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INTERNATIONAL TRANSFER, ENVIRONMENTAL POLICY, AND WELFARE

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International Transfer, Environmental Policy, and Welfare*

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Abstract

This paper examines the effects of country size and international transfer on emission taxes which are determined non-cooperatively by a donor and a recipient. First we show that the larger country levies higher emission tax. Second, the international transfer lowers the emission tax of the donor and raises that of the recipient. Finally, we show that the international transfer can be welfare-improving for both countries if pollution is transboundary.

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1. Introduction

The issue of trade and environment has appeared in most trade negotiations including WTO. Developing countries, however, tend to be against incorporating environmental issues in the trade negotiations. The income of those countries is not so high that their main concern is to attain the expansion of their economy or higher growth. The environmental policies raising domestic production costs may reduce the international competitiveness of dirty industries in those countries, and so lead to a loss of national income. Their concern for competitiveness yields the resentment against taking more strict policies to improve the quality of environment.

In order to give an incentive for developing countries to take the stiffer environmental policies, developed countries have been asked to take actions first. They include foreign aid to developing countries and capacity building of them like a technical assistance or technology transfer. The environmental Kuznetz curve hypothesis indicates the countries with the higher income emit less pollution if the income becomes larger than some level. Increasing the income or enhancing the ability of abatement of pollution in the developing countries may make them to have more concern on the environment, and to take stiffer environmental policies.

This paper examines the role of country size and international transfer, or untied aid, in determination of each country's environmental policies, and the welfare effects of the transfer. We set up a model with a donor and a recipient whose production emits pollution. At first the donor makes international transfer to the recipient. Then, the two countries set their emission tax non-cooperatively. Finally, they trade commodities in competitive world markets. In this model, the countries' characteristics like size and the international transfer affect the endogenous emission taxes determined in the second stage.

We obtain the following main results. First, the lager country tends to levy the higher emission tax than the smaller country. This result is consistent to the fact that developed countries tend to have stiffer environmental policies than developing countries. Second, the international transfer, or untied aid, raises the emission tax of the recipient, and lower that of the donor. This implies that, for example, developed countries can give an incentive for the developing countries to take the harder environmental actions. Finally, such international transfer can improve the welfare of the donor as well as the recipient if the pollution is transboundary. That is, the developed countries may have an incentive to make the international transfer.

The role of international transfer in terms of environment has been analyzed

recently in several papers. Chao and Yu (1999) and Hatzipanayotou, Lahiri, and Michael (2002) incorporate emission taxes and public abatement activities financed by tied aid, and investigate the welfare effects of tied aid in the presence of a non-corporative policy game between the two countries.[1] They do not, however, investigate how an international transfer affects the emission taxes determined non-cooperatively between the donor and the recipient. Copeland and Taylor (1995) examine the effects of an international transfer on non-cooperative determination of pollution permits in a Ricardian model incorporating pollution as a factor of production, and show that the international transfer does not affects the level of world pollution and each country's welfare. While our model is similar to their model, we introduce, on the other hand, emission taxes explicitly as an environmental policy in a many-good and many-factor model to derive different policy implications.[2]

This paper is organized as follows. In section 2, we present equilibrium conditions to determine pollution and welfare in the two small open economies. Section 3 shows the non-cooperative determination of emission taxes between the donor and the recipient. Section 4 discusses how a difference in the country size affects the levels of emission taxes. Section 5 investigates the welfare effects of international transfer in this model. Final section gives concluding remarks.

2. Pollution and Welfare with International Trade

Let us consider two countries, a donor and a recipient, producing many commodities by using many factors of production. The factor endowment vectors of the donor and the recipient are v and v^*, respectively.[3] The goods are traded in competitive international markets, but the factors of production are immobile internationally. We assume that their market share is so small that they do not affect the international price of the goods.

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[1] Ono (1998) extends the framework of Warr (1983), which analyzes income transfer in a non-cooperative supply of public goods, to show Pareto-improving international transfer in the presence of pollution from consumption. Naito (2003) also show a possibility of Pareto-improvement by international transfer without emission taxes.

[2] Pollution in our model is transboundary or local while it is defined as a pure international public bad in Copeland and Taylor (1995). Lahiri, Raimondos-Moller, Wong, and Woodland (2002) also present a similar game structure where the donor first makes international transfer and then the donor and the recipient determine their trade taxes non-cooperatively, while they do not consider pollution and emission taxes.

[3] The asterisk on the variables and functions indicates the recipient.

