Is International Emissions Trading Always Beneficial?

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Economic efficiency is a major argument for international emissions trading under the Kyoto Protocol. We show that permit trading can be welfare decreasing for countries, even though private trading parties benefit. The result is a case of "immiserizing" growth in the sense of Bhagwati where the negative terms of trade and tax interaction effects wipe out the gains from trading. Simulation and welfare decomposition results based on a CGE model of the global economy show that under EU-wide trading countries that are net permit sellers generally lose, due primarily to the existence of distortionary energy taxes.

INTRODUCTION

There is an extensive literature in climate change economics assessing the potential economic gains from emission trading under the Kyoto Protocol (Weyant, 1999). This literature emphasizes that the aggregate economic cost of achieving the Kyoto target might be reduced if marginal abatement costs are equalized across countries. This result is consistent with textbooks in environmental economics insisting on the cost-effectiveness of a transferable

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emission permit system and explaining that polluters have an incentive to use the flexibility created by the system to achieve a given target at the lowest possible cost (e.g., Tietenberg, 2000). Indeed, all polluters are supposed to gain from emission trading, whether sellers or buyers of permits, compared to the case where permits are not freely transferable. The logic appears irrefutable: why would parties freely enter a trade if they did not gain? Indeed, the gains to all parties can be demonstrated graphically in a simple partial equilibrium framework. And, empirically the economic benefits of carbon emission trading have been verified with model-based analysis using energy system models (e.g., Criqui et al. 1999; Gielen and Kram, 2000).

The conditions under which international permit trading would be introduced, however, diverge from the standard environmental economics textbook analysis in several important ways. In particular, in the case of international permit trading we are interested in the impacts on a nation or region whose economies diverge from the idealized perfectly competitive economies. Real economies include taxes, monopoly power, externalities, and instances of goods that are not traded internationally, which together are often referred to as economic distortions. Moreover, carbon policies may have effects on the terms of trade for economies, and these effects are external to the decisions of private sellers and buyers of permits.

And, while not always clearly specified, the idea is that the traders are private firms within the countries, rather than the countries themselves. Thus, what may be beneficial to individual trading entities may not result in a net benefit for the country. We draw on the general theory of second best (Lipsey and Lancaster, 1956), and the international trade literature on "immiserizing growth" started by Bhagwati (1958) to explain why, in the more general case, all countries may not benefit from the introduction of a permit trading system. Trade economists will immediately recognize that immiserizing growth can occur only when there are pre-existing distortions and others will see this as an extension or application of the theory of the second best. However, the possibility that emission permits trade might be welfare decreasing in some cases seems not to have been generally appreciated in the environmental economics literature, nor has its empirical importance been explored for the case of carbon permit trading.

In section 2, we briefly present the general theories of second best and immiserizing growth, and their relevance to international emissions trading. Then, in section 3, we explain geometrically why international emission trading might be a suboptimal policy in second best setting. Finally, we present in section 4 simulation results based on a version of the MIT Emissions Prediction and Policy Analysis (EPPA) model that disaggregates nine European countries. We focus the empirical analysis on introduction of a permit trading system limited to trading within the European Union.

1. INTERNATIONAL EMISSIONS TRADING IN A SECOND BEST SETTING

Different fuels are taxed at very different rates within almost all European countries, and the same fuel is taxed at very different rates from one country to another (Newbery, 2001). Are energy taxes completely justified by the internalization of environmental damages and the charge for road use? According to Newbery (2001), in most cases the taxes predate environmental concerns, are not related in any systematic way to environmental damage, and do not meet minimal criteria for so doing. Coal is almost invariably the most environmentally damaging fuel, but it is usually the least heavily taxed, and in many countries its production is heavily subsidized. If road fuel taxes can to a considerable extent be justified as road user charges, there is little evidence that road taxes are set on the basis of charging the long-run marginal cost of expanding roads (Newbery, 1992).

Since climate policy will be implemented under imperfections and distortions in the energy markets, one might expect the general propositions of the second best theory and the theory of trade policies to be valid for the analysis of markets for tradable emissions permits. Our general proposition is that international emissions trading (IET) may be welfare decreasing when primary gains from trading are outweighed by "secondary costs" associated with pre-existing distortions and market imperfections. In this section, we will focus on the efficiency costs of IET due to the "tax-interaction effect" and the terms of trade effect.

1.1 The Tax-Interaction Effect of IET

Lipsey and Lancaster (1956) have shown that, generally, when one optimal equilibrium condition is not satisfied, for whatever reason, all of the other equilibrium conditions will change. Thus if one market does not clear, it would no longer be optimal for firms to set price equal to marginal cost or for consumers to set the price ratio equal to the marginal rate of substitution.[1]

When imperfections or distortions are present, the standard policy prescriptions to maximize national welfare in a first-best or non-distorted economy will no longer hold true. Also the implementation of what would be a detrimental policy in a first-best world can become a beneficial policy when implemented within a second-best world.

1. The general theorem for the second best optimum is formulated by Lipsey and Lancaster (1956) as follows: "[If] there is introduced into a general equilibrium system a constraint which prevent the attainment of one of the Paretian conditions, the other Paretian conditions, although still attainable, are, in general, no longer desirable."

Applying the theory of the second-best in international trade theory, Bhagwati (1971) provides a framework for understanding the welfare implications of trade policies in the presence of market distortions. He demonstrates the result that trade policies can improve national welfare if they occur in the presence of a market distortion and if they act to correct the detrimental effects caused by the distortion. Bhagwati also shows that for each distortion, it is possible to analyze the welfare ranking of all alternative policies, from the first best optimal to the second best.

Recent studies have focused on the ranking of alternative environmental policy instruments in a second best setting. It is shown that the presence of distortionary taxes raises the costs of pollution abatement under each policy instrument relative to its costs in a first-best world (e.g., Fullerton and Metcalf, 1997; Goulder et al. 1998; Parry and Williams, 1999). In a first best setting, the relative cost-effectiveness of different policies can be explained fully in terms of the difference in primary costs, including the cost from the "abatement effect" and the cost from the "output-substitution effect". In a second best setting, the gross efficiency cost of various environmental policies comprise the primary costs and the cost impact of pre-existing taxes, including the "tax-interaction effect"[2] and the "revenue-recycling effect."[3] Usually, pre-existing distortionary taxes raise the costs of a given tax since the tax interaction effect dominates the revenue-recycling effect.

