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**CARBON TAXES: AN INTERNATIONAL TAX OR  
HARMONIZED DOMESTIC TAXES?<sup>1</sup>**

by

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**Abstract**

The use of some kind of carbon tax is often proposed as part of an international climate policy. In particular, an international climate convention may require a harmonization of domestic carbon taxes. Alternatively, it could introduce a scheme of an international carbon tax, in which the governments of the participating countries pay a tax to an international agency which depends on the countries' CO<sub>2</sub> emissions. The paper shows that under quite general conditions, an international CO<sub>2</sub> tax can be designed so that it is both efficient and satisfies whatever distributional objectives one might have. It is also shown that harmonization of domestic CO<sub>2</sub> taxes will usually not have the same desirable properties as an international tax, although such an agreement is likely to be preferable to rigid agreements of the type "uniform percentage reductions of emissions".

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<sup>1</sup> The paper is based on research at CICERO and the Centre for Research in Economics and Business Administration (SNF), Oslo. It was presented at the European Economic Association Sixth Annual Congress (Cambridge, UK, 30 August-2 September, 1991), and will be published in *European Economic Review* in 1992.

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## 1. Introduction

At least since Pigou, it is well known that emission taxes are efficient instruments in environmental policy. It is therefore not surprising that some kind of carbon tax often is proposed as part of an international climate policy. It is, however, not always clear exactly what kind of carbon tax the proponents have in mind. It is important to distinguish between three types of carbon taxes:

- a domestic tax to achieve a domestic target
- an international carbon tax
- internationally harmonized domestic taxes

After a brief discussion of the first of these three types of carbon taxes in section 2, sections 3 and 4 discuss the two latter types of carbon taxes. It is for these two latter types of carbon taxes that the tax rate(s) are determined as part of an international greenhouse gas agreement. It is shown that provided emissions of CO<sub>2</sub> can be monitored at negligible costs, an international carbon tax is superior to harmonized domestic taxes.

## 2. A domestic carbon tax

A domestic carbon tax is relevant no matter how a country's emission target is determined. A country may have a unilateral policy of reducing CO<sub>2</sub> emissions; it may have a target level imposed on it through some rigid type of international agreement<sup>3</sup>; or it may have chosen its own emission level taking account of the price it has to pay for emission permits under an international agreement involving tradeable emission permits. No matter how the target level of emissions is determined, a domestic carbon tax is superior to most other policy instruments to achieve the target level of emissions, provided we are considering a country which has reasonably well functioning markets.

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<sup>3</sup> e.g. a uniform percent reduction of emissions for all participating countries.

### 3. An international carbon tax

An international tax could be designed in the following way: The government of each country pays a tax, proportional to its CO<sub>2</sub> emissions, to an international agency. The tax revenue (minus administrative costs) is reimbursed to the governments of the participating countries according to some specified rules. Without loss of generality, we may think of these rules as a set of fixed reimbursement shares. Assuming that each country is so small that it considers both total CO<sub>2</sub> emissions and total tax revenue as (practically) independent of its own CO<sub>2</sub> emissions, it also considers its own reimbursement as given, since this reimbursement is a constant share of the total tax revenue.<sup>4</sup> A country which maximizes its national income therefore chooses its emission level so that the sum of CO<sub>2</sub> taxes paid to the international agency and its domestic costs of reducing CO<sub>2</sub> emissions are minimized. This cost minimization implies that CO<sub>2</sub> emissions should be chosen so that the marginal cost of reducing CO<sub>2</sub> emissions is equal to the international tax rate per unit of CO<sub>2</sub> emissions. Since this tax rate is the same for all countries, we thus get an outcome in which the marginal cost of reducing CO<sub>2</sub> emissions are equal for all countries. This is the condition for international cost efficiency, defined as an emission pattern which achieves a goal for world wide emissions at as low costs as possible. An international CO<sub>2</sub> tax of the above type thus gives a distribution of CO<sub>2</sub> emissions which minimizes the costs of reaching a specified level of total CO<sub>2</sub> emissions. Total CO<sub>2</sub> emissions follow from the choice of the tax rate: the higher the tax rate, the lower are total emissions.

An important feature of the scheme above is that no matter how the tax revenue is reimbursed, the end result is an efficient allocation of emissions between countries. The distribution of total costs (i.e., costs of reducing emissions plus net taxes) between the participating countries is determined by the reimbursement rules. These rules can thus be determined purely from considerations of fairness. It is beyond the scope of the

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<sup>4</sup> See Hoel (1991a,c,d) for a discussion of the complications which arise if some countries are "large", in the sense that they do not ignore their own influence on total emissions.

present paper to discuss various concepts of "fairness". However, in order to achieve broad voluntary participation in an agreement, a plausible minimum requirement is that each country regards itself better off under the agreement than without any international cooperation<sup>5</sup>.