Production of goods emits pollution in both countries. Each government levies emission tax on domestic producers. The emission tax in the donor and the recipient are τ and τ^*, respectively. Then, the GDP functions of the donor and the recipient are expressed by $r(\tau, v)$ and $r^*(\tau^*, v^*)$, respectively. [4] It is well known that the amounts of emission from the donor's and the recipient's production are $-r_\tau(\tau, v) = -\partial r(\tau, v)/\partial\tau$ and $-r^*_\tau(\tau^*, v^*) = -\partial r^*(\tau^*, v^*)/\partial\tau^*$, respectively. The GNP function is convex in emission taxes, and we assume that $-r_{\tau\tau} = -\partial r_\tau/\partial\tau < 0$ and $-r^*_{\tau\tau} = -\partial r^*_\tau/\partial\tau^* < 0$.[5] It implies that a raise in the emission tax in each country decreases the emission level of the country. The GNP function is linearly homogeneous and concave in the factor endowments.

Pollution may be transboundary or local. Let $\beta \in [0,1]$ show the ratio of the emission from one country to the other. Pollution is completely transboundary if β=1, while it is local if β=0. Then, the levels of pollution in the donor and the recipient are expressed as

$$z = -\{r_\tau(\tau, v) + \beta r^*_\tau(\tau^*, v^*)\}, \tag{1}$$

$$z^* = -\{\beta r_\tau(\tau, v) + r^*_\tau(\tau^*, v^*)\}, \tag{2}$$

respectively.

Pollution in a country gives disutility to consumers in the country. Let the disutility in the donor and the recipient be expressed as $\phi(z)$ and $\phi^*(z^*)$, respectively. We assume that $\phi_z(z) > 0$, $\phi^*_z(z^*) > 0$, $\phi_{zz}(z) > 0$, and $\phi^*_{zz}(z^*) > 0$. The expenditure functions of the donor and the recipient are assumed to be $e(u + \phi(z))$ and $e^*(u^* + \phi^*(z^*))$, where u and u^* are the is utility or welfare of the donor and the

[4] We omit the price vector in the function since we do not change it in this paper. See Copeland and Taylor (2003) for the explanation of this GNP function.

[5] Subscripts on a function indicate the partial derivative of the function with respect to the corresponding variables throughout this paper. For example, $r_\tau = \partial r/\partial\tau$, and $r_{\tau\tau} = \partial^2 r/\partial\tau^2$.

recipient, respectively.[6] We assume that those functions are increasing and strictly concave in utility level.

The donor gives international transfer, or untied aid, to the recipient. The amount of the transfer is T. Then, the budget constraints of consumers of the donor and the recipient are

$$e(u+\phi(z)) = r(\tau, v) - \tau r_{\tau}(\tau, v) - T\,, \tag{3}$$

$$e^*(u^*+\phi^*(z^*)) = r^*(\tau^*, v^*) - \tau^* r^*_{\tau}(\tau^*, v^*) + T\,. \tag{4}$$

We will examine the role of country size later, and then introduce a parameter of country size. We assume that $v^* = \alpha v$ where $\alpha \in (0,1]$, i.e., the donor is larger than, or equal to, the recipient in the endowment size.

Equations (1)-(4) descript the equilibrium in the final stage of our model. Given transfer, T, emission taxes, τ and τ^*, and endowments of each country, v and $v^* = \alpha v$, the equation system determines the pollution and utility levels of each country z, z^*, u and u^*. Let the solution functions of these variables be $z(\tau, \tau^*, \alpha, T)$, $z^*(\tau, \tau^*, \alpha, T)$, $u(\tau, \tau^*, \alpha, T)$, and $u^*(\tau, \tau^*, \alpha, T)$, where the difference in the country size is given by α and we omit v in the functions.

Taking (1) and (2) into consideration and totally differentiating (3) and (4), we obtain

$$e_u du = (e_u\phi_z - \tau) r_{\tau\tau} d\tau + \beta e_u \phi_z r^*_{\tau\tau} d\tau^* + \alpha^{-1}\beta e_u \phi_z r^*_{\tau} d\alpha - dT\,, \tag{5}$$

$$e^*_u du^* = \beta e^*_u \phi^*_z r_{\tau\tau} d\tau + (e^*_u \phi^*_z - \tau^*) r^*_{\tau\tau} d\tau^* + \alpha^{-1}\{r^* + (e^*_u \phi^*_z - \tau^*) r^*_{\tau}\} d\alpha + dT\,. \tag{6}$$

Therefore, we have $u_{\tau} = (e_u\phi_z - \tau) e_u^{-1} r_{\tau\tau}$, $u_{\tau^*} = \beta\phi_z r^*_{\tau\tau}$, $u_{\alpha} = \alpha^{-1}\beta\phi_z r^*_{\tau}$, $u_T = -e_u^{-1}$,

[6] The price vector of the goods is omitted in this function since we do not change them throughout this paper. In addition, we assume that the utility function of a country is additive separable in the consumption bundle and pollution.