Free trade in emission permits is a cost-effective solution in a first best setting. However, in a second best world, one needs to take into account efficiency loss due to pre-existing distortionary taxes. Selling emission permits generates primary income gains but also may cause income losses due to restructuring of production in the selling country. Since the post-trading price of the permit is higher than the pre-trading price in the selling country, emission trading raises the costs of producing output, increases the relative price of consumption goods and reduces the real household wage. The selling country might be worse off compared to the case where a uniform carbon tax is implemented domestically if the efficiency costs from the "tax-interaction effect" outweigh the primary income gains from emissions trading.

1.2 The Terms of Trade Effect of IET

Bhagwati (1958) has underlined the paradoxical possibility of "immiserizing growth," where a country finds that the growth induced

2. The tax-interaction effect has two components (Goulder et al. 1998): the policy instrument increases the price of goods, implying an increase in the cost of consumption and thus a reduction in the real wage. This reduces labor supply and produces a marginal efficiency loss which equals the tax wedge between the gross and net wage multiplied by the reduction in labor supply. In addition, the reduction in labor supply contributes to a reduction in tax revenues.

3. The revenue recycling effect corresponds to the efficiency gain from the reduction in the rate of pre-existing distortionary tax obtained with the revenues raised from the emissions tax (Goulder, 1995).

deterioration in its terms of trade that implies a sufficiently large loss of welfare to outweigh the primary income gain from growth. In the original Bhagwati case, growth can be welfare decreasing when it occurs in a country with monopoly power in trade, even if the country has an optimal tariff policy in the pre-growth situation.[4] In the Johnson case (1967), immiserizing growth can arise without any monopoly power in trade if the country has a sub-optimal tariff policy in the pre-growth situation. Bhagwati (1968) demonstrates that immiserizing growth can arise under any kind of distortion, whether endogenous (monopoly) or policy-imposed (e.g., distortionary wage differentials), and showed that immiserizing growth is also possible when growth occurs in a country with monopoly power under a distortionary tariff policy. The general theory of immiserizing growth states that growth can be welfare decreasing only if (1) the pre-growth situation departs from full optimality and (2) if the distortion is not removed by a policy intervention (Bhagwati, 1969).[5]

The theorem on immiserizing growth applies to the case of international emissions trading as well. One might define the pre-emissions trading situation as a state where countries reach their emissions targets through domestic actions, i.e. economy-wide emissions trading systems. In the no distortion case, this situation is a suboptimal situation compared to the case where emissions permits can be freely traded internationally. Since markets for emission permits are imperfect, some countries will have higher marginal abatement costs than the others. Competitiveness effects are expected in that policy case. Countries with low abatement costs will gain a cost advantage (term of trade gains) compared to countries with high abatement costs. This cost advantage disappears when emissions permits are freely traded across countries. IET may be immiserizing for a selling country if the primary gains from permits selling are outweighed by the negative terms of trade effect.

A terms of trade effect can occur if the policy is big enough to affect international prices of goods, even in the absence of any other distortions. These changes could positively or adversely affect an economy, an effect Copeland and Taylor (2000) analytically demonstrate and that has been empirically evaluated by others (McKibbin et al. 1999; Babiker et al. 2000a; Böhringer, 2002).

4. The necessary conditions for export-biased immiserizing growth (Bhagwati and Brecher, 1982; Kindelberger and Lindert, 1978) are: (1) the country's growth must be biased toward the export sector, (2) the country must already be heavily dependent on trade (so that the terms of trade effect is strong enough to offset the gains from higher supply of exportable goods), (3) the rest of the world must have an inelastic offer curve or growth of the export sector must decrease the production of the import sector at the initial product-price ratio.

5. The possibility of immiserizing growth has been expanded into a whole set of arguments regarding the effect of policymaking in developing countries. For example, it is recognized that trade liberalization, in the presence of foreign capital, may be immiserizing (Bhagwati, 1973; Bhagwati and Tironi, 1980). Based on this logic, it is also affirmed that foreign aid and domestic capital should be channeled away from the exporting sectors (e.g., agricultural or mineral productions) into industry (Bhagwati and Brecher, 1982).

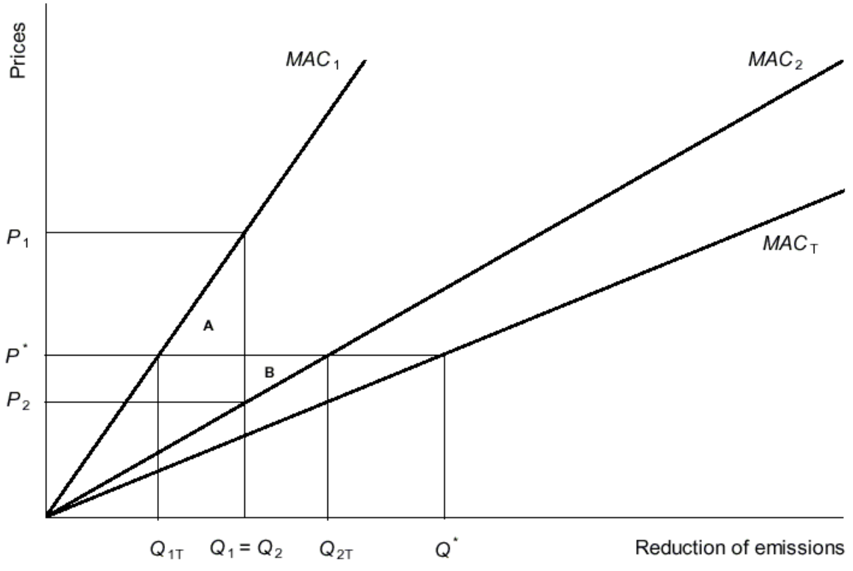
2. ECONOMIC IMPACTS OF IET

2.1 Gains from Trading - The No Distortion Case

Many economists favor transferable emission permits because they rely on market forces to seek out the least cost reductions, and require no knowledge on the part of the control authority with respect to where these least costly abatement opportunities exist (Tietenberg, 2000). Rather, the main task of the control authority is to issue the appropriate number of emission permits. A cost-effective outcome can be achieved in the market regardless of the initial distribution of permits (Knight, 1924; Coase, 1960; Dales, 1968). In fact, a tradable permit system allows the policy maker to effectively separate efficiency and equity issues, allocating permits on the basis of equity, or perhaps as an incentive for political support of the control policy, and letting the permit market seek out where the most cost-effective reductions can be achieved.

