Discussion Papers In Economics And Business

Ecological dumping under foreign investment quotas

Yasuyuki Sugiyama and Muneyuki Saito

Discussion Paper 08-31

Graduate School of Economics and
Osaka School of International Public Policy (OSIPP)
Osaka University, Toyonaka, Osaka 560-0043, JAPAN

Ecological dumping under foreign investment quotas

Yasuyuki Sugiyama and Muneyuki Saito

Discussion Paper 08-31

September 2008

この研究は「大学院経済学研究科・経済学部記念事業」
基金より援助を受けた、記して感謝する。

Graduate School of Economics and
Osaka School of International Public Policy (OSIPP)
Osaka University, Toyonaka, Osaka 560-0043, JAPAN

Ecological dumping under foreign investment quotas *

Yasuyuki Sugiyama † and Muneyuki Saito ‡

Abstract

In this paper, we examine the discrimination of emission taxes between the export and nontradable sectors in a small country. A few articles indicate that there should be no differentiation of environmental policies between sectors in a small country if the government uses indirect instruments as emission taxes. However, we show that the discrimination of emission taxes may occur in a small country that imposes foreign investment quotas. In particular, the possibility that ecological dumping occurs is higher if export goods are more labor intensive than import goods, as in developing countries. Moreover, in the case where imported goods are most capital intensive, both emission tax rates may be lower than marginal environmental damage, and ecological dumping may occur. It is also shown that easing foreign capital quotas may deteriorate the small country's welfare.

Key words: ecological dumping, emission tax, nontraded goods, international trade, capital movement

JEL classification: F18, F20

*Acknowledgment: We are indebted to Kenzo Abe for advice and encouragement. We also wish to thank Katsuhiko Suzuki, Akihiko Yanase, and Laixun Zhao for their helpful and constructive comments.

†Graduate School of Economics, Osaka University, 1-7 Machikaneyama, Toyonaka, Osaka 560-0043, Japan. E-mail: jk802sy@srv.econ.osaka-u.ac.jp

‡Graduate School of Economics, Osaka University, 1-7 Machikaneyama, Toyonaka, Osaka 560-0043, Japan. E-mail: bg063sm@srv.econ.osaka-u.ac.jp

1 Introduction

Environmental preservation is an important contemporary issue, and many countries are attempting to develop institutional design and policies to deal with this issue. However, environmental preservation is difficult in countries that place high priority on economic growth, because such countries are concerned about the decline in the international competitiveness of domestic firms. Thus, the government in such countries may impose lax environmental regulations on firms so that they are able to retain their competitiveness. This situation is characterized by the term "ecological dumping".

Definitions of ecological dumping are given in Rauscher (1994, 1997, Ch.2). For example, Rauscher (1997, Ch.2) defines dumping as "an environmental legislation that does not fully internalize the domestic social cost of pollution and, thereby gives domestic producers an advantage in international markets". Moreover, Rauscher (1994, 1997, Ch.2) proposes the utilization of nontradable goods as a criterion to evaluate ecological dumping, because trade-related measures of environmental policy are primarily targeted at the sectors that produce traded goods. In such a case, ecological dumping is defined as "the discrimination of the nontraded goods sectors against the exporting sectors in terms of higher pollution-abatement requirements for the same pollutants". [1]

According to the latter definition, Rauscher (1994, 1997, Ch.5) shows that whether the government pursues differentiation of environmental policies between these sectors depends on how the country's terms of trade are affected by these policies. Hence, the government does not have an incentive to differentiate environmental policy between the export and nontradable sectors in the case of a small country, because the distortions other than environmental externalities do not exist in this economy. However, this discussion may be modified if other

[1] As denoted in Rauscher (1994, 1997, Ch.2), the government must implement a sector-specific environmental policy to enable dumping. Actual examples of differential tax systems are offered by the OECD (2001). In addition, refer to Hoel (1996) for differentiation of carbon taxes across production sectors, and see Richter and Schneider (2003) about the discrimination of energy taxes between households and the production sector.

distortions exist. [2] In fact, while allowance of foreign capital inflows progresses gradually through negotiations with international groups such as the World Trade Organization, both developed and developing countries still regulate investment from abroad or impose trade-related investment measures (TRIMs) in order to protect domestic industries. Therefore, we need to investigate how environmental policy should be implemented in the case where not only external diseconomies from pollution emissions exist but also where distortions caused by regulation against foreign capital inflows are present.

In the case of a small open economy, Beladi, Chao, and Frasca (1999) examine the welfare effects of foreign investment quotas in addition to emission taxes. [3] If foreign investment quotas are implemented, the optimal emission tax rate is higher than the marginal environmental damage because an increase in the emission tax reduces the rate of return on capital, and, thus, the payments to foreign capital owners are decreased. Meanwhile, an easing of foreign investment quotas does not change the rate of capital return and accelerates the discharge of pollutants. Then, if the emission tax is higher than the marginal damage, the lax quotas improve the country's welfare because pollution tax revenue is increased. However, their research does not involve nontraded goods; thus, whether differentiation of emission taxes between export and nontraded goods sectors is optimal has not been revealed.

On the other hand, Schneider and Wellisch (1997) apply Rauscher's discussion to the case of a small country with international capital movement, and show that, if the country's government regulates the aggregate level of pollution emissions in each sector, then allocates its permits to firms according to their capital employment, then such direct controls that achieve social welfare maximization may be differentiated in the case of the opposite of ecological

[2] Many researchers have examined the effects of environmental policies in models involving pollution and trade distortions, for instance, Copeland (1994), Ulph (1997), and Neary (2006). While Copeland (1994) considers gradual policy reforms, Ulph (1997) and Neary (2006) demonstrate that, in view of the optimal policy, environmental policies deviate from the first-best policy if trade taxes cannot be removed, and that free trade may not be executed if first-best environmental policies are absent.

