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Abstract

To what extent do the welfare costs associated with the implementation of the Burden Sharing Agreement in the European Union depend on sectoral allocation of emissions rights? What are the prospects for strategic climate policy to favor domestic production? This paper attempts to answer those questions using a CGE model featuring a detailed representation of the European economies. First, numerical simulations show that equalizing marginal abatement costs across domestic sectors greatly reduces the burden of the emissions constraint but also that other allocations may be preferable for some countries because of pre-existing tax distortions. Second, we show that the effect of a single country's attempt to undertake a strategic policy to limit impacts on its domestic energy-intensive industries has mixed effects. Exempting energy-intensive industries from the reduction program is a costly solution to maintain the international competitiveness of these industries; a tax-cum-subsidy approach is shown to be better than exemption policy to sustain exports. The welfare impact either policy—exemption or subsidy—on other European countries is likely to be small because of general equilibrium effects.

Contents

1. INTRODUCTION

Many analyses of the impact of carbon emissions reduction policies impose a uniform carbon tax or an economy-wide cap and trade system. There are, however, few if any examples in environmental policy where such an ideal economic instrument has actually been implemented. And importantly, real world economies are not as idealized as often assumed or represented in economic models. In this paper, we focus on the economies of the European Union (EU) and consider the economic implications when, for one reason or another, policies designed to limit carbon diverge from the "idealized" policies usually represented in economic models.

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An important part of our story is that the energy markets of the European Community are already heavily distorted by energy taxes that vary widely across fuels, sectors, and countries. In such a circumstance, one can do better than the "first-best" policies. Preexisting tax distortions produce a "tax-interaction effect" that increases the costs of environmental taxes (see Bovenberg and Mooij, 1994; Parry, 1995; Bovenberg and Goulder, 1996; Fullerton and Metcalf, 1997).

We use a Computable General Equilibrium (CGE) model of the world economy (EPPA-EU), including a breakdown of the European Union into 9 countries, and 1 region representing the Rest of the EU (ROE), to address questions of second-best policies in a second best world. The data set we use, GTAP 4-E, includes distortionary energy taxes and we are thus able to consider how this divergence from idealized markets affects the estimates of the economic cost of the various policies we evaluate. We have augmented the GTAP 4 data with prerelease data from GTAP 5 to disaggregate the EU into its member states and we use Eurostat data to disaggregate transportation from the basic GTAP social accounting matrices. This disaggregation allows us to study interactions among EU countries and to focus on sectoral differences.

We focus here on carbon policies implemented domestically in each of the EU countries, *i.e.* without emissions permit trading among EU members or with other countries outside the EU. We take the EU burden sharing agreement that differentially allocated the EU-wide reduction of 8 percent below 1990 among member states as the basis for determining reductions. As shown elsewhere (Viguier *et al*., 2001), there are widely varying economic impacts of the burden sharing agreement among States.

We then consider three reasons why EU Member States might institute policies that diverge from the ideal domestic economy-wide cap and trade system and consider the economic implications of them doing so. First, while there is growing interest in emissions permit trading within the EU, there is no experience with such a system for carbon or for other pollutants. Many EU Member States have thus considered sector targets, where different measures might be used to achieve each sector's target. Member States might, for example, experiment with cap and trade systems in electric utilities or energy intensive industries but use more traditional tax measures in the household or transportation sectors. Here we find that the allocation of permits to sectors is critical in determining the overall economic cost but, because of existing energy taxes, it is possible to "do better" than the implied allocation from an economy-wide cap and trade system.

Second, countries often are concerned about international competitiveness. Competitiveness is not a well-defined term in economics and has a variety of meanings among non-economists. In economics the focus in international trade theory is on comparative advantage, recognizing that an economy should specialize more in producing goods it is comparatively better at, whether or not it has an absolute advantage over its trading partners. Implementing an ideal carbon policy will shift advantage from carbon-intensive industries toward less carbon intensive industries compared with trading partners that do not implement such a carbon policy. Allowing this shift to occur, at least under standard assumptions of a small country, homogeneous goods, and non-distorted markets will reduce the cost of achieving the carbon policy within the country taking the actions. The decline in carbon-intensive industry exports is, however, often seen as a loss in competitiveness, with countries implementing policies to protect those industries most affected. Exempting the sector from a constraint is expected to increase the cost of the policy (in the general case see, for example, Bhagwati and Ramaswami, 1963; Dixit and Kyle, 1985; Krugman, 1996, and for climate policy, see, for example, Bohringer and Rutherford, 1997; Jensen, 1998; Babiker *et al*., 2000a; Bernard and Vielle, 2001). With regard to protecting an industry's exports from the effects of the policy, this literature also finds generally that a "tax-cum-subsidy" policy is better than an exemption policy in terms of economy-wide welfare losses.

The export industries whose trade competitiveness will be most affected by a carbon policy are energy-intensive industries. In the EPPA model we use, these are aggregated as a single sector. We consider the cost to the overall economy and the implications for energy intensive industry of either exempting it from the carbon constraint or, instead, of constraining emissions in the sector but subsidizing output equal to the amount of the carbon permit costs to the sector.

Third, we consider the possibilities for a single EU country—we use France as an example—to strategically design its climate policies to gain a competitive advantage for its energy intensive industries. Within the EU there has been considerable attention on harmonization of climate (and other) policies because of concerns about unfair competition and industry relocation if Member States were to pursue independent policies (see, for example EC, 2000). European and broader international debates give voice to fears that climate change policies could alter industry-location choices and that States will enter a "race to the bottom"—that is, a country might lower its environmental standards to further its competitiveness in international trade (see, for example, Barrett, 1994). Our investigation assumes that France meets its overall emissions target but either exempts its energy intensive industry from carbon policies or subsidizes it at a level equal to the direct cost of the carbon permit purchases by the sector. Our interest in this case is to consider whether harmonization of the details of a climate policy has significant effects across the EU. Here, our general finding is that harmonization at the detail of how a given cap is met does not have much affect on other countries.

