purchaser price for a given level of the carbon tax. Thus, a larger carbon tax is needed to achieve a comparable level of emission abatement. In addition, accounting for domestic transport costs is particularly relevant for the cement and lime industries that are included in the EU ETS. Trade in these industries is restricted to about 200 km radius because of transport costs (Demailly and Quirion, forthcoming).

3 Data and Model Aggregation

The data used to implement the model is based on version 6.0 the GTAP data base. Peterson (2006) has developed a domestic margin inclusive version of the GTAP version 6 data base that contains information on trade and transportation margins for all intermediate input purchases, purchases by households, and purchases by governments of domestically produced and imported commodities. It also includes all domestic trade and transport margins required to get exports to the port of departure. This margin data is based on data from the Input-Output accounts of 22 countries (Australia, Austria, Belgium, Denmark, Estonia, Germany, Greece, Finland, France, Hungary, Italy, Japan, Malta, the Netherlands, Poland, Portugal, Spain, Sweden, Slovakia, Slovenia, the United Kingdom, and the United States). For regions where no margin data are available, average margin shares are used (see Peterson, 2006, for more details). The levels of initial CO_2 emissions for each region by energy commodities are based on the GTAP version 6 energy data base. The base year of the data used in this analysis is 2001.[4]

An eleven region and seventeen commodity aggregation is used in this paper. The eleven regions are Australia (AUS), Rest of Annex B countries (ROB), Rest of Asia (ROA), China and India (CHIND), Japan, (JPN), the United States (US), Rest of Central and South America (CSAM), EU15, Rest of European Union (REU), Rest of Eastern Europe and former Soviet Union, (REFSU), and Middle East and Africa (MEAF). The European Union is disaggregated into two regions because of differences in CO_2 emissions, product carbon content, and reduction targets between the EU15 and rest of the member states. Japan is identified separately from the rest of the Annex B countries due its larger amount of CO_2 emissions. The United States, Australia, and China and India are identified as separate regions because these are relatively large CO_2 emitters and/or failed to ratify the Kyoto Protocol. All other composite regions are defined based on geographic proximity. Table 1 provides a detailed description of the regional aggregation.

4 Because the base year is 2001, the GTAP version 6.0 data base contains trade barriers between some of the new EU member states, such as Poland, and other EU member states. These barriers are removed in an initial simulation that creates an updated data base with no trade barriers between EU member states. We use this updata data as the base for all simulations conducted in this paper.

Table 1: Regional/country Aggregation

Region	Description	GTAP Regions	Emission Target*
EU15	EU15	aut, bel, dnk, fin, fra, deu, gbr, grc, irl, ita, lux, nld, prt, esp, swe	-6.9%
REU	Rest of EU	bgr, cyp, cze, hun, mlt, pol, rom, svk, svn, est, lva, ltu	33.0%
JPN	Japan	jpn	-12.7%
REFSU	Rest of Eastern Europe & Former Soviet Union	xer, alb, hrv, rus, xsu	
ROB	Rest of Annex B	can, che, xef, nzl	-25.1%
AUS	Australia	aus	
CHIND	China and India	chn, hkg, ind	
MEAF	Middle East & Africa	tur, xme, mar, tun, xnf, bwa, zaf, xsc, mwi, moz, tza, zmb, zwe, xsd, mdg, uga, xss	
CSAM	Central & South America	mex, xna, col, per, ven, xap, arg, bra, chl, ury, xsm, xca, xfa, xcb	
ROA	Rest of Asia	xoc, kor, twn, xea, idn, mys, phl, sgp, tha, vnm, xse, bgd, lka, xsa	
US	United States	usa	

* Based on Ziesing (2006). Total emission reduction of 5.2% across all Annex B regions

The seventeen commodities/sectors in the model are agriculture (agr), food, coal, oil, gas, other natural resources (onres), paper products (ppp), petroleum and coal products (p_c), chemical, rubber, plastic products (crp), other mineral products (nmm), ferrous metals (i_s), other metals (nfm), other manufacturing (oman), electricity (ely), trade (trd), transport (trans), and services (serv). The sectors ppp, p_c, nmm, i_s, and ely are the GTAP sectors that most closely correspond to those covered by the EU ETS. The sectors crp and nfm are also relatively larger users of energy and may be included in a BTA policy. Coal, oil, and gas represent the extraction of the fossil based energy commodities. Trade and transports sectors are identified separately because of their use in providing domestic margin services and relatively large use of petroleum products by the transport sector. Food, agr, onres, and serv are composite commodities that represent the remaining sectors. Table 2 provides a detailed description of the commodity/sector aggregation.

