The Private Provision of International Impure Public Goods: the Case of Climate Policy

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Abstract

Impure public good provision is regularly inefficient low on an international scale. Like in the case of pure public goods, not supranational coercive authority exists that can enforce an efficient provision to the impure public good. Consequently, a decentralized and voluntary negotiation between countries has to take place in order to improve the suboptimal outcome.

This paper investigates a voluntary scheme which induces individual countries to raise their contribution to the public good to a Pareto efficient level. It is analyzed whether and how the occurrence of privatising features of the public good affect the functioning of the scheme.

Keywords: climate policy, impure public goods, environmental taxation, international transfers

JEL Classification: Q38, H23, D62

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1 Introduction

As Nordhaus (2006b: 90) stresses “a few public goods are really pure because most public goods have some privateness at different points of space or time.” Such goods which - in contrast to pure public goods – generate co-effects that can be exclusively consumed by the agent producing these goods are called impure public goods. Impure public goods play an important role in all spheres of life, but especially on an international level the problem of inefficiently low provision of impure public goods is prominent. This is due to the fact that there is no transnational authority which can enforce the efficient provision of international impure public goods.

There are plenty of examples of international impure public goods which were analyzed in the economics literature. Sandler and Murdoch (1990) as well as Sandler and Hartley (2001) regard military activity of the NATO alliance in an impure public good setting. Kotchen (2005, 2006) develops an impure public good approach in order to analyze environmentally friendly consumption producing an international public characteristic, e.g., in the shape of the protection of tropical biodiversity. Pittel and Rübbelke (2008) investigate international climate policy, which simultaneously reduces greenhouse gas emissions as well as local/regional air pollution, in a game-theoretic framework. They find that the inclusion of private (or domestic public) co-effects into the analysis improves the outcome of international negotiations on climate change.

Although international public goods are in general impure public, in scientific analyses they are treated regularly like pure public goods. This facilitates the analysis, but important aspects of the regarded problems may be ignored with serious implications for policy recommendations. Therefore, it is reasonable to test whether research results still hold when impure publicness is introduced and whether proposed policy schemes are affected in their functionality.

Recently, a couple of price-influencing schemes to generate an efficient provision of the international public good ‘climate protection’ have been proposed. Nordhaus (2006a: 32) suggests employing “essentially a dynamic Pigovian pollution tax for a global public good”. An international carbon tax scheme where no international emission limits are dictated is considered to have several significant advantages over the Kyoto mechanism. This scheme could also contain side-payments in order to motivate countries to participate.[1]

A proposal employing taxes and side-payments in order to overcome inefficient low production of international public goods has also been provided by Altemeyer-Bartscher, Rübbelke and Sheshinski[2] (2009). Within a pure public good model they regard climate protection as a global public good and develop a scheme which induces countries to provide this public good in a globally efficient way. As Lau, Sheshinski and Stiglitz (1978: 269) remark: "When government's production of public goods is financed by distortionary taxes, the conventional optimality rule of equality between the sum of marginal rates of substitution and the marginal rate of transformation has to be modified so as to take account of the excess-burden created by the means of finance." Yet, the ARS scheme does not involve distortionary taxation,[3] but, contrarily, the public good provision (climate protection or mitigation of greenhouse gases) is induced by corrective taxation internalizing externalities. The incentives for countries to raise their protection efforts from a suboptimal low uncoordinated level to the Pareto-efficient level are generated by mutual bribing of countries. Countries offer international transfers to their counterparts in order to bring about higher environmental taxation rates in the transfer-receptor countries, and, with it, Pareto efficient protection levels. The transfers are in turn funded by the revenues obtained from environmental taxation. A critique concerning the ARS scheme is that the corrective-tax base might be insufficient to fund the international transfers.

In this paper we will suggest two important extensions to the analysis by ARS, which will address the following two aspects. First, we check whether the positive result obtained by the mechanism proposed by ARS also holds in an impure-public-good setting. Second, we investigate the implications of impure publicness for the practicability of the proposed scheme.

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[1] "Additionally, poor countries might receive transfers to encourage early participation", Nordhaus (2006: 32).

[2] Subsequently referred to as ARS.