[3] See Rauscher (1997, Ch.3) and Chao and Yu (1998) for the economic and environmental impacts of a tax on foreign capital.

dumping between the export and nontraded goods sectors. However, in contrast to the direct controls, environmental rents do not accrue to producers if the small country's government uses price instruments such as emission taxes. Thus, even according to Schneider and Wellisch (1997), it is not optimal that the government discriminates the tax rates between these sectors as in Rauscher (1994, 1997, Ch.5). [4]

In this paper, we investigate whether ecological dumping can arise in a model involving foreign investment quotas, and examine the welfare effect of the quotas. [5] Our model generalizes those of Rauscher (1994, 1997, Ch.5) and Schneider and Wellisch (1997) in that not only are export and nontraded goods produced and consumed in the country, but also imported goods. Then, we show that, unless foreign capital inflows are zero, either ecological dumping or the opposite of ecological dumping may take place even if the host country's government uses emission taxes. In particular, we derive the following results. First, the possibility that ecological dumping occurs is higher if the export sector is more labor intensive than the import sector, such as in developing countries. Moreover, in the case where the import sector is most capital intensive, both optimal emission tax rates may be lower than the marginal damage, and the emission tax rate on the nontradable sector may be higher than that on the export sector. Secondly, the opposite of ecological dumping can occur if the export sector is more capital intensive than the import sector, such as in developed countries. However, in the case where the import sector is most labor intensive, both emission tax rates are higher than the marginal damage, and the emission tax rate on the nontradable sector may be higher than that on the export sector. Thirdly, a relaxation of foreign investment quotas may reduce the small country's welfare.

[4]Recently, Withagen et al. (2007) examined whether preferential treatment of the export sector is optimal under several market structures. They introduce an upper bound on emissions, and assume that the target corresponding to the upper bound is implemented by emission taxes. Their model is discriminative in that 'n' varieties are produced in the export sector. However, ecological dumping still does not occur in the case of a small country.

[5]We assume perfectly competitive markets throughout this paper. For the analysis of imperfect competitive markets, refer to, e.g., Walz and Wellisch (1997), Ulph and Valentini (2001), and Greaker (2003) for the case of oligopoly in addition to Withagen et al. (2007) cited above, and see Pflüger (2001) for the case of monopolistic competition.

The paper is organized as follows. Below, we reconsider the definition of ecological dumping to clarify the subsequent discussion. Section 2 presents the framework of our model. Section 3 obtains some comparative static results with respect to emission taxes. In Section 4, we derive the combination of optimal emission taxes levied against the export and nontraded goods sectors, then analyze whether each of the jointly optimal emission tax rates is higher or lower than the marginal environmental damage. We analyze the effect of easing foreign investment quotas on a nation's welfare in Section 5. The final section gives concluding remarks.

Definition of ecological dumping

As shown in Rauscher (1994, 1997, Ch.2), ecological dumping occurs when environmental policies are less strict in the tradable goods sector than in the nontradable goods sector. We can easily confirm the direction of the discrimination if either of the environmental taxes is higher than the marginal environmental damage, and the other is lower than the damage. However, in our general model, it is possible that both emission taxes imposed on the export and nontradable sectors are higher or lower than the marginal environmental damage, and these tax rates are discriminated. Hence, by elaborating the definitions of Rauscher (1994, 1997, Ch.2), we redefine ecological dumping in a model involving the nontraded goods sector as follows.

Definition 1: Strong ecological dumping

Strong ecological dumping means that the emission tax of the export sector is lower than the marginal damage and that of the nontradable sector is higher.

Definition 2: Weak ecological dumping:

Weak ecological dumping means that both emission taxes are either lower or higher than the marginal damage, and the emission tax of the export sector is lower than that of the nontradable sector.

2 The model

We consider a small open economy. Three types of final goods are produced in the economy, and one of them is a nontraded good. [6] Production in each sector is assumed to exhibit constant returns to scale. We represent the production of an imported good, an exported good, and a nontraded good as y_0, y_1, and y_2, respectively. [7] The economy is endowed with labor ($\bar{l}$) and capital ($\bar{k}$) as primary factors of production, which are supplied inelastically. We assume that capital inflows from abroad are regulated by foreign investment quotas. Then, if we denote the restricted level of capital inflows as k^*, then the total supply of capital in the economy is $\bar{k} + k^*$.

Pollution is generated as a by-product in the production processes of the exported and nontraded goods, and only has an effect within the country. We denote pollution emissions as z_I $(I = 1, 2)$. Emissions of each sector are associated with their own output. We describe the relation as $z_I = e_i y_I$, where e_I is pollution emissions per unit of output and is assumed to be constant. The total amount of pollution (z) with which the country is confronted is written as the sum of each sector's emissions ($z = z_1 + z_2$). The government imposes emission taxes. We denote the tax rates imposed on the export and nontradable sectors by t and τ, respectively. The revenue from these taxes is redistributed in a lump-sum fashion to consumers.

We assume a representative consumer whose utility function is quasilinear. The utility function is additively separable with respect to pollution damage and consumption of each good. Namely, it is written by $u = x_0 + u_1(x_1) + u_2(x_2) - \phi(z)$, where x_I $(I = 0, 1, 2)$ is the consumption level of I good, and u_I is the utility function received from the consumption of I good. Moreover, the subutility function $u_I(x_I)$ is continuously differentiable, increasing, and strictly concave. The damage function $\phi(z)$ is continuously differentiable, increasing, and strictly convex. We represent the relative price of the exported good as p

[6]For example, see Komiya (1967) for the role of nontraded goods in international trade theory.