$u_{\tau}^{*} = \beta\phi_{z}^{*}r_{\tau\tau}$, $u_{\tau^{*}}^{*} = (e_{u}^{*}\phi_{z}^{*} - \tau^{*})e_{u}^{*-1}r_{\tau\tau}^{*}$, $u_{\alpha}^{*} = \alpha^{-1}e_{u}^{*-1}\{r^{*} + (e_{u}^{*}\phi_{z}^{*} - \tau^{*})r_{\tau}^{*}\}$, and $u_{T}^{*} = e_{u}^{*-1}$.

We will examine how international transfer affects the emission taxes chosen non-cooperatively by each country. In order to do so, we assume the following order of policy implementation. First, the donor makes international transfer, or untied aid to the recipient. Second, both countries set their emission taxes non-cooperatively to maximize their own welfare. Finally, the goods are traded internationally.

3. Determination of Emission Taxes

In the second stage, both governments choose their emission taxes non-cooperatively to maximize their own welfare, taking a change in the resource allocation into consideration. The Nash equilibrium of emission taxes are given by

$$u_{\tau}(\tau, \tau^{*}, \alpha, T) = 0, \tag{7}$$

$$u_{\tau^{*}}^{*}(\tau, \tau^{*}, \alpha, T) = 0. \tag{8}$$

Then, from (5) and (6), the equilibrium taxes must satisfy the conditions

$$\tau = e_{u}(u + \phi(z))\phi_{z}(z), \tag{9}$$

$$\tau^{*} = e_{u}^{*}(u^{*} + \phi^{*}(z^{*}))\phi_{z}^{*}(z^{*}). \tag{10}$$

The conditions (9) and (10) show that, at the Nash equilibrium, the emission tax of each country should be the value of marginal damage of pollution. That is, they should be Pigouvian taxes.

A difference in the country size and international transfer affect the equilibrium emission taxes. A change in the emission taxes can be derived by total differentiation of (7) and (8). It yields

$$\begin{bmatrix} u_{\tau\tau} & u_{\tau\tau^*} \\ u^*_{\tau^*\tau} & u^*_{\tau^*\tau^*} \end{bmatrix} \begin{bmatrix} d\tau \\ d\tau^* \end{bmatrix} = -\begin{bmatrix} u_{\tau\alpha} \\ u^*_{\tau^*\alpha} \end{bmatrix} d\alpha - \begin{bmatrix} u_{\tau T} \\ u^*_{\tau^* T} \end{bmatrix} dT , \tag{11}$$

where

$$u_{\tau\tau} = -e_u^{-1} r_{\tau\tau} \{(e_{uu}\phi_z^2 + e_u \phi_{zz}) r_{\tau\tau} + 1\} < 0$$

$$u_{\tau\tau^*} = -\beta \phi_{zz} r_{\tau\tau} r^*_{\tau\tau} < 0$$

$$u^*_{\tau^*\tau} = -\beta \phi^*_{zz} r_{\tau\tau} r^*_{\tau\tau} < 0$$

$$u^*_{\tau^*\tau^*} = -e^{*-1}_u r^*_{\tau\tau} \{(e^*_{uu}\phi^{*2}_z + e^*_u \phi^*_{zz}) r^*_{\tau\tau} + 1\} < 0$$

$$u_{\tau\alpha} = -\alpha^{-1} \beta \phi_{zz} r_{\tau\tau} r^*_{\tau} > 0$$

$$u^*_{\tau^*\alpha} = \alpha^{-1} e^{*-1}_u r^*_{\tau\tau} \{\phi^*_z e^{*-1}_u e^*_{uu} (r^* - \tau^* r^*_{\tau}) - e^*_u \phi^*_{zz} r^*_{\tau}\} > 0$$

$$u_{\tau T} = -e_u^{-2} e_{uu} \phi_z r_{\tau\tau} < 0$$

$$u^*_{\tau^* T} = \phi^*_z e^{*-2}_u e^*_{uu} r^*_{\tau\tau} > 0$$

The emission taxes are strategic substitutes since $u_{\tau\tau}$, $u_{\tau\tau^*}$, $u^*_{\tau^*\tau}$, and $u^*_{\tau^*\tau^*}$ are all negative unless $\beta = 0$. If $\beta = 0$, $u_{\tau\tau^*}$ and $u^*_{\tau^*\tau}$ becomes zero and strategic effects disappear. We assume that the determinant of the coefficient matrix is positive, i.e., $J = u_{\tau\tau} u^*_{\tau^*\tau^*} - u_{\tau\tau^*} u^*_{\tau^*\tau} > 0$.