Table 2: Commodity/sector Aggregation

Sector	Description	GTAP Sectors
agr	Agriculture	pdr, wht, gro, v_f, osd, c_b, pfb, ocr, ctl, oap, rmk, wol
food	Food	cmt, omt, vol, mil, pcr, sgr, ofd, b_t
coal	Coal	coa
oil	Oil	oil
gas	Gas	gas, gdt
onres	Other natural resources	frs, fsh, omn
ppp*	Paper products	ppp
p_c*	Petroleum and coal products	p_c
crp**	Chemicals, rubber, plastic products	crp
nmm*	Other mineral products	nmm
i_s*	Ferrous metals	i_s
nfm**	Other metal products	nfm
oman	Other manufacturing	tex, wap, lea, lum, fmp, mvh, otn, ele, ome, omf
ely*	Electricity	ely
trd	Trade	trd
trans	Transport	otp, wtp, atp
serv	Services	cmn, ofi, isr, obs, ros, osg, dwe

* ETS sector

** ETS affected sector

The production, margin, and trade elasticities of substitution utilized in the model are listed in table 3. No substitution is allowed between non-energy intermediate inputs and value-added (σ_T). We also assume fixed margins and set the values of σ_{pm} and σ_{pt} equal to zero. The elasticities of substitution among the components of value-added (σ_{VA}) are set equal to those values in the GTAP version 6.0 data base. Because we believe that the elasticities of substitution between energy and capital (σ_{KE}), electricity and non-electricity (σ_{ELY}), and coal and non-coal (σ_{COAL}), and between non-coal energy intermediate inputs (σ_{FU}) in Burniaux and Truong (2002) are too large for the short to intermediate run, we consider alternative scenarios where the values of these parameters are set equal to 0.1 and 0.25 respectively.[5] Following Burniaux and Truong (2002), we do not allow for substitution among energy commodities or between energy and

5 In a recent micro-panel econometric study of industrial companies, Arberg and Bjørner (2007) find that electricity and other energy inputs are complements with capital rather than substitutes.

capital in the mining and refining of fossil fuels (i.e., σ_{KE}, σ_{ELY}, σ_{COAL}, and σ_{FU} are set equal to zero for coal, oil, gas, and p_c). We also do not allow substitution between electricity and non-electricity in the electricity (ely) sector. Finally, the elasticities of substitution between domestic and the composite imported commodity (σ_D) and between imported commodities (σ_M) are equal to the values in the GTAP v6 data base with the exception of oil, where the trade elasticities are set equal to 30, reflecting the belief that crude oil is a more homogeneous commodity.

Table 3: Production, Margin, and Trade Elasticities of Substitution

	Production						Margin		Trade	
Sectors	σ_T	σ_{VA}	σ_{KE}	σ_{ELY}	σ_{COAL}	σ_{FU}	σ_{pt}	σ_{pm}	σ_D	σ_M
agr	0.0	0.24	0.1	0.1	0.1	0.1	0.0	0.0	2.51	5.04
food	0.0	1.12	0.1	0.1	0.1	0.1	0.0	0.0	2.49	5.04
coal	0.0	0.20	0.0	0.0	0.0	0.0	0.0	0.0	3.05	6.10
oil	0.0	0.20	0.0	0.0	0.0	0.0	0.0	0.0	30.00	30.00
gas	0.0	0.62	0.0	0.0	0.0	0.0	0.0	0.0	11.03	33.04
onres	0.0	0.20	0.1	0.1	0.1	0.1	0.0	0.0	1.40	2.44
ppp	0.0	1.26	0.1	0.1	0.1	0.1	0.0	0.0	2.95	5.90
p_c	0.0	1.26	0.0	0.0	0.0	0.0	0.0	0.0	2.10	4.20
crp	0.0	1.26	0.1	0.1	0.1	0.1	0.0	0.0	3.30	6.60
nmm	0.0	1.26	0.1	0.1	0.1	0.1	0.0	0.0	2.90	5.80
i_s	0.0	1.26	0.1	0.1	0.1	0.1	0.0	0.0	2.95	5.90
nfm	0.0	1.26	0.1	0.1	0.1	0.1	0.0	0.0	4.20	8.40
oman	0.0	1.26	0.1	0.1	0.1	0.1	0.0	0.0	3.79	7.73
ely	0.0	1.26	0.1	0.0	0.1	0.1	0.0	0.0	2.80	5.60
trd	0.0	1.68	0.1	0.1	0.1	0.1	0.0	0.0	1.90	3.80
trans	0.0	1.68	0.1	0.1	0.1	0.1	0.0	0.0	1.90	3.80
serv	0.0	1.28	0.1	0.1	0.1	0.1	0.0	0.0	1.91	3.80
CGDS	0.0	1.00	0.00	0.0	0.00	0.0	0.0	0.0		

4 Description of Scenarios

4.1 Implementing Kyoto Without BTA

To implement the Kyoto targets for the different regions in the model, we apply the reduction factors given in table 1 (for all greenhouse gases) to the CO_2 emissions level of the regions, except for REFSU where no emission limits are applied. Applying the reduction rates to CO_2 only implies a proportional reduction in all greenhouse gases. We assume that Russia and the Ukraine use the number of AAUs corresponding to their emissions, but they will not sell excess permits ("hot air") to other Annex B regions. This assumption may be rationalized by Russia and the Ukraine deciding to bank the "hot air" for likely tighter targets in the post Kyoto period rather than flooding the market in 2008-2012, which would, given the quantities involved, result in a significant drop in prices.[6] Also, other Annex B countries may not be willing to purchase "hot air" because of domestic political pressure from powerful environmental lobby groups. Similarly, the REU also holds excess permits which could affect the level of the carbon tax when emission trading is allowed. We therefore consider alternative scenarios where the REU banks all, none, or some of their excess permits. For the remaining Annex B countries, the emission reduction rates are the differences between the 2005 level of emissions and the Kyoto targets. We have chosen to base the emission reduction rates on the 2005 levels rather than emissions in the 2001 base year of the data because emissions in these countries have risen 2.4% between 2001 and 2005. Thus using the difference between the 2001 emission levels and the Kyoto targets would underestimate the reduction efforts required to achieve their targets.