[7]In the following analysis, we designate the imported good as the numeraire.

and the price of the nontraded good as q. Hence, the minimum expenditure function is defined as:

$$E(p, q, z, u) \equiv \min_{x_1, x_2} \{px_1 + qx_2 + u + \phi(z) - u_1(x_1) - u_2(x_2)\}. \qquad (1)$$

If the expenditure function is continuously twice differentiable, the first- and second-order derivatives for the function have the following properties: [8]

$$E_p = h_1(p), \quad E_q = h_2(q), \quad E_u = 1, \quad E_z = \phi'(z),$$
$$E_{pp} = h_1'(p) < 0, \quad E_{qq} = h_2'(q) < 0, \quad E_{zz} = \phi''(z) > 0,$$

where $h_1(p)$ and $h_2(q)$ are compensated demand functions for the exported and nontraded goods, respectively. [9] All of the other second-order derivatives are zero except for E_{pp}, E_{qq}, and E_{zz}.

Noticing the assumptions of a small country and constant returns-to-scale technology, the zero-profit conditions are expressed as:

$$1 = c^0(w, r), \qquad (2)$$
$$p = c^1(w, r) + te_1, \qquad (3)$$
$$q = c^2(w, r) + \tau e_2, \qquad (4)$$

where c^I is the unit cost function with respect to labor and capital in the i-th sector, w is the wage rate, and r is the domestic rental rate.

The factor market equilibrium conditions for labor and capital are:

$$\bar{l} = c_w^0(w, r)y_0 + c_w^1(w, r)y_1 + c_w^2(w, r)y_2, \qquad (5)$$
$$\bar{k} + k^* = c_r^0(w, r)y_0 + c_r^1(w, r)y_1 + c_r^2(w, r)y_2, \qquad (6)$$

where $c_j^I (I = 0, 1, 2, \ j = w, r)$ is the partial derivative of the unit cost functions with respect to factor prices, and denotes the factor requirements for producing a unit of the i-th good from Shepard's lemma. In addition, the market clearing

[8] Throughout the paper the subscripts on expenditure, unit cost, and the GDP functions represent the partial derivative with respect to the corresponding variables.

[9] The compensated demand function accords with an ordinary demand function because we assume a quasilinear utility function.

condition for the nontraded good, and the total amount of pollution in the country are written as follows:

$$y_2 = h_2(q), \tag{7}$$

$$z = e_1 y_1 + e_2 y_2. \tag{8}$$

Note that the nontraded good's demand does not depend directly on the utility level and the pollution damage under our assumption.

There are seven endogenous variables, w, r, q, y_0, y_1, y_2, and z from (2) to (8). In the next section, we confirm the effects of emission taxes t and τ on these variables, and thereafter examine the welfare effects of the taxes and derive the conditions arising from the ecological dumping or the opposite of ecological dumping.

3 Preliminaries

3.1 Prices of labor, capital, and a nontraded good

First of all, we consider the influences of the emission tax imposed on the export sector on the prices of labor, capital, and the nontraded good. The total derivatives of (2) and (3) yield:

$$\begin{bmatrix} c_w^0 & c_r^0 \\ c_w^1 & c_r^1 \end{bmatrix} \begin{bmatrix} dw \\ dr \end{bmatrix} = \begin{bmatrix} 0 \\ -e_1 \end{bmatrix} dt, \tag{9}$$

where the determinant of the coefficient matrix ($|A|$) in (9) is given by:

$$|A| \equiv c_w^0 c_r^1 - c_r^0 c_w^1 = c_w^0 c_w^1 (\kappa_1 - \kappa_0). \tag{10}$$

On the right-hand side of (10), κ_I denotes the capital–labor ratio in each sector, and is defined by $\kappa_I \equiv c_r^I / c_w^I$. The sign of the determinant depends on the factor intensity of the import and export sectors. If $\kappa_0 > (<) \kappa_1$, the sign of $|A|$ is negative (positive).

The effects of t on w and r are as follows:

$$w_t \equiv dw/dt = |A|^{-1} e_1 c_r^0, \quad r_t \equiv dr/dt = -|A|^{-1} e_1 c_w^0. \tag{11}$$

A rise in the emission tax rate on the export sector decreases the return to the factor that is intensively used in the export sector and increases the return to the factor that the import sector intensively uses. That is, if $\kappa_0 > (<)\kappa_1$, we get $w_t < (>)0$ and $r_t > (<)0$.

Next, considering (11), the change of the nontraded good's price is derived from (4):

$$q_t \equiv dq/dt = |A|^{-1} e_1 c_w^0 c_w^2 (\kappa_0 - \kappa_2). \tag{12}$$

Thus, it is clear that the effect of a rise in t on q depends on the order of factor intensities between the three sectors. We can classify the effect on the nontraded good's price as follows:

$$q_t > 0 \quad \text{if} \quad \begin{cases} \text{condition (Ia)}: \ \kappa_2 > \kappa_0 > \kappa_1, \\ \text{condition (Ib)}: \ \kappa_2 < \kappa_0 < \kappa_1, \end{cases} \tag{13}$$

$$q_t < 0 \quad \text{if} \quad \begin{cases} \text{condition (IIa)}: \ \kappa_0 > \kappa_1 \text{ and } \kappa_2, \\ \text{condition (IIb)}: \ \kappa_0 < \kappa_1 \text{ and } \kappa_2, \end{cases} \tag{14}$$

where 'a' and 'b' in these conditions represent the classification based on the factor intensity of the import and export sectors: 'a' denotes that $\kappa_0 > \kappa_1$ and 'b' that $\kappa_0 < \kappa_1$.