4. Country Size and Emission Taxes

In this section we will consider the effect of country size on the equilibrium emission taxes. Suppose that both countries have identical preferences and technologies. The country size is also the same initially, i.e., $\alpha = 1$. There is no international transfer initially, i.e., $T = 0$. Then, the two countries are completely symmetric initially, and the

equilibrium emission taxes become identical.

Now we introduce the difference in the country size. From (11), we obtain

$$d\tau / d\alpha - d\tau^* / d\alpha = J^{-1}(u_{\tau\tau} + u_{\tau\tau^*})(u^*_{\tau^*\alpha} - u_{\tau\alpha}) \tag{12}$$

Taking the initial symmetry into consideration, and evaluating $u^*_{\tau^*\alpha} - u_{\tau\alpha}$ at $\alpha = 1$, we have $u^*_{\tau^*\alpha} - u_{\tau\alpha} = e^{*-2}_u e^*_{uu}\phi^*_z r^*_{\tau\tau} e^* + (\beta - 1)\phi^*_{zz} r^*_\tau r^*_{\tau\tau} > 0$. Thus, we have $d\tau / d\alpha - d\tau^* / d\alpha < 0$. A decrease in α makes τ / τ^* lager than one. Therefore we obtain

Proposition 1. *Suppose that the two countries are identical in all respects, and introduce a marginal difference in the country size. Then, the larger country has the higher emission tax than the smaller country.*

Proposition 1 holds by the following reason. A decrease in α implies the smaller country size of the recipient. Then, the real income and emission of pollution decrease in the recipient, and the marginal damage of pollution expressed by the RHS of (10) becomes smaller. If pollution spills over to the donor, pollution level in the donor decreases, and the marginal damage expressed by the RHS of (9) becomes smaller. The effects in the recipient are larger than in the donor, the relative magnitude of the effects in the recipient overweighs those in the donor. So the emission tax in the donor becomes higher than in the recipient.

If there is no spillover of pollution, we have $u_{\tau\alpha} = 0$. Since there is no strategic effect, the marginal damage in the donor does not change and the emission tax remains at the same level. Thus, only the emission tax in the recipient decreases as α becomes smaller.[7]

This proposition is consistent to the fact that developed countries tend to have stiffer environmental policies than developing countries. It also explains a part of the environmental Kuznetz curve. The larger country will have the larger income if all the other aspects of two countries are identical. Since the larger country levies the higher

[7] This is what is called “scale effects”. See Chapter 2 in Copeland and Taylor (2003).

emission tax, it implies that the emission level in the higher income country becomes smaller.

5. The Effects of International Transfer

Proposition 1 shows that the donor levies the smaller emission tax and the recipient levies the larger one if the country size of the donor is larger than the recipient. In this section, we will consider the following two questions: (i) Can international transfer makes the emission tax of the recipient higher? (ii) Can such international transfer raise the welfare of both countries?

We have, from (11),

$$d\tau / dT = J^{-1}(u_{\tau\tau^*}u^*_{\tau^*T} - u_{\tau T}u^*_{\tau^*\tau^*}) < 0\,, \tag{13}$$

$$d\tau^* / dT = J^{-1}(u_{\tau T}u^*_{\tau^*\tau} - u_{\tau\tau}u^*_{\tau^*T}) > 0\,. \tag{14}$$

Therefore, we obtain

Proposition 2. *The international transfer, or untied aid, lowers the emission tax of the donor and raises that of the recipient.*

International transfer decreases the real income of the donor, and increases that of the recipient directly. Then, the marginal damage of pollution becomes smaller in the donor while it increases in the recipient. By this direct income effect, the donor lowers its emission tax and the emission increases, while the recipient raises the emission tax and the emission decreases.

If pollution spills over to the other country, additional strategic effect appears. The spillover of pollution from the recipient to the donor decreases and the marginal damage, or the emission tax, in the donor becomes smaller. On the other hand, increased emission in the donor spills over to the recipient, the marginal damage, or its emission tax, increases in the recipient. Thus, the possibility of spillover of pollution magnifies the direct income effect.

