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Abstract

We analyze how trade liberalization affects environmental policies in a context of bilateral trade and imperfect competition. Instead of looking at the strategic distortions that trade causes in environmental policies, we analyze how these distortions change in the face of a bilateral reduction in tariffs. Then, the basic trade-off between higher consumption standards and a dirtier environment takes the spot-light, displacing the much-commented motives of rent appropriation and pollution shifting. In particular, freer trade does not necessarily mean weaker environmental policies. In fact, freer trade can even reduce the damage to the environment.

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1.-Introduction

Environmentalists have generally considered international commercial flow as a source of threat to adequate environmental regulation, as has become clear in the discussions aroused by recent moves towards free trade, like the NAFTA. As Kennedy (1994, p. 49) points out, one of the worries is that "freer trade will lead governments to relax their environmental standards in order to gain a competitive edge over their trading partners."

In line with these concerns, a literature has developed which studies how strategic environmental policies differ from efficient policies as a consequence of trade-linked incentives (and usually under the assumption of free trade; see, for instance, Barrett, 1994, Conrad, 1993, Kennedy, 1994, Markusen, 1975, Ulph and Ulph, 1995; see Ulph, 1996, for a good revision of the literature). By and large, the generalized conclusion is that environmental policies should indeed be expected to be weaker than efficient. [1]

However, and contrary to what one is usually tempted to infer, the above conclusion is not an answer to the question as to whether trade liberalization works against the environment. Trade liberalization is not a change from autarky to trade, but a change from one trade regime to another. Commercial flows, and then trade-linked incentives, are present under both regimes, as is environmental policy competition. Thus, even if we accept that trade is bad for environmental protection, we still don't know whether freer or managed trade is worse.

This paper is a contribution to filling the gap. We analyze the effect that a bilateral reduction in trade protection (tariffs) has on environmental policies. To our knowledge, this is the first paper to formally consider this issue in a model of strategic interaction and environmental externalities. [2] We carry out the analysis in a context of bilateral trade and imperfect competition. In other words, we consider a case in which trade policies have a rationale, even in the absence of environmental considerations, as instruments for coping with

[1] There are exceptions to this conclusion, however: see Markusen, Morey and Olewiler (1995) or Burguet and Sempere (1999).

[2] Ludema and Wooton (1994) compare a free trade regime with one of managed trade. However, they assume perfect competition. Also, in their model only one country pollutes, and only one (the other) cares about pollution. Then in the situation of managed trade, the tariff set by the non polluting country has components designed to reduce pollution. Trade liberalization makes this instrument for pollution control disappear. Also Walz and Wellish (1997) show that symmetric reductions in export subsidies will lead to less environmental protection in a model with two exporting countries selling to a third country, that is, without bilateral trade. Closely related are Copeland and Taylor (1994, 1995, and 1997) and Antweiler, Copeland, and Taylor (1998). However, they consider whether freer trade will damage the environment when the status quo is an autarkic equilibrium without tariffs. Turunen-Red and Woodland (1998) consider the interactions between tariffs and environmental policies but they seek for Pareto improving reforms of trade and environmental policies.

the effects of market power: tougher environmental policies mean higher domestic production costs.

We start by analyzing the simplest model with these features: one where the environmental damage is directly related to output, and the only environmental instrument available to the government is a tax on this output. As a result of a generalized reduction in tariffs one should expect higher total output in each country. This means higher marginal damage to the environment and lower marginal willingness to pay for consumption. Both these effects actually reduce the incentives for governments to use environmental policies strategically as a way to gain a competitive edge over trading partners. However, lower tariffs mean lower marginal tariff revenue from imports and exports, and from the government point of view this reduces the appeal of imports and increases that of exports. This is an incentive to use environmental policies as an instrument to gain international market share. In other words, an incentive to lower environmental protection. These two effects are the main forces at work when determining the sign of the change in environmental policies as a result of a bilateral reduction in tariffs. Neither of the two clearly dominates the other: we give examples of both cases. In particular, freer trade need not weaken environmental policies (lower the tax on output).