In the case of condition (Ia) (condition (Ib)), we get $w_t < (>)0$ and $r_t > (<)0$ from (11). In addition, the nontraded goods sector is more capital intensive (labor intensive) than the import sector. Thus, the unit cost in the nontraded goods sector rises because of an increase in the return to the factor intensively used in the nontradable sector, which then increases the nontraded good's price. Alternatively, suppose that condition (IIa) (condition (IIb)) is satisfied so that we obtain $w_t > (<)0$ and $r_t < (>)0$, and the nontradable sector is more capital intensive (labor intensive) than the import sector. Hence, we can show that a decrease in the return to the factor that is used in the nontradable sector reduces the unit cost in the nontradable sector, and reduces the price.

On the other hand, the effects of the emission tax in the nontradable sector are very clear. From (2) and (3), we can confirm that the emission tax does not change factor prices ($dw/d\tau = dr/d\tau = 0$). Then, the influence on the price of the nontraded good is derived from (4):

$$dq/d\tau = e_2 > 0. \tag{15}$$

With regards to payments to foreign capital, (11) indicates that a rise in the emission tax rate on the export sector increases the payment, while an increase in the emission tax on the nontraded goods sector does not influence the rental rate of capital from (15).

3.2 Outputs of exported and nontraded Goods

Secondly, we consider the effects of emission taxes on output in each sector. Noticing that the price of the nontraded good varies with the emission taxes, from (7), the change in y_2 is given as:

$$dy_2/dj = h_2'(dq/dj), \quad j = t, \tau. \tag{16}$$

The emission tax on the nontraded goods sector definitely decreases this sector's output ($dy_2/d\tau = h_2' e_2 < 0$). On the other hand, an increase in the emission tax on the export sector affects the output of the nontraded good through a change in the good's price. Noticing $h_2' < 0$ and the conditions for the sign of q_t given in (13) and (14), we can classify the sign of dy_2/dt as follows:

$$dy_2/dt < 0 \quad \text{if} \quad \text{condition (Ia)} \quad \text{or} \quad \text{condition (Ib)}, \tag{17}$$

$$dy_2/dt > 0 \quad \text{if} \quad \text{condition (IIa)} \quad \text{or} \quad \text{condition (IIb)}. \tag{18}$$

The demand for the nontraded good decreases (increases) if $q_t > (<) 0$, and, thus, output of the nontraded good also decreases (increases).

Next, let us examine the effects of emission taxes and easing foreign investment quotas on the production of an export good. Totally differentiating (5) and (6), we get the following simultaneous equation: [10]

$$\begin{bmatrix} c_w^0 & c_w^1 \\ c_r^0 & c_r^1 \end{bmatrix} \begin{bmatrix} dy_0 \\ dy_1 \end{bmatrix} = \begin{bmatrix} \delta^l \\ \delta^k \end{bmatrix} dt - h_2' e_2 \begin{bmatrix} c_w^2 \\ c_r^2 \end{bmatrix} d\tau + \begin{bmatrix} 0 \\ 1 \end{bmatrix} dk^*, \tag{19}$$

[10] To simplify the notation, we define the partial derivatives of w, r, and q with respect to j ($j = t, \tau$) as w_j, r_j, and q_j, respectively.

where δ^l and δ^k are defined by:

$$\delta^l \equiv -(\Sigma_i c^I_{ww} y_I) w_t - (\Sigma_i c^I_{wr} y_I) r_t - h'_2 c^2_w q_t,$$
$$\delta^k \equiv -(\Sigma_i c^I_{rw} y_I) w_t - (\Sigma_i c^I_{rr} y_I) r_t - h'_2 c^2_r q_t.$$

Thus, the influence of emission taxes on the output of the export good are written as:

$$dy_1/dt = |A|^{-2} e_1 \{h'_2 (c^0_w)^2 (c^2_w)^2 (\kappa_0 - \kappa_2)^2 - (c^0_r \Omega^l + c^0_w \Omega^k)\} < 0, \quad (20)$$
$$dy_1/d\tau = |A|^{-1} h'_2 e_2 c^0_w c^2_w (\kappa_0 - \kappa_2), \quad (21)$$

where Ω^l and Ω^k are defined as follows:

$$\Omega^l \equiv c^0_w (\Sigma_i c^I_{wr} y_I) - c^0_r (\Sigma_i c^I_{ww} y_I) > 0,$$
$$\Omega^k \equiv c^0_r (\Sigma_i c^I_{rw} y_I) - c^0_w (\Sigma_i c^I_{rr} y_I) > 0.$$

The signs of Ω^l and Ω^k follow from the well-known properties of the unit cost function.

We can confirm that the emission tax on the export sector definitely decreases this sector's output from (20). On the other hand, considering that the emission tax on the nontraded good's sector raises this good's price, we find that the effect of the emission tax on the export sector depends on the capital–labor ratio between the three sectors. Hence, utilizing the above conditions, we can classify the effects of the emission tax on the exported products as follows:

$$dy_1/d\tau < 0 \quad \text{if} \quad \text{condition (Ia)} \quad \text{or} \quad \text{condition (Ib)}, \quad (22)$$
$$dy_1/d\tau > 0 \quad \text{if} \quad \text{condition (IIa)} \quad \text{or} \quad \text{condition (IIb)}. \quad (23)$$

Next, we investigate the effect of the easing of foreign investment quotas. In our model, the quotas do not change the prices of the nontraded good and production factor, and therefore production of the nontraded good is constant. Considering these points, the effect of a relaxation of the quotas prices on the production of the exported goods results in the following:

$$dy_1/dk^* > (<) 0 \quad \text{if} \quad \kappa_1 > (<)\ \kappa_0. \quad (24)$$

That is, the export sector expands if the export sector is more capital intensive than the import sector. This result is known as the *Rybczynski effect*. The relaxing of foreign investment quotas influences only the outputs of the export and import sectors.