In the discussion above, each country has been assumed to maximize its national income, defined as its GDP minus net tax payments to the international agency. This is obviously a drastic simplification compared to real world policy goals. An important question is therefore to what extent our conclusions from previous sections remain valid with more complex preferences and/or various market failures and constraints on economic policy. In particular: How robust is the conclusion that an international CO<sub>2</sub> tax (combined with some reimbursement rules) gives an efficient allocation of CO<sub>2</sub> emissions between countries?

To see whether or not a uniform international CO<sub>2</sub> tax is efficient, consider the welfare function  $w_j(v_j, s_j)$ , where  $v_j$  is emissions from country  $j$ , while  $s_j$  is net transfers to country  $j$  from other countries. This function is defined as follows:

$$(3.1) \quad w_j(v_j, s_j) = \max_{x_j} \{u_j(x_j) \text{ s.t. } x_j \in X_j(s_j); v_j = f_j(x_j)\}$$

Here  $x_j$  is a vector of economic variables, such as production and consumption of different goods, employment in particular sectors, various prices, policy instruments such as taxes and subsidies, etc. The objective function of the country is  $u_j(x_j)$ , and may depend in a complex way of all variables included in the vector  $x_j$ . The feasible

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<sup>5</sup> For a further discussion of issues of fairness and of the decision of whether or not to participate in an international climate agreement, see Barrett (1989, 1990), Grubb (1989), Hoel (1991b), Pearce (1990) and Welsch (1991).

set  $X_j$  of possible  $x_j$ -vectors may depend on the net transfers from abroad<sup>6</sup>. Finally, total emissions depend on the vector  $x_j$ , usually in a very simple way.<sup>7</sup>

Since  $u_j(x_j)$  is a very general function, and the constraints implied by  $X_j(s_j)$  may include all relevant institutional constraints, the welfare function  $w_j(v_j, s_j)$  is very general. A reasonable assumption is that  $w_j$  is strictly increasing in  $s_j$ . Moreover, we assume that  $w_j$  is increasing in  $v_j$  for  $v_j$ -values below some critical value.

Given a constraint on total emissions, denoted by  $V$ , an efficient  $(v_1, \dots, v_N, s_1, \dots, s_N)$  vector is defined by the following maximization problem:

$$(3.2) \quad \begin{array}{ll} \text{Maximize} & \sum_i \alpha_i w_i(v_i, s_i) \\ \text{s.t.} & \sum_i v_i \leq V \\ \text{and} & \sum_i s_i = 0 \end{array}$$

where the  $\alpha_i$ 's are some non-negative weights. The solution to this maximization problem of course depends on the vector  $\alpha = (\alpha_1, \dots, \alpha_N)$ . Whatever the  $\alpha$ -vector is, the solution to (3.2) must satisfy the condition

$$(3.3) \quad \frac{w_{1v}}{w_{1s}} = \dots = \frac{w_{Nv}}{w_{Ns}}$$

(where  $w_{jv} = \partial w_j / \partial v_j$ , etc.). All allocations of  $(v_1, \dots, v_N, s_1, \dots, s_N)$  satisfying (3.3) are thus efficient in standard economic terminology. Which of these efficient allocations is regarded as best depends on the  $\alpha$ -vector.

The special case in which the objective of each country is to maximize its national income is given by  $w_j = r_j(v_j) - s_j$ , where  $r_j(v_j)$  is country  $j$ 's GDP. In this case

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<sup>6</sup> In the optimization problem below, the sum of emissions from all countries are exogenous, and is therefore not explicitly included as a variable which will affect  $u_j$  and possibly  $X_j$ .

<sup>7</sup> If one only considers CO<sub>2</sub> emissions from fossil fuels, the function  $f_j$  will be a linear function of the use of different types of fossil fuels.

(3.3) implies that the marginal income of emissions,  $r_j'(v_j)$ , should be equalized across countries. For this special case there is thus a unique efficient emission vector  $(v_1, \dots, v_N)$ , while the vector  $(s_1, \dots, s_N)$  will depend on the  $\alpha$ -vector. For more general  $w_j$ -functions, however, the vector  $(v_1, \dots, v_N)$  will depend on the  $\alpha$ -vector.

Consider an international tax on CO<sub>2</sub> emissions. Country  $j$  pays a tax equal to  $tv_j$ , and is given a reimbursement equal to  $\beta_j tV$ . Without loss of generality we may ignore other transfers between countries, so that  $s_j = -tv_j + \beta_j tV$  and  $w_j = w_j(v_j, -tv_j + \beta_j tV)$ . By assumption, country  $j$  regards  $t$ ,  $\beta_j$  and  $V$  as exogenous, so that maximization of  $w_j(\cdot)$  implies

$$(3.4) \quad \frac{w_{jv}}{w_{js}} = t$$

It is immediately clear from (3.3) and (3.4) that as long as all countries face the same CO<sub>2</sub> tax  $t$ , an efficient allocation of emissions is reached.