It is easy to demonstrate graphically the cost-effectiveness of international emission trading when there are no distortions. Figure 1 is drawn by measuring the marginal cost of emission reduction for country 1 (MAC_1) and country 2 (MAC_2). In the initial situation, we assume that carbon emissions are constrained in the two countries, so that emissions have to be reduced (without emission trading) by Q, where Q is a paired reduction target for the two countries (Q_1, Q_2) such that $Q_1 + Q_2 = Q$, and where $Q_1 = Q_2$. As shown, the marginal abatement cost of emission reductions at Q are higher in country 1 than in country 2 ($P_1 > P_2$).

Figure 1. Cost-Effectiveness of International Emissions Trading



Now, let's assume that an international emission trading regime is implemented, so that marginal abatement costs can be equalized across the two countries. As shown in Figure 1, the optimal reduction levels in the two countries are given by quantity pair labeled Q^* and the marginal abatement costs (or carbon prices) P^* in both regions. In that trading regime, country 1 reduces emissions by Q_{1T} and buys emission permits whereas country 2 reduces emissions by Q_{2T} and sells permits. As shown in Figure 1, the two countries are necessarily better off with international emission trading compared to the no trading case. The net income gains are equal to area A for country 1 and to area B for country 2.

2.2 Emissions Trading - The Pre-Existing Distortion Case

A recent literature in public finance is devoted to the analysis and measure of the incremental welfare costs of raising extra revenues from an already existing distorting tax (e.g., Browning, 1976; Ballard et al. 1985; Browning, 1987; Fullerton, 1991). The basic concepts of that literature can be used to analyze IET in a second best setting.

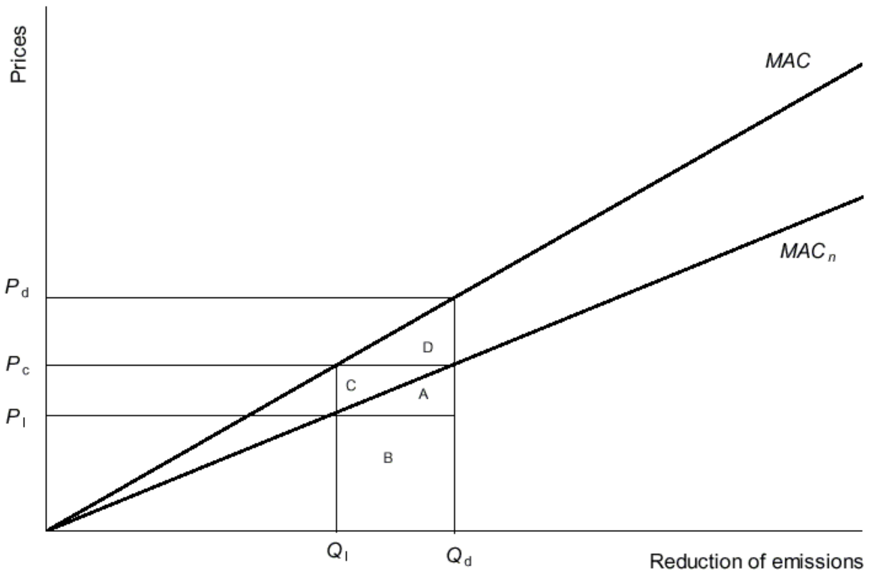
According to Browning (1976), the marginal cost of public funds is defined as the direct tax burden plus the marginal welfare cost produced in acquiring the tax revenue. The marginal welfare cost is the ratio of the change in total welfare cost to the change in tax revenue produced when tax rates are varied in some specific way (Browning, 1985). The direct tax burden is the direct cost per dollar of tax revenue. It corresponds to the marginal cost of public funds with no distortions.[6]

In order to measure the welfare impact of international emission trading in a second-best world, one might distinguish between the marginal abatement cost in the first best setting (MAC_n), the marginal welfare cost of emission reduction (MWC), and the marginal abatement cost in the presence of pre-existing distortions (MAC). Representing only the primary costs of the carbon policy (direct tax burden), MAC_n is defined as $\partial T/\partial C$, where T is the total abatement cost in the no distortion case and C represents the abatement level. The marginal welfare cost (MWC) of emissions reduction is the ratio of the change in total welfare cost to the change in carbon abatement; $\partial W/\partial C$ where W is the total welfare cost of abatement. MWC measures the secondary

6. The marginal welfare cost per dollar of revenue is equal to $\partial W/\partial R$ where W is the marginal welfare cost produced by a change in the tax rate and where R is the additional revenue. The marginal cost of public funds is simply equal to $(\partial W/\partial R) + 1$ when we assume that the tax base did not change in response to a change in the tax rate (Browning, 1976). The "marginal excess burden" (MEB) of taxation that measures the incremental welfare costs of raising extra revenues from an already existing distorting tax is $(\partial W - \partial R)/ \partial R$. According to Fullerton (1991), no measure of MEB is really necessary. The "marginal cost of funds" (MCF) is enough information to compare the distorting effects of different tax changes.

costs of pre-existing distortions, including the tax-interaction effect and the terms of trade effect. MAC is equal to the direct cost of abatement plus the marginal welfare cost of abatement $(\partial T + \partial W)/\partial C$.[7]

Figure 2. Impact of IET for the Net Buyer of Permits



In Figure 2, we draw marginal abatement costs curves in the no distortion case (MAC_n) and in the distortion case (MAC) for a given country. In the reference case, we suppose that the country meets a reduction target Q_d through an economy-wide emission trading scheme but without international emission trading. In that case, the marginal abatement cost associated with this target is P_c. If we suppose the presence of distortionary taxation, the marginal abatement cost of the domestic reduction is equal to P_d, with $P_d > P_c$.