Finally, by using these comparative static results about the output of each sector, we can verify whether emission taxes and foreign investment quotas reduce pollution emissions. In our model, because emissions per unit of output are fixed, it is simply given as:

$$z_{ij} \equiv dz_I/dj = e_i dy_I/dj, \quad (I = 1, 2, \; j = t, \tau, k^*). \tag{25}$$

4 Jointly optimal emission taxes

In this section, we analyze the welfare effects of emission taxes and whether ecological dumping actually occurs or not.

Considering the expenditure function, the budget constraint of the country is written as:

$$E(p, q, z, u) = y_0 + \tilde{p}y_1 + \tilde{q}y_2 + tz_1 + \tau z_2 - rk^*, \tag{26}$$

where $\tilde{p} \equiv p - te_1$, $\tilde{q} \equiv q - \tau e_2$. Then, the effects of emission taxes on domestic welfare are expressed as:

$$du/dt = (t - E_z)z_{1t} + (\tau - E_z)z_{2t} - k^* r_t, \tag{27}$$

$$du/d\tau = (t - E_z)z_{1\tau} + (\tau - E_z)z_{2\tau}. \tag{28}$$

(27) and (28) show that the country confronts two kinds of distortions, that is, external diseconomies generated from each sector, and the deviation of the rental rate between domestic and world capital markets caused by foreign investment quotas. Noting that the level of the quotas is positive and constant, the government might use the emission taxes on the export sector in order to decrease the payment to foreign capital, because the emission tax on the nontradable sector cannot affect the rental rate.

Next, we derive the combination of optimal emission taxes (t^*, τ^*) for which $du/dt = du/\tau = 0$ are satisfied, and show that the optimal level of these taxes is not equal even if a small country's government uses a price instrument such as an emission tax. We obtain the following simultaneous equations from (27) and (28):

$$\begin{bmatrix} z_{1t} & z_{2t} \\ z_{1\tau} & z_{2\tau} \end{bmatrix} \begin{bmatrix} t \\ \tau \end{bmatrix} = \begin{bmatrix} k^* r_t + E_z(z_{1t} + z_{2t}) \\ E_z(z_{1\tau} + z_{2\tau}) \end{bmatrix}, \tag{29}$$

where r_t and z_{ij} $(I = 1, 2,\ j = t, \tau)$ have already been given in (11) and (25), respectively.

We represent the determinant of the coefficient matrix in (29) as $|B|$. Considering z_{ij}, substituting (16), (20), and (21) into (25), $|B|$ is written as:

$$|B| = z_{1t}z_{2\tau} - z_{1\tau}z_{2t} = -|A|^{-2}h_2'(e_1e_2)^2(c_r^0\Omega^l + c_w^0\Omega^k) > 0.$$

The sign of $|B|$ is positive despite the order of the factor intensities between the three sectors. Then, jointly the optimal emission tax rates are expressed as:

$$t^* = E_z + |B|^{-1}k^* r_t z_{2\tau} = E_z - |A|^{-1}|B|^{-1}k^* h_2' e_1 e_2^2 c_w^0, \tag{30}$$

$$\tau^* = E_z - |B|^{-1}k^* r_t z_{1\tau} = E_z + |A|^{-2}|B|^{-1}k^* h_2' e_1^2 e_2 (c_w^0)^2 c_w^2 (\kappa_0 - \kappa_2). \tag{31}$$

From (30) and (31), we confirm that, as long as the foreign capital inflow is not zero, the optimal emission tax of each sector should differ from the marginal damage caused by domestic pollution emissions.

In the following subsection, considering the influences of emission taxes on outputs of exported and nontraded goods depends on conditions (Ia), (Ib), (IIa), and (IIb), we classify the conditions into $\kappa_0 > (<)\kappa_1$ according to the capital–labor ratio of import and export sectors, and concretely examine the discrimination of emission taxes under the conditions.

4.1 The case where an import sector is more capital intensive than an export sector ($\kappa_0 > \kappa_1$)

At the beginning, we consider the case (Ia). If condition (Ia), that is $\kappa_2 > \kappa_0 > \kappa_1$ is satisfied, the direction of the differentiation of optimal emission taxes is

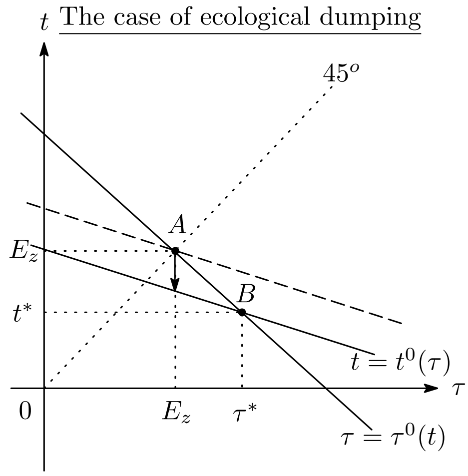

Figure 1: Jointly optimal emission taxes under condition (Ia)

clear. Noticing $h_2' < 0$, the emission tax on the export sector depends on the sign of $|A|$, and therefore the sign of $\kappa_1 - \kappa_0$. If we assume $\kappa_0 > \kappa_1$, the optimal level of the tax is lower than the marginal damage. That is, $t^* < E_z$. On the other hand, the emission tax on the nontraded goods sector depends on the sign of $\kappa_0 - \kappa_2$, so that the optimal level is higher than the marginal damage if $\kappa_0 < \kappa_2$. That is, $\tau^* > E_z$.

The following proposition summarizes the argument concerning ecological dumping under condition (Ia).

Proposition 1: *Suppose that the emission tax rates on the export and nontraded goods sectors are jointly chosen to maximize domestic welfare. Then, strong ecological dumping occurs under condition (Ia).*

The diagram is useful to instinctively comprehend the patterns of the discrimination in optimal emission tax rates.