Notice that any efficient allocation  $(v_1^*, \dots, v_N^*, s_1^*, \dots, s_N^*)$ , i.e. a solution to (3.2) for any non-negative  $\alpha$ -vector, may be reached by an international CO<sub>2</sub> tax and a suitable  $\beta$ -vector. The appropriate CO<sub>2</sub> tax follows directly from (3.3) and (3.4):

$$(3.5) \quad t = \frac{w_{jv}(v_j^*, s_j^*)}{w_{js}(v_j^*, s_j^*)}$$

and the appropriate tax reimbursement vector  $\beta$  follows from the equality  $s_j^* = -tv_j^* + \beta_j t \sum_i v_i^*$ , giving



$$(3.6) \quad \beta_j = \frac{s_j^* + tv_j^*}{t \sum_i v_i^*}$$

In particular, all efficient allocations satisfying the constraint

$$(3.7) \quad w_j(v_j^*, s_j^*) \geq w_j^0 \quad \forall j$$

may be reached through a suitable choice of  $(t, \beta)$ , where  $w_j^0$  is country  $j$ 's welfare level under the non-cooperative equilibrium.<sup>8</sup>

#### 4. Harmonized domestic taxes

Consider next an international agreement which instead of an international tax requires each participating country to impose a specific domestic carbon tax on its CO<sub>2</sub> emissions. Wouldn't such an agreement have properties which are quite similar to those of the international carbon tax discussed above? The answer is no: The most important difference is that an agreement of harmonizing domestic carbon taxes would have no built in mechanism to make the distribution of burdens satisfactory. As a first approximation (see below for other differences), harmonized domestic taxes would be similar to an international tax where the reimbursement rules happened to be set so that each county in equilibrium pays zero net taxes. This gives a particular cost distribution between countries, which only by chance would be reasonably fair by any chosen criterium.

Distributional issues aside, there are other problems with an international agreement of harmonizing domestic CO<sub>2</sub> taxes: It is not clear what such an agreement implies, in particular if some of the participating countries are non-market economies.

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<sup>8</sup> The results above should not come as any surprise: As John Moore pointed out to me in private conversation, they follow directly from the two fundamental theorems of welfare economics applied to the present context.

Even in market economies, it is not clear whether such a harmonized CO<sub>2</sub> should be in addition to various other domestic taxes on fossil fuels the countries might have, or instead of all existing taxes on fossil fuels. If existing taxes reflect domestic externalities in transportation etc., an internationally agreed upon CO<sub>2</sub> tax ought to be an addition to existing taxes, while one could argue that the CO<sub>2</sub> tax should take the place of other taxes on fossil fuels if these taxes are pure revenue raising taxes.

Another problem with an international agreement requiring equal domestic CO<sub>2</sub> taxes is the free rider problem: It is in each country's interest to have little or no restrictions on their own CO<sub>2</sub> emissions, given the CO<sub>2</sub> emissions from other countries. If a country is required to have a CO<sub>2</sub> tax through an international agreement, it is therefore in the interest of the country to try to make this tax be as ineffective as possible. One way to do this is to reduce other domestic taxes on fossil fuels, e.g. taxes on gasoline which several countries have for domestic purposes. Even if a country doesn't directly reduce such domestic taxes, it might raise them less than it would have, had it not been for the imposed CO<sub>2</sub> tax. Another way to reduce the effect of the imposed CO<sub>2</sub> tax is to manipulate prices of other domestic goods. Roughly speaking, a country should tax close substitutes to fossil fuels and subsidize complements. Obvious examples are taxes on other types of energy (e.g. hydroelectric power) and subsidies on automobiles and air conditioning. This type of price policy will reduce the effect of an imposed CO<sub>2</sub> tax on a country's consumption and production pattern, and thereby reduce the cost for the country, even though the country in a formal sense is sticking to the international agreement. In spite of the possibility of each country to reduce the effect of a CO<sub>2</sub> tax, any realistic goal of global CO<sub>2</sub> emissions could probably be achieved with a sufficiently high CO<sub>2</sub> tax. The point is, however, that each country's attempts to reduce the effect of the CO<sub>2</sub> tax leads to inefficiencies at the national level: Each country could have achieved whatever emission level it has in equilibrium at a lower cost if it was allowed to reduce the CO<sub>2</sub> tax and at the same time remove all counteracting policies of the type mentioned above.

## 6. Concluding comments.

The analysis above suggests that an international tax has some advantages over internationally harmonized domestic taxes. However, it may be politically more realistic to reach an agreement of harmonizing domestic taxes rather than setting up the necessary international institutional framework for an international carbon tax. In any case, harmonization of domestic taxes is likely to be preferable on efficiency grounds to rigid types of agreements of the type "uniform percentage reductions of emissions". It might also be easier to monitor compliance with an agreement of harmonizing domestic taxes than the necessary monitoring of emissions under an international carbon tax: Although CO<sub>2</sub> emissions are closely linked to the burning of fossil fuels, and one today has reasonably good statistics over uses of such fuels, this need no longer be the case if one introduces an international tax on the use of fossil fuels.

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