[3] In second-best situations it may be desirable to impose taxes also on goods which do not produce externalities (Green and Sheshinski 1976:798). For a discussion of such a case, see Sheshinski (2004).

The results will provide some indication whether it is helpful to pay more regard to private (or domestic) co-effects in international negotiations on international public goods, e.g., the international negotiations on climate change. Intuitively, a positive influence of the integration of co-effects is expected, since the occurrence of additional externalities will raise the efficient tax rates. However, as we will see, this does not necessarily imply a rise in the tax revenues available for international transfers. Consequently, although the integration of ancillary effects induces higher abatement levels and improves the global welfare, the consequences for the practicability of the ARS scheme are not unambiguous.

2 Climate-unfriendly Consumption is a Joint Production

Climate policy generates different kinds of benefits simultaneously. Primary benefits are the benefits derived from pursuing climate policy's primary aim, which is climate stabilization (Markandya and Rübbelke 2004). In contrast, according to the IPCC (2001), ancillary benefits "are the monetized secondary, or side benefits of mitigation policies on problems such as reductions in local air pollution associated with the reduction of fossil fuels, and possibly indirect effects on congestion, land quality, employment, and fuel security." Considered the other way round climate threatening consumption like the consumption/burning of fossil fuels causes two different kinds of costs. One group of costs is associated with the global warming effect of induced greenhouse gas (GHG) emissions and the other group is concerning negative local or regional effects like air pollution. Therefore, we can distinguish three different characteristics of climate-unfriendly consumption: a private effect to the individual consumer and two negative externalities of which one is global, while the other is more domestic from an individual country's point of view (see Figure 1).

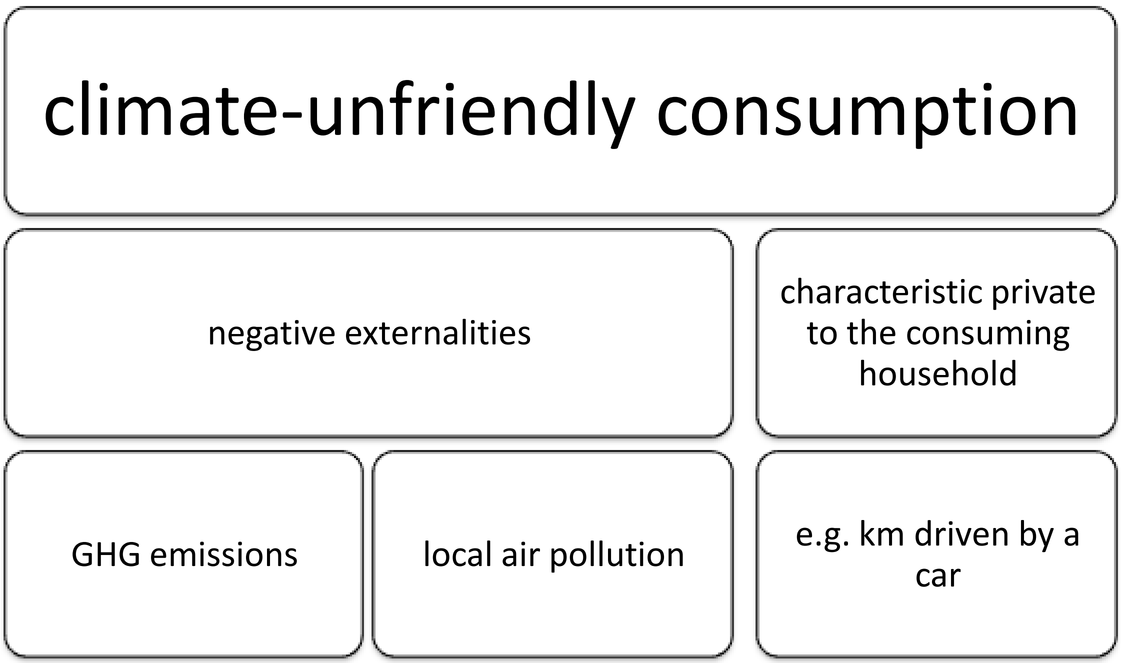

Figure 1: Joint Production of Private, Domestic and Global Characteristics.