Setting $du/dt = 0$ in (27), we can derive the optimal tax rate on the export sector given the nonoptimal emission tax rate on the nontradable sector. We represent this relation as $t = t^0(\tau)$. In the same way, we can obtain $\tau = \tau^0(t)$ by setting $du/d\tau = 0$ in (28). As shown in Figure 1, we can draw t^0 and τ^0 schedules in the (t, τ) space. From (27) and (28), the slopes of these schedules depend on the effects of the emission taxes on the production of export and nontraded goods, and the associated emissions discharged from these sectors. Under condition (Ia), the nontraded goods sector's emission tax decreases pollution emissions of its own sector and the export sector, $z_{1\tau} < 0$ and $z_{2\tau} < 0$, and the emission tax on the export sector also decreases pollution emissions of these sectors, $z_{1t} < 0$ and $z_{2t} < 0$. Hence, the slopes of the two schedules are negative.

Moreover, if foreign capital inflow is zero ($k^* = 0$) in (27), the schedule of the export sector's optimal emission tax is depicted as the dashed line through point A in Figure 1. We can confirm that the dashed line is located below the line τ^0 comparing the vertical intercepts of these lines. [11] In this case, either of the optimal emission tax rates is equal to marginal environmental damage; and thus the tax rates do not differentiate between the export and nontraded goods sectors.

Here, the payment to foreign capital can be decreased below (11) if the government reduces the export sector's emission tax, while an increase in the emission tax on a nontraded goods sector does not influence the rental rate of capital from (15). Hence, the emission tax rate on the export sector tends to be set below the marginal environmental damage, reflecting the influence on the rental rate. This means that $t < E_z$ must be satisfied to hold $du/dt = 0$ in (28) if $\tau = E_z$, and a reduction in the export sector's emission tax causes a downward shift of the dashed line in Figure 1. As a consequence, the line $t = t^0(\tau)$ corresponds to the schedule of the export sector's optimal emission tax in the case of $k^* > 0$.

However, total pollution emissions increase if the emission tax rate on the export sector is set below the marginal damage. In contrast, because an increase in the emission tax on the nontraded goods sector decreases emissions in both

[11] Setting $\tau = 0$, we obtain the following relation with respect to the position of these lines:

$$\tilde{t}^0(0) - [\tau^0]^{-1}(0) = E_z \left(\frac{z_{2t}}{z_{1t}} - \frac{z_{2\tau}}{z_{1\tau}} \right) = -\frac{E_z|B|}{z_{1t}z_{1\tau}},$$

where $t = \tilde{t}^0(\tau)$ denotes the export sector's optimal emission tax under $k^* = 0$, and $[\tau^0]^{-1}(\tau)$ means the inverse function of $\tau = \tau^0(t)$. Hence, the dashed line is located below the line τ^0 under condition (Ia), when we compare them at their vertical intercepts. Of course, this discussion can be applied to other conditions.

sectors, the nontraded goods sector's emission tax rate should be higher than the marginal damage in order to decrease total emissions. Hence, the government has an incentive to set the lower emission tax rate on the export sector and the higher one on the nontraded goods sector, so that jointly optimal emission taxes are achieved at point B in Figure 1.

Next, we consider the case of condition (IIa). In contrast to condition (Ia), whether the combination of the jointly optimal emission taxes is ecological dumping or not is ambiguous in condition (IIa). However, we can confirm that both of these tax rates are set below the marginal damage under the condition given by (30) and (31). In addition, if we calculate $t^* - \tau^*$, the following equation is derived with respect to the differentiation in the optimal emission tax rates:

$$\begin{aligned} t^* - \tau^* &= |B|^{-1} k^* r_t (z_{1\tau} + z_{2\tau}) \\ &= -\frac{k^* h_2' e_1 e_2^2 (c_w^0)^2 c_w^2}{|A|^2 |B|} \left\{ \kappa_0 \left(\frac{e_1}{e_2} - \frac{c_w^1}{c_w^2} \right) + \kappa_2 \left(\frac{c_r^1}{c_r^2} - \frac{e_1}{e_2} \right) \right\}. \end{aligned} \tag{32}$$

We need to examine the order of each factor's ratio in the export and nontraded goods sectors to clarify the direction of the discrimination in the emission taxes, because condition (IIa) merely denotes that the import good is most capital intensive. Then, we can summarize the discussion as the following proposition.

Proposition 2: *Suppose that the emission tax rates on the export and nontraded sectors are jointly chosen to maximize domestic welfare. Then, under condition (IIa), both of the emission tax rates are lower than the marginal environmental damage. Moreover, weak ecological dumping (the opposite of weak ecological dumping) occurs if* $c_w^1/c_w^2 < (>) e_1/e_2 < (>) c_r^1/c_r^2$.

In the case of condition (IIa), either of the optimal emission tax rates is lower than the marginal damage. The reason why the emission tax rate on the export sector is lower than the marginal damage is the same as for the case of condition (Ia). It reflects the influence on the rental rate. On the other hand, The case of ecological dumping

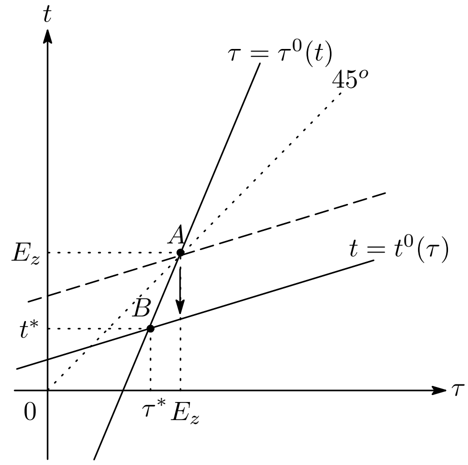

Figure 2: Jointly optimal emission taxes under condition (IIa)

each emission tax reduces pollution emissions in its own sector, and increases the other sector's emissions under condition (IIa): $z_{1t} < 0$, $z_{2\tau} < 0$, $z_{1\tau} > 0$ and $z_{2t} > 0$. Hence, considering the influence on total emissions, the nontraded goods sector's emission tax rate should also be lower than the marginal damage, if the emission tax rate on the export sector is lower than the marginal damage.