We begin in Section 2 by a brief presentation of the policy background of GHG emissions reductions in Europe. Section 3 presents the basic model structure and the model specifications (model default parameters). Section 4 describes the policy scenarios and reports the computational results. Finally, in Section 5 we draw some conclusion from our findings.

2. POLICY BACKGROUND

At the Third Conference of the Parties (COP-3) to the United Nations Framework Convention on Climate Change (UNFCCC), Annex B[1] Parties committed to reducing, either individually or

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[1] Annex B refers to the group of developed countries comprising of OECD (as defined in 1990), Russia and the East European Associates.

jointly, their total emissions of six greenhouse gases (GHGs) by at least 5 percent within the period 2008 to 2012, relative to these gases' 1990 levels.

The European Union (EU) is a full Party to the UNFCCC and a signatory of the Kyoto Protocol, and has accepted a quantitative absolute reduction of 8 percent of its GHG emissions. Article 4 of the Protocol allows the EU to allocate its target among the Member States. A political agreement on that redistribution was reached at the environmental Council meeting in June 1998, and is referred to as the "Burden Sharing" Agreement (BSA). **Table 1** shows the BSA adopted at the environmental Council meeting by Member States on June 1998. The sharing scheme specifies emissions targets for each member country with the objective to reflect opportunities and constraints that vary from one country to another, and to share "equitably" the economic burden of climate protection.

Table 1. *Burden Sharing Agreement for 2010*

	Base 1990 = 100
Austria	87.0
Belgium	92.5
Germany	79.0
Denmark	79.0
Spain	115.0
Finland	100.0
France	100.0
United Kingdom	87.5
Greece	125.0
Ireland	113.0
Italy	93.5
Luxemburg	72.0
Netherlands	94.0
Portugal	127.0
Sweden	104.0
Total European Union	**92.0**

The Kyoto Protocol allows Annex B Parties to meet their commitments by three "flexible mechanisms" (emission trading, clean development mechanism, and Joint Implementation) in order to reduce the economic cost of emissions reductions. Flexible mechanisms could be implemented at the domestic level in the first place.

3. THE MODEL

The Emissions Prediction and Policy Analysis (EPPA) model is a recursive dynamic multi-regional general equilibrium model of the world economy that has been developed for analysis of climate change policy (see, for example, Babiker *et al.*, 2000a,c,d; Ellerman and Wing, 2000; Babiker and Eckaus, 2000; Babiker and Jacoby, 1999). Previous versions of the model have been used extensively for this purpose (*e.g.*, Jacoby *et al.*, 1997; Ellerman and Decaux, 1998; Jacoby and Sue Wing, 1999; Reilly *et al.*, 1999). The current version of EPPA is built on a comprehensive energy-economy data set (GTAP4-E[2]) that accommodates a consistent representation of energy markets in physical units as well as detailed accounts of regional production and bilateral trade flows. The base year for the model is 1995 and it is solved recursively at 5-year intervals. A full documentation of EPPA is provided in Babiker *et al.* (2001). In this paper, we use a new version of the model (EPPA-EU) including a breakdown for the European Union. The reference case for Europe in EPPA-EU is presented, and compared with other economic models, in Viguier *et al.* (2001).

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[2] For description of the GTAP database see Hertel, 1997.

3.1 EU Disaggregation

EPPA-EU extended the current version of EPPA by bringing in a detailed breakdown of the EU and incorporating an industry and a household transport sectors for each region. The regional, sectoral, and factors aggregation shown in **Table 2**, together with the substitution elasticities in **Table 3** completely specify the benchmark equilibrium.

The European Union is disaggregated into 9 countries and 1 region representing the Rest of Europe (ROE). Four out of the 9 EU countries (France, Spain, Italy, and the Netherlands) were aggregated together with ROE in the GTAP4-E database. We disaggregated this region using data from the GTAP-5 Pre-release that provides a complete disaggregation of the EU.[3] To accomplish this task we developed an optimization algorithm that uses the economic structure of these 4 countries in GTAP-5 Pre-release while imposing the output, demand, and trade balances for their corresponding aggregate region in GTAP4-E. This allowed us to leave unchanged all other regions of the standard EPPA based on GTAP4-E.

Table 2. *Dimensions of the EPPA-EU Model*

Production Sectors	Name	Countries and Regions	Name
Non-Energy		***Annex B***	
1. Agriculture	AGRI	United States	USA
2. Energy-Intensive Industries	EINT	Japan	JPN
3. Other Industries and Services	OIND	Europe	EEC
4. Transportation	TRAN	Denmark	DNK
Energy		Finland	FIN
5. Crude Oil	OIL	France	FR
6. Natural Gas	GAS	Germany	DEU
7. Refined Oil	REFOIL	Italy	ITA
8. Coal	COAL	Netherlands	NLD
9. Electricity	ELEC	Spain	ESP
Future Energy Supply		Sweden	SWE
10. Carbon Liquids		United Kingdom	GBR
11. Carbon-Free Electric		Rest of EU[a]	ROE
		Other OECD	OOE
Households (Consumers) Sector	H	Former Soviet Union	FSU
		Central European Associates	EET
Primary Factors		***Non-Annex B***	
1. Labor	L	Brazil	BRA
2. Capital	K	China	CHN
3. Fixed Factors for Fuel and Agriculture		India	IND
		Energy Exporting Countries	EEX
		Dynamic Asian Economies	DAE
		Rest of World	ROW

[a] Includes Austria, Belgium, Greece, Ireland, Luxemburg, and Portugal.