3 The Basic Model

3.1 Transboundary Pollution Spillovers

In a two-country setting, we model the case of private consumption generating negative global spillover effects (GHG emissions) harming all countries i ($i = 1,2$) as well as negative domestic externalities in the shape of local emissions exclusively affecting the emitting country respectively.[4]

In country i a representative household's production of both externalities accompanies its consumption of a polluting private good, which amounts to x_i. It also consumes a second (clean) private good of the amount y_i, which is not associated with any externality. It is assumed that households behave competitively, i.e., they ignore their own effect on total pollution. Furthermore, they take the other agents' pollution levels as given. The global level of environmental externalities perceived in country i amounts to $\phi_2=\phi_2(X_1,X_2)=\phi_2(X_1+X_2)$ where X_1 represents the total amount of the pollution-generating private good consumption in country 1 and X_2 is the respective consumption in country 2. By means of the specific functional form of ϕ_2 we take into account that global environmental externalities are determined by the aggregated global greenhouse gas (GHG) emissions caused by the consumption of the polluting private good. Such pollution is a perfect substitute among countries, i.e. it does not make a difference for either country where the GHG emission is produced. The domestic pollution in country i is represented by $\phi_{1i}=\phi_{1i}(X_i)$. An eco-tax in the shape of an excise tax is levied which burdens the consumption of the polluting commodity.[5]

[4] The case of one-sided spillovers has been analyzed by Rübbelke and Sheshinski (2005).
[5] "In the case of reciprocal consumption externalities, the common interpretation of the Pigouvian principle calls for taxes on the externality-creating commodities" (Green and Sheshinski 1976: 798).

3.2 The Individual Household's Maximization Problem

The maximization problem of a representative household in country *i* can be expressed as follows:

$$\text{Max!} \quad u_i(x_i, y_i, \phi_{1i}, \phi_2) \tag{1}$$

s.t.

$$(p + t_i)x_i + y_i = m_i + \tau_i - \sigma_i,$$

where m_i denotes the level of the representative household's income, t_i denotes the excise tax rate, $\tau_i = t_i x_i$ stands for the tax funds raised from the representative household and σ_i is the amount of tax funds τ_i redistributed to others, such that $\tau_i - \sigma_i$ is the amount of tax funds which the representative household gets back from its government. It is assumed that the households are *naive*, i.e., they do not consider the effects of their behavior on τ_i and σ_i. This is plausible because the impact of a single household onto the rest of the world is negligible.

We obtain the following first-order conditions:

$$\frac{\partial u_i}{\partial x_i}(x_i, y_i, \phi_{1i}, \phi_2) - \lambda(p + t_i) = 0, \tag{2}$$

$$\frac{\partial u_i}{\partial y_i}(x_i, y_i, \phi_{1i}, \phi_2) - \lambda = 0, \tag{3}$$

$$px_i + y_i - m_i + \sigma_i = 0. \tag{4}$$

3.3 Take-it-or-leave-it Offer

Regional welfare maximizing decision makers in country *i* do not take into account negative external effects they exert on their neighbouring country *j* ($j=1,2$ and $j \neq i$) and hence raise inefficiently low eco-taxes on the consumption of the dirty good X_1. One method of coordinating environmental policy among regions to overcome inefficiently high transnational externality production is the implementation of a system of international side-payments. We assume that each country can make a take-it-or-leave-it offer. Country *i*, for example, could offer $\left(S_j, t_j\right)$, i.e. country *i* offers a transfer payment S_j which is channeled to country *j* in order to induce this country to raise its eco-tax rate t_j to a certain level desired by *i*. Country *j* can either accept or reject the offer. We assume that both countries can make binding commitments with respect to their transfer payment and eco-tax levels. Local governments simultaneously offer take-it-or-leave-it contracts. In doing so, each country anticipates the subject matter (S_k, t_k), with $k = i,j$, of the contract offered by the opponent.

