POLICIES TO INTERNALIZE RECIPROCAL INTERNATIONAL SPILLOVERS

MARTIN ALTEMEYER-BARTSCHER
DIRK T. G. RÜBBELKE
EYTAN SHESHINSKI

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Abstract

An effective policy scheme to overcome the suboptimal low provision levels of global public goods is developed in this paper. By suggesting a decentralized approach to raise environmental public good provision levels we take account of the lack of a coercive global authority that is able to enforce efficient international environmental regulations. In our model individual regions voluntarily commence international negotiations on public good provision, which are accompanied by side-payments. These side-payments are financed by means of regional externality-correcting taxes. Side-payments and national tax rates are designed in a mutually dependent way. The decentralized scheme we recommend for approaching Pareto efficient Nash equilibria is based on the ideas of Coasean negotiations and Pigouvian taxes. As it is implementable for a wide class of Nash solutions, it is applicable to various international externality problems.

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Martin Altemeyer-Bartscher
Chemnitz University of Technology
09107 Chemnitz
Germany
martin.altemeyer-bartscher@wirtschaft.tu-chemnitz.de

Dirk T. G. Rübbelke
Chemnitz University of Technology
09107 Chemnitz
Germany
d.ruebbelke@wirtschaft.tu-chemnitz.de

Eytan Sheshinski
Hebrew University of Jerusalem
Mount Scopus
91905 Jerusalem
Israel
mseytan@mscc.huji.ac.il

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1 Introduction

Threats to the global environment have become a main issue on the political agenda of countries. Since policies to combat these threats represent global public goods, free rider incentives prevail in the international arena. Due to the absence of an international authority, which can enforce environmental regulations on a global scale and consequently helps to overcome free-rider behavior, voluntary transnational environmental agreements are considered to be most capable of generating a more efficient environmental protection level.

Most prominent examples of international environmental agreements are the Montreal Protocol which stipulates rules to protect the ozone layer and the Kyoto Protocol which contains rules for climate protection. The latter gives reasons for fierce disputes about the best way to combat global warming. This holds even more since the Kyoto Protocol expires in 2012 and a new international regulation – a post-Kyoto mechanism – has to be found.

Recently, a price-influencing international climate protection scheme has been proposed by Nordhaus (2006) as a proper successor of the quantity approach of the Kyoto type. “This is essentially a dynamic Pigovian pollution tax for a global public good” (Nordhaus (2006: 32)). 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]

In this paper we will elaborate Nordhaus’ proposal. We will analyze how individual countries or regions could negotiate the design of an international carbon tax scheme in a decentralized way. Such decentralized bargaining is necessary, since there is no central global authority that can appoint compulsory tax rates to individual nations. In the scheme we suggest, countries offer side-payments to their opponents that are conditional on the level of the environmental tax rates implemented in the transfer-receiving opponent country. For simplicity we focus on a world consisting of two

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

regions which enter into mutual negotiations. We investigate whether our scheme could Pareto-improve the outcome in global environmental protection or even generate a Pareto-efficient result.

In line with Rübbelke and Sheshinski (2005) we analyze the effects of taxes and transfers on the level of externalities. However, our analysis differs significantly from their investigation, since ours deals with reciprocal global externalities while their analysis considers asymmetric (unilateral) international externalities with limited geographical impact. The asymmetry they consider is an element which is in some sense equivalent to the desire to redistribute in Sheshinski (2004). In Sheshinski's analysis the tax on the externality-generating good contains a uniform component (efficiency factor) and a component that varies across households and reflects an income redistribution objective (redistributive factor). In contrast to Sheshinski (2004), the asymmetry in the model suggested by Rübbelke and Sheshinski (2005) just results from an asymmetric distribution of pollution. In analyzing the asymmetric international regional problem they combine the ideas of Coase (1960) and Pigou (1932) of solving externality problems. In our investigation of global environmental problems we revive this idea of combining the ideas of Coase (1960) and Pigou (1932).

An important advantage of the mechanism is that there is no need for a central authority to regulate environmental policy. In practice there is in general a low willingness of regional governments to give away power to a central authority, see Falkinger, Hackl and Pruckner (1996). Furthermore, a simple scheme of mutual side-payments is easy enough to be understood by local authorities. In particular, it emerges to be difficult in real word applications to determine a baseline against which countries set their environmental policy. Nordhaus (2006) points out that especially quantity limits are troublesome because of different economic growth and heterogeneous technological circumstances across regions. However, in our paper the base line of environmental policy is simply the individual rational environmental tax raised by regional decision makers. Countries' eco-tax policy is evaluated relative to its base line, so that the opponent country does only pay transfers for the internalization of transboundary externalities.