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[3] Though GTAP-5 Pre-release has all 9 of these countries broken out we chose to focus on disaggregating only the 4 largest of these countries.

Table 3. *Model Parameters*

Parameter	Description		Value
σ_{ERVA}	Elasticity of substitution between energy resource composite & value-added (agriculture only)		0.6
σ_{ER}	Substitution between land and energy-material bundle (agriculture only)		0.6
σ_{AE}	Substitution between energy and material composite (agriculture only)		0.3
σ_{VA}	Substitution between labor & capital[a]		1
σ_{ENOE}	Substitution between electric and non electric energy		0.5
σ_{EN}	Substitution among non-electric energy[b]		1
σ_{GR}	Substitution between fixed factor and the rest of inputs		0.6
σ_{EVA}	Substitution between energy and value added composite[c]		0.4
σ_{DM}	Armington substitution between domestic and imports[d]		3
σ_{MM}	Armington substitution across imports:	Non energy goods:	5.0
		Energy goods:[e]	4.0
σ_{CS}	Temporal substitution between consumption and saving		1
σ_{C}	Substitution across consumption goods[f]		
G0	Labor supply annual growth rate in efficiency units:	Developed countries:	1-3%
		Developing countries:	2.5-6%

[a] Except nuclear in which it is 0.5.

[b] Except for electricity where coal and oil generation substitute at 0.3 among themselves and at 1.0 with gas.

[c] Except energy intensive and other industry where it is 0.5.

[d] Except Electricity where it is 0.3.

[e] Except refined oil (6) and electricity (0.5).

[f] Varies across countries and is updated with income recursively to reflect income elasticities based on an econometrically estimated equation. See Babiker *et al*. (2001) for details.

3.2 Transportation Sector Disaggregation

The other change in this version of the model is the disaggregation of the transportation sector. With transportation disaggregated, there are now nine output sectors for each of the 22 regions in EPPA-EU, as shown in the left-hand column of Table 2. The EPPA model also includes future or “backstop” sources of fuels and electricity, but they do not play a significant role in this analysis which looks only out to 2010. Eight of the production sectors follow the standard EPPA definitions. The GTAP database does not include a separate transportation sector within industry, nor does it contain a separate category for private automobile services in the household sector. We followed the methodology developed by Babiker *et al*. (2000a) for the United States to break out transportation from EPPA’s OTHERIND sector and to create a household supplied transportation sector (*i.e*. private automobiles) in the EU.

The basic approach for the TRANS sectors is to use GTAP’s trade and transport sector that combines transport with trade margins in combination with data from Input-Output tables produced by the European statistical office (Eurostat). These tables provide the data to disaggregate trade margins from transportation for each European country. For the other regions in the model, we used the US input-output coefficients from Babiker *et al.* (2000a). The TRANS industry supplies transportation services (both passenger and freight) to other sectors and to households.

We have also made adjustments directly to the Household (H) sector to represent own-supplied transportation services, primarily that provided by personal automobiles. Households produce transportation services for their own consumption using inputs from the Other Industry Products (OIND) and Refined Oil sectors. Consumption expenditure of private households reported by Eurostat (1999) and energy statistics from the International Energy Agency (IEA, 1998a; IEA, 1998b; IEA, 2000) along with the coefficients reported in Babiker *et al.* (2000a) were used to separate the household purchases that are part of household production of transportation from other household purchases.

The new breakout yields a sector of own-supplied personal transportation (private automobiles) separate from other household activities, and a separate transportation sector in industry that supplies transport services to both industry (*i.e.*, freight transportation and any passenger transportation purchased by business) and households (purchased transportation service, mainly passenger transportation services such as air and rail service). Services from private automobiles involve inputs from OIND that include the automobile itself, repairs, insurance, parking, and vehicle fuel from the REFOIL sector. The procedure involves allocating OIND and REFOILS output between direct uses in the household.

4. SCENARIOS AND RESULTS

In our simulations, we suppose that each Annex B country implements the necessary policies to meet their Kyoto commitment by 2010. In addition, the reallocation made by the BSA is applied for European countries. We also assume that Annex B countries outside the EU bubble meet their target only by domestic actions (without international flexibility). Finally, no restriction is put on non-Annex B countries.

4.1 Sector Targets

To consider the impact of sector targets we examine 3 cases. As a comparison with the many studies that have applied uniform economy-wide policies, we first consider a case with an economy-wide cap and trade system (equivalently, a single economy-wide carbon tax). We place the cap on top of the existing fuel taxes. We then compare this with two cases where targets are assigned to sectors but trade is not allowed across sectors. The two comparison cases are based on two different methods for allocating sector targets. In one case, we allocate the Member State’s economy-wide target reduction from the EU BSA to each sector without differentiating on the basis of expected growth in emissions or on the availability of reduction options for the sector (labeled SBSA for Sector BSA). For the second allocation rule, we recognize that the EU and Member States would likely attempt to differentiate among sectors based on an assessment of expected growth and technical capability of sectors to reduce emissions. To mimic a process that might be used to look ahead to create sector targets, we use a global partial equilibrium model of the world energy system—the POLES model (see Criqui *et al*., 1996, 1999; Criqui and

Viguier, 2000a,b), developed at IEPE (Institut d'Economie et de Politique de l'Energie-CNRS) —to establish sector targets. This model has more technical detail on sectors than exists in the EPPA model. We establish sector targets by meeting each EU Member States BSA target in POLES such that the marginal abatement costs across domestic sectors are equalized. We then apply this allocation of emissions rights (in percentage terms) to the EPPA model assuming no emissions trading within Europe. To summarize, the cases we construct to investigate the economic effects of establishing sector targets without trade or with limited trade are:

ETR: Economy-wide trading (without trade across countries) as a benchmark to compare with many other studies that have assumed an economy-wide policy.