The above discussion may remind us of another well known trade-off: weaker environmental protection works as a substitute for tariff protection when this is not available, but increased pressure on the environment due to higher output tends to strengthen environmental policies. [3] Note, however, that a bilateral reduction in tariffs does not mean less protection for domestic firms. Indeed, domestic firms face tougher competition in the domestic market, but also enjoy a better competitive position in the foreign one. Thus, the change in the level of protection of domestic firms is itself ambiguous.

In the simple version of the model we have just described, the total damage to the environment increases even when environmental policies are strengthen as a consequence of trade liberalization: output is still larger. Thus, this suggests that the right arena for the debate on the effects of trade liberalization is not so much its effect on public policies, but rather the well known trade-off between higher consumption and a cleaner environment.

After studying the simplest model sketched above, we also consider more general types of environmental externalities and public instruments which have been proposed in the literature. Our generalized model admits the existence of different technologies with a different impact on the environment, be it in terms of input used or in terms of processes. It also admits

[3] For instance, in a standard competitive model of trade with endogeneous environmental regulation, Copeland and Taylor (1994) show that if trade liberalization leads to an increase in the output of the pollution-intensive good, then it leads to increased pressure on the environment, and the optimal pollution tax tends to rise.

the possibility of taxing emissions directly or taxing dirty input. That is, we consider cases where the policy instrument can have a direct impact on environmental damage, and not only through the effect on total output. The expanded output that results from trade liberalization now changes the marginal direct effect of the environmental instrument on environmental damage. This is a new effect to add to the already mentioned ones. Still, whether freer trade implies tougher or weaker environmental policies has no unambiguous answer. The novelty here is that now even the damage to the environment can be lower as a result of a reduction in tariffs. That is, higher output may now enhance the incentives for governments to induce cleaner technologies to the point of actually reducing the total damage.

The rest of the paper is structured as follows. Section 2 presents the simplest model in which environmental damage (cost) depends on output only. Then Section 3 extends the analysis to cases where the policy instrument may directly affect the environmental damage. Finally, Section 4 concludes with some additional remarks.

2.- The simplest case: dirty output and taxes

Consider a two-country Brander-Spencer (1984) model of bilateral trade. Two firms, each located in a different country, produce a homogeneous, tradable good. The demand for this good in each country is given by the inverse demand function $P(Q)$. We assume that this is a concave function. Firms sell in both their domestic and foreign markets. Competition in each market is in quantities.

Production generates local environmental damage as a byproduct.[4] In this section we assume that the level of this damage depends solely on the level of output. In the next section we will consider a more general model of environmental externalities. For now, let $h(q)$ be the environmental damage, where q represents domestic output. We assume this function to be convex and increasing in q. [5]

Governments set taxes on local production. In addition to this, and in the absence of a trade agreement, both governments set trade policies that take the form of tariffs on imports. We simplify the analysis by assuming that both tariffs and taxes are linear and that input marginal costs are constant, and normalize them to 0. Then markets in both countries are separate. After observing tax and tariff rates in both countries, each firm decides how much to produce for each of the markets. Here, a free trade agreement means that tariffs are banned.

[4]The same features would be obtained under spill overs in pollution, in as much as there is still a component of local pollution.

[5] This is the model in Hung (1994).

This defines a two-stage game. In the first stage, governments simultaneously set environmental taxes and, eventually, tariffs. In the second, firms set quantities. Firms are interested in maximizing profits for given tax and tariff rates c_i and t_i, $i = 1,2$. We denote by q_i and q_i^* respectively the quantities that firm i sells in its domestic (i) and foreign (j) markets. Government i is interested in maximizing (domestic) surplus minus social (in this section, only environmental) cost $h(q_i + q_i^*)$ plus tariff revenue $t_i\, q_j^*$.