Many solutions to the free-rider problem call for coercion in order to internalize transboundary external effects. In line with Guttman (1978, 1987), Danziger and Schnytzer (1991) as well as Guttman and Schnytzer (1992), we propose a mechanism which neither postulates any property right on pollution nor requires any negations prior to the game played.[2] Local governments are free to raise eco-taxes so that the take-it-or-leave-it offer must meet an individual rationality constraint. As a distinctive feature of our paper to the existing literature we consider economies in which the efficient allocation of private goods is implemented by an eco-tax. The eco-tax revenue is then used to finance the side-payments to correct for transboundary externalities which stem from the neighbouring country. Hence, the suggested policy generates a double environmental dividend: 1) the own eco-tax corrects national market failures (externalities due to inefficiently high environmental pollution) and 2) the raised eco-tax funds induce a correction of market failures (transnational negative externalities) in the neighbouring country. By means of the tax-transfer scheme a first-best optimum can be set up.

With respect to the literature, several contributors have analysed the internalization of reciprocal externalities by means of a transfer mechanism. Oates (1972), for example, examines the problem of reciprocal externalities in the provision of local public goods arising in a federal state. He analyses the design of federal grants which achieve an efficient allocation in the federation. Buchholz and Konrad (1995) investigate the impact of strategic transfers on the private provision of public goods. Yet, the transfers they regard are of an unconditional type. Barrett (1995) suggests collecting funds from industrialized countries in order to finance greenhouse gas abatement in developing countries. Therefore, the funds are transferred in a conditional way. Barrett (1995) recommends to collect these funds by means of a matching scheme – like the one suggested by Guttman (1978, 1987) –, because this scheme reduces the industrialized countries' incentives to take a free ride. Scheffran and Pickl (2000) also analyse conditionally transferred funds. They consider Joint Implementation measures in international climate policy, where the industrialized world can invest a fraction of its budget into new power plants in the developing world, using low-emission

[2] Althammer and Buchholz (1993) revive the analysis by Danziger and Schnytzer (1991) and reveal the true mechanism underlying the results of the analysis by Danziger and Schnytzer (1991). Barrett (1992) emphasizes the relevance of Guttman's (matching) approach as an effective means to move us closer to a fully cooperative outcome in international climate protection.

technology. Environmental technology transfer is also investigated by e.g. Stranlund (1996), Itoh and Tawada (2003) and Takarada (2005). In contrast, our paper considers monetary transfers.

Carraro and Siniscalco (1993, 1995) analyse transfers as a means to broaden stable coalitions in international environmental protection. In the case of symmetric countries this broadening of coalitions requires the introduction of a minimum degree of commitment. Botteon and Carraro (1997) show for the case of heterogeneous parties that transfers might help to expand coalitions even without any forms of partial commitment. Although the analysis of stable environmental coalitions is an important one, our analysis does not consider coalition formation. Instead we regard countries non-cooperatively choosing their environmental protection levels by comparing their marginal effective cost and benefits of environmental protection.

In our analysis we proceed as follows: In Section 2 we suggest a tax-transfer scheme to overcome inefficiencies and we present the features of our model. Section 3 is dedicated to the special case of a one-sided spillover. In Section 4 we extend the analysis to the case of reciprocal externalities. Finally, Section 5 concludes.

2 The Basic Model

2.1 Transboundary Pollution Spillovers

Consider the case of a reciprocal spillover effect harming country i ($i = 1,2$). Assume this effect to be a negative externality in the shape of transboundary environmental pollution. In country i a representative household's production of the externality accompanies its consumption of a private good which amounts to x_i. It also consumes a second private good of the amount y_i which is not associated with an 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 total environmental externalities perceived in country i amount to $\phi=\phi(X_1,X_2)$ 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. An eco-tax in the shape of an excise tax is levied which burdens the consumption of the polluting commodity.[3]

2.2 The Individual Household's Maximization Problem

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

$$\text{Max!} \qquad u_i(x_i, y_i, \phi) \tag{1}$$

s.t.

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

where m_1 denotes the level of the representative household's income, t_i denotes the excise tax rate, $\tau_i=t_ix_i$ 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 τ_i-σ_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.

We obtain the following first-order conditions:

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

$$\frac{\partial u_i}{\partial y_i}(x_i, y_i, \phi) - \lambda = 0, \tag{3}$$

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

2.3 Take-it-or-leave-it Offer

Regional welfare maximizing decision makers in country *i* do not take into account

[3] "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)).

negative external effects they exert on 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 (S_j, t_j), 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.