Now, let's assume that emission permits can be traded internationally, and that the international permits price is P_I. In that context, domestic emissions are reduced by Q^* with $Q^* < Q_d$. As a net buyer of emission permits, the firm will reduce its total cost of reduction by area A. At the same time, a lower domestic effort to limit carbon emissions has the effect of reducing secondary effects (tax-interaction effect and terms of trade effect) due to pre-existing

7. A comparable approach can be found in Bernard and Vielle (2001). The authors break down the income effect into two components: (1) the pure cost of carbon taxation and (2) the “distortion” cost of carbon taxation. The pure cost of carbon taxation is the income change (in EV) produced by the carbon policy in a first-best world without distortions, or in a second-best economy based on optimal taxation.

taxation (area C + D). If we add primary and secondary gains, international emission trading is thus welfare improving for the buyer country (area A + C + D).

Figure 3. Impact of IET for the Net Seller of Permits

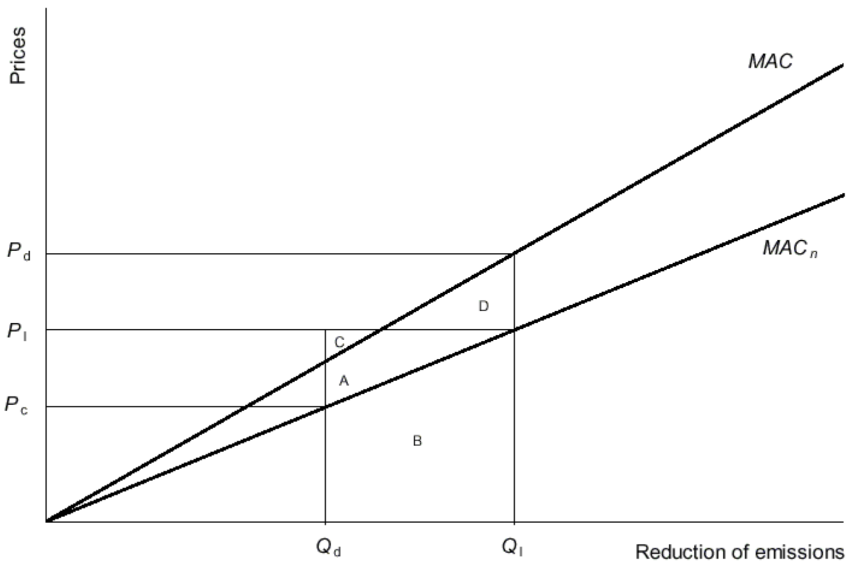


Figure 3 shows that the situation may be very different for the seller country. Lets assume that the country goes beyond its emissions target in order to sell emission permits. In that case, domestic emissions reduction may increase from Q_d to Q^*. The total cost of the extra reduction is then equal to area B and the trading gains for the firm are equal to area A + C. However, this reduction has the effect of increasing secondary costs associated with pre-existing taxes (area A + D), and the net welfare effect of permits selling, λ, is equal to area C minus D. λ can be positive or negative depending on the size of the distortions and the amount of permits traded. When the two curves are close (i.e. the marginal distortion is small) and the international price is such that a lot of permits are exported, λ can be positive. In contrast, when the economy is highly distorted and the size of the emissions trading market is rather limited, λ can be negative.

When these effects result from domestic distortions, an economy might correct those distortions and avoid the losses, or intervene in the permit market to prevent amplification of the distortions. In the case where the effects external to the permit trading firms stem from a change in the terms of trade, a "small" country could not, through its own actions, affect its terms of trade and thus could not improve its welfare given the existence of the trading system. It might, however, oppose the introduction of a trading regime in hopes of blocking it and, thus, avoiding the negative welfare effects of the trading system. The fact that countries can be strongly affected by a terms of trade effect, positively or negatively, quite apart from their own actions has been studied extensively with regard to the effect of Kyoto on the non-participating developing countries where both negative and positive terms of trade effects occur (e.g., Babiker et al. 2000a).

Figure 4. Emission Permit Market with Distortions

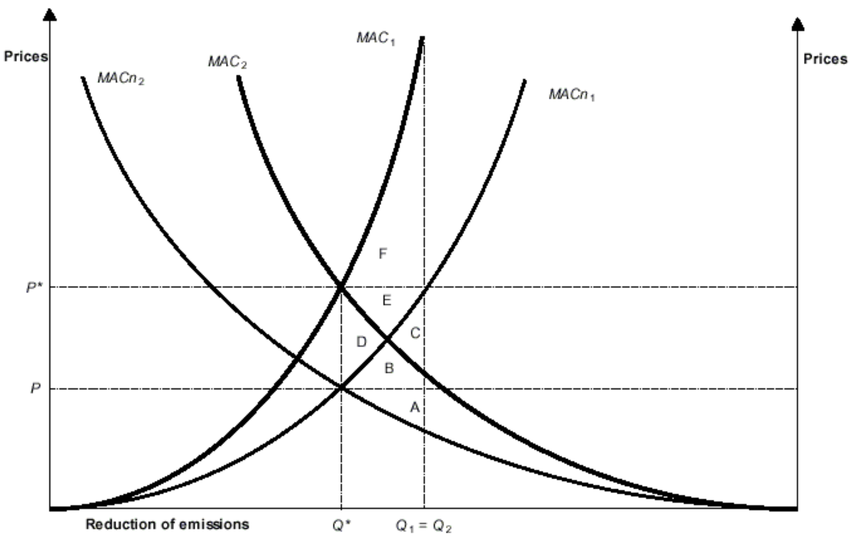


Figure 4 is drawn by comparing what the market price would be without any notion of the government trying to take into account externalities (option 1), and what the government should take into account in terms of externalities in intervening to set the carbon price (option 2). MAC_n and MAC are depicted for two countries. The curves are plotted from the left-hand axis for country 1 (MAC_{n1} and MAC_1) and from the right-hand axis for country 2 (MAC_{n2} and MAC_2). In the initial situation, we assume that carbon emissions are constrained in the two countries, so that emissions have to be reduced by Q in each country (with $Q_1 = Q_2$), and that MAC_n and MAC are lower in country 2 than in country 1.