SBSA: Each sector in each Member State is assigned that Member State's BSA allocation without differentiating among sectors.

POLES: Each sector is assigned a target based on the POLES model. The target is the percentage reduction when marginal abatement costs were equalized across sectors based on the POLES projection.

Figure 1 shows the welfare losses from implementing the BSA in Europe under different allocation schemes, expressed as percentage changes in the equivalent variation index for year 2010 (equivalent variation is a measure of welfare that shows by how much regional well-being, roughly the level of consumption, changes as a result of a policy intervention). The implementation of the BSA by uniform reductions across domestic sectors (SBSA) generates welfare costs in the range of 1-9%. As shown in Viguier *et al*. (2001), the BSA imposes very different emissions reduction rates from one Member State to another. Given to the EPPA-EU reference case, the economic costs are highest in Denmark, Netherlands, and Finland.

Equalizing marginal abatement costs across economic sectors at the domestic level with a domestic emissions trading (or taxation) scheme can greatly reduce the cost of the burden in all EU countries. The gains from using economic instruments are high because marginal abatement costs vary across sectors. In general, the greater reductions occur in electricity and energy-intensive industries under the economy-wide trading case where marginal abatement costs are

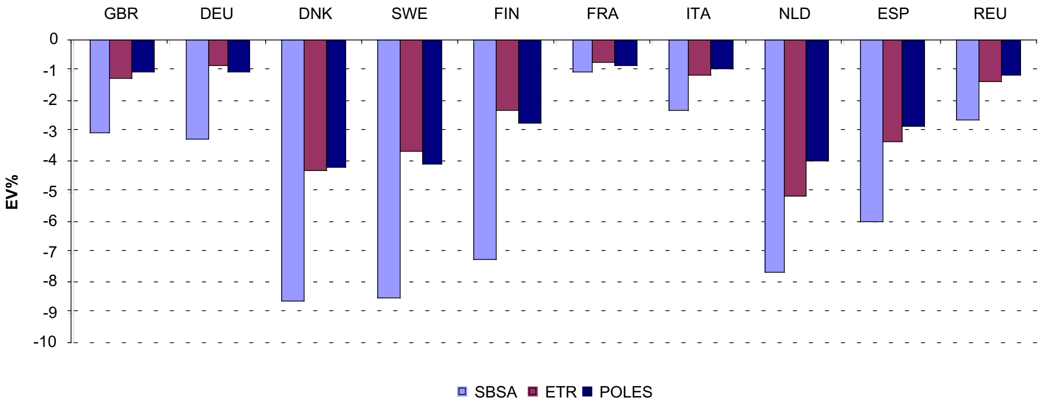

Figure 1. *Welfare Effects of the Kyoto Protocol under Different Allocation Schemes*

relatively low compared to households, transportation and agriculture. This is particularly true in the United Kingdom, Germany or Finland where the predominance of coal and other fossil fuels provide plenty of abatement opportunities. The BSA targets for France, the United Kingdom, and Germany combined with projected growth in emissions means costs are relatively lower for these countries as compared with Denmark, Sweden or Netherlands where emissions growth is projected to be more rapid.

Figure 1 shows that welfare losses can be reduced in some countries, compared to the ETR case, when we apply the POLES allocation in EPPA. Indeed, simulations are made in a second-best world with pre-existing distortions in the economies such as fuel taxes. Consequently, the allocation scheme equalizing marginal abatement costs across domestic sectors in EPPA under the ETR cases is not guaranteed to be the best allocation of emission rights. For example, other allocations can be welfare improving if they give more permits to sectors with high pre-existing energy taxes. This is the case with the allocation of permits based on the POLES model results that tend to give more permits to households and transportation sectors where energy taxes are high. As a result, some countries like Netherlands, Spain or the United Kingdom are better off with the POLES allocation than under the ETR case because it gives more permits to Households (including own-supplied transportation).

To illustrate this impact of pre-existing distortions, we run the EPPA-EU model under different sectoral allocations in France and plot the results in **Figure 2**. The *y*-axis is the change in welfare in equivalent variation for the economy as a whole. On the *x*-axis are the different sectoral allocations of permits. The 0.00 point on the *x*-axis corresponds to the sector reductions