We also abstract from accounting for the use of JI and CDM credits by governments or companies, recognizing that employing these instruments is likely to bring down marginal (and total) emission reduction costs in the EU and other Annex B countries. Trading of emission permits (AAUs) by countries/regions is allowed between Annex B countries other than REFSU, yielding the same (endogenous) nominal tax rate on emissions in all Annex B countries. Within the Annex B countries, we assume that a single carbon tax is applied to all sectors,

---

6 See also Böhringer and Löschel (2003). In our simulations, assumptions regarding the disposition of excess permits in the REU, which are approximately 4.5 times smaller than those held by Russia and the Ukraine, yielded large changes in the permit prices. Allowing Russia and the Ukraine to sell their excess permits would drive the permit price close to zero.

whether or not these sectors participate in an emission trading program. Using a single carbon tax implies that the emission targets between sectors within a country/region will be allocated optimally. We recognize that this may differ from the outcome of the allocation process in the EU for the second period (2008 – 2012) where trading sectors (i.e. industry and energy sectors) tend to get more allowances than would be optimal from a cost-efficiency perspective (e.g. Betz et al. 2006).

4.2 BTA Scenarios

In the BTA scenarios, we consider alternative scenarios for determining the power of the BTA and what products are subject to the BTA. The power of the BTA is set equal to the percentage change in costs for sectors that are subject to the BTA.[7] Two alternative sectoral coverage scenarios are considered. In the *EUETS coverage scenario,* the BTA is applied to those sectors that are covered directly by the EU ETS: ppp, p_c, nmm, and i_s. Because electricity is typically not traded, the BTA is not applied to ely. In the *full coverage scenarios*, the BTA is also applied to chemicals (crp) and non-ferrous metals (nfm). Because the production processes in these sectors are energy (electricity) intensive, international competitiveness may be negatively affected by higher energy prices caused by the EU ETS.

7 We also considered a second scenario where the power of the BTA was set at 80% of the percentage change in costs to reflect the potential cost change for a “best available technology.” Because the results of this scenario did not differ significantly, they are not reported in this paper, but are available from the authors upon request.

5 Model Results

5.1 Implementing Kyoto Without BTA

Because the potential impacts of a BTA policy will depend on the magnitude of the effects from implementing the Kyoto Protocol, we consider several alternative scenarios that vary the level of excess credits banked by the REU and the ability of firms to substitute away from energy commodities. Six different scenarios are considered. Three alternative assumptions on credit banking by the REU: none, 50%, and 100%. The values for σ_{KE}, σ_{ELY}, σ_{COAL}, and σ_{FU} are set equal to 0.1 and 0.25, except for the coal, oil, gas, and p_c sectors where all elasticities are set equal to zero. The results from these scenarios are listed in table 4.

Whether or not the REU decides to sell its excess permits has a large impact on the nominal carbon tax, or the price of the permits. The nominal carbon tax when the REU does not bank any of its excess permits is roughly half of the nominal carbon tax if the REU banks all of its excess permits. This result holds regardless of the elasticities of substitution. Because the REU sells its excess permits to other Annex B countries, this reduces the amount of emission abatement required in these countries to meet the Kyoto targets. If the REU sells all of its excess permits, the EU15, JPN, and the ROB reduce emissions by 4.9%, 3.1%, and 5.7% respectively (for low elasticities of substitution) while their emission reduction targets (relative to 2005 base levels) were 6.9%, 12.7%, and 25.1% respectively. This lower level of emission abatement leads to a lower nominal carbon tax. Note that even if the REU sells its excess permits, because of lower marginal abatement costs in the REU, CO_2 emissions are reduced by 10.7%, compared to base emissions. By withholding some of all of the REU's excess permits, fewer permits are available for the other Annex B countries to purchase, requiring greater emission abatement in those regions, leading to higher nominal carbon taxes.

