Does Trade Liberalization Lead to Protect the Environment?

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Ⅰ. Introduction

It is well known that reduction in tariffs is conducive to protecting the environment because tariff-protected sectors are sometimes polluting sectors, e.g. iron and steel industries in Colombia. In the relevant theoretical literature, Copeland (1994) derives welfare-enhancing conditions arising from tariff reform implemented in a small open economy where the protected sectors are polluting sectors. In this sense, policy that recommends reducing tariffs for the purpose of environmental protection is highly convincing although it is remote from the first best environmental policy. However, it comes with one important caveat: when the economy relies on public abatement through the government abating pollution financed by pollution tax revenue, a mere reduction in tariffs does not always result in pollution reduction. It lies in the nature of pollution tax that there is a trade-off between pollution abatement and pollution tax revenue procurement in the sense that pollution tax revenue declines with reduction in pollution (see OECD, 1993). It is likely that tariff reduction increases pollution since pollution tax revenue loss incurred by reducing tariffs would jeopardize public abatement. Moreover, the relationship between public abatement and private goods production is a key to determining the effect of tariff reduction on pollution. To show this, I develope a public abatement model expressed by a general equilibrium framework[1] and derive certain conditions under which reducing (or imposition) a tariff leads to increased (or decreased) welfare. The results described in this paper give an important caveat to countries[2] when they attempt to harmonize free trade and environmental protection demonstrated by public abatement. The layout of this paper is as follows: section 2 introduces the model

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featured by a general equilibrium framework, section 3 shows the welfare consequences of a tariff reduction (imposition) and section 4 concludes this article.

Ⅱ. The Model

The model structure is based on Chao and Yu (1999), who use a general equilibrium framework to address a model of public abatement in a two-country framework. However, in this model, to make the analysis tractable, I assume a small open economy producing two goods, Good x and Good y, and a public abatement provided by the government. At this point, it should be noted that the economy imposes a tariff on Good x and environmental pollution is generated from that sector. In this sense, Good x is the imported good (dirty good) while Good y is the exported good. To abate pollution, the government imposes a pollution tax on Good x so that the producer of Good x will privately abate pollution. In addition, the government undertakes pollution abatement under the name of public abatement. In this circumstance, I assume that the government uses pollution tax revenue collected from the private sector. To describe the production side more formally, I define the following GDP function R as:

$$\overline{R}(p,t,v^p)=\max_{x,y,z}\{px+y-tz:T(v^p)\}$$

where x denotes the amount of output of Good x and y denotes that of Good y, p denotes the relative price of Good x in terms of Good y, z denotes the amount of pollution generated by the production of Good x, and t denotes the pollution tax rate. v^p denotes the factors used for the private goods' production, and thus $T(v^p)$ is the production technology of the economy. By using appropriate manipulations, one can give the restricted GDP function as $R(p,g,t)=\overline{R}(p,t,v^p)$[3], where g denotes the amount of public abatement provided by the government and we assume $g\le z$. At this point, the property of the GDP function states that $R_p=x, R_{pp}>0, R_g=-C^g, R_{gg}=0$, where C^g is the unit cost of public abatement. Regarding the GDP function, one obtains:

$$z=-R_t(p,g,t) \tag{1}$$

Equation (1) shows private abatement undertaken by imposing pollution tax

on the private sector for Good x. Moreover, it is customary to assume that $R_{tt} = -\partial z/\partial t > 0$, $R_{tp} = -\partial z/\partial p < 0$. The assumption $R_{tp} = -\partial z/\partial p < 0$ implies that the production of Good x generates pollution in the sense that the emission of pollution rises when the price of Good x goes up. It is also assumed that $R_{gt} = -\partial C^g/\partial t > 0$, implying that an increase in the pollution tax rate reduces the unit cost of public abatement.