2.4 The First-best Policy

As a reference we examine the maximization problem of a social planner who maximizes global welfare, 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:

$$\max_{X_1, X_2} \; W = U_1(X_1, \phi) + U_2(X_2, \phi)$$

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

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 writes:

$$\frac{\partial U_1}{\partial X_1} + \frac{\partial U_1}{\partial \phi}\frac{\partial \phi}{\partial X_1} + \frac{\partial U_2}{\partial \phi}\frac{\partial \phi}{\partial X_1} = \text{p}\lambda \tag{5}$$

$$\frac{\partial U_2}{\partial X_2} + \frac{\partial U_2}{\partial \phi}\frac{\partial \phi}{\partial X_2} + \frac{\partial U_1}{\partial \phi}\frac{\partial \phi}{\partial X_2} = \text{p}\lambda, \tag{6}$$

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:

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

and

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

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

3 Unilateral Externalities

In this section we consider the special case of a one-sided pollution spillover-effect from country 2 to country 1. We assume that pollution is produced in both countries but it only affects welfare in country 1, i.e. for $\phi(X_1, X_2) > 0$ with $X_1, X_2 > 0$ it follows $\frac{\partial U_1}{\partial \phi} < 0$ and $\frac{\partial U_2}{\partial \phi} = 0$. One can think of the case that country 2 can easily adapt to the adverse effects of the global warming problem, while it will cause an important loss in country 1. Schelling (1992: 4-7), for example, pointed out that climate change would entail higher costs in countries with an important agriculture sector, while industrial states are less vulnerable to global warming.[4] Thus, country 2, which does not internalize consumption externalities in country 1, has no incentives to raise a positive eco-tax on the consumption of good X_2. However, country 1 raises taxes which fully internalize the adverse effects of consumption as there are no transboundary spillover-effects.

3.1 The Relationship between Taxes and Transfers in Country 2

The government of country 1 intends to induce country 2 to raise an eco-tax. Therefore it offers a take-it-or-leave-it offer which fulfills the following individual-rational condition:

$$U_2\left(X_2\left(t_2, S_2\right), Y_2\left(t_2, S_2\right)\right) = U_2\left(X_2\left(0,0\right), Y_2\left(0,0\right)\right), \tag{9}$$

Country 2 will accept country 1's offer if the its utility level before the tax (LHS) has to be at least as high as its welfare after implementation of the eco-tax (RHS). The utility level U of a country is assumed to be simply equal to the sum of the utility levels of its households and is described by indirect utility functions as employed in

[4] Yet, mainly in developing countries the agricultural sector constitutes a main part of the economy and these countries are unlikely to pay positive net transfers to the developing world. "Poorer countries are probably more vulnerable to climate change than wealthier countries" (Schelling (1995: 401)). And as the IPCC (1998: 8) stresses: "Africa is the continent most vulnerable to the impacts of projected changes because widespread poverty limits adaptation capabilities."

(1). After taking into account the first-order conditions of the households' decision problem (2) and (3) and the differentiation of the sum of all households' budget constraints in country 2, which is

$$p\left(\frac{\partial X_2}{\partial t_2}+\frac{\partial X_2}{\partial I_2}\frac{dS_2}{dt_2}\right)+\frac{\partial Y_2}{\partial t_2}+\frac{\partial Y_2}{\partial I_2}\frac{dS_2}{dt_2}=\frac{dS_2}{dt_2}, \tag{10}$$

we obtain after some mathematical manipulations:

$$\frac{dS_2}{dt_2}=-\left(\frac{t_2}{1+t_2\dfrac{\partial X_2}{\partial I_2}}\right)\frac{\partial X_2}{\partial t_2}>0. \tag{11}$$

Thereby I_2 represents the country's national income. By the individual rationality constraint (9) country 1 must compensate country 2 for the loss of regional welfare induced by the eco-tax t_2. Consequently the transfer from country 1 to country 2 has to be the higher, the higher the tax in country 2 desired by country 1.

3.2 Country 1's Choices

The government of country 1 intends to maximize regional welfare. It raises an eco-tax rate t_1 on home consumption and induces the implementation of an eco-tax t_2 in the neighbouring country 2 by take-it-or-leave-it contract as well. The government of the transfer paying country 1 maximizes the following indirect utility function:

$$\underset{t_1,t_2}{\text{Max!}}\quad U_1(X_1(t_1,S_2,X_2),Y_1(t_1,S_2,X_2),\phi(X_1,X_2)), \tag{12}$$

where $\phi=\phi(X_1,X_2)$ represents the total amount of environmental externalities perceived in country 1.