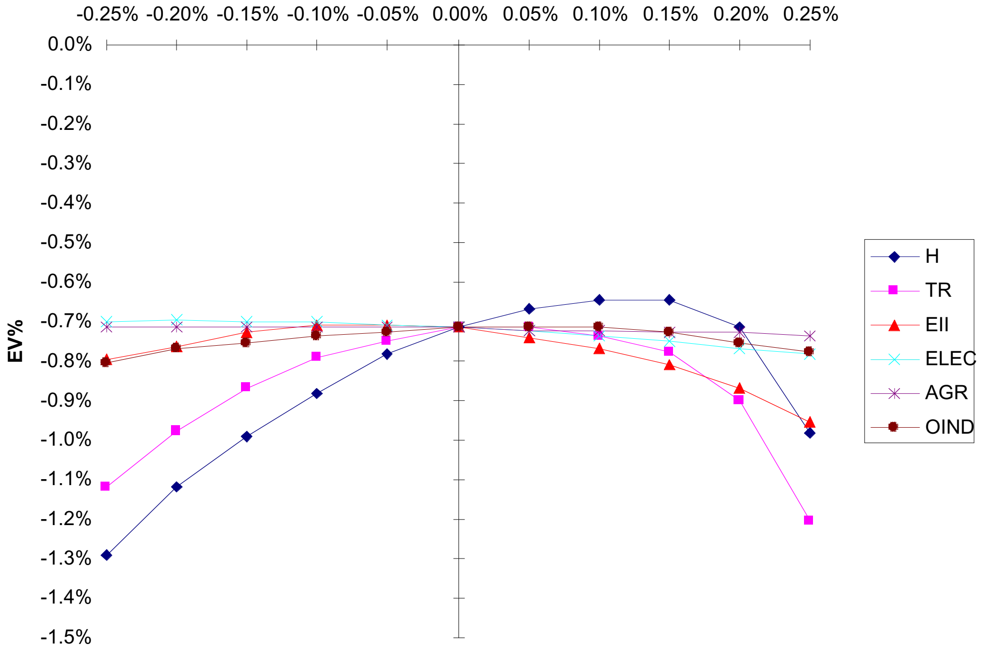

Figure 2. *Welfare Effects of Changing Sectoral Allocation in France (variation from the ETR case)*

projected by EPPA under the ETR case. Other points were calculated by reallocating permits to (or away from) a sector (*e.g.*, transportation) proportionally from (or to) all other sectors. If there were no other preexisting distortions in the economy the allocation of permits in the ETR case would generate the smallest welfare loss, *i.e.* the plotted curves would reach their maximum value at the 0.00 point.

Figure 2 shows that the 0.71% reduction in welfare associated to the ETR scenario can be reduced by reallocating permits toward the household sector. For example, a 10-15% increase of emission rights for the highly distorted household sector would lower the welfare costs of meeting the BSA commitment in France as compared with the ETR case where a cap and trade system is placed on top of existing fuel taxes. At the opposite, a domestic policy that would increase the burden on the households and the transportation sector, while reducing the constraint on energy-intensive industries, would increase costs for the economy as a whole.

We also examine the impacts of fuel price distortions by running the same two scenarios but assuming that fuel taxes are reduced by 50 percent (ETR_tax and POLES_tax). **Figure 3** shows that in this case the POLES allocation is welfare decreasing for all EU countries ex cept Italy compared to the NTR case.[4]

This result is consistent with the findings of the literature on the interaction between distortionary taxations and environmental policies (see, for example, Bovenberg and Mooij, 1994; Parry, 1995; Bovenberg and Goulder, 1996; Fullerton and Metcalf, 1997). A carbon tax interacts with existing taxation and functions effectively as an increase in existing fuel taxes. A first-best solution is to remove the preexisting distortions although removing fuel taxes, a major source of government revenue in Europe, may not be politically feasible. "Over-allocating" permits to the heavily taxed sector and disallowing trade, the basis by which we constructed Figure 2, can be an improvement over a cap and trade system if distortionary taxes are not removed. Such a remedy requires, however, accurate projections of sector emissions and

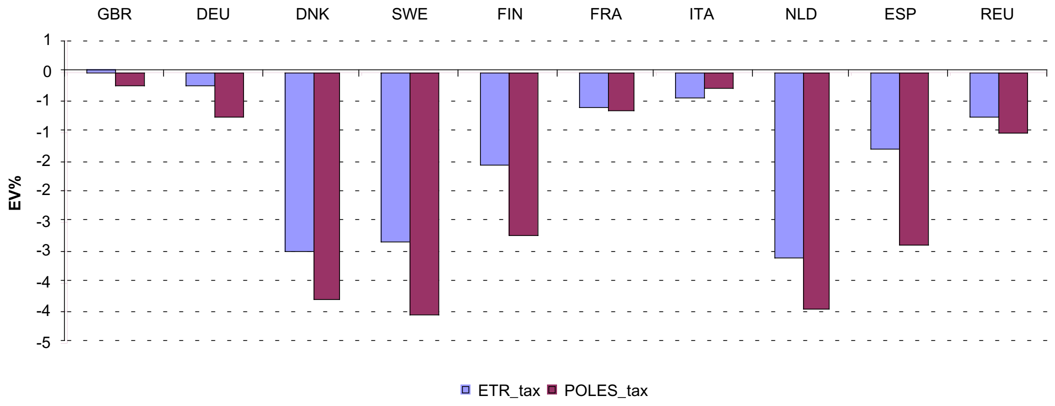

Figure 3. *Kyoto and Welfare: The Implication of Pre-Existing Distortions in Europe*

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[4] As we removed only 50% of pre-existing distortions, some countries may still be worse off with the EPPA allocation; this is the case for Italy.

reduction possibilities because, as is evident from Figure 2, the wrong reallocation can increase costs substantially. A preferred scheme might be to place a carbon tax on emissions but provide allow credit against the tax for existing fuel taxes based on the carbon content of the fuels. Once the carbon taxes were sufficiently high so that all fuel tax payments could be credited, such a system would essentially equalize marginal carbon taxes across fuels without loss of revenue.