When option 1 is implemented, trading units recognize only the primary costs and so MAC_n are equalized across the two countries. As shown in Figure 4, the optimal reduction is Q^* and the permits price is P. In that trading regime, trading gains are equal to area B + C for legal entities in country 1 and to area A for legal entities in country 2. If we assume distorted economies, the welfare impact of international trading would be positive for country 1 (area B + C + D + E + F) and negative for country 2 (area B + D).

When option 2 is implemented, and if we assume governments can evaluate the social cost and all of them will trade to optimize domestic welfare, then as constructed in Figure 4, the optimal reduction of emission will remain Q^* in the two countries but the international permits price will be at P^* (with $P^* > P$). In that institutional framework, both countries will be better off compared to the no-trade case. In our example, the welfare gains will be equal to area F for country 1 and area E + C for country 2.

3. A GENERAL EQUILIBRIUM ANALYSIS BASED ON THE EPPA-EU MODEL

3. 1 The EPPA-EU 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; Ellerman and Wing, 2000). 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)[8] 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. (2003). The EPPA-EU model has also been used to analyze welfare impacts of hybrid carbon policies in the European Union (Babiker et al. 2003). EPPA-EU extends the current version of EPPA by bringing in a detailed breakdown of the EU and incorporating industry and household transport sectors for each region. The regional, sectoral, and factor aggregation shown in Table 1, together with the substitution elasticities in Table 2, completely specify the benchmark equilibrium.[9] Capital stock is vintaged in EPPA-EU. There are two types of capital stocks: rigid and malleable. The rigid portion is divided by age into five classes of vintages and carried over time subject to depreciation. The addition to the malleable component (new investment) is assessed

8. For description of the GTAP database see Hertel (1997).

9. The elasticities of substitution are the same across regions except for nuclear where elasticities are varied to simulate the baseline for nuclear supplies in the different regions. Nonetheless the factor shares and the implied supply price elasticities are different across regions.

each period according to a fixed marginal propensity to invest and economic growth. The details of the implementation of the structure and the evolution of capital stock in EPPA are documented in Babiker et al. (2001). The existing taxes and distortions in EPPA include fuel taxes, factor taxes, excise taxes, tariffs and export taxes, and taxes on consumption and intermediate inputs.

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.[10] 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 1. 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 Europe Associates	EET
Primary Factors		**Non-Annex B**	
1. Labor	L	Brazil	BRA
2. Capital	K	China	CHN
3. Fixed Factors for Fuel & Agriculture		India	IND
		Energy Exporting Countries	EEX
		Dynamic Asian Economies	DAE
		Rest of World	ROW

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

We followed the methodology developed by Babiker et al. (2000b) 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

10. 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.

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. (2000b) study. We have also made adjustments directly to the Household (H) sector to represent own-supplied transportation services, primarily those provided by personal automobiles. We used consumption expenditure of private households reported by Eurostat (1999) and energy prices and taxes from the International Energy Agency (IEA, 1998a; IEA, 1998b; IEA, 2000) along with the coefficients reported in the Babiker et al. (2000b) study 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).

Table 2. 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 and 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
	Energy goods [e]:	4
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 A Simple Approach to Welfare Decomposition

Building on the conventional Hicks and Slutsky partial equilibrium decomposition analysis of a price change into income and substitution effects, we extend the approach to the carbon policy and the general equilibrium context. Under general equilibrium the welfare effect of a carbon constraint is channelled through income and prices. The imposition of a carbon policy raises production costs and consumer prices (depending on the carbon intensities of the produced and/or consumed goods), and thereby induces changes in welfare. Also, by raising production costs, carbon policy causes output and income losses, which affect consumption and thereby welfare. Emission trading is thought, by equating marginal costs, to reduce the welfare costs of any given carbon policy. Whether this is always true, however, depends on the effects of equating marginal costs on incomes and consumer relative prices. Thus a welfare decomposition of these effects helps to explain when and why a country may benefit or lose from emission trading, and to trace back the sources of these benefits or losses.

Ignoring the environmental benefits from emission reductions, we define the indirect welfare function as:

$$W = W(P(carbon), M(carbon)) \tag{1}$$

where P is the consumer price vector and M is income, and where we use "carbon" to indicate the carbon policy regime. The effect of an infinitesimal change in the carbon policy regime on welfare at values $\overline{M}$ and $\overline{P}$ is then:

$$\frac{dW}{dcarbon} = \sum_i \frac{\partial W}{\partial p_i} \frac{\partial p_i}{\partial carbon} | \overline{M} + \frac{\partial W}{\partial M} \frac{\partial M}{\partial carbon} | \overline{P} \tag{2}$$

where i refers to the consumption goods. The first term on the right hand side is then the price effect and the second term is the income effect. For a large change in the carbon policy regime such as moving from national caps to international permit trading the decomposition may be approximated as:

$$\Delta W \approx \sum_i \frac{\partial W}{\partial p_i} \Delta p_i | \overline{M} + \frac{\partial W}{\partial M} \Delta M | \overline{P} \tag{3}$$

where we have assumed linearity in the welfare response to prices and income.[11] In addition to linearity, two further problems with the above formulation in the general equilibrium context are the interdependence among prices (i.e., substitutability and complementarities) and the joint determination of incomes and prices. The numerical method we develop allows us to test whether these assumptions are quantitatively important. We apply this technique to decompose the welfare impacts of emission trading among the EU member countries using the EPPA-EU model.