3.4 The First-best Policy

As a reference scenario we examine the maximization problem of a social planner who maximizes global welfare in our two-country world, i.e. the sum of both countries' welfare. We suppose that a country's welfare level is equal to the sum of the welfare levels enjoyed by the individual households located in the respective country:

$$\max_{X_1,X_2} W = U_1(X_1, \phi_{11}, \phi_2) + U_2(X_2, \phi_{12}, \phi_2)$$

$$\text{s. t.} \qquad p(X_1 + X_2) + Y_1 + Y_2 = M,$$

where $M_1 + M_2 = M$ denotes the sum of national income M_1 in country 1 and of national income M_2 in country 2. The first-order conditions are:

$$\frac{\partial U_1}{\partial X_1} + \frac{\partial U_1}{\partial \phi_{11}}\frac{\partial \phi_{11}}{\partial X_1} + \frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1} + \frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1} = p\lambda \tag{5}$$

$$\frac{\partial U_2}{\partial X_2} + \frac{\partial U_2}{\partial \phi_{12}}\frac{\partial \phi_{12}}{\partial X_2} + \frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2} + \frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2} = p\lambda \tag{6}$$

where the third terms on the LHS of (5) and (6) respectively denote the marginal external effects of pollution. From equations (5) and (6) as well as equation (7) we obtain the Pareto-efficient tax rates:

$$t_1^{fb} = \frac{\frac{\partial U_1}{\partial X_1}}{\lambda} - p = -\frac{\frac{\partial U_1}{\partial \phi_{11}}\frac{\partial \phi_{11}}{\partial X_1} + \frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1} + \frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1}}{\lambda} \tag{7}$$

and

$$t_2^{fb} = \frac{\frac{\partial U_2}{\partial X_2}}{\lambda} - p = -\frac{\frac{\partial U_2}{\partial \phi_{12}}\frac{\partial \phi_{12}}{\partial X_2} + \frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2} + \frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}}{\lambda} . \tag{8}$$

The first-best optimal eco-tax policy $\left(t_1^{fb}, t_2^{fb}\right)$ fully internalises pollution externalities.

4 Decentralized Policy

Let us turn to the case where individual countries voluntarily negotiate about international pollution abatement. Each individual country's welfare is affected by pollution $\boldsymbol{\phi_2}$. The pollution in turn depends on the consumption level in both countries, so that both countries will have incentives to offer a take-it-or-leave-it contract to their neighbour in order to influence the eco-tax policy of the opponent.

Relationship between Taxes and Transfers in Country 2

The government of country 1 could benefit by inducing country 2 to raise an eco-tax. We suppose that country 1 will therefore provide a take-it-or-leave-it offer to country 2. However, in the case of reciprocal externalities – which we will focus on – country 2 also provides such an offer to its opponent. In order to fulfill the individual rationality condition no country should be better off by unilaterally rejecting the offer of its opponent. Let us consider the condition under which country 2 will accept the other country's offer; it must hold:

$$U_2\left(X_2(t_2^*, S_1, S_2, X_1), Y_2(t_2^*, S_1, S_2, X_1), \phi_{12}\big(X_2(t_2^*, S_1, S_2, X_1)\big), \phi_2\big(X_1, X_2(t_2^*, S_1, S_2, X_1)\big)\right) \geq$$
$$U_2\left(X_2(t_2, S_1, 0, X_1), Y_2(t_2, S_1, 0, X_1), \phi_{12}\big(X_2(t_2, S_1, 0, X_1)\big), \phi_2\big(X_1, X_2(t_2, S_1, 0, X_1)\big)\right),$$

(9)

where S_2 represents the sum of transfers received from country 1. We claim that country 2 will only accept to implement a tax when its utility after the tax (LHS) remains at least equal to the state before the implementation of a tax (RHS). X_2 is the equilibrium amount of the polluting good consumed in country 2 and Y_2 is the respective amount of the second private good. The LHS denotes the welfare of country 2 if it accepts country 1's offer $\left(S_2, t_2^*\right)$. In case of a rejection of the offer it raises an individual rational tax t_2.