4.2 Protecting Competitiveness of Energy Intensive Industries

In this section, we consider two cases to study strategies that might limit the impact of a carbon constraint on exports of the energy intensive sector. We consider the energy intensive sector because it is one of the most carbon-intensive sectors whose products are traded in international markets. Transportation and electric utilities are energy-intensive but face limited international competition outside of the EU. Similarly households do not produce traded goods. Agriculture and other industry are less energy intensive and therefore not as seriously disadvantaged by the carbon control as the energy-intensive industry. The cases we examine are:

EXEMP: Energy-intensive sector is exempted from the climate policy but other sectors must reduce further so that each Member States achieves its target under the BSA.

SUBS: The energy-intensive sector is subsidized in each Member State at a level equal to the amount of carbon tax it pays. In all other ways, the scenario is identical to the ETR case, with economy-wide trading among sectors but not across countries. The compensative tax rebate makes up the difference between prices of energy-intensive goods and actual cost of production. Of course, prices of energy-intensive goods will differ from the business-as-usual case because of relative prices changes in the production inputs from other sectors, for example electric power, that face a carbon constraint.

We compare these cases to the reference ETR policy case.

Exempting energy-intensive industries from the cap program imposes an additional burden on the European economy of over 1 percent welfare loss for some countries, although the increased cost varies among countries (**Figure 4**). The European energy-intensive industries clearly benefit from exemptions (**Table 4**), but this policy shifts the burden of emission reduction to other sectors. As a result, output levels are significantly reduced in other sectors such as agriculture and other industries in many EU countries.[5] This additional cost placed on other sectors by the exemption is higher than the gains of energy-intensive industries activities.

Figure 4 shows that a tax-cum-subsidy policy is Pareto-superior to an exemption policy. The welfare cost of subsidizing energy-intensive industries is very low for most of Member States compared to the exemption case. However, the subsidy policy is not exactly equivalent to the business-as-usual scenario for the subsidized sectors because of relative prices changes due to the carbon constraint. Energy-intensive industries benefit from this policy whereas the excess

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[5] Except in the UK and Germany where OIND and AGRI reduce imports and increase domestic production compared to the NTR case as a result of the comparative advantage create by the exemption policy.

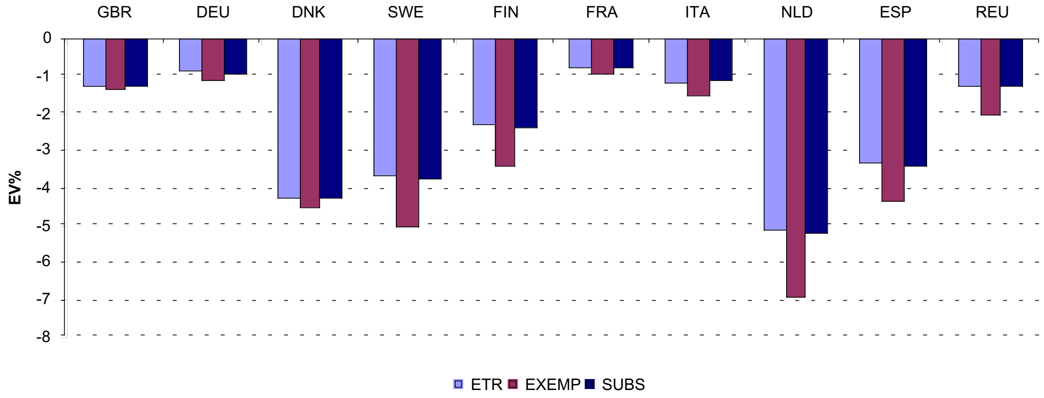

Figure 4. *Welfare Effects of Exemption versus Subsidy*

Table 4. *Output Levels in Selected Sectors (% change)*

	ETR			EXEMP			SUBS		
	EINT	**OIND**	**AGRI**	**EINT**	**OIND**	**AGRI**	**EINT**	**OIND**	**AGRI**
GBR	3.01	-0.09	1.36	3.38	-0.05	1.91	3.64	-0.13	1.30
DEU	-0.16	-0.50	0.76	0.07	-0.45	1.05	0.20	-0.53	0.63
DNK	-0.51	-0.66	-2.62	0.52	-0.70	-2.75	0.20	-0.70	-2.75
SWE	-2.01	-0.97	-0.39	2.10	-1.44	-0.02	-1.04	-1.11	-0.38
FIN	-5.56	-0.13	-0.87	-3.59	-0.53	-1.16	-4.15	-0.37	-0.95
FRA	-2.19	-0.34	-1.84	0.10	-0.42	-1.85	-1.33	-0.40	-1.72
ITA	-5.13	-1.01	-1.58	0.29	-1.95	-3.04	-2.85	-1.27	-1.93
NLD	-10.23	-0.54	4.69	-1.40	-0.90	2.60	-4.58	-0.82	4.45
ESP	-8.31	-0.36	-5.29	-3.98	-0.61	-6.71	-6.11	-0.52	-5.45
REU	-6.87	-0.19	5.39	0.43	-0.72	1.84	-1.88	-0.47	5.23

burden imposed on other economic sectors is limited.[6] The reason for the less adverse effects of the subsidy case is fairly straightforward. Imposing the tax on the energy-intensive industry provides incentives for the industry to substitute away from fuels on the basis of their carbon price whereas there is no economic incentive in the exemption case for these industries to substitute. The remaining distortion from the subsidy is that it encourages sector output, and hence energy use, to be higher than under the ETR case. Based on these results, this output effect is relatively small.

