International Journal of Global Energy Issues, Volume 11, Nos. 1-4, 1998

Global CO_2 emissions and unilateral action: policy implications of induced trade effects

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Abstract: Unilateral action to combat an international externality such as CO_2 emissions produces efficiency losses through spill-over effects of carbon emission constraints on international markets. Emissions by non-participating countries may be increased through the relocation of energy-intensive production or reductions in the international oil price (so-called carbon leakage). Grandfathered emission permit systems are considered as one unilateral mitigation strategy which could avoid carbon leakage and increase efficiency of global CO_2 reduction as compared to unilateral uniform CO_2 taxes. This paper summarizes results from a multiregional computable general equilibrium (CGE) model application [1] which show that the efficiency argument for the use of grandfathered permits depends crucially on the specification of international trade.

Keywords: CO_2 abatement strategies, unilateral action, grandfathered emission permits

Reference to this article should be made as follows: Böhringer, C., Rutherford, T.F. and Voß, A. (1998) 'Global CO_2 emissions and unilateral action: policy implications of induced trade effects', *Int. J. of Global Energy Issues,* Vol. 11, Nos 1-4, pp. 18-22.

1 INTRODUCTION

Carbon taxes are considered a key instrument of climate policy in response to the greenhouse problem. Global cost effectiveness suggests that a carbon tax should be uniform across countries and sectors in order to equalize the marginal cost of emission reduction across sources [2]. Because the cost of uniform taxes may be inequitable and side-payments to assure 'fair' burden sharing are very difficult to assess, no concerted action has yet been undertaken. At the same time, no single country has an incentive to significantly cut its own emissions given the negligible impact on the overall carbon concentrations in the atmosphere. Despite this dilemma there might be reasons for single countries to take a leading role and act unilaterally. For example, a country may decide to make short-term sacrifices in the expectation of long run benefits from an increase in the number of signatory countries. Another motivation which is especially relevant in the EU context could be the domestic political environment where voters demand concrete environmental action. However, when one country acts unilaterally, significant efficiency losses could arise due to carbon leakage. Emission reduction in one region can be partially offset by increased emissions elsewhere, through the relocation of energy-intensive production or reductions in the international oil price. One approach for countries acting unilaterally to avoid leakage and increase the efficiency of global CO_2 reduction are grandfathered permit systems where emission permits are freely distributed to firms who subsequently can use the permits for their own emissions or sell the permits to others. Overall emissions can be reduced with the number of permits. Depending on the initial allocation scheme of permits and subsequent reduction rules, grandfathered permits may be suited to reduce leakage when they give emission-intensive industries a cost advantage, as compared to uniform carbon taxes and thus lower international relocation effects due to unilateral action. Whereas grandfathered permits retain the advantage of uniform CO_2 taxes on the input side of production, (i.e. equalization of marginal abatement cost) they work as subsidies on the output side. With uniform taxes or auctioned permits the tax revenue could be returned lump-sum, i.e. in a non-distortionary way, to a representative consumer. Under grandfathered permit systems, revenues from emission rights accrue to the industries changing the competitive position. In fact, grandfathered permits imply typically disproportionate subsidies to the production industries. Relative prices then no longer indicate the *true* social cost of resource use (after accounting for the additional carbon emission resource); resources are diverted from efficient production. The distortion on the output side of the economy can induce a significant excess burden of emission abatement. The additional cost of grandfathered permits as compared to uniform taxes depend on the initial distribution of permits and its subsequent reduction schedule. The question to what extent these costs are offset by the benefits of reduced leakage rates has in part motivated the development of a large-scale multi-regional, general equilibrium model which can address this issue in a consistent, analytical way [1]. Numerical evidence from the application of this model suggests that grandfathering is justified on efficiency grounds only when leakage rates are substantial. The model-based results depend crucially on the formulation of international trade. In an Armington model with traded goods differentiated by region (i.e. wine from France is different from Italian wine), leakage rates are low and grandfathered permits are costly as compared to uniform taxes. In a Ricardo-Viner model with homogeneity of traded goods, leakage rates are high and grandfathered permits are pareto-superior as compared to uniform taxes.