Competition among firms:

We start by analyzing the behavior of firms in the second stage of this game. Firm i chooses q_i and q_i^* taking the output of the rival firm j, q_j and q_j^* as given. Under our assumptions, each firm faces two separate markets. Each of the markets is a regular Cournot duopoly market in which one firm (the domestic firm) faces unit cost c_i and competes with another firm (the foreign firm) with unit cost $c_j + t_i$, $i = 1,2$; $i \neq j$. The first order conditions for profit maximization for each firm in market (country) i are

$$P'(q_i + q_j^*)\, q_i + P(q_i + q_j^*) - c_i = 0, \tag{1}$$

$$P'(q_i + q_j^*)\, q^{*}{}_{j} + P(q_i + q_j^*) - (c_j + t_i) = 0. \tag{2}$$

Equations (1) and (2) and the corresponding equations for country j implicitly define the equilibrium outputs as functions of tariffs and taxes. In particular, q_i and q_j^* do not depend on t_j. In addition, the quantities supplied to country i, q_i and q_j^*, only depend on (c_j+t_i) and c_i. Thus, we can write the solutions to (1) and (2) as $q_i(c_i, c_j+t_i)$ and $q_j^*(c_i, c_j + t_i)$. Concavity of the demand function is sufficient for existence and uniqueness (see for instance Tirole, 1988).

Figure 1 approximately here

The effect of a reduction of t in market i

The reaction functions defined by (1) and (2) are downward sloping and, given our assumptions, their slopes are less than 1 in absolute values. Keeping this in mind, we can already take a first look at the effect of bilateral reductions in tariffs. A reduction in t_i shifts the reaction function of firm j in country i outwards (see Figure 1). That is, $\frac{\partial q_j^*}{\partial t_i} < 0$. Therefore firm j becomes more aggressive and, as a consequence, the output of firm i in its home market is lower when t_i is lower. The government of country i may try to compensate for this increase in competition by reducing the marginal cost of its domestic firms, that is, softening environmental policies (reducing c_i). This reasoning is the origin of most worries voiced in relation to the effects of freer trade on the environment.

But freer trade means a simultaneous reduction in both t_1 and t_2. That is, firm i sees its marginal costs cut in its foreign market. That is, the competitiveness of firm i decreases in its home country but increases in country j. What, then, is the total effect of this bilateral reduction in tariffs? In Figure 1 we represent the change in one market for given environmental policies (values of c_i) as the change from E to E'. Since the slope of the reaction function is less than 1, the increase in output by the foreign firm is not matched by the reduction in output by the domestic firm. That is, E' represents a larger total output. But by symmetry, the total output in a market coincides with the total output of one of the firms (imports and exports coincide). Thus, whereas it is unclear if the bilateral reduction in tariffs leaves the national firm less protected from competition, what is clear is that output is higher. And this, as we will see below, is the important factor. Indeed, on the one hand the reduction in tariffs lowers consumer surplus. On the other hand, it raises the marginal social cost of output (for convex $h(q)$). Both effects act as incentives for tougher environmental protection. Finally, marginal tariff revenue is lower and this, as we will see, is an incentive for less environmental protection.

Competition among governments:

We now analyze the first stage of the game, that is, the governments' competition on taxes and tariffs. Let $Q_i = q_i + q_j^*$ denote the supply in country i. Also, let π_i represent the revenue of firm i in its domestic market and π_i^* represent its exports revenue and denote by $T = (t_1, t_2)$ and $C = (c_1, c_2)$. Then, we can write the government's objective function as

$$W_i(C,T) = CS(Q_i) + t_i\, q_j^* + c_i\,(q_i + q_i^*) + \pi_i[q_i,\, q_j^*] + \pi_i^*\,[q_j,\, q_i^*] - h(q_i + q_i^*) \tag{3}$$

where q_i and q_i^* for $i = 1,2$, are defined by the equilibrium equations (1) and (2), and where

$$CS(Q_i) = \int_0^{Q_i} [P(x) - P(Q_i)]dx.$$

is the consumer surplus in country i. The first order conditions for this problem are

$$\frac{\partial W_i(C,T)}{\partial c_i} = 0 = \frac{\partial W_i(C,T)}{\partial t_i}. \tag{4}$$