Assuming that condition (9) holds with equality and total differentiating yields

$$\left(\frac{\partial U_2}{\partial X_2}+\frac{\partial U_2}{\partial \phi_{12}}\frac{\partial \phi_{12}}{\partial X_2}+\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}+\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1}\frac{\partial X_1}{\partial X_2}\right)\left(\frac{\partial X_2}{\partial t_2^*}+\frac{\partial X_2}{\partial I_2}\frac{\partial S_2}{\partial t_2^*}\right)$$
$$+\frac{\partial U_2}{\partial Y_2}\left(\frac{\partial Y_2}{\partial t_2^*}+\frac{\partial Y_2}{\partial I_2}\frac{\partial S_2}{\partial t_2^*}\right)=0,$$

where I_2 is the net income in country 2. When we take account of conditions (2) and (3) and the differentiation of the sum of all households' budget constraints we can also write:

$$\left(t_2+\frac{\frac{\partial U_2}{\partial \phi_{12}}\frac{\partial \phi_{12}}{\partial X_2}}{\lambda}+\frac{\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}}{\lambda}+\frac{\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1}\frac{\partial X_1}{\partial X_2}}{\lambda}\right)\left(\frac{\partial X_2}{\partial t_2}+\frac{\partial X_2}{\partial I_2}\frac{\partial S_2}{\partial t_2}\right)+\frac{\partial S_2}{\partial t_2}=0$$

(10)

Rearranging terms yields:

$$\frac{\partial S_2}{\partial t_2}=-\frac{\left(t_2+\frac{\frac{\partial U_2}{\partial \phi_{12}}\frac{\partial \phi_{12}}{\partial X_2}+\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}+\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1}\frac{\partial X_1}{\partial X_2}}{\lambda}\right)\frac{\partial X_2}{\partial t_2}}{\left[1+\left(t_2+\frac{\frac{\partial U_2}{\partial \phi_{12}}\frac{\partial \phi_{12}}{\partial X_2}+\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}+\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1}\frac{\partial X_1}{\partial X_2}}{\lambda}\right)\frac{\partial X_2}{\partial I_2}\right]}$$

(11)

The amount of money which country 1 must at least pay to country 2 is uniquely determined by the choice of the tax rate t_2. In particular, S_2 is an increasing function of t_2 for all $t_2 < t_2^*$. Analogously, we can derive the marginal impact of t_1 on S_1.

4.1 Transfer-paying Country 1's Maximization Problem

Countries 1 and 2, both intend to maximize national welfare by making take-it-or-leave-it offers (S_2, t_2) and (S_1, t_1), respectively. In the simultaneous-move game country 1 can correctly anticipate (S_1, t_1) offered by country 2 and vice versa.

In the equilibrium both countries will accept the offers of their opponents respectively so that we can restrict our analysis to the following maximization problem:

$$\max_{t_2} U_1\big(X_1(t_1,S_1,S_2,X_2),Y_1(t_1,S_1,S_2,X_2),\phi_{11}(X_1),\phi_2(X_1,X_2)\big). \tag{12}$$

Maximization yields

$$\left(\frac{\partial U_1}{\partial X_1}+\frac{\partial U_1}{\partial \phi_{11}}\frac{\partial \phi_{11}}{\partial X_1}+\frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1}\right)\left[\frac{\partial X_1}{\partial I_2}\frac{dS_2}{dt_2}+\frac{\partial X_1}{\partial X_2}\left(\frac{\partial X_2}{\partial t_2}+\frac{\partial X_2}{\partial I_2}\frac{dS_2}{dt_2}\right)\right] + \frac{\partial U_1}{\partial Y_1}\left[\frac{\partial Y_1}{\partial I_2}\frac{dS_2}{dt_2}+\frac{\partial Y_1}{\partial X_2}\left(\frac{\partial X_2}{\partial t_2}+\frac{\partial X_2}{\partial I_2}\frac{dS_2}{dt_2}\right)\right]+\frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}\left[\frac{\partial X_2}{\partial t_2}+\frac{\partial X_2}{\partial I_2}\frac{dS_2}{dt_2}\right] = 0 \tag{13}$$

In order to derive country 1's optimal choice of t_2, we insert (7) and (8) aggregated over all households in country 1 and the derivative of the budget constraint for t_2, which is $\frac{\partial X_1}{\partial t_2}+\frac{\partial Y_1}{\partial t_2}=-\frac{\partial S_2}{\partial t_2}$ into (13). Then we obtain

$$\left(t_1\frac{\partial X_1}{\partial X_2}+\frac{\frac{\partial U_1}{\partial \phi_{11}}\frac{\partial \phi_{11}}{\partial X_1}+\frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1}}{\lambda}\frac{\partial X_1}{\partial X_2}+\frac{\frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}}{\lambda}\right)\left(\frac{dX_2}{dt_2}+\frac{\partial X_2}{\partial I_2}\frac{dS_2}{dt_2}\right)=\frac{\partial S_2}{\partial t_2} \; . \tag{14}$$