2 LEAKAGE AND IMPLICATIONS FOR MODEL DESIGN

For CO_2 emissions as a global externality, the cost of unilateral abatement must be related to the effect on global emissions.

Let:

E_A denote the emission reduction of the unilaterally acting country A.

E_N be the effect from unilateral action on emissions of other countries N (Note: the sign of E_N is negative for an increase of emissions of other countries N).

E_{TOT} (= $E_A + E_N$) be the effect on global emissions from unilateral action of country A.

l define the average leakage rate equal to E_N/E_A.

C_A represent a monotonously increasing function in E_A which summarizes the economic cost for a representative agent in country A of unilateral reduction.

The cost of meeting a global reduction target E_{TOT} by unilateral action can be expressed as:

$$C_A(E_{TOT}) = C_A(E_A + E_N) = C_A\{E_A(I - l)\}$$

which indicates that positive leakage increases the unilateral cost for meeting a given global reduction target.

The phenomena of leakage explains why grandfathered permits systems might be preferable to uniform taxes, if reduced leakage rates more than offset the distorting effects of grandfathered permits on the output side of production.

There are two basic channels through which carbon leakage can occur. First, leakage can arise when the production of CO_2-intensive goods relocates and increased the emission levels in the non-participating regions. Secondly, cut-backs of energy demands in a large region due to CO_2 taxes may induce a significant drop in world energy prices, which, in turn, could lead to an increase of demand in other regions. This again could offset part of the CO_2 reductions in the unilaterally acting region. If the unilaterally acting country has a relatively small share in world-wide energy supply and demand, it is a reasonable approach to focus on leakage from trade in energy-intensive goods and neglect leakage from energy market effects.

The scope for CO_2 leakage then crucially depends on the pattern of carbon intensity in the production of traded goods across different regions and the trade volumes of specific goods. This has at least three important implications for the model design meant to analyse leakage effects. Firstly, the regional disaggregation of the model should include all major trading partners of the unilaterally acting country. Secondly, the sectoral disaggregation of the model must cover those sectors which are emission- and trade-intensive. Thirdly, the representation of international trade (following either the proposition of Armington or Ricardo-Viner) needs careful analysis in terms of empirical evidence. The Armington assumption treats products of the same variety produced in different regions as qualitatively different. This treatment allows bilateral trade to be matched with cross-hauling of data and avoids unrealistically strong specialization effects for exogenous changes in trade tax policy. Finite elasticities of substitution (transformation) capture the heterogeneity of traded goods belonging to the same variety with respect to consumer preferences. Under the Ricardo-Viner assumption traded goods are homogeneous, which implies large moves towards specialization for small changes in trade tax policy.

As will be shown below the choice between these paradigms in trade modelling is crucial for model-based predictions on the cost-efficiency of alternative unilateral abatement strategies.

The above implications for model design have been incorporated in the development of a static large-scale general equilibrium model for the European Union based on the most recently available consistent data of bilateral trade and energy flows as well as national statistics on domestic production and consumption patterns [1]. The model includes a detailed description of 23 production sectors and final demand in 6 EU member countries which together account for more than 90% of the overall EU trade volume and production output: Germany (DE), France (FR), United Kingdom (UK), Spain (ES), Italy (IT) and Denmark (DK).

3 SCENARIOS AND COMPUTATIONAL RESULTS

In the simulations summarized below, two alternative strategies for unilateral action in a single EU member country (here: Germany DE) are distinguished. Firstly, the unilaterally acting country applies uniform carbon taxes sufficient to meet exogenous unilateral reduction targets. Secondly, the country initially issues grandfathered emission permits proportional to base year sectoral emissions; subsequent reduction in emission rights to meet exogenous reduction targets are proportional across sectors. Both abatement strategies are simulated for two different assumptions on the degree of substitutability of traded goods from different regions. The resulting four scenarios are listed in Table 1.