Turning next to demand, the following expenditure function expresses the representative households' preference such that $E(p,z,u) = \min_{C_x,C_y}\{pC_x + C_y : u(C_x,C_y,z) : u = \Phi(C_x,C_y) + \varphi(z-g)\}$, where C_x, C_y are the compensated demand for Good x and Good y respectively and, since pollution harms households' utility, $\varphi'(\cdot) < 0$. The usual expenditure function states that $E_p = C_x$, $E_{pp} < 0$. Also, we know $E_u > 0$[4], which indicates the reciprocal of marginal utility of income, and we have $E_{pu} > 0$, since we assume that there are no inferior goods in the economy. Moreover, it is natural to assume $E_z > 0$, say, marginal willingness to pay for reduction in pollution, which households should increase expenditure to keep their utility level constant from pollution damage. The economy's budget constraint is expressed as

$$E(p,z-g,u) = R(p,g,t) - gR_g(p,g,t) + (1-\alpha)tz + sM_p(p,z,g,t,u) \quad (2)$$

where s stands for the tariff rate, and thus, the price that households and producers face is $p = p^* + s$ where p^* stands for the world relative price of Good x. Regarding the right-hand side of equation (2), the first term indicates the factor income generated by private production while the second term indicates the factor income generated by public abatement. The third term indicates the pollution tax revenue rebated to households. However, some fraction of pollution tax revenue, say fraction of pollution tax revenue[5], is earmarked for public abatement. The forth term on the right-hand side of the equation is the tariff revenue rebated to households.

The government's budget constraint for public abatement requires that

$$-gR_g(p,g,t) = \alpha tz \quad (3)$$

By substituting equation (3) into (2), one can rewrite the economy's budget constraint as

$$E(p, z-g, u) = R(p, g, t) + tz + sM_p(p, z, g, t, u) \quad (2)'$$

By using equation (1), (2)' and (3), one can observe the changes in three unknown variables z, g, u when the policy variable, say, the tariff rate s, varies.

Ⅲ. Welfare Effects by a Tariff

To investigate the welfare consequences on tariff changes, equations (1)-(3) are totally differentiated to give[6],

$$\begin{bmatrix} (1-sE_{pu}) & -[(E_z - t - sE_{pz}) + (sM_{pg} + E_z + R_g)] \\ 0 & (R_g - tR_{tg}) \end{bmatrix} \begin{bmatrix} du \\ dg \end{bmatrix} = \begin{bmatrix} [sM_{pp} + (E_z - t - sE_{pz})R_{tp}] \\ (\alpha tR_{tp} - gR_{gp}) \end{bmatrix} ds$$

$$dg/ds = (\alpha tR_{tp} - gR_{gp})(1-sE_{pu})/(R_g - tR_{tg}) \quad (4)$$

$$du/ds = (E_z - t)R_{tp}(R_g - tR_{tg})/\Theta + (\alpha tR_{tp} - gR_{gp})[(E_z - t)R_{tg} + (E_z + R_g)]/\Theta + s[\cdot] \quad (5)$$

where $\Theta = (1-sE_{pu})(R_g - tR_{tg}) < 0,$

$$s[\cdot] = s[(M_{pp}(R_g - tR_{tg}) + (M_{pg} - E_{pz}R_{tg})(\alpha tR_{tp} - gR_{gp})]/\Theta$$

Equation (4) indicates the changes in the amount of public abatement provided by the government. There are two primary effects on public abatement. The first effect is the pollution tax revenue effect. When the government reduces a tariff (i.e. trade liberalization), the amount of pollution and therefore pollution tax revenue declines, leading to reduced public abatement; this is captured by the term $tR_{tp}(1-sE_{pu})/(R_g - tR_{tg}) > 0$. In contrast, if the production of Good x is a substitute for public abatement such that $R_{gp} < 0$, then a reduction in tariff reduces the production of Good x and increases public abatement $-gR_{gp}(1-sE_{pu})/(R_g - tR_{tg}) < 0$. This is the indirect public abatement effect. Overall, the relative strength of these effects can determine the sign of equation (4). At this point, suppose that $|\alpha tR_{tp}| < |gR_{gp}|$, indicating that the indirect public abatement effect dominates the private pollution effect; then public abatement rises by reducing a tariff. This condition is satisfied if the pollution tax rate t is sufficiently small[7]. It turns out that trade liberalization facilitates public abatement and reduces pollution, which is confirmed by differentiating equation (2) $dz/ds = -[R_{tp} + R_{tg}(dg/ds)] > 0$. On the other hand, suppose that the economy boosts the tariff rate (i.e. for the purpose