A raise (reduction) in the emission tax in a country decreases (increases) the emission of pollution in that country. Therefore, proposition 2 implies that the

international transfer raises the emission in the donor and reduces the emission in the recipient.[8]

Finally, we analyze the welfare effects of international transfer in our model. The welfare effects of international transfer is in general given by

$$du/dT = u_T + u_{\tau^*}(d\tau^*/dT), \tag{15}$$

$$du^*/dT = u_T^* + u_\tau^*(d\tau/dT). \tag{16}$$

The first term in the RHS of (15) and (16) indicates the direct income effect of international transfer. By this effect, it impoverishes the donor while it enriches the recipient. The second term in the RHS of (15) and (16) shows the strategic effect of international transfer through a change in the emission taxes. If one country raises (lowers) the emission tax, it reduces (increases) the amount of pollution spilled over to the other country and increases (decreases) its welfare.

It is strait forward, however, to see that international transfer impoverishes the donor and enriches the recipient when the pollution is local, since we have $u_{\tau^*} = u_\tau^* = 0$ if $\beta = 0$.

Proposition 3. *Transfer paradox does not occur when the pollution is local.*

Now substituting (13) and (14) into (15) and (16), we obtain

$$du/dT = J^{-1}\{u_{\tau\tau}(u_T u^*_{\tau^*\tau^*} - u_{\tau^*}u^*_{\tau^* T}) + u^*_{\tau^*\tau}(u_{\tau^*}u_{\tau T} - u_T u_{\tau\tau^*})\}, \tag{17}$$

$$du^*/dT = J^{-1}\{u^*_{\tau^*\tau^*}(u^*_T u_{\tau\tau} - u^*_\tau u_{\tau T}) + u_{\tau\tau^*}(u^*_\tau u^*_{\tau^* T} - u^*_T u^*_{\tau^*\tau})\}. \tag{18}$$

[8] Proposition 7 of Copeland and Taylor (1995) shows the same result in a different framework.

The welfare effects of international transfer is ambiguous because the sing of terms, $u_T u^*_{\tau^*\tau^*} - u_{\tau^*} u^*_{\tau^* T}$ and $u^*_T u_{\tau\tau} - u^*_\tau u_{\tau T}$, are ambiguous. This arises from the fact that the direct income and the strategic effects work toward a different direction each other as is shown by (15), (16) and proposition 2.

Then, let us consider the special case where the utility level or the emission of the donor is so large that e_u approaches to infinity initially. In this case, the direct income effect in the donor becomes infinitesimally small, and the strategic effect becomes dominant. So the international transfer improves the welfare of the donor. In addition, we have $du^*/dT = -J^{-1}\phi_{zz} r^2_{\tau\tau} r^*_{\tau\tau} e^{*-2}_u \{(\beta^2 - 1) r^*_{\tau\tau} (\phi^{*2}_z e^*_{uu} + e^*_u \phi^*_{zz}) - 1\} > 0$. That is, the direct income effect in the recipient dominates the strategic effect, and the welfare of the recipient increases by the international transfer. Therefore, we have.

Proposition 4. *International transfer is welfare-improving for the donor as well as for the recipient if pollution is transboundary and the utility or the emission level of the donor is sufficiently high.*

Proposition 4 implies that the donor may an incentive to make international transfer voluntarily if pollution is transboundary. In this case the donor can make the recipient employ higher emission tax, or stiffer environmental policy, strategically through the international transfer. The decreased amount of spillover of pollution from the recipient to the donor raises the welfare of the donor.

6. Concluding Remarks

This paper has analyzed how the international transfer affects the emission taxes levied by a donor and a recipient. The results imply that international transfer from developed countries to developing countries would give an incentive for the latter countries to take stiffer environmental policies, and it can improve the welfare of the developed countries if pollution is transboundary. We have, however, constructed a very simple model to analyze the role of international transfer, so it has some rooms for future extension.

First, the donor and the recipient are assumed to be a small country which does not affect the international price of the commodities. Most of the analysis of international transfer so far has assumed large countries, and a terms of trade effect

appears in such a case. It may be useful to extend our model to the large country case when we compare our results with the traditional ones.

Second, we have considered international transfer in the form of untied aid in this paper. Environmental assistance to developing countries includes a technical support to pollution abatement, tied aid to the activities which improves the quality of environment in the recipient, and so on. Introduction of tied aid might yield new insights on the role of international transfer related to environment.

Finally, pollution in our model is emitted from production activities, but pollution may be generated by consumption of commodities. Pollution from consumption is also a very important in the areas where population is concentrated. It may be worth analyzing international transfer in a model with pollution from consumption.

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