Taking derivatives in (3), we can write the first condition above as

$$\frac{\partial W_i(C,T)}{\partial c_i} = CS'(Q_i)\frac{\partial Q_i}{\partial c_i} +$$

$$[P(Q_i) - c_i]\frac{\partial q_i}{\partial c_i} + P'(Q_i)\frac{\partial Q_i}{\partial c_i}q_i + \left[P(Q_j) - c_i - t_j\right]\frac{\partial q_i^*}{\partial c_i} + P'(Q_j)\frac{\partial Q_j}{\partial c_i}q_i^*$$

$$+\left[c_i - h'(q_i + q_i^*)\right]\frac{\partial(q_i + q_i^*)}{\partial c_i} + t_i\frac{\partial q_j^*}{\partial c_i} = 0.$$

The first line in the expression is the change in consumer surplus induced by a change in output that follows a change in c_i. The second line represents the change in the domestic firm's profits, both as a consequence of changes in prices in both markets and as a consequence of the change in the production of the firm. The third line represents the change in the environmental externality (the difference between the internalized cost and the real marginal -environmental- cost) that the change in output induces, and the change in tariff revenue. Notice that $CS'(Q_i) = P'(Q_i)Q_i$, and then under perfect competition (price equal to marginal cost) and without trade, the solution to the above problem would be to set $c_i = h'$; that is, to make the firm internalize the real marginal cost. However, under imperfect competition and trade, several distortions appear. First, and related to imperfect competition, the price is larger than the marginal cost faced by firms, and this is an incentive to set lower c_i. But also, as Kennedy (1994, page 57) puts it, "a unilateral change in a country's tax (environmental) rate has a bigger effect on the equilibrium domestic production than it does on equilibrium domestic consumption", and this is an additional incentive related to trade: *a rent capture effect*. This is reinforced if there are tariffs in place. Finally, the possibility of importing the good, and then *shifting pollution* abroad is an incentive that works in the opposite direction. Thus, by rearranging terms we can write

$$\frac{\partial W_i(C,T)}{\partial c_i} = -P_i'\frac{\partial Q_i}{\partial c_i}q_j^* + P_j'\frac{\partial Q_j}{\partial c_i}q_i^* + t_i\frac{\partial q_j^*}{\partial c_i} - t_j\frac{\partial q_i^*}{\partial c_i} + [P_i - h']\frac{\partial q_i}{\partial c_i} + \left[P_j - h'\right]\frac{\partial q_i^*}{\partial c_i},$$

where we have omitted the arguments of the indirect demand function and used subscripts to identify the country that the price refers to. However, under symmetry and constant marginal costs, $\frac{\partial Q_i}{\partial c_i} = \frac{\partial Q_j}{\partial c_i}$, and then (4) can be written as

$$\frac{\partial W_i(C,T)}{\partial c_i} = t_i\frac{\partial q_j^*}{\partial c_i} - t_j\frac{\partial q_i^*}{\partial c_i} + [P_i - h']\frac{\partial q_i}{\partial c_i} + \left[P_j - h'\right]\frac{\partial q_i^*}{\partial c_i}, \qquad (5)$$

$$\frac{\partial W_i(C,T)}{\partial t_i} = -P_i'\frac{\partial Q_i}{\partial t_i}q_j^* + [P_i - h']\frac{\partial q_i}{\partial t_i} + \left[t_i\frac{\partial q_j^*}{\partial t_i} + q_j^*\right],$$

(6)

The set of these equations (for $i = 1,2$) plus equations (1) and (2) define (interior) equilibrium in the two stage game.