Moreover, the increasing effect of the nontraded goods sector's emission tax on emissions from the export sector is larger (smaller) than the decreasing effect on its own emissions, if the nontraded goods sector is labor (capital) intensive relative to the export sector. Hence, using the above definition of ecological dumping again, we can confirm that the opposite of weak ecological dumping takes place if $c_w^1/c_w^2 < e_1/e_2 < c_r^1/c_r^2$, or weak ecological dumping arises if $c_r^1/c_r^2 < e_1/e_2 < c_w^1/c_w^2$. [12]

We draw the case of ecological dumping in Figure 2. From (27) and (28), the slopes of t^0 and τ^0 are positive under condition (IIa) because z_{1j} and z_{2j} ($j = t, \tau$) have opposite signs. In addition, if foreign capital inflow is zero ($k^* = 0$) in (27), the dashed line is located above the line τ^0 comparing the vertical intercept of these lines because $\tilde{t}^0(0) - [\tau^0]^{-1}(0) = -E_z|B|/z_{1t}z_{1\tau} > 0$.

[12] These conditions are often found in the traditional two-good and three-factor model; see e.g., Batra and Casas (1976) and Suzuki (1983).

Here, because $k^* \neq 0$, an increase in the export sector's emission tax also causes a downward shift of the dashed line in Figure 2 as in the case of condition (Ia), so that the jointly optimal emission taxes is achieved at point B.

4.2 The case where an import sector is more labor intensive than an export sector ($\kappa_0 < \kappa_1$)

Conditions (Ia) and (IIa) represent the case where the import sector is more capital intensive than the export sector. However, we can derive different results if the factor intensity of the import and export sectors is opposite to these conditions. In this subsection, we demonstrate these results.

First, we consider the case of condition (Ib). For $h_2' < 0$, the emission tax on the export sector depends on the sign of $|A|$ and $\kappa_1 - \kappa_0$. If we assume $\kappa_0 < \kappa_1$, the optimal level of the tax is lower than the marginal damage. That is, $t^* > E_z$. On the other hand, the emission tax on the nontraded goods sector depends on the sign of $\kappa_0 - \kappa_2$, and the optimal level is higher than the marginal damage if $\kappa_0 > \kappa_2$. That is, $\tau^* < E_z$. This is a situation for the opposite of strong ecological dumping.

Next, let us check the case of condition (IIb). Under this condition, both jointly optimal rates of emission taxes are higher than the marginal environmental damage. However, we have already derived (32) with respect to the direction of the discrimination. Hence, the discussion under conditions (Ib) and (IIb) is summarized as the following proposition.

Proposition 3: *Suppose that the emission tax rates on the export and nontraded sectors are jointly chosen to maximize domestic welfare. Then, the opposite of strong ecological dumping occurs under condition (Ib). On the other hand, under condition (IIb), both of the emission tax rates are higher than the marginal environmental damage. Moreover, weak ecological dumping (the opposite of weak ecological dumping) arises if* $c_w^1/c_w^2 < (>) e_1/e_2 < (>) c_r^1/c_r^2$.

If we assume condition (Ib), $r_t < 0$ because $\kappa_1 > \kappa_2$. Namely, the rental price falls when the emission tax of the export sector is increased. In this case, the government has an incentive to ensure that the emission tax of the export sector is higher than the marginal environmental damage. On the other hand, the government can set the emission tax of the nontradable sector lower than the marginal damage, because this decreases total pollution emissions. Hence, the opposite of strong ecological dumping arises.

On the other hand, in the case of condition (IIb), both optimal emission tax rates are higher than the marginal damage of domestic pollution, because a rise in t reduces the rate of return to foreign capital and has a positive impact on domestic welfare. Then, a rise in t decreases the output of the export good and increases the output of the nontraded good, whereas an increase of τ makes the output of the export good increase and the output of the nontraded good decrease. As well as the case of condition (IIa), whether ecological dumping arises in the country depends on the magnitude of c_w^1/c_w^2, e_1/e_2 and c_r^1/c_r^2, where the emission is the middle factor.

5 A Relaxation of Foreign Investment Quotas

In this section, we investigate the welfare effect of easing foreign investment quotas. The effect of k^* on the welfare of a nation under consideration is presented from the differential of (26) using (25) as:

$$du/dk^* = (t - E_z)z_{1k}. \tag{33}$$

Thus, considering that the quotas do not influence the production of nontradables, the welfare effect of the quotas depends on the change in emissions from the export sector and the level of the emission tax rate on this sector.

The increase in foreign capital inflows makes the export sector contract and total emissions decrease if $\kappa_1 < \kappa_0$. In this case, the relaxing of foreign investment quotas improves (deteriorates) welfare if the emission tax rate on the export sector is (lower) higher than the marginal environmental damage. In contrast, total emissions increase if $\kappa_1 > \kappa_0$. Hence, welfare improves (deteriorates) if the emission tax rate of the export sector is higher (lower) than the marginal environmental damage.

Moreover, the welfare effect becomes clearer if we adopt the optimal tax level (t^*). Noticing that $t^* < (>) E_z$ if $\kappa_1 < (>)\ \kappa_0$, a relaxation of foreign investment quotas improves the country's welfare irrespective of the factor intensity of the import and export sectors.

The above discussion can be summarized as the following proposition.

