Economics Bulletin

Volume 29, Issue 4

On trade liberalization and transboundary pollution

Soham Baksi
University of Winnipeg

Amrita Ray chaudhuri
CentER, TILEC, Tilburg University

Abstract

We examine the impact of freer trade on equilibrium pollution tax and welfare when markets are imperfectly competitive and pollution is transboundary. In the symmetric case, bilateral tariff reduction (i) strengthens environmental protection if and only if pollution is sufficiently harmful, and (ii) decreases welfare in the neighbourhood of free trade.

Citation: Soham Baksi and Amrita Ray chaudhuri, (2009) "On trade liberalization and transboundary pollution", *Economics Bulletin*, Vol. 29 no.4 pp. 2605-2612.
Submitted: Jun 23 2009. **Published:** October 16, 2009.

1. Introduction

A continuing concern amongst environmentalists is that expanded international trade may harm the environment. It is feared that competitive pressures generated by freer trade will force governments to relax their environmental policies in a "race to the bottom". The transboundary nature of many pollutants will make it even less likely that globally efficient environmental policies are pursued by individual countries acting non-cooperatively. A growing body of literature has examined these concerns (see, for examples, Krutilla, 1991; Barrett, 1994; Kennedy, 1994; Antweiler, *et al.*, 2001; Copeland and Taylor, 2003).While identifying situations where countries may strategically weaken their environmental regulations in order to capture additional gains from trade, the literature has also pointed out other situations where trade can improve environmental quality. The latter may occur, for instance, as a consequence of higher demand for environmental quality that emerges as national income grows with international trade.

For the case of symmetric countries and transboundary pollution, Kennedy (1994) identifies various strategic considerations that can motivate individual countries to distort their pollution tax. He concludes that under *free trade* the non-cooperative equilibrium pollution tax in each country will be set at a level lower than what is globally efficient.

Burguet and Sempere (2003) examine how *bilateral tariff reduction* affects environmental policy and welfare in symmetric countries when pollution is purely local. On the one hand, by increasing output, trade liberalization increases marginal social cost of output, which tends to tighten environmental policy. On the other hand, lower tariffs imply lower import revenue which tends to make environmental policy more lax. The net impact on equilibrium environmental policy depends on the relative strength of these counteracting forces. Furthermore, Burguet and Sempere show that, when the environmental policy instrument is a pollution tax, marginal social cost is always less than price. Consequently, by increasing output, a bilateral tariff reduction always increases welfare of each country.[1]

This note uses a model similar to Burguet and Sempere (2003) and shows that freer trade can reduce welfare when pollution is transboundary. The extent to which pollution crosses borders also influences whether or not trade liberalization will enhance environmental protection. Much pollution in the world involves two international dimensions – international trade in polluting goods and the cross-boundary nature of the associated pollution (e.g. greenhouse gases). While there has been a recent move towards incorporating environmental issues in international trade agreements, the coordination of trade and environmental policies across countries remains largely absent. In fact the progressive weakening of control over their tariff policy, following the signing of international trade agreements, has motivated many countries to use environmental policy instruments in order to achieve trade policy objectives (Ederington and Minier, 2003).

We proceed as follows. Section 2 presents the model and derives the equilibrium. The effect of bilateral trade liberalization on equilibrium pollution tax and welfare are analyzed in sections 3 and 4 respectively. The last section concludes.

[1] In their Proposition (p. 31), Burguet and Sempere (2003) note, "If the environmental instrument is a tax (either on output, input, or emissions), a bilateral reduction in tariffs increases welfare."

2. The model

Consider two identical countries, Home and Foreign, with segmented markets. There are n firms in each country ($n \geq 1$). All firms produce a homogeneous good and face a constant marginal cost of production c. Each Home (Foreign) firm sells x (y) units of the good in the Home market and x^* (y^*) units in the Foreign market. Foreign variables are denoted by the superscript "$*$".

In each market, firms compete in quantities. Demand in each country is identical and given by

$$p(q) = p(0) - q$$

where $p(0) - c \equiv a > 0$, and q is total quantity sold in the relevant country. Each country charges a tariff at the same rate of z per unit of import from the other country. The tariff is given exogenously in our model, and trade liberalization takes the form of equal bilateral reduction in the tariff rate. This reflects the situation subsequent to the signing of free trade agreements between countries.[2]

A by-product of production in this industry is pollution. It is assumed that, for every unit of output produced, the firms emit one unit of pollution.[3] The pollution is transboundary and $\gamma \in [0,1]$ fraction of pollution generated in one country affects the other country. Different values of the "transboundary pollution parameter", γ, allow us to consider a continuum of cases ranging from strictly local pollution ($\gamma = 0$) to perfectly transboundary pollution ($\gamma = 1$).