The method proceeds as follows. Utilizing the price-quantity duality in the model, we use the unit expenditure function, which defines the consumer price index (CPI), to summarize the price effect on welfare. Yet the challenge is how to disentangle numerically the joint determination of income and prices in the general equilibrium model. We do this by using simultaneously two instruments, one to control the consumer price index and the other to control income. The more general form of the welfare decomposition that we use is thus:

$$\Delta W \approx \Delta W|\overline{M} + \Delta W|\overline{P} \tag{4}$$

where P here is the CPI or the unit expenditure index and where ΔW is the welfare after trading minus the welfare before trading. According to this expression the change in welfare due to the introduction of emission trading is approximately equal to the welfare change due to changes in relative prices only (the price effect) plus the welfare change due to change in income only (the income effect). Numerically we compute one effect and obtain the other by subtraction. To assess our handling of the non-linearity in the price income relationship, we reverse the order and compute the other effect first and then compare the results from the two procedures. After ensuring a satisfactory agreement in results, we use the procedure that fixes income to do a further decomposition of the price effect into a pure domestic price effect and a terms-of-trade effect. The extent to which the two estimates differ indicates the accuracy of the decomposition approach; that is, how much the empirical modeling diverges from the assumptions of linearity and independence of the two effects. The results from applying the decomposition technique are presented and explained in the results section.

11. The welfare function in the model is a nonlinear CES representation that includes the different commodities consumed by the household subject to a fixed marginal propensity to save constraint on income. The linearization in eq(3) is a simplification of the analytical decomposition of the welfare change into an income and a price effect. The derivatives are taken with respect to changes in price (represented by the cost of the consumption bundle, i.e., unit expenditure price) and with respect to changes in income. The numerical decomposition takes into account the nonlinearities and the ordering when computing the partial derivatives.

3.3 Scenarios and Results

In our simulations, we suppose that each Annex B country implements the necessary policies to meet their Kyoto commitment by 2010.[12] In addition, the reallocation made by the Burden Sharing Agreement (BSA) is applied for European countries (Viguier, 2003). 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, and the emission market is assumed to be perfectly competitive.[13]

The cases we construct to investigate the welfare effects of international emission trading (by which we refer to trading among the EU member countries) are:

ETR: **E**conomy-wide **TR**ading where each EU country implements a full domestic emission trading system but without trade across countries (including pre-existing energy market distortions).

IET$_d$: **I**nternational **E**mission **T**rading where emission permits can be traded across sectors within the European Union in the presence of pre-existing **d**istortions.

IET$_{nd}$: **I**nternational **E**mission **T**rading where emission permits can be traded across sectors within the European Union, and where 50% of pre-existing distortions (e.g., energy taxations) are removed (**n**o **d**istortion).

Figure 5 illustrates welfare losses associated with the Kyoto constraint when a uniform carbon tax[14] is applied in each EU country (ETR case). According to the EPPA-EU model, welfare cost of Kyoto range from -0.7% in France to over -5% in Netherlands. Figure 5 also shows the effect of implementing a EU-wide emission trading in the presence of existing energy taxes. Some countries, like Scandinavian countries or Spain (mainly importers of carbon permits), would be better off with international trading whereas

12. The analysis examines only CO_2 emissions from fossil fuels. Kyoto includes flexibility to abate other greenhouse gases and to offset emissions with limited forest and land use sinks for carbon, which are not considered here.

13. It is a strong assumption since Kyoto might engender large sellers and buyers of permits. For example, the Russian Federation, perhaps acting with other potential sellers such as the Ukraine, has a heightened incentive to adopt monopolistic behavior, and sell only a share of available permits from the hot air in order to maximize revenues from permits sales (Bernard et al. 2002; Bernard et al. 2003; Haurie and Viguier, 2003).

14. Under both the carbon tax (which is taken as equivalent to a national permit trading) and EU-wide permit trading carbon revenues are recycled as lump-sum to the household sector in the model. Thus there is no distributional issue and the tax and the permit are equivalent.

other, like the United Kingdom, Germany or France (mainly exporters of carbon permits) are worse off with trading than without.

Figure 5. Welfare Effects of EU-Wide Emissions Trading (in EV%)

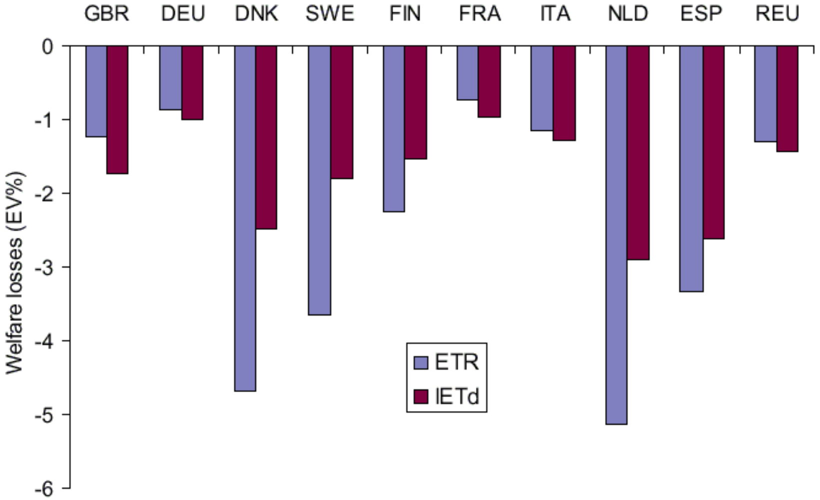


Figure 6 depicts the trade position of EU countries in the carbon market under the IETd case. According to the EPPA-EU model, 25 MtC are expected to be traded in this carbon market by 2010. The estimated carbon price for the EU bubble is around $175/tC. The United Kingdom, Germany, France, Italy and the rest of Europe are projected to sell emission permits to Netherlands, Spain, Denmark, Sweden and Finland. If we compare the welfare effects of international emission trading with trade positions, we can see that net sellers of permits are those that are expected to be damaged with international emission trading whereas net buyer of permits correspond to winner countries.