Welfare maximization yields the tax rate t_1 chosen by the transfer-paying country's government:

$$t_1 = -\frac{\frac{\partial U_1}{\partial \phi}\frac{\partial \phi}{\partial X_1}}{\lambda} > 0. \tag{13}$$

The calculation of country 1's optimal choice of the tax rate t_2 in country 2 which it influences via its transfer payments yields:

$$t_2 = \left(\frac{1 + t_2 \frac{\partial X_2}{\partial I_2}}{1 - \frac{\frac{\partial U_1}{\partial \phi}\frac{\partial \phi}{\partial X_2}}{\lambda}\frac{\partial X_2}{\partial I_2}} \right) \left(-\frac{\frac{\partial U_1}{\partial \phi}\frac{\partial \phi}{\partial X_2}}{\lambda} \right)$$

(14)

$$= -\frac{\frac{\partial U_1}{\partial \phi}\frac{\partial \phi}{\partial X_2}}{\lambda}.$$

By comparing equations (13) and (14) with the first-best optimal reference solution derived in section 2 it becomes obvious that the choices of country 1 and therefore the tax-transfer scheme yields a Pareto-efficient outcome.

4 Reciprocal Externalities

Let us turn to the generalized set-up of our model with reciprocal spillover effects. Here, each country's welfare is affected by pollution ϕ which again depends on the consumption level in both countries. Unlike the unilateral problem in Section 3, both countries will have incentives to offer a contract to their neighbour in order to influence the eco-tax policy of the opponent.

4.1 Relationship between Taxes and Transfers in Country 2

Country 1 makes a take-it-or-leave-it offer to country 2. In turn, it also receives an offer by its opponent. In order to fulfill the individual rationality condition no country should be better off by unilaterally rejecting the offer of its opponent. 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):

$$\begin{aligned} &U_2(X_2(t_2^*,S_1,S_2,X_1),Y_2(t_2^*,S_1,S_2,X_1),\phi_2(X_1,X_2(t_2^*,S_1,S_2,X_1))) = \\ &U_2(X_2(t_2,S_1,0,X_1),Y_2(t_2,S_1,0,X_1),\phi_2(X_1,X_2(t_2,S_1,0,X_1))) \end{aligned} \tag{15}$$

where S_2 represents the sum of transfers received from country 1. 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.

Total differentiation yields

$$\left(\frac{\partial U_2}{\partial X_2}+\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}+\frac{\partial U_2}{\partial \phi}\frac{\partial \phi}{\partial X_1}\frac{\partial X_1}{\partial X_2}\right)\left(\frac{\partial X_2}{\partial t_2^*}+\frac{\partial X_2}{\partial I_2}\frac{dS_2}{dt_2^*}\right)+\frac{\partial U_2}{\partial Y_2}\left(\frac{\partial Y_2}{\partial t_2^*}+\frac{\partial Y_2}{\partial I_2}\frac{dS_2}{dt_2^*}\right)=0,$$

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:

$$\left(t_2+\frac{\frac{\partial U_2}{\partial \phi_2}\frac{\partial \phi_2}{\partial X_2}}{\lambda}+\frac{\frac{\partial U_2}{\partial \phi}\frac{\partial \phi}{\partial X_1}}{\lambda}\frac{\partial X_1}{\partial X_2}\right)\left(\frac{\partial X_2}{\partial t_2}+\frac{\partial X_2}{\partial I_2}\frac{dS_2}{dt_2}\right)+\frac{\partial S_2}{\partial t_2}=0. \tag{16}$$

Rearranging terms yields:

$$\frac{\partial S_2}{\partial t_2} = -\frac{\left(t_2 + \frac{\frac{\partial U_2}{\partial \phi}\frac{\partial \phi}{\partial X_2}}{\lambda} + \frac{\frac{\partial U_2}{\partial \phi}\frac{\partial \phi}{\partial X_1}}{\lambda}\frac{\partial X_1}{\partial X_2} \right)\frac{\partial X_2}{\partial t_2}}{\left[1 + \left(t_2 + \frac{\frac{\partial U_2}{\partial \phi}\frac{\partial \phi}{\partial X_2}}{\lambda} + \frac{\frac{\partial U_2}{\partial \phi}\frac{\partial \phi}{\partial X_1}}{\lambda}\frac{\partial X_1}{\partial X_2} \right)\frac{\partial X_2}{\partial I_2} \right]} \quad . \tag{17}$$

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 $t_2 < t_2^*$. Reciprocally, we can derive the marginal impact of t_1 on S_1.