of tariff revenue procurement etc,), then it is also possible that public abatement rises. Consider, for example, when the production of Good x is a complement to public abatement such that $R_{gp} > 0$; then one can conjuncture that public abatement rises by increasing the tariff rate. Moreover, unlike the trade liberalization case, the pollution tax revenue effect is conducive to increased public abatement, because an increase in a tariff raises pollution generated by the production of Good x and also increases pollution tax revenue earmarked for public abatement. This pollution tax revenue gain can increase public abatement. Hence, given that $R_{gp} > 0$, it can be established that a tariff protection increases public abatement provision.

Equation (5) indicates the welfare changes by a tariff. The first term of the right-hand side captures the private pollution effect $(E_z - t)R_{tp} < 0$. This effect states that a decrease in the tariff rate can reduce pollution and therefore enhance welfare. The reason is quite evident that a tariff protected sector is generating pollution through its production process. A reduction in the production of that sector due to removal of a tariff leads to decrease the amount of pollution.

The second term of the right-hand side of equation (5) captures the indirect public abatement effect. If we assume $R_{gp} < 0, E_z + R_g > 0, E_z > t$, then reducing a tariff raises welfare through an increase in public abatement. The second term involves both the private pollution and the public abatement effect. At this point, the pollution tax revenue effect serves to reduce the amount of pollution and thereby pollution tax revenue earmarked for public abatement, by reducing a tariff. Nevertheless, the government demonstrates public abatement if the pollution tax rate t is sufficiently small such that $|\alpha t R_{tp}| < |g R_{gp}|$.

The last term on the right-hand side of equation (5) $s[\cdot] = s[(M_{pp}(R_g - tR_{tg}) + (M_{pg} - E_{pz}R_{tg})(\alpha t R_{tp} - gR_{gp})]/\Theta$ captures the tariff revenue effect.

In this circumstance, when public abatement provision is complementary to domestic imports $M_{pg} > 0$ and the consumption of Good x is a substitute for pollution $E_{pz} < 0$, reducing a tariff can increase tariff revenue rebated to households, leading to welfare gain. To determine the sign of this, one should invoke the previous assumption $|\alpha t R_{tp}| < |g R_{gp}|$ such that the indirect public abatement effect is more significant than the pollution tax revenue effect in terms of public abatement

provision. Overall, welfare rises by reducing a tariff when the pollution tax rate is sufficiently small in order that we can establish $\left|\alpha tR_{tp}\right| < \left|gR_{gp}\right|$. It implies that the pollution tax revenue effect would be negligible to affect welfare.

Proposition: *Suppose that the economy demonstrates public abatement financed by pollution tax revenue. The required conditions for welfare improvement by reducing a tariff are: i) marginal damage of pollution is greater than the pollution tax rate, ii) public abatement provision is undersupplied, iii) public abatement is a substitute for (complement to) the production of Good x (domestic imports) while the consumption of Good x is a substitute for pollution, iv) the pollution tax rate is sufficiently small.*

On the other hand, relaxing the assumptions could yield another result. Consider, for example, the economy introduces a small tariff; equation (5) reduces,

$$du/ds\big|_{s=0} = (E_z - t)R_{tp}(R_g - tR_{tg})/\Theta + (\alpha tR_{tp} - gR_{gp})[(E_z - t)R_{tg} + (E_z + R_g)]/\Theta \qquad (5)'$$