Proposition 4: *An increase in foreign capital inflows reduces welfare if the emission tax rate on the export sector is higher (lower) than the marginal environmental damage and the export good sector is more labor intensive (capital intensive) than the imported good sector. Meanwhile, suppose that the country chooses the optimal emission tax. Then, easing of foreign investment quotas improves the country's welfare.*

This conclusion expands the findings of Beladi, Chao, and Frasca (1999). They showed that foreign investment quotas increase total emissions and improve welfare if the emission tax is more stringent than the marginal environmental damage. Our result in the case of $\kappa_1 > \kappa_0$ is very similar to that of Beladi, Chao, and Frasca (1999). However, in our model, foreign investment quotas can reduce total emissions if $\kappa_1 < \kappa_0$. Thus, the easing of quotas increases welfare even if the emission tax on the export sector is lower than the marginal damage. Moreover, the optimal emission tax imposed on the export sector satisfies this requirement.

6 Concluding Remarks

In this paper, we analyzed the effects of emission taxes on the export and non-tradable sectors under foreign investment quotas and the effect of a marginal opening of the quotas. As long as foreign capital inflows are not zero, differentiation of environmental policies between these sectors can arise even if we consider a price instrument such as emission taxes in a small country, and relaxation of foreign investment quotas improves the country's welfare irrespective of the direction of the differentiation of the emission taxes if the country chooses the optimal emission tax. On the other hand, that measure reduces welfare if the emission tax rate on the export sector is higher (lower) than the marginal environmental damage, and the export sector is more labor intensive (capital intensive) than the import sector.

In particular, our conclusions concerning jointly optimal emission taxes provide very interesting proposals from the perspective of developed and developing countries. If the export goods are more labor intensive than the import goods such as in developing countries, ecological dumping may be preferred from the standpoint of domestic welfare. Moreover, in a country in which the import good is most capital intensive, both emission tax rates are lower than the marginal environmental damage, and ecological dumping may arise. Meanwhile, the opposite of ecological dumping may be chosen if the export goods are more capital intensive than the import goods such as in developed countries. In addition, if the imported goods are the most labor intensive, the jointly optimal emission taxes are both higher than the marginal damage of pollution emissions, and the opposite of ecological dumping may occur.

Further research is required to address the following two points. First, we do not consider pollution emissions from the import sector. If the emission tax on this sector is also expected to influence the rental rate of capital, then the government may use the emission tax on the sector in order to reduce the payment to foreign capital owners. Hence, we must analyze the combination of optimal emission taxes including taxation to the import sector.

Second, there are two distortions that are brought about by domestic pollution emissions and foreign investment quotas in our model. However, the existence of other distortions, e.g., trade taxes and minimum wages, may also cause differentiation in emission taxes between the export and nontradable sectors. Thus, we need to further investigate the discrimination in the emission taxes considering other types of distortions.

References

[1] Batra, R. N. and Casas, F. R. (1976), "A Synthesis of the Heckscher–Ohlin and the Neoclassical Models of International Trade," *Journal of International Economics* 6: 21–38.

[2] Beladi, H., Chao, C. C., and Frasca, R. (1999), "Foreign Investment and Environmental Regulations in LDCs," *Resource and Energy Economics* 21: 191–199.

[3] Chao, C. C. and Yu, E. (1998), "Optimal Pollution and Foreign-Investment Taxes in a Small Open Economy," *Journal of International Trade and Economic Development* 7: 71–85

[4] Copeland, B. R. (1994), "International Trade and the Environment: Policy Reform in a Polluted Small Open Economy," *Journal of Environmental Economics and Management* 26: 44–65.

[5] Greaker, M. (2003), "Strategic Environmental Policy; Eco-Dumping or a Green Strategy?," *Journal of Environmental Economics and Management* 45: 692–707.

[6] Hoel, M. (1996), "Should a Carbon Tax be Differentiated across Sectors," *Journal of Public Economics* 59: 17–32.

[7] Komiya, R. (1967), "Non-Traded goods and the Pure Theory of International Trade," *International Economic Review* 8: 132–152.

[8] Neary, P. (2006), "International Trade and the Environment: Theory and Policy Linkages," *Environmental and Resource Economics* 33: 95–118.

[9] OECD. (2001), *Environmentally Related Taxes in OECD Contries: Issues and Strategies*, Paris: Organisation for Economic Co-operation and Development.

[10] Pflüger, M. (2001), "Ecological Dumping under Monopolistic Competition," *Scandinavian Journal of Economics* 103: 689–706.

[11] Rauscher, M. (1994), "On Ecological Dumping," *Oxford Economic Papers* 46: 822–840.

[12] Rauscher, M. (1997), *International Trade, Factor Movements, and the Environment*, Oxford: Clarendon Press.

[13] Richter, W. R. and Schneider, K. (2003), "Energy Taxation: Reasons for Discriminating in Favor of the Production Sector," *European Economic Review* 47: 461–476.

[14] Schneider, K. and Wellisch, D. (1997), "Eco-Dumping, Capital Mobility, and International Trade," *Environmental and Resource Economics* 10: 387–404.

[15] Suzuki, K. (1983), "A Synthesis of the Heckscher–Ohlin and the Neoclassical Models of International Trade: A Comment," *Journal of International Economics* 14: 141–144.

[16] Ulph, A. (1997), "Environmental Policy and International Trade," in C. Carraro and D. Siniscalco (eds.), *New Directions in the Economic Theory of the Environment*, Cambridge: Cambridge University Press, 147–192.

[17] Ulph, A. and Valentini, L. (2001), "Is Environmental Dumping Greater When Plants are Footloose?," *Scandinavian Journal of Economics* 103: 673–688.

[18] Walz, U. and Wellisch, D. (1997), "Is Free Trade in the Interest of Exporting Countries When There is Ecological Dumping?," *Journal of Public Economics* 66: 275–291.

[19] Withagen, C. A., Florax, R. J. G. M., and Mulatu, A. (2007), "Optimal Environmental Policy Differentials in Open Economies under Emissions Constraints," *Journal of Economics* 91: 129–149.