Some caution in interpretation is in order here, however, because of the aggregation of all of energy intensive industry as a single sector, an artifact of our modeling approach. More realistically one might expect the caps and subsidies to be applied industry-by-industry or firm-by-firm. By aggregating across energy-intensive industries and all firms, we implicitly assume some product shift from the most energy-intensive industries to the relatively less so among those in this aggregated sector. One might also expect a shift in output toward those firms that

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[6] In the case of the UK and Germany, OIND and AGRI are worse off because their loose the comparative advantage that was created by the exemption policy.

are most efficient. Firm-by-firm output subsidies would likely create more distortions than the industry-wide subsidy modeled here. We generally expect the subsidy case to be less costly than the exemption case but because of aggregation the additional costs are likely to be an underestimate of the true cost of these approaches to limiting competitiveness effects.

To conclude, an exemption policy is a costly option to favor economic sectors opened to international competition. Exemption introduces new distortions in the allocation of productive factors and in consumption involving welfare losses. Our analysis verifies standard results from economic literature: a "tax-cum-subsidy" policy is superior to an exemption policy to sustain exports by limiting welfare losses (see, for example, Bhagwati and Ramaswami, 1963; Dixit and Kyle, 1985; Krugman, 1996).

4.3 Impacts of Strategic Policies

The final set of cases we examine consider the possibility that a single country within the EU might seek to gain a strategic trade advantage compared with other EU countries by exempting or subsidizing its energy intensive sector while other EU Member States pursue a harmonized policy of cap and trade. The broader issue here is whether harmonization of all the details of climate policy is essential within the EU or whether individual countries might deviate from a common policy. Our assumption is that if the deviation of a State from a common policy has large effects across the EU then it will be more likely that Member States will demand harmonization; on the other hand, if the effects are minor then less attention need be paid to each country implementation details. We choose one of the larger EU States, France, and consider policies in the energy intensive sectors where the trade effects are likely to be the greatest. We assume, however, that France complies with the overall target set for it in the EU BSA. The specific cases, identical to EXEMP and SUBS cases above except that the special treatment of energy intensive industry is unilaterally pursued by France, are:

FR_ex: France unilaterally exempts its energy-intensive industries from any cap on carbon emissions. We run this scenario without international emissions trading assuming that the other EU countries meet their target by an economy-wide tax (or cap and trade) system.

FR_sub: France subsidizes its energy-intensive industries by a "tax-cum-subsidy" policy whereas other Member States meet their target by an economy-wide tax (or cap and trade) system.

Figure 5 computes the welfare impacts of strategic behavior in France. Exempting energy-intensive industries from the cap program in France when other Member States apply an economy-wide system causes an additional cost on the French economy. The exempted industries are favored by the exemption, but output and exports are reduced in other sectors due to the extra cost on them entailed by this policy (see **Table 5**). The closure rules in the foreign accounts of the EPPA model essentially dictate that improved exports in one sector will be met with reduced production and exports in another sector. In particular, the capital flows are

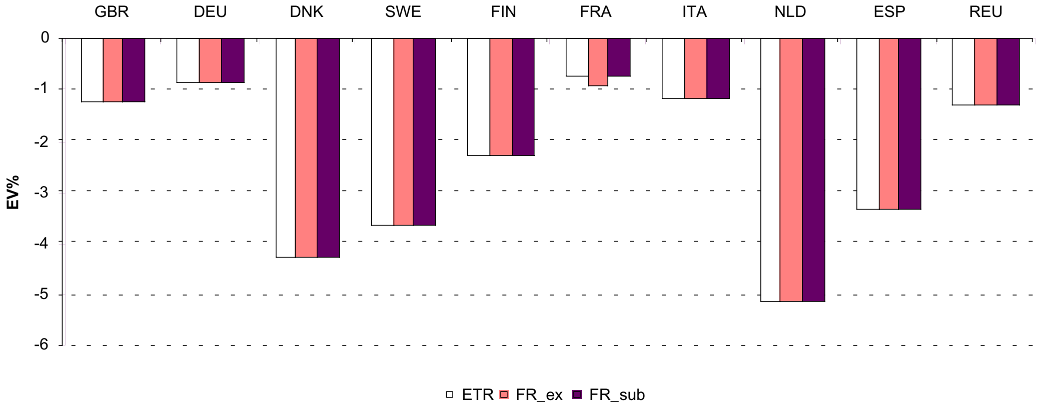

Figure 5. *Welfare Effects of Strategic Policies in France*

Table 5. *Output and exports in France (% change)*

	OUTPUT			EXPORTS		
	ETR	**FR_ex**	**FR_sub**	**ETR**	**FR_ex**	**FR_sub**
AGRI	-1.84	-2.38	-1.89	-5.40	-7.90	-5.73
COAL	-26.83	-26.02	-27.64	-29.27	-31.71	-31.71
OIL	-14.26	-14.57	-14.47	–	–	–
GAS	-11.82	-12.38	-12.07	-1.59	-1.98	-1.98
REFOIL	-10.83	-11.11	-10.94	-6.13	-6.56	-6.46
ELEC	-7.78	-9.28	-7.69	–	–	–
TRN	-1.56	-1.70	-1.48	–	–	–
EINT	-2.19	1.95	-0.36	-3.10	4.36	0.21
OIND	-0.34	-0.55	-0.48	-2.10	-4.04	-3.03
TOTAL	-0.77	-0.57	-0.69	-2.54	-1.97	-2.31

exogenously set in EPPA (and gradually decline to zero). The net goods trade flows must exactly balance the capital flows for the international accounts to balance. In reality, a country might in the short-run decrease (or increase) its foreign debt as a result of a carbon policy and thus could increase (or decrease) it total exports of goods. Such a change in foreign debt would depend on the countries monetary policy. EPPA models the real economy (it does not include financial markets or monetary policy). The closure rule of exogenous capital flows reflects the assumption that a country cannot run up an indefinitely large foreign debt, nor would a country accumulate an indefinitely large foreign surplus.