Table 3 and Table 4 provide the decomposition of the welfare gains from international emission trading in the context of Kyoto Agreement, expressed in EV%[15] points (i.e., EV% for case IETd minus EV% for case ETR) for year 2010. According to our explanation in section 3, international emission trading has a positive income effect and a negative price effect on seller countries. In the presence of existing energy taxes, welfare is reduced in all permit-exporting countries since income gains from international emission trading are outweighed by the negative price effect. Conversely, international emission trading is welfare increasing for permit-importing countries.

15. EV% is the change in equivalent variation as a percentage of baseline income. The welfare reductions are thus measured relative to the baseline welfare levels.

Figure 6. EU-Wide Emission Trading Market, IETd Case

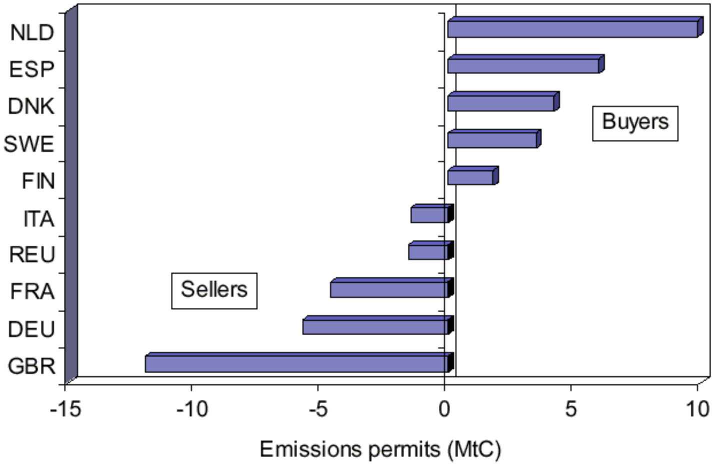


Table 3. Decomposition of Welfare Change from Emission Trading, IETd Case (in EV%)

	Method (A) control for the price effect			Method (B) control for the income effect		
	Income effect	Price effect	Total effect	Income effect	Price effect	Total effect
GBR	0.29	-0.80	-0.51	0.41	-0.92	-0.51
DEU	0.09	-0.23	-0.13	0.11	-0.25	-0.13
DNK	-1.95	4.15	2.20	-2.05	4.25	2.20
SWE	-1.06	2.90	1.84	0.99	2.83	1.84
FIN	-0.26	0.97	0.71	-0.28	1.00	0.71
FRA	0.09	-0.33	-0.24	0.06	-0.30	-0.24
ITA	-0.02	-0.11	-0.13	-0.04	-0.09	-0.13
NLD	-1.09	3.33	2.23	-1.54	3.77	2.23
ESP	-0.30	1.01	0.71	-0.40	1.12	0.71
REU	-0.10	-0.13	-0.13	0.00	-0.13	-0.13

This example based on the EPPA-EU model demonstrates that international emission trading could be welfare decreasing in some countries because of general equilibrium effects. Despite the gains from trading, exporting countries are worse off in this example because of the small size of permit trade and because of the existing price structure, which involves already very high energy taxes. Exporters lose in the case of European trading because carbon-based energy is heavily taxed in Europe, particularly in the transport sector. By selling permits a country's carbon price rises compared to the autarkic case. The carbon price is, essentially, a further tax on fuels that causes a non-marginal welfare loss because it comes on top of existing fuel tax distortions. In contrast, permit importing countries are better off mainly because the welfare gains from reducing the carbon tax (through permit trading) in the presence of the pre-existing energy tax system are more than needed to compensate the welfare loss due to giving away money in exchange for permits.

Table 4. Decomposition of the Price Effect from Emission Trading, IETd case (in EV%)

	Domestic price effect	Terms of trade effect	Total price effect
GBR	-0.84	-0.08	-0.51
DEU	-0.18	-0.06	-0.13
DNK	1.86	2.39	2.20
SWE	1.61	1.22	1.84
FIN	-0.01	1.01	0.71
FRA	-0.21	-0.10	-0.24
ITA	-0.09	0.01	-0.13
NLD	3.31	0.46	2.23
ESP	1.24	-0.12	0.71
REU	-0.01	-0.13	-0.13

To further demonstrate that energy taxes are the distortions that lead to losses from trading we conducted additional simulations where we removed existing energy taxes in the EPPA-EU model. As shown in Figure 7, the distortionary effect of the carbon constraint is reduced when existing taxations are removed. On one side, welfare gains from emission trading are more limited in importing countries in the IET_{nd} case, compared to the IET_{d} case. On the other side, most of permit-exporting countries become better off with international emission trading.

Table 5 presents the decomposition of welfare gains from emission trading when existing taxes are removed, expressed in EV% units for year 2010. In general, the direction of the income and price effects is the same as in the case of distortions shown in Table 3.[16] However, the magnitude of these effects is significantly different. In particular removing existing taxes has greatly alleviated the welfare burden of the incremental carbon tax (caused by trading), and as a result we see the positive income effect offsets the negative price effect leading to a net welfare gain for all exporting countries, except France. In the importing countries, on the other hand, the positive price effect still dominates the negative income effect but net welfare gains are reduced (except in Italy and Rest of Europe).

16. The results are sensitive to the size of pre-existing distortions. The smaller the pre-existing distortions the smaller their welfare effects. So when just removing 50% of these distortions the conventional results from emissions trading occur. Yet, the scenario of removing 50% is just meant to make this point in the paper and does not imply that we are overstating the pre-existing distortions in our main calculations.