Table 4. Simulation Results for Implementation of Kyoto Protocol

	Low Energy Substitution[a]			High Energy Substitution[b]		
	REU Credit Banking			REU Credit Banking		
Variable	None	Half	All	None	Half	All
Nominal Carbon Tax ($)	$14.39	$20.65	$27.46	$10.54	$15.12	$20.09
Change in CO_2 Emissions			Percentage			
Australia	0.5	0.6	0.8	0.7	0.9	1.2
Rest of Annex B	-5.7	-7.7	-9.7	-6.0	-8.2	-10.4
Rest of Asia	0.4	0.5	0.7	0.4	0.6	0.8
China/India	0.2	0.3	0.4	0.3	0.4	0.6
Japan	-3.1	-4.4	-5.6	-3.4	-4.7	-6.1
United States	0.2	0.3	0.4	0.2	0.3	0.4
Central & South America	0.3	0.4	0.6	0.3	0.4	0.6
EU15	-4.9	-6.8	-8.7	-4.8	-6.6	-8.5
Rest of EU	-10.7	-14.4	-17.9	-10.6	-14.2	-17.7
Eastern Europe & FSU	0.7	1.0	1.3	0.7	0.9	1.2
Middle East & Africa	0.5	0.6	0.8	0.5	0.6	0.8
			Million Metric Tons CO_2			
Global Emission Reduction	-242.1	-330.7	-419.0	-235.9	-323.1	-410.2
Leakage	60.8	83.8	107.0	66.9	91.4	115.9
Output			Percentage			
EU15						
Paper (ppp)	-0.1	-0.2	-0.3	-0.1	-0.2	-0.3
Refined petroleum (p_c)	-3.6	-5.2	-6.8	-2.9	-4.1	-5.5
Chemicals (crp)	-0.6	-0.9	-1.2	-0.5	-0.7	-1.0
Non-metalic mineral (nmm)	-0.2	-0.4	-0.5	-0.2	-0.3	-0.5
Iron and steel (i_s)	-0.4	-0.6	-0.9	-0.4	-0.6	-0.8
Non-ferrous metals (nfm)	-0.8	-1.1	-1.5	-0.7	-1.0	-1.4
Electricity (ely)	-2.0	-2.8	-3.7	-1.8	-2.5	-3.3
REU						
Paper (ppp)	0.6	1.0	1.6	0.2	0.4	0.7
Refined petroleum (p_c)	-9.5	-13.1	-16.7	-7.6	-10.6	-13.6
Chemicals (crp)	-2.9	-3.6	-4.2	-2.4	-3.0	-3.5
Non-metalic mineral (nmm)	-1.4	-1.6	-1.7	-1.2	-1.5	-1.6
Iron and steel (i_s)	-4.7	-6.0	-6.9	-3.8	-4.8	-5.7
Non-ferrous metals (nfm)	-1.1	-0.9	-0.2	-1.2	-1.2	-0.9
Electricity (ely)	-6.3	-8.6	-10.9	-5.4	-7.4	-9.5

a Values for σ_{KE}, σ_{ELY}, σ_{COAL}, and σ_{FU} are equal to 0.1 except for the coal, oil, gas, and p_c sectors where all elasticities are equal to zero.

b Values of σ_{KE}, σ_{ELY}, σ_{COAL}, and σ_{FU} are equal to 0.25 with the exceptions listed above.

Banking credits into future periods may be rationalized by expected higher future carbon taxes due to more ambitious future emission reduction targets. For example, the European Council recommends emission reductions of 60-80% by

2050 for the EU to help limit the mean global temperature increase to 2°degrees Celsius compared to pre-industrialized levels (European Council 2005). However, the future architecture of post-Kyoto climate policies in the EU is still under debate, including the allocation of emission reductions among the Member States and the possible role of any banked AAUs by the Member States in setting those targets. Similarly, it is not clear whether a future Emission Trading Directive will again allow EU Member States to control the number of allowances that will be allocated to their companies. Thus, Member States may have an incentive to bank any excess credits into the future via their companies participating in the EU ETS. There is empirical evidence that most REU Member States attempted to allocate allowances rather generously to their companies in phase two of the EU ETS (2008-2012) (e.g. Betz et al. 2006). For most REU MS such a strategy would be feasible since they will easily meet their Kyoto-targets. Companies in REU Member States may then transfer any excess allowances into future periods.

Increased banking of credits by the REU also leads to larger increases in CO_2 emissions in non-Annex B countries; in other words greater carbon leakage. The banking of excess credits by the REU requires greater emission reductions in the Annex B countries to meet their Kyoto commitments, which reduces the global demand for energy commodities and leads to a reduction in the price of energy commodities. In the regions that do not implement climate change policy, the reduction in the price of energy commodities provides an incentive to increase their use, leading to higher emissions in those countries and greater carbon leakage. The amount of leakage increases by approximately 75% when the REU banks all of their excess credit compared to when it banks none of its excess credits.

The ability of firms to substitute between and away from energy commodities during the production process also affects the potential cost of implementing the Kyoto Protocol. Increasing the elasticities of substitution from 0.1 to 0.25 reduces the nominal carbon tax by 27%, regardless of the amount of excess credits banked by the REU. The level of carbon leakage also increases by 8 to 10% because firms in non-Annex B regions can more easily substitute to energy commodities, whose prices decrease relative to capital.

Table 5. Change in EU Output Attributable to Trade

	EU15			Rest of EU		
Sector	Imports	Exports	Share of Output Change	Imports	Exports	Share of Output Change
			Implementation of Kyoto Protocol[a]			
	Percentage Change			Percentage Change		
Paper (ppp)	0.01	-0.02	0.10	0.20	0.30	0.86
Petroleum and coal (p_c)	-0.25	-0.89	0.31	-1.43	-3.64	0.52
Chemicals (crp)	-0.06	-0.39	0.74	-0.76	-1.55	0.80
Non-metalic minerals (nmm)	-0.04	-0.12	0.64	-0.18	-0.39	0.43
Iron and steel (i_s)	-0.05	-0.24	0.74	-0.90	-3.08	0.83
Non-ferrous metals (nfm)	-0.17	-0.49	0.87	-0.13	-0.41	0.49
			BTA: EUETS Coverage Scenario[a]			
Paper (ppp)	0.02	0.04	2.87	0.20	0.33	0.85
Petroleum and coal (p_c)	-0.13	-0.60	0.23	-1.39	-3.47	0.51
Chemicals (crp)	-0.07	-0.42	0.75	-0.76	-1.56	0.80
Non-metalic minerals (nmm)	0.03	0.14	1.44	-0.16	-0.24	0.36
Iron and steel (i_s)	0.02	0.24	0.79	-0.89	-2.65	0.83
Non-ferrous metals (nfm)	-0.19	-0.54	0.87	-0.14	-0.45	0.52
			BTA: Full Coverage Scenario[a]			
Paper (ppp)	0.01	0.03	2.23	0.20	0.33	0.84
Petroleum and coal (p_c)	-0.13	-0.60	0.23	-1.41	-3.49	0.52
Chemicals (crp)	0.02	0.27	1.20	-0.70	-1.23	0.79
Non-metalic minerals (nmm)	0.02	0.12	1.44	-0.16	-0.24	0.37
Iron and steel (i_s)	0.02	0.21	0.93	-0.90	-2.68	0.83
Non-ferrous metals (nfm)	0.00	0.24	1.06	-0.08	0.02	0.11