Again, our analysis shows that a tax-cum-subsidy policy is a better way to sustain domestic exporting industries than an exemption policy. Figure 5 shows that welfare costs of subsidizing energy-intensive industries are lower for France compared to the exemption case. The positive effect of this strategic policy on energy-intensive industries is more limited than with exemption, but the adverse affects on other sectors are much more reduced. As a result, the net adverse effect of the subsidy policy on the French economy is lower compared to the exemption policy.

Table 6. *Output Levels in Selected Sectors (% change)*

	ETR			FR_ex			FR_sub		
	EINT	**OIND**	**AGRI**	**EINT**	**OIND**	**AGRI**	**EINT**	**OIND**	**AGRI**
GBR	3.01	-0.09	1.36	2.56	-0.05	1.45	2.81	-0.07	1.38
DEU	-0.16	-0.50	0.76	-0.56	-0.46	0.83	-0.34	-0.48	0.77
DNK	-0.51	-0.66	-2.62	-1.05	-0.63	-2.56	-0.75	-0.64	-2.61
SWE	-2.01	-0.97	-0.39	-2.44	-0.90	-0.41	-2.20	-0.94	-0.41
FIN	-5.56	-0.13	-0.87	-5.88	-0.07	-0.86	-5.70	-0.10	-0.87
FRA	-2.19	-0.34	-1.84	1.95	-0.55	-2.38	-0.36	-0.48	-1.89
ITA	-5.13	-1.01	-1.58	-5.31	-0.99	-1.53	-5.21	-1.00	-1.57
NLD	-10.23	-0.54	4.69	-10.54	-0.53	4.78	-10.37	-0.53	4.72
ESP	-8.31	-0.36	-5.29	-8.49	-0.35	-5.24	-8.39	-0.36	-5.28
REU	-6.87	-0.19	5.39	-7.52	-0.16	5.43	-7.17	-0.18	5.40

Finally, Figure 5 and **Table 6** show that the impact of unilateral exemptions on other EU countries is negligible. Indeed, the adverse effect of exemption on Member States' energy-intensive industries is compensated by an increase of output and exports of other industries. There are substantial differential effects among countries of the BSA targets. Thus, the extent to which differentiation under a burden sharing agreement is "fair" can result in different economic burdens across countries. Our results indicate that the detailed implementation of carbon policies in one country does not substantially affect other countries within the EU (see Viguier, 2000). The lack of harmonization of the details of a climate policy need not be a significant concern in the EU because the broader economic effects on other countries are small.

5. SUMMARY AND CONCLUSIONS

In this study, we have considered alternative climate change policy options for the European Union with an emphasis on welfare, international trade, and sectoral effects of alternative schemes to allocate emissions rights. We have also analyzed the economic impacts of strategic behaviors by one Member State. We used the EU Burden Sharing Agreement as a basis for establishing reduction levels required for each member state. We found, as others have, that the welfare losses associated to the BSA implementation greatly vary from one Member State to another. If the BSA reduction targets are uniformly extended to sectors without emissions trading across sectors—that is if the same percentage of emissions reduction is applied in every sector without marginal abatement costs equalization—the costs of climate policy increase to all EU countries and the differences among countries widen. The major focus of this paper has been on (1) the economic implications of choosing sectoral targets and forcing sectors to achieve these reductions without trading across sectors, (2) policies that might limit impacts on exports of the energy intensive sectors, and (3) the economic effects of a Member State pursuing a carbon policy that differed in details from that of the rest of the EU, perhaps aimed at gaining a strategic advantage in a key export industry. Our main conclusions are:

- The gains from tradable permits (or uniform carbon taxes) at the domestic level can be rather large because abatement costs depend crucially on the allocation of permits and comparative growth in the sectors.
- A striking effect in terms of sector allocation is the effects of pre-existing energy taxes. Allocations of permits that differ from the trading solution of the CGE model we used, lowered economic costs in terms of welfare. The broader lesson here is that "ideal" policies imposed in a second-best world where significant market distortions exist can be easily improved upon. The first-best policy is to remove the pre-existing distortions. High energy taxes in the EU, disproportionately levied on some fuels and some sectors, are responsible for this effect. Considering these existing taxes when allocating permits or somehow crediting fuel taxes paid in terms of their carbon equivalent would reduce the costs of a climate policy in most EU States as compared with new carbon permit trading scheme introduced on top of fuel taxes.
- Exempting energy-intensive industries from the carbon policy is costly for the European economy as a whole. The comparison of an exemption policy with a "tax-cum-subsidy" policy revealed that the second of these options is much less costly for the economy.
- If a Member States attempt to strategize on climate policies, and distort international competition via subsidies or exemptions, the economic impacts of this type of behavior on other European countries is small for the policies we examine because of general equilibrium effects. Yet, the cost of such policies for the country undertaking them can be substantial.

Many economic analyses estimate the costs of climate policies assuming idealized policies applied in economies without pre-existing distortions. Neither of these assumptions is realistic. Countries may seek to pursue sector-specific policies or otherwise attempt to protect some industries such as major export industries that might be disproportionately affected by higher energy costs. Further, European energy markets are highly distorted by the existence of high fuel taxes that vary by sector and fuel. Our general findings are that diverging from ideal policies can increase costs, but possible to do better than an "ideal policy" where there are obvious and substantial pre-existing distortions.

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