Table 1 *Specification of scenarios*

	Unilateral abatement strategy		*Trade specification*	
	Uniform Taxes	Grand-fathered permits	Armington	Ricardo-Viner
DE_1	X		X	
DE_2		X	X	
DE_3	X			X
DE_4		X		X

Table 2 *Summary of results*

	DE_1			*DE_2*			*DE_3*			*DE_4*		
	Uniform taxes Armington			*Grandfathered permits Armington*			*Uniform taxes Ricardo-Viner*			*Grandfathered permits Ricardo-Viner*		
	10%	20%	30%	10%	20%	30%	10%	20%	30%	10%	20%	30%
	Welfare effects (Hicksian equivalent variations (EV) in income - % change to benchmark)											
DE		− 0.4	− 1.2	− 0.1	− 0.8	− 2.3		− 0.3	− 0.8	− 0.1	− 0.7	− 1.9
FR		− 0.1	− 0.1						0.1		0.1	0.1
ES		− 0.1	− 0.1						0.1			0.1
IT		− 0.1	− 0.1						0.1			0.1
UK		− 0.1	− 0.1			− 0.1			0.1		0.1	0.1
DK	− 0.1	− 0.1	− 0.2					0.1	0.2	0.1	0.1	0.2
EU		− 0.2	− 0.4		− 0.2	− 0.7			− 0.2		− 0.2	− 0.5
	Carbon tax rates and grandfathered permit prices (DM per ton CO_2)											
DE	51	125	234	90	252	490	25	63	123	78	213	444
	Carbon emissions reductions by country- % of benchmark emissions											
DE	− 10	− 20	− 30	− 10	− 20	− 30	− 10	− 20	-30	− 10	− 20	− 30
FR		1	1				8	15	18	1	2	4
ES							1	2	3		1	2
IT			1					1	3			1
DK			1				2	5	8	1	3	5
UK			1				2	7	14	1	2	4
EU	− 3	− 6	− 8	− 3	− 6	− 9	− 1	− 2	− 3	− 2	− 5	− 7

Key: DE - Germany, FR - France, ES - Spain, IT - Italy, DK - Denmark, UK - United Kingdom, EU - European Union (all member countries above)

Source: [1]