The damage from pollution is monotonically increasing and convex in the level of emissions affecting a country. The damage functions in Home and Foreign are given by D and D^* respectively,

$$D = \frac{1}{2}\beta\left(n\left(x + x^*\right) + \gamma n\left(y + y^*\right)\right)^2 \tag{1}$$

$$D^* = \frac{1}{2}\beta\left(n\left(y + y^*\right) + \gamma n\left(x + x^*\right)\right)^2 \tag{2}$$

where $\beta \geq 0$ is the pollution damage parameter. In (1) and (2), $n(x + x^*)$ denotes the total production undertaken in Home and $n(y + y^*)$ the total production undertaken in Foreign. The environmental policy in each country is a tax imposed per unit of emission by domestic firms.[4] The pollution taxes are denoted by t and t^* for Home and Foreign, respectively.

The sequence of moves is as follows. In the first stage, (an environmental authority in) each country chooses its pollution tax to maximize the country's own welfare, taking the other country's pollution tax as given. In the second stage, each firm takes the policies set by the countries and the output decisions of the $(2n - 1)$ other firms as given, and maximizes its profits. The equilibrium is computed using backward induction.

[2]For example, NAFTA required member countries to reduce their tariffs in equal annual stages over a specified number of years.

[3]Allowing abatement by firms does not change our results qualitatively.

[4]Given our assumption of constant emission intensity of output, a tax per unit of emission is equivalent to a tax per unit of the polluting good.

2.1 Second stage: Output decision of firms

Let the total quantity sold in Home be $Q = n(x+y)$ and that in Foreign be $Q^* = n(x^*+y^*)$. Each Home firm chooses x and x^* to maximize its profit

$$\max_{x,x^*} \quad x(a-Q) + x^*(a-Q^*) - t(x+x^*) - zx^* \tag{3}$$

Similarly, each Foreign firm chooses y and y^* to maximize its profit

$$\max_{y,y^*} \quad y(a-Q) + y^*(a-Q^*) - t^*(y+y^*) - zy \tag{4}$$

The Cournot-Nash equilibrium quantities sold in Home and Foreign are computed as

$$x = \frac{a-(n+1)t+nt^*+nz}{2n+1} \tag{5}$$

$$y = \frac{a+nt-(n+1)t^*-(n+1)z}{2n+1} \tag{6}$$

$$x^* = \frac{a-(n+1)t+nt^*-(n+1)z}{2n+1} \tag{7}$$

$$y^* = \frac{a+nt-(n+1)t^*+nz}{2n+1} \tag{8}$$

We assume that parameter values are such that each of the above quantities is positive. Home's total production is $n(x+x^*)$, total consumption is $n(x+y)$, and net import is $n(y-x^*) = n(t-t^*)$. Home's net import thus depends positively on Home's pollution tax and negatively on Foreign's pollution tax. Similarly, net import of Foreign is $n(x^*-y) = n(t^*-t)$.

2.2 First stage: Equilibrium environmental policy

In the first stage, each country chooses the pollution tax that maximizes its own welfare, taking as given the tariff level and the other country's pollution tax. In Home, social welfare, W, is given by

$$W(t,t^*) \equiv CS + PS + TR + ER - D \tag{9}$$

where consumer surplus $CS = \frac{1}{2}(n(x+y))^2$, producer surplus $PS = n\left(x^2+(x^*)^2\right)$, tariff revenue $TR = zny$, pollution tax revenue $ER = tn(x+x^*)$, and pollution damage D is as given by (1).

The FOC for welfare maximization, $\frac{\partial W(t,t^*)}{\partial t} = 0$, yields an expression for Home's tax, $t(t^*)$, which is its best response to Foreign's tax, t^*. The SOC is satisfied since

$$\frac{\partial^2 W(t,t^*)}{\partial t^2} = -n^2 \frac{4\beta n^2(1-\gamma)^2 + 4n(2\beta(1-\gamma)+1) + 4\beta + 3}{(1+2n)^2} < 0$$

In a symmetric equilibrium, where both countries are identical, the pollution tax of each country will be equal. Hence, imposing $t = t^*$ in the expression for Home's tax, $t(t^*)$, gives the Nash equilibrium tax in each country as

$$\bar{t}(z) = \frac{2n\beta(1+\gamma)(1+n-n\gamma)(2a-z) - 2(1+n)(a-nz) + z}{4n((1+\beta)(1+n) + \beta\gamma(1-n\gamma))} \tag{10}$$

Three sources of distortions that tend to make the equilibrium tax globally inefficient are as follows.[5] First, there is the "transboundary externality effect" that tends to lower $\bar{t}$ from its globally efficient level, as each country ignores the impact of pollution created within its boundary on welfare in the other country. Second, there is the "rent capture effect" that also works to lower the pollution tax. Each government has a strategic incentive to provide a competitive advantage to its domestic firms so that they are able to capture more foreign rent. Third, there is a "pollution-shifting effect" (or NIMBY effect) that tends to increase $\bar{t}$, as each country tries to drive polluting production from itself to the other country.