a The Rest of EU does not bank any of its excess emission credits. Results are similar for scenarios where the Rest of EU banks half or all of their excess emission credits.

Table 5 shows the degree to which the change in international competitiveness accounts for the output changes within the energy-intensive sectors in the EU. The change in output in each energy-intensive sector is decomposed into changes attributable to import and export competitiveness. Note that a negative sign reflects a reduction in output from increased import competition or a reduction in output from decreased export competitiveness. Within the EU15 countries, at least two-thirds of the output reduction in crp, nmm, i_s, and nfm is trade related with the majority of this being a reduction in exports. The trade effects are much lower for ppp and p_c in the EU15 countries with less than one-third of the reduction in output from these sectors attributable to trade. In the REU, approximately 80% of the reduction in crp and i_s production is trade related and approximately one-half of the reduction in p_c, nmm, and nfm is trade related. Again, the majority of these losses are due to loss of export sales.

The impact of increased import competition for the energy-intensive sectors is much smaller than the reduction in export competitiveness because the products from these sectors are mainly used as intermediate inputs. So while the imported intermediate inputs will be less expensive than their EU counterparts, leading firms to substitute imported inputs for EU produced inputs, the overall production in these sectors is also decreasing. Thus the substitution effects are offset by expansion (or contraction in this case) effect, leading to a smaller loss of output due to increase import competition. For crp, nmm, and i_s the substitution effect is almost totally offset by the expansion effect.

The only exception to the above discussion is the ppp sector in the REU region; where implementing Kyoto actually results in slightly higher output. To achieve the large reduction in CO_2 emissions in the REU, there are significant reductions in the output of several energy-intensive sectors, such as p_c, crp, i_s, and ely. Due to the model assumption that all primary factors of production (i.e., labor and capital) are fully employed, the reduction in output leads to a decreased demand for the primary factors of production. This in turn leads to a reduction in their price. Because the REU has the largest reduction in emissions, it also has the largest reduction in factor prices. Combined with the model assumption of perfectly competitive markets, where the market price is equal to the average (and marginal) cost of production, the reduction in factor prices in the REU leads to the market price of ppp decreasing relative to the price of ppp in other regions. This enhances the trade competitiveness of ppp from the REU. The increase in exports and reduction in import competition accounts for 86% of the expansion in production of ppp in the REU.

5.2 BTA Scenarios

The imposition of the BTA has two effects for the included sectors. First, the tariff imposed on imported products from non-Annex B countries will reduce the level of import competition by increasing the price within the EU of those products. With the exception of p_c, the BTA neutralizes the reduction in EU15 output from increased import competition from the implementation of climate change policies. This can be seen by comparing the results in the first column in table 5 for the EU15. For the sectors covered by the BTA, the reduction in output from imports from implementing the Kyoto Protocol are replaced by zero or small positive effects after the imposition of the BTA. The BTA does not neutralize the increased import competition for p_c in the EU15 because approximately three-quarters of all p_c imports in the EU15 are from the REU, REFSU, or from other EU15 countries. Thus, these imports are not subject to the BTA.

While the BTA is effective in neutralizing the increased import competition for most energy-intensive sectors in the EU15, it has little effect on import competitiveness in the REU for two reasons. First, approximately 90% of all imports of energy-intensive products into the REU are from the EU15, REFSU, or other REU countries. As such, these imports are not subject to the BTA tariffs. Second, because most energy-intensive sectors in the REU are more carbon-intensive than in the EU15, the exception being nfm, the post-tax prices for REU energy-intensive products are higher than their EU15 competitors. This helps to maintain the increased import competition in the REU.

In implementing climate change policies, the largest impact on EU trade is a loss in export competitiveness. As shown in the second column of table 5, with the exception of p_c, the subsidies on exports of energy intensive products to the Non-Annex B countries lead to an increase in EU15 exports of these products. Thus, the loss in export competitiveness from implementing climate change policy is not just neutralized, but reversed. The BTA does effectively neutralize the increase in production costs on the *cif* prices of EU15 exports of energy intensive products to the Non-Annex B countries. However, while the *cif* prices for EU15 products remain constant, relative to the initial equilibrium, the *cif* prices of other exporters of energy intensive products do not remain constant. The implementation of the Kyoto Protocol and the BTA in the EU leads to producer price increases for ppp, crp, nmm, i_s, and nfm in all regions. The price increases in the Non-Annex B regions are due to increases in primary factor prices and the prices of non-energy inputs. This in turn leads to higher *fob* and *cif* prices for the exports of energy intensive products from the non-EU regions, leading to substitution towards energy-intensive products from the EU15 and away from all other regions. The BTA is not effective in neutralizing the loss in export competitiveness for p_c in the EU15 because approximately 80% of all exports go to other Annex B regions.