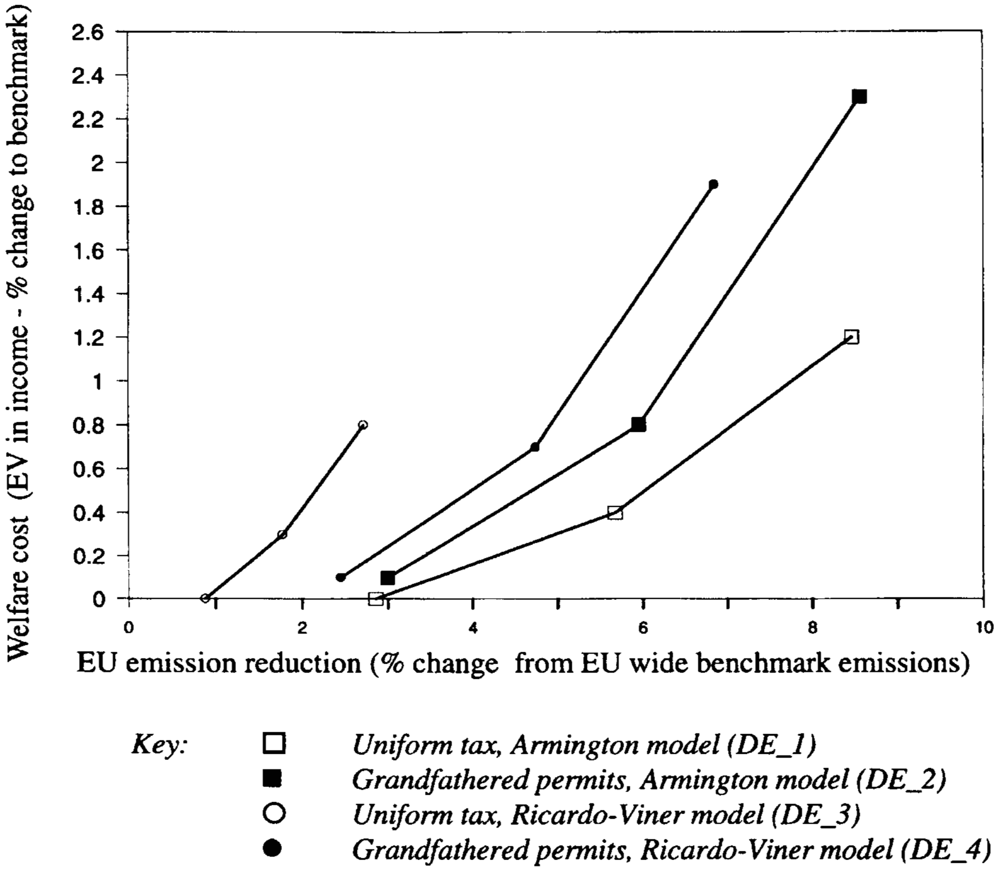

Figure 1 *Welfare cost for a representative agent in Germany of alternative schemes for reducing EU carbon emission through unilateral action by Germany.*

For each of the scenarios equilibria are computed for unilateral target reductions of 10%, 20% and 30%. It should be noted that leakage calculations from unilateral action of Germany do not account for extra-EU emission effects. The omission of leakage effects from outside the EU can be justified through the substantial share of the EU in German imports and exports. Table 2 summarizes the results.

Welfare cost for a representative agent is measured as a Hicksian equivalent variation (EV) in benchmark income. The equivalent variation indicates how much money a particular change that has taken place between equilibria, (here: counterfactuals DE_1 - DE_4 as compared to the benchmark equilibrium) is equivalent to.

The main findings are as follows:

- From a unilateral perspective where only national emissions are relevant for policy makers grandfathered permit systems induce significant additional cost as compared to uniform taxes.
- Leakage rates are very small with an Armington trade formulation and very high with a Ricardo-Viner approach. This explains why, from a global efficiency point of view, grandfathered permits are preferable to uniform taxes in the Ricardo-Viner model and not justified on global efficiency grounds in the Armington model. This crucial result is illustrated in Figure 1 below where the welfare cost of EU-wide reduction stemming from unilateral action are represented (neglecting leakage effects from outside the EU).
- Not surprisingly, an Armington trade specification increases the welfare cost of meeting unilateral (!) reduction targets as compared to the Ricardo-Viner trade specification independent of the policy design for unilateral abatement (here: uniform tax versus grandfathered permits). The lower the elasticities in trade, the higher are ceteris paribus the adjustment cost to environmental restrictions (see also Figure 1 where the markers on the abatement-cost-curves - from left to right - indicate emission reduction by Germany of 10%, 20% and 30%).

4 CONCLUSION

This paper has stressed the importance of trade specification for model based predictions on the economic and emission implications of alternative unilateral CO_2 mitigation strategies. In a Ricardo-Viner model, the induced trade effects of unilateral action would make a policy of grandfathered permits pareto-superior as compared to uniform taxes. In an Armington model leakage from trade in emission-intensive goods is low and from a global efficiency point of view unilateral policy is better advised to apply uniform taxes than a grandfathered permit system.

There are several issues that are absent from the analytical framework yet potentially important. First, the interaction of environmental restrictions with other taxes in the economy are neglected. Initial tax distortions can seriously affect the total cost of alternative environmental policy initiatives [3]. Secondly, environmental constraints involve adjustment costs of physical and human capital stocks which are not captured in the static framework above. Thirdly, monetary aspects (financial markets) are not incorporated. Beyond the discussion of trade specification these issues indicate lines of additional future research.

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Biographical notes

Christoph Böhringer was born in 1965 and studied Economics and Engineering (M.Sc.) from 1986 to 1991 at the Technical University in Karlsruhe. He received his Ph.D. in Economics at the University of Stuttgart in 1995 (summa cum laude distinction). Since 1996 he has been Head of Section 'Energy Economy Analysis' at the Institute for Energy Economics, the University of Stuttgart. He has a wide experience in both developing and applying computable general equilibrium models. He has published several articles and books in the field of energy, environmental and trade economics.