4.2 Transfer-paying Country 1's Maximization Problem

Countries 1 and 2, both intend to maximize national welfare. Counties 1 and 2 make a take-it-or-leave-it offer (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 and we can restrict our analysis to the following maximization problem:

$$\underset{t_2}{Max!} \qquad U_1(X_1(t_1,S_1,S_2,X_2), Y_1(t_1,S_1,S_2,X_2), \phi_1(X_1,X_2)). \tag{18}$$

Maximization yields

$$\frac{\partial U_1}{\partial X_1}\left[\frac{\partial X_1}{\partial I_2}\frac{dS_2}{dt_2} + \frac{\partial X_1}{\partial X_2}\left(\frac{\partial X_2}{\partial t_2} + \frac{\partial X_2}{\partial I_2}\frac{dS_2}{dt_2}\right)\right] + \frac{\partial U_1}{\partial Y_1}\left[\frac{\partial Y_1}{\partial I_2}\frac{dS_2}{dt_2} + \frac{\partial Y_1}{\partial X_2}\left(\frac{\partial X_2}{\partial t_2} + \frac{\partial X_2}{\partial I_2}\frac{dS_2}{dt_2}\right)\right] +$$
$$\frac{\partial U_1}{\partial \phi}\frac{\partial \phi}{\partial X_1}\left[\frac{\partial X_1}{\partial I_2}\frac{dS_2}{dt_2} + \frac{\partial X_1}{\partial X_2}\left(\frac{\partial X_2}{\partial t_2} + \frac{\partial X_2}{\partial I_2}\frac{dS_2}{dt_2}\right)\right] + \frac{\partial U_1}{\partial \phi}\frac{\partial \phi}{\partial X_2}\left[\frac{\partial X_2}{\partial t_2} + \frac{\partial X_2}{\partial I_2}\frac{dS_2}{dt_2}\right]. \tag{19}$$

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 $p\frac{\partial X_1}{\partial t_2}+\frac{\partial Y_1}{\partial t_2}=-\frac{\partial S_2}{\partial t_2}$, into (19). Then we obtain

$$\left(t_1\frac{\partial X_1}{\partial X_2}+\frac{\frac{\partial U_1}{\partial \phi}\frac{\partial \phi}{\partial X_1}}{\lambda}\frac{\partial X_1}{\partial t_2}+\frac{\frac{\partial U_1}{\partial \phi}\frac{\partial \phi}{\partial X_2}}{\lambda}\right)\left(\frac{\partial X_2}{\partial t_2}+\frac{\partial X_2}{\partial I_2}\frac{dS_2}{dt_2}\right)=\frac{\partial S_2}{\partial t_2}. \qquad (20)$$

Country 2 in turn counterbids a contract to 1 so that we can write the following system of equations:

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

(21)

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

Inserting equation (16) the equivalent marginal effect for country 1 into the system of equations (21) 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:

$$t_1^*=\frac{\frac{\partial U_1}{\partial \phi}\frac{\partial \phi}{\partial X_1}}{\lambda}+\frac{\frac{\partial U_2}{\partial \phi}\frac{\partial \phi}{\partial X_1}}{\lambda} \qquad (22)$$

$$t_2^*=\frac{\frac{\partial U_2}{\partial \phi}\frac{\partial \phi}{\partial X_2}}{\lambda}+\frac{\frac{\partial U_1}{\partial \phi}\frac{\partial \phi}{\partial X_2}}{\lambda} \qquad (23)$$

5 Concluding Remarks

Contemporarily, in the climate protection debate several different schemes are suggested to become successors of the current Kyoto scheme. Many proposals are based on a quantity approach, i.e. the targets of these schemes are certain levels for greenhouse gas abatement (e.g., 50%-emission reduction until 2050). In contrast, price approaches intend to raise the effective price of pollution, e.g. by levying carbon taxes world-wide. In this paper we focus on the analysis of the latter.

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.

We show that in a simultaneous move game with two countries both players will offer a take-it-or-leave-it contract that entails a side-payment which meets the individual rationality constraint of the opponent player in combination with the first-best optimal tax policy. Therefore the suggested tax-transfer scheme represents an effective means to induce a global carbon-tax scheme. The scheme does not require the coercive power of a central global authority but carbon taxes are implemented voluntarily by the individual countries.

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