Again, a BTA does little to mitigate the loss in export competitiveness for the REU for most energy-intensive sectors. This is because 80% to 90% of the REU exports of energy-intensive products goes to other Annex B regions, and therefore do not receive any subsidies. The exception is nfm, where the BTA does neutralize the loss in export competitiveness for the REU. This occurs because of increased nfm exports to the EU15. A relatively low carbon intensity in production along with a larger reduction in the prices of primary factors of production in the REU yields a smaller increase in the *cif* price in the EU15 than the BTA tariff inclusive *cif* prices of nfm from the Non-Annex B countries. This leads agents in the EU15 to purchase more nfm from the REU. Since approximately two-thirds of all nfm exports from the REU go to the EU15, the increase in exports to the EU15 is enough to offset the loss of export sales to other regions.

By encouraging increased output of energy-intensive products in the EU, a BTA will lead to a higher carbon tax compared to the Kyoto only scenario. This is because with the same CO_2 reduction targets for the Annex B countries, the less energy-intensive sectors and private households must reduce their CO_2 emissions more in the BTA scenario than the Kyoto scenario. This leads to higher marginal abatement costs and a higher carbon tax. However, because the effects of implementing Kyoto on the output and production costs in the EU15 for the sectors that are included in a BTA are relatively small, implementing a BTA does not lead to large changes in production. Therefore, the distribution of emission reductions across sectors, the private households, and regions do not change substantially and the increase in marginal abatement costs are small. With *EUETS* coverage, the carbon tax increases by about 0.25% while the full sector coverage increases the carbon tax by about 1%, regardless of the elasticity of substitution or level of REU permit banking (see table 6).

Table 6. Simulation Results for EU Implementation of Border Tax Adjustments

	Low Energy Substitution[a]			High Energy Substitution[b]		
	Kyoto	BTA Scenario		Kyoto	BTA Scenario	
Variable	Only[c]	EUETS[d]	Full[e]	Only[c]	EUETS[d]	Full[e]
Nominal Carbon Tax ($)	$14.39	$14.43	$14.55	$10.54	$10.57	$10.63
Change in CO_2 Emissions			Percentage			
Australia	0.5	0.5	0.4	0.7	0.7	0.7
Rest of Annex B	-5.7	-5.7	-5.7	-6.0	-6.0	-6.1
Rest of Asia	0.4	0.3	0.3	0.4	0.4	0.4
China/India	0.2	0.2	0.2	0.3	0.3	0.3
Japan	-3.1	-3.2	-3.2	-3.4	-3.4	-3.4
United States	0.2	0.2	0.2	0.2	0.2	0.2
Central & South America	0.3	0.3	0.3	0.3	0.3	0.3
EU15	-4.9	-4.9	-4.9	-4.8	-4.8	-4.8
Rest of EU	-10.7	-10.7	-10.8	-10.6	-10.6	-10.6
Eastern Europe & FSU	0.7	0.7	0.7	0.7	0.7	0.7
Middle East & Africa	0.5	0.4	0.3	0.5	0.4	0.4
			Million Metric Tons CO_2			
Global Emission Reduction	-242.1	-245.4	-249.9	-235.9	-238.2	-241.3
Leakage	60.8	57.4	52.9	66.9	64.7	61.5
Output			Percentage			
EU15						
Paper (ppp)	-0.1	0.0	0.0	-0.1	-0.1	-0.1
Refined petroleum (p_c)	-3.6	-3.2	-3.1	-2.9	-2.6	-2.5
Chemicals (crp)	-0.6	-0.7	0.2	-0.5	-0.5	0.1
Non-metalic mineral (nmm)	-0.2	0.1	0.1	-0.2	0.0	0.0
Iron and steel (i_s)	-0.4	0.3	0.2	-0.4	0.2	0.1
Non-ferrous metals (nfm)	-0.8	-0.8	0.2	-0.7	-0.7	0.0
Electricity (ely)	-2.0	-2.0	-1.9	-1.8	-1.8	-1.7
REU						
Paper (ppp)	0.6	0.6	0.6	0.2	0.2	0.2
Refined petroleum (p_c)	-9.5	-9.2	-9.3	-7.6	-7.4	-7.4
Chemicals (crp)	-2.9	-2.9	-2.4	-2.4	-2.4	-2.1
Non-metalic mineral (nmm)	-1.4	-1.1	-1.1	-1.2	-1.0	-1.0
Iron and steel (i_s)	-4.7	-4.2	-4.3	-3.8	-3.4	-3.5
Non-ferrous metals (nfm)	-1.1	-1.2	-0.6	-1.2	-1.3	-0.9
Electricity (ely)	-6.3	-6.3	-6.3	-5.4	-5.4	-5.4

a Values for σKE, σELY, $\sigma COAL$, and σFU are equal to 0.1 except for the coal, oil, gas, and p_c sectors where all elasticities are equal to zero.
b Values of σKE, σELY, $\sigma COAL$, and σFU are equal to 0.25 with the exceptions listed above.
c Implementation of Kyoto without BTA. REU does not bank any excess emission credits.
d Sectors included in BTA: ppp, p_c, nmm, and i_s.
e Sectors included in BTA: ppp, p_c, nmm, i_s, crp, and nfm.