In the simultaneous move game country 2 in turn counterbids a contract to country 1 so that we can write the following system of equations:

$$\frac{\partial S_2}{\partial t_2}\left[1-\left(t_1\frac{\partial X_1}{\partial X_2}+\frac{\frac{\partial U_1}{\partial \phi_{11}}\frac{\partial \phi_{11}}{\partial X_1}+\frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1}}{\lambda}\frac{\partial X_1}{\partial X_2}+\frac{\frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}}{\lambda}\right)\frac{\partial X_2}{\partial I_2}\right]$$
$$=\left(t_1\frac{\partial X_1}{\partial X_2}+\frac{\frac{\partial U_1}{\partial \phi_{11}}\frac{\partial \phi_{11}}{\partial X_1}+\frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1}}{\lambda}\frac{\partial X_1}{\partial X_2}+\frac{\frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}}{\lambda}\right)\frac{dX_2}{dt_2}$$

(15)

$$\frac{\partial S_1}{\partial t_1}\left[1-\left(t_2\frac{\partial X_2}{\partial X_1}+\frac{\frac{\partial U_2}{\partial \phi_{12}}\frac{\partial \phi_{12}}{\partial X_2}+\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}}{\lambda}\frac{\partial X_2}{\partial X_1}+\frac{\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1}}{\lambda}\right)\frac{\partial X_1}{\partial I_1}\right]$$
$$=\left(t_2\frac{\partial X_2}{\partial X_1}+\frac{\frac{\partial U_2}{\partial \phi_{12}}\frac{\partial \phi_{12}}{\partial X_2}+\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}}{\lambda}\frac{\partial X_2}{\partial X_1}+\frac{\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1}}{\lambda}\right)\frac{dX_1}{dt_1}$$

Inserting equation (11) the equivalent marginal effect for country 1 into the system of equations (15) shows that the two countries with reciprocal spillover-effects can coordinate to play a first-best optimal eco-tax policy by a system of take-it-or-leave-it offers:

$$t_1^*=\frac{\frac{\partial U_1}{\partial \phi_{11}}\frac{\partial \phi_{11}}{\partial X_1}+\frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1}+\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_1}}{\lambda}$$

(16)

$$t_2^*=\frac{\frac{\partial U_2}{\partial \phi_{12}}\frac{\partial \phi_{12}}{\partial X_2}+\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}+\frac{\partial U_1}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}}{\lambda}$$

(17)

In the proposed efficiency-generating scheme, transfers are financed by revenues raised from Pigouvian taxes imposed within each country and any excess revenues are redistributed to households using lump-sum transfers. However, not necessarily the revenues cover the required funds required for the transfers. In such a case the mechanism may not lead to a full internalization of the spillovers.

5 Concluding Remarks

We examine a take-it-or-leave-it mechanism to combat global environmental externalities. Countries offer a contract to neighbouring countries to influence these countries' eco-tax policies. The contract includes the pledge to pay an income transfer to the neighbouring countries provided that these countries raise their eco-tax levels up to a level desired by the transfer-offering countries.

Welfare losses which may go along with an increase of eco-tax rates are compensated by the side-payments offered in the contracts. As a distinctive feature of our paper to the existing literature we propose a mechanism in which side-payments are financed by the revenue raised by means of the eco-taxes. Therefore there exists a double environmental dividend of these eco-taxes. On the one hand global externalities are corrected by means of the Pigouvian tax within the tax-raising country and on the other hand the respective tax revenue can be used for side-payments inducing other countries to further mitigate global environmental pollution.

Compared to the reference case where regional pollution is disregarded, the tax rates increase by the marginal regional external. Yet, higher tax rates do not necessarily imply higher tax revenues and hence more funds available for transfers. In the paper we derive conditions under which the tax revenues increase due to the domestic co-effects of global climate protection and hence, which improve the functionality of the transfer scheme.

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