The transboundary externality effect and the pollution-shifting effect exists only when pollution crosses jurisdictions. As γ increases from 0 to 1, the former effect becomes stronger while the latter effect becomes weaker. Note that when the good is clean (i.e. $\beta = 0$), both these effects are non-existent. Moreover, the rent capture effect disappears when the market becomes competitive (i.e. as $n \to \infty$). The equilibrium pollution tax (10) then becomes

$$\lim_{n\to\infty} \bar{t}|_{\beta=0} = \frac{1}{2}z \tag{11}$$

As long as there is positive tariff, each country enjoys tariff revenue on imports and has to pay for exports. This gives them an incentive to substitute foreign production for domestic production, and consequently to tax domestic firms (the "tariff effect" on the equilibrium tax). Only when trade is free (i.e. $z = 0$) as well, will the equilibrium tax rate (11) in each country become zero.[6]

The interaction of the above-mentioned effects determines each country's choice of the pollution tax. In the symmetric equilibrium, substituting $t = t^* = \bar{t}(z)$ in (5)-(8), we have total output produced equal to total output consumed in each country, so that its net import is zero.[7] The total output, produced or consumed, in each country is

$$Q = n(x + x^*) = n(x + y) = \frac{1}{2}\frac{2(n+1)(a-z) + z}{(1+\beta)(n+1) + \beta\gamma(1-\gamma n)}$$

A bilateral reduction in tariff leads to an increase in total output as $\frac{\partial Q}{\partial z} < 0$ for $\gamma \in [0, 1]$.

[5] The globally efficient tax rate is given by $\hat{t} = \frac{n\beta(2a-z)(\gamma+1)^2 - (a+nz)}{2n\left(1+\beta(\gamma+1)^2\right)}$.

[6] The impact of the rent capture effect on the equilibrium tax is given by $\bar{t}|_{\beta=z=0} = -\frac{a}{2n}$. Similarly, the impact of the pollution shifting effect is given by $\lim_{n\to\infty} \bar{t}|_{z=0} = \frac{a\beta\left(1-\gamma^2\right)}{1+\beta\left(1-\gamma^2\right)}$.

[7] This is similar to reciprocal dumping (Brander and Krugman, 1983).

3. Impact of trade liberalization on pollution tax

The impact of bilateral tariff reduction on the previously mentioned effects, and their trade-off, determines how equilibrium pollution tax changes. It is observed that $\frac{\partial \bar{t}(z)}{\partial z} \geq 0$ if and only if

$$\beta \leq \frac{1+2n+2n^2}{2n\left(\gamma+1\right)\left(1+n-n\gamma\right)} \equiv \beta_1$$

Consequently, we have

Proposition 1: *Bilateral trade liberalization increases the equilibrium pollution tax if and only if pollution is sufficiently harmful (i.e. $\beta > \beta_1$).*

Note that the threshold value of the pollution damage parameter β_1 itself depends on the extent to which pollution is transboundary. As output increases and price falls with trade liberalization, it increases the generation of and damage from pollution, and decreases rents. Consequently, a country's incentive to raise tax to drive out polluting production increases, and its incentive to lower tax to capture additional rents decreases. These exert an *upward pressure* on the equilibrium pollution tax. However, a lower tariff also reduces tariff revenues from imports. This reduces the country's incentive to substitute foreign production for domestic production by increasing the tax. As a result, equilibrium pollution tax tends to *decrease*. The net impact on the tax depends on the relative strength of the two counteracting forces.

4. Impact of trade liberalization on welfare

The equilibrium welfare of each country, denoted by $\overline{W}\left(z\right)$, can be derived by substituting $t = t^* = \bar{t}\left(z\right)$ into $W\left(t, t^*\right)$, where $\bar{t}\left(z\right)$ is the equilibrium pollution tax given by (10) and $W\left(t, t^*\right)$ is given by (9). The effect of bilateral trade liberalization on welfare is then given by

$$\frac{\partial \overline{W}\left(z\right)}{\partial z} = \frac{\left(2n+1\right)^2\left(2\gamma\beta a\left(\gamma+1\right) - z\left(\beta\left(\gamma+1\right)^2+1\right)\right)}{4\left(\beta\left(\gamma+1\right)\left(n\gamma-n-1\right)-1-n\right)^2} \tag{12}$$

From (12), Proposition 2 follows.