Suppose that public abatement provision is a complement to the production of Good x, $R_{gp} > 0$, then the second term of the right-hand side of equation (5) becomes positive; implying that reducing a tariff generates welfare loss since a reduction in the production of Good x also reduces public abatement provision. In this case, the indirect public abatement effect causes a negative impact on welfare. If the indirect public abatement outweighs the private pollution effect, overall welfare declines by reducing a tariff. This result involves a serious concern regarding the compatibility of free trade and environmental protection. As explained in the introduction, removal of tariffs is conducive to environmental protection since the heavily protected polluting sectors' output declines and so does pollution. However, it also holds true that tariffs reduction reduces environmental protection. That is, a mere reduction of pollution by reducing a tariff does not mean overall pollution reduction since there is another pollution abatement, say public abatement, also affects the changes in pollution.

Ⅳ. Conclusion

The main finding of this paper is that a tariff reduction is justified to protect the environment under the economy where the government demonstrates public abatement by using pollution tax revenue. However, this result involves two serious concerns regarding the nature of public abatement. Firstly, there involves a trade-off between pollution abatement and revenue procurement. Indeed, a reduction in pollution by reducing a tariff decreases pollution tax revenue earmarked for public abatement and it therefore can reduce public abatement provision. Yet, this pollution tax revenue effect would be negligible since the pollution tax rate and thereby pollution tax revenue is sufficiently small in developing countries. Secondly, the relationship between the private goods production and public abatement provision also plays an important role to increase public abatement. Unless the private goods (dirty goods) production is a substitute for public abatement provision, a tariff reduction generates welfare loss. At this point, one can not definitely say that they are substitute (or complement) each other. It may depend on the nature of private goods. With those concerns in mind, this paper would provide a guideline for countries, especially transition countries (i.e. central and eastern Europe), in which they heavily rely on pollution tax financed public abatement, so as to harmonize free trade and environmental protection. In addition, the results obtained by this paper may generate controversies among free trade advocates and trade protectionists in terms of environmental protection.

Appendix

Totally differentiating (1), (2)' and (3) yields,

$$dz = -R_{tp}ds - R_{tg}dg \tag{A.1}$$

$$(1 - sE_{pu})du + (E_z - t - sE_{pz})dz - (E_z + R_g + sM_{pg})dg = sM_{pp}\,ds \tag{A.2}$$

$$-R_g dg - gR_{gp}ds = \alpha t dz \tag{A.3}$$

After substituting (A.1) into (A.2) and (A.3), the following equation results.

$$\begin{bmatrix} (1-sE_{pu}) & -[(E_z - t - sE_{pz})R_{tg} + (E_z + R_g + sM_{pg})] \\ 0 & (R_g - tR_{tg}) \end{bmatrix} \begin{bmatrix} du \\ dg \end{bmatrix} = \begin{bmatrix} [(E_z - t - sE_{pz})R_{tp} + sM_{pp}] \\ (\alpha t R_{tp} - gR_{gp}) \end{bmatrix}$$

Notes

1. Recent advances in the public abatement model featured by a general equilibrium framework are demonstrated by Khan (1995), Chao and Yu (1999), and Hatzipanayotou, Lahiri and Michael (2002, 2003). They analyze the effect of aid and/or the pollution tax rate on welfare in a small or large open economy. Yet, very few attempts have been made at incorporating trade policies into public abatement models.
2. According to OECD (1995), in central and eastern European countries, emission charges on the discharges of air, water, or soil are levied and accruing revenues are used for environmental funds.
3. See Abe (1992).
4. We normalize $E_u = 1$ in this paper.
5. Haibara (2006) assumes that all of pollution tax revenue or tariff revenue is earmarked for public abatement and analyzes the effect of a tariff changes on welfare. Yet, to set all of pollution tax revenue aside for a public abatement activity is somewhat strong assumption and so it may remote from the reality. Hence, this paper relaxes the assumption in order that some part of pollution tax revenue is financed for public abatement.
6. Mathematical derivations are provided in the appendix.
7. Beghin et al (1997) argues that pollution taxes are very low in most of developing countries.

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