Even though the impact on the magnitude of the carbon tax is small, any increase will adversely affect the energy-intensive sectors not included in a BTA. Under a BTA applied to the *EUETS* sectors, both crp and nfm experience a larger reduction in production compared to the Kyoto only scenario (see table 6). This occurs because the higher carbon tax leads to further increases in the cost of production for these sectors, compared to the Kyoto only scenario, which further increases import competition and reduces export competitiveness. While the additional reductions in output are not large, they clearly show that all energy-intensive sectors will want to be included in the BTA.

One of the stated benefits of a BTA is to reduce the amount of carbon leakage from the partial regional adoption of climate change policies. As shown in table 6, the impacts on carbon leakage are relatively small: a 3% to 6% reduction in leakage with *EUETS* coverage and an 8% to 13% reduction in leakage for full sectoral coverage. This corresponds to about a 2.5 million mt. to 8 million mt. reduction in CO_2 emissions globally due to reduced leakage.

In terms of welfare, the imposition of a BTA has little additional effects on equivalent variation (EV) in the EU15 and REU compared to change in EV for implementing the Kyoto Protocol without a BTA. Across the different scenarios and elasticity of substitution values, there is only a 1% to 2% difference in the EV when a BTA is implemented compared to when it is not implemented. This small difference is due to the small powers of the BTA. With low values for the elasticities of substitution, the powers of the BTA ranges from 0.3% to 1.4% when the REU does not bank any excess credits to 0.5% to 2.8% when the REU banks all of its excess credits. The p_c and i_s sectors have the highest power and ppp has the lowest power across all scenarios. For the higher value of the elasticity of substitution, the powers of the BTA are 25% to 35% lower across all scenarios.

6 Conclusions

The principle purpose of a BTA is to address competitive distortions resulting from the partial implementation of global climate change policies, such as the EU ETS. Our model results illustrate this concern. The energy-intensive sectors in the EU15 and REU face increased import competition and a loss of export sales when implementing the Kyoto Protocol without a BTA. This effect was much higher in the REU due to the higher carbon content in its energy intensive products. For most energy-intensive sectors in the EU15, implementing a BTA will neutralize the increased import competition and more than neutralize the loss in export sales. The BTA is not effective for the p_c sector because the majority of EU15 trade is with regions that are not subject to the BTA. Export sales of energy intensive products from the EU15 are enhanced under a BTA because the export subsidy offsets the increase in EU15 production costs while the partial implementation of Kyoto leads to higher prices for energy intensive goods in all other regions. Thus, by offsetting the price/cost increase in the EU15, the BTA enhances the export competitiveness of the energy-intensive sectors rather than just eliminating any loss of competitiveness.

While the BTA is effective for most energy-intensive sectors in the EU15, in general it is not effective for the energy-intensive sectors in the REU. This is because approximately 80% to 90% of REU trade in energy intensive products is with regions that are not subject to the BTA: the EU15, the REFSU, and other REU countries.

Even though implementing a BTA will encourage production in energy-intensive sectors, it does not substantially increase the marginal abatement costs (carbon tax) required to achieve the emission reduction targets under the Kyoto Protocol. The marginal abatement costs increase by less than 1%. This is because the impacts on the energy-intensive sectors in the EU15 of implementing Kyoto without a BTA are small and most REU trade in energy intensive products is between regions not subject to the BTA. The small increase in marginal abatement costs implies that the BTA will not lead to significant changes in the distribution of emission reductions across sectors and regions. Thus, implementing a BTA will not significantly reduce the carbon leakage from a partial implementation of climate change policies.

While the carbon tax rates predicted from our model are in the range of current market prices for EU allowances, once discounting is applied, of around € 15 for phase 2 of the EU ETS (2008-2012), there are several limitations of the model.

First, a static model cannot account for the expected growth in emissions from expanding economies like China and India. Second, the model does not allow for effects which tend to lower the price of carbon, like the use of CDM by Annex B countries, technology transfer through CDM projects in developing countries, or price-induced technological change in the model. Third, the base year of the database is 2001. Because Annex B countries have increased emissions since 2001, updating the database to a more recent year, such as 2005, would likely yield higher carbon taxes due to more stringent emission reduction effects and would therefore increase the effects of BTAs. However, since the carbon content of some products in Non-Annex B regions may have decreased since 2001, due to technological progress, would tend to lessen the effects of implementing a BTA. Finally, the effects of BTAs on competition and leakage vary with the regional coverage. In particular, these effects would be more pronounced if the EU decided to impose BTAs on all regions which do not commit to substantial greenhouse gas emission reductions in a post Kyoto climate regime, including current Annex B regions.

Acknowledgement

The authors are thankful for comments by the audience of the 10th Annual Conference on Global Economic Analysis in July 2007 at Purdue University, where an earlier version of this paper was presented. Joachim Schleich received financial support for this work from the Prof-X^2-fellowship program by the Fraunhofer Society.

List of References

Arnberg, S. and Bjørner, T., 2007. Substitution between energy, capital and labour within industrial companies: A micro panel data analysis. Resource and Energy Economics 29, 122–136.