Proposition 2: *In the presence of transboundary pollution, a marginal bilateral tariff reduction leads to an increase in the welfare of each country (i.e. $\frac{\partial \overline{W}}{\partial z} \leq 0$) if and only if the initial tariff rate z is sufficiently large (specifically $z \geq \frac{2\beta\gamma a(1+\gamma)}{\beta(1+\gamma)^2+1} \equiv z_1$).*

By increasing output, tariff reduction increases marginal social cost and reduces price. Whether this increases welfare of a country or not depends on whether initially price exceeds marginal social cost of output in that country. When pollution is cross-boundary, Proposition 2 indicates that welfare is non-monotonic and concave in z. It is only when tariff is sufficiently high ($z > z_1$), and the associated output sufficiently low, that price exceeds marginal social cost. An increase in output due to bilateral tariff reduction then increases welfare. The opposite result holds when $z < z_1$.[8] The appendix provides a numerical example in support of Proposition 2.

Note that the threshold value of tariff, z_1, is an increasing function of the transboundary pollution parameter γ (i.e. $\frac{\partial z_1}{\partial \gamma} > 0$). In fact when pollution is purely local (as in Burguet and Sempere, 2003), trade liberalization always improves welfare as (12) implies $\frac{\partial \overline{W}}{\partial z}|_{\gamma=0} = -\frac{z(2n+1)^2}{4(\beta+1)(n+1)^2} < 0$.

5. Conclusion

This paper examines the impact of trade liberalization on the non-cooperative equilibrium pollution tax and welfare when pollution is transboundary. The extent to which pollution crosses borders affects the magnitude of the pollution shifting effect and the tradeoff between this effect, the rent capture effect, and the tariff effect. Liberalizing trade changes the tradeoff, and is shown in the paper to affect equilibrium pollution tax and welfare in ways that depend on the transboundary pollution parameter. Specifically, when pollution is transboundary and the tariff rate is sufficiently small, freer trade is likely to reduce welfare. A further implication is that welfare changes due to marginal bilateral changes in tariff can be an inaccurate predictor of welfare changes due to discrete jumps in tariff (to free trade, for example).

While the various effects described above will exist even in a more general setting, the simplifying assumptions in our model provide sufficient conditions for the results we obtain.■

Appendix

Here we provide a numerical example in support of Proposition 2. Suppose the previously-defined parameters in our model take the following values

$$a = 100, \quad n = 2, \quad \beta = 1, \quad \gamma = 0.1$$

Then the threshold value of the tariff, as defined in Proposition 2, is $z_1 = 9.95$.

Suppose the prevailing tariff rate is $z = 1$. Then the equilibrium pollution tax is $\bar{t} = 38.37$, quantities are $x = y^* = 12.73$ and $x^* = y = 11.73$, and welfare is $\overline{W} = 2247.5$. Moreover, from (12), we have $\frac{\partial \overline{W}}{\partial z} = 3.35 > 0$. Thus a marginal bilateral tariff reduction causes welfare of each country to *decrease* in this case. For instance when tariff falls to $z = 0$, welfare decreases to $\overline{W} = 2243.9$.

Alternatively, suppose $z = 12$. Then $\bar{t} = 38.49$, $x = y^* = 17.1$, $x^* = y = 5.1$, and $\overline{W} = 2261.7$. Moreover, from (12), we have $\frac{\partial \overline{W}}{\partial z} = -0.76 < 0$. Thus a marginal bilateral tariff reduction leads to an *increase* in welfare in this case. For instance when tariff falls to $z = 11$, welfare increases to $\overline{W} = 2262.2$.

[8] Maximizing W with respect to both t and z yields optimal value of the tariff as z_1.

References

Antweiler, W., B. Copeland, and M.S. Taylor (2001) "Is Free Trade Good for the Environment" *American Economic Review* **91**, 877-908.

Barrett, S. (1994) "Strategic Environmental Policy and International Trade" *Journal of Public Economics* **54**, 325-338.

Brander, J. and P. Krugman (1983) "A 'Reciprocal Dumping' Model of International Trade" *Journal of International Economics* **15**, 313-321.

Burguet, R. and J. Sempere (2003) "Trade Liberalization, Environmental Policy, and Welfare" *Journal of Environmental Economics and Management* **46**, 25-37.

Copeland, B. and M.S. Taylor (2003) *Trade and the Environment: Theory and Evidence*, Princeton: Princeton University Press.

Ederington, J. and J. Minier (2003) "Is Environmental Policy a Secondary Trade Barrier? An Empirical Analysis" *Canadian Journal of Economics* **36**(1), 137-154.

Kennedy, P. (1994) "Equilibrium Pollution Taxes in Open Economies with Imperfect Competition" *Journal of Environmental Economics and Management* **27**, 49-63.

Krutilla, K. (1991) "Environmental Regulation in an Open Economy" *Journal of Environmental Economics and Management* **20**, 127-142.