Figure 7. Welfare Effects of EU-Wide Emission Trading With and Without Pre-Existing Distortions (in EV%)

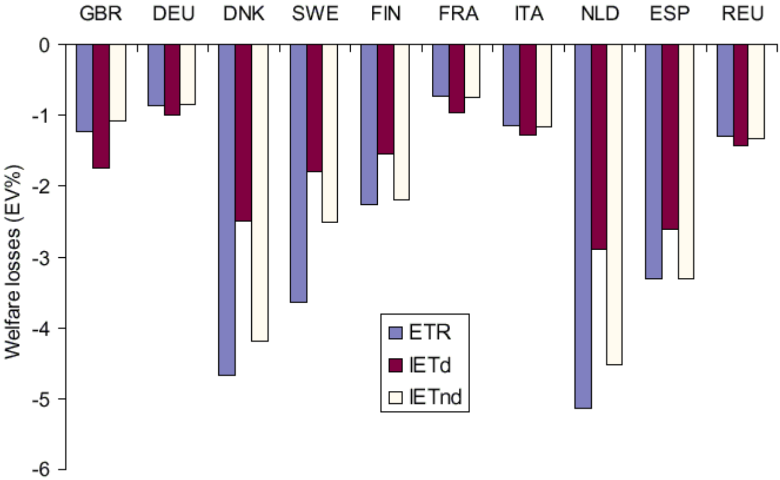


Table 5. Decomposition of Welfare Change from Emission Trading, IETnd Case (in EV%)

	Income effect	Price effect	Total effect
GBR	0.0350	-0.0324	0.0026
DEU	0.0072	-0.0067	0.0005
DNK	-0.0773	0.0873	0.0100
SWE	-0.0757	0.0987	0.0230
FIN	-0.0115	0.0126	0.0011
FRA	-0.0003	-0.0006	-0.0003
ITA	-0.0007	0.0004	-0.0003
NLD	-0.0568	0.0666	0.0098
ESP	-0.0018	0.0020	0.0002
REU	-0.0085	0.0082	-0.0003

4. CONCLUSION

This paper has explored the proposition that is almost always taken as given in the climate change literature, that international permit trading will always be welfare enhancing. Other authors have pointed to possible problems of permit trading. One criticism is that although economically efficient, permit trading may not lead to an equitable distribution of the revenue to the people who are hurt by emissions targets within a society and therefore might make some groups within countries worse off. Another critique is that the volatility induced by trading in other markets (such as foreign exchange rate fluctuations) because of large transfers of real resources across borders, might lead to the collapse of the permit market (McKibbin and Wilcoxen, 2002). However, the current paper directly examines the case that there might be direct welfare losses from permit trading under particular circumstances. This is a different argument to the issue of income transfers already in the literature. Our analysis shows that international emissions trading can be welfare decreasing because of general equilibrium effects when there are distortions. It occurs in countries exporting emission permits when efficiency costs associated with pre-existing distortionary taxes are larger than the primary gains from emission trading. The case can arise because (1) energy markets are already highly distorted in the European Union, and (2) EU countries are heavily dependent on trade. It means that the tax-interaction effect and the drop in the terms of trade can be great enough to offset the direct income gains from emissions trading. Note that the adverse effect of trading occurs in countries that gained a comparative advantage from the absence of free trade in carbon emission permits.

The adverse effects of emission permits in exporting countries are largely explained by the presence of non-optimal taxation in the pre-trade situation. When pre-existing distortions are removed, most of European countries exporting permits are better off when an international emission trading regime is implemented. Thus, our analysis highlights the interaction of pre-existing energy taxes and the Kyoto regime. The implementation of Kyoto by economy-wide carbon taxes tend to create high distortions and deadweight losses in Europe because of existing energy taxation. We find that an EU-wide emissions trading regime in the presence of existing energy taxes is immiserizing for permit-exporting countries. This basic result is found to be quite robust and stable across a wide range of elasticity and structure representations.

A critical aspect of our conclusions is that existing energy taxes are viewed as pure distortions. Of course some taxes may be justified if they internalize other externalities, environmental or not. However, can we assume energy taxes in Europe are set at levels that optimally correct externalities? Probably not if we accept the analysis that have found little connection between fuel tax levels and externalities (e.g., Newbery, 2001). Thus, a carbon emissions trading system could easily be welfare worsening in the EU. In this respect, the EC proposal to limit the possibility to trade across Europe to energy companies and energy-intensive industries, and by this way to exclude the more distorted sectors from the trading market is probably a good one. Another policy option would be to let legal entities freely trade emission permits domestically while limiting international trade to national governments in hopes that government sponsored trades would reflect social costs.

The first best solution is to remove the existing distortions. In the absence of a willingness to do that, these result show that it is possible for a country to lose as a result of introducing international permit trading. It may therefore be possible for a country to intervene in an international trading system and improve its welfare. Perhaps more importantly, this may help explain the political difficulties of introducing and sustaining an international permit trading system, and the interests expressed in government-to-government trading instead of international firm-to-firm trading. In the case we examined, and with existing distortions, no country had an economic incentive to be a permit seller--clearly a market with no sellers, and only buyers is not feasible. Thus, there does not appear to exist a coalition of countries among those we examined where there is an economic incentive to have a trading system, absent a set of side-payments from those who would gain from trading to those who would lose.

Neither the direction nor magnitude of the effect of pre-existing distortions or terms of trade effects can be known without careful examination of the particular circumstances. Empirical results will depend on exactly how a trading system is formulated, which countries trade, and the types of pre-existing distortions in each country. The burden of meeting the Kyoto target in Europe will also depend on how the EU-wide trading regime promoted by the European Commission is implemented, and on how the burden is distributed across sectors. Current discussions in Europe regarding a proposed trading system would exempt the transportation sector completely from the trading system, and since most of the distorting taxes are on transportation fuels an analysis of that proposal would show quite different results. Kyoto itself includes the non-CO_2 greenhouse gases, which come from many different sources, with agriculture a major contributor. The energy sector with high, but widely varying tax rates among fuels, sectors, and countries, agriculture with large subsidies and tariff barriers, and incompletely controlled pollution from both sectors means that these sectors diverge widely from the idealized efficient markets. Thus, our broader policy result is that extra caution, and further analysis with attention to these distortions, seems warranted in proposing first best solutions for greenhouse gas mitigation when there is ample evidence that these measures will be applied in sectors with an array of existing distortions that vary among countries.

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