Bernard A., Fischer, C. and Fox, A., 2007. Is there a rationale for output-based rebating of environmental levies? Resource and Energy Economics 29, 83–101.

Betz, R., Rogge, K. und Schleich, J., 2006. EU Emission Trading: An early analysis of national allocation plans for 2008-2012. Climate Policy 6, 361–394.

Böhringer C. and Löschel, A., 2003. Market power and hot air in international emissions trading: The impacts of U.S. withdrawal from Kyoto-Protocol. Applied Economics 35, 651-664.

Bradford, S. and Gohin, A., 2006. Modeling marketing services and assessing their welfare Effects in a general equilibrium model. Review of Development Economics 10, 87-102.

Burniaux, J.-M., and Truong, T., 2002. GTAP-E: An Energy-environmental version of the GTAP model. Global Trade Analysis Technical Paper No. 16, Center for Global Trade Analysis, Purdue University, (January 2002) 61 pp.

CEC, 2005. EU action against climate change. EU emissions trading — an open scheme promoting global innovation, Brussels: Commission of the European Communities.

CEC, 2007. Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions - Limiting global climate change to 2 degrees Celsius - The way ahead for 2020 and beyond. COM/2007/0002 final. Brussels: Commission of the European Communities.

Demailly, D. and Quirion, P., 2007. Changing the allocation rules for EU greenhouse gas allowances: Impact on competitiveness, revenue distribution and economic efficiency, paper presented at the European Association of Environmental and Resource Economists Conference, 27-30 June 2007, Thessaloniki.

Demailly, D. and Quirion, P., forthcoming. Leakage from climate policies and border tax adjustment: lessons from a geographic model of the cement industry, in: Guesnerieand, R. Tulkens, H. (Eds.), The Design of Climate Policy, MIT Press.

Demailly, D. and Quirion, P., 2006. CO_2 abatement, competitiveness and leakage in the European cement industry under the EU ETS: grandfathering versus output-based allocation. Climate Policy 6, 93–113.

European Council, 2005. Presidency Conclusions 7619/1/05 Rev., 23 March 2005 Brussels; (15.06.2006) http://ue.eu.int/ueDocs/cms_Data/docs/pressData/en/ec/84335.pdf

Fischer, C. and Fox, A., 2007. Output-Based Allocation of Emissions Permits for Mitigation Tax and Trade Interactions. Land Economics, forthcoming.

Grubb, M. and Neuhoff, K., 2006. Allocation and competitiveness in the EU emissions trading scheme: policy overview. Climate Policy 6, 7–30.

Hertel, T. and Tsigas, M., 1997. Structure of GTAP, in Hertel, T.W. (Ed.), Global Trade Analysis: Modeling and Applications. Cambridge University Press, Cambridge, pp. 9–71.

Holloway, G., 1989. Distribution of research gains in multistage production systems: Further results. American Journal of Agricultural Economics 71, 338-343.

Ismer, R., and K. Neuhoff, 2004. Border tax adjustments: A feasible way to address nonparticipation in emission trading. Cambridge MIT Electricity Project Working Paper 36.

Klepper and Peterson, 2006. Emissions trading, CDM, JI and more - The climate strategy of the EU. The Energy Journal 27, 1-26.

Kremers, H., Nijkamp, P. and Wang, S., 2002. A comparison of computable general equilibrium models for analyzing climate change policies. Journal of Environmental Systems 28, 41–65.

Mathiesen, L. and Mæstad, O., 2004. Climate policy and the steel industry: achieving global emission reductions by an incomplete climate agreement. Energy Journal 25, 91-114.

Nijkamp, P., Wang, S. and Kremers, H., 2005. Modeling the impacts of international climate change policies in a CGE context: The use of the GTAP-E model. Economic Modelling 22, 955–974.

Peterson, E., 2006. GTAP-M: A GTAP model and database that incorporates domestic margins. Global Trade Analysis Technical Paper No. 26, Center for Global Trade Analysis, Purdue University, (January 2006) 72 pp.

Peterson, E. and Lee, H., 2005. Incorporating domestic margins into the GTAP-E model: Implications for energy taxation, paper presented at the 8th Annual Conference on Global Economic Analysis, Lübeck, Germany, June 9-11, 2005.

Stiglitz, J, 2006. Conference at the Center for Global Development, 27 September 2006 (http://www.cgdev.org/doc/events/9.27.06/ StiglitzTranscript9.27.06.pdf.

Truong, P.T., Kemfert, C., Burniaux, J.-M., 2007. GTAP-E, An energy-environmental version of the GTAP model with emission trading, Discussion Paper 668, DIW, Berlin.

van Asselt, H. and Biermann, F., 2007. European Emissions trading and the international competitiveness of energy-intensive industries: A legal and political evaluation of possible supporting measures. Energy Policy 35, 497–506.

Wohlgenant, M., 1989. Demand for farm output in a complete system of demand functions. American Journal of Agricultural Economics 71, 241–252.

Contact:

Brigitte Kallfass
Fraunhofer Institute for Systems
and Innovation Research (Fraunhofer ISI)
Breslauer Strasse 48
D-76139 Karlsruhe
Telephone: +49 / 721 / 6809-150
Telefax: +49 / 721 / 6809-272
e-mail: brigitte.kallfass@isi.fraunhofer.de
URL: www.isi.fraunhofer.de

Karlsruhe 2007