Most of the received literature on whether freer trade should be expected to weaken or strengthen environmental policies focuses on whether (5) (for the particular model considered) is positive or negative when evaluated at the "non strategic" solution (see Kennedy, 1994, for the closest example). However, when one is interested in analyzing the effect of a bilateral reduction in tariffs, what one should analyze is the effect of a change in (both) tariff rates on the solutions to equations (5) and (6) above. That is, what is important is not so much the trade-off between rent capture and pollution shifting, but how this trade-off is affected by a change in the level of tariffs. This is what we consider in the next subsection.

<u>The effect of bilateral reductions in tariffs:</u>

We now address the question of what effect a bilateral reduction in tariffs has on the equilibrium values for the environmental tax. Equation (5) above holds for equilibrium values of the tariffs and should also hold after the bilateral reduction in tariffs has been decided. Therefore the effect on the environmental tax due to this (small) reduction can be obtained, differentiating in (5), as

$$\frac{dc_i}{dT} = -\frac{\partial^2 W_i(C,T)/\partial c_i \partial t_1 + \partial^2 W_i(C,T)/\partial c_i \partial t_2}{\partial^2 W_i(C,T)/\partial c_i \partial c_i},$$

where dT represents an equal change in both t_1 <u>and</u> t_2. The second order conditions for the maximization of $W_i(C,T)$ with respect to c_i include that $\partial^2 W_i(C,T)/\partial c_i \partial c_i$ be negative. Then a reduction in tariffs induces a higher c_i in equilibrium iff

$$\frac{\partial^2 W_i(C,T)}{\partial c_i \partial t_1} + \frac{\partial^2 W_i(C,T)}{\partial c_i \partial t_2} \tag{7}$$

is negative. We now analyze the sign of this cross derivative. The first component, using the symmetry of the model, can be written as

$$\frac{\partial\left\{t_i \frac{\partial q_j^*}{\partial c_i} - t_j \frac{\partial q_i^*}{\partial c_i}\right\}}{\partial T} = t_i \left[\frac{\partial^2 q_j^*}{\partial c_i \partial t_i} - \frac{\partial^2 q_i^*}{\partial c_i \partial t_j}\right] + \frac{\partial q_i^*}{\partial c_i} - \frac{\partial q_j^*}{\partial c_i} \tag{8}$$

The second component of (7), again using symmetry, can be written as

$$\frac{\partial\left\{[P_i - h']\frac{\partial q_i}{\partial c_i} + [P_j - h']\frac{\partial q_i^*}{\partial c_i}\right\}}{\partial T} = [P_i' - h'']\frac{\partial Q_i}{\partial t_i}\frac{\partial[q_i + q_i^*]}{\partial c_i} + [P_i - h']\left(\frac{\partial^2 q_i}{\partial c_i \partial t_i} + \frac{\partial^2 q_i^*}{\partial c_i \partial t_j}\right). \tag{9}$$

We can group (8) and (9) into the following effects of different tariff levels:

-1- A change in the direct responsiveness of net tariff revenue to the environmental variable. An increase in the environmental tax reduces exports and increases imports, and then increases the net tariff revenue that accrues to the country. Higher (per unit) tariffs make this increase greater:

$$\frac{\partial q_j^*}{\partial c_i} - \frac{\partial q_i^*}{\partial c_i}.$$

(10)

-2- A change in the responsiveness of exports to the environmental variable. The marginal effect of the environmental tax on exports may be different for different tariff levels. But the last unit exported leaves a surplus to the country which is equal to the difference between the price (abroad) and the social cost: the marginal environmental cost plus the tariff paid to the foreign country:

$$[P_j - h' - t_j]\frac{\partial^2 q_i^*}{\partial c_i \partial t_j}. \tag{11}$$

-3- A change in the responsiveness of the supply in the country to the environmental variable. The marginal effect of the environmental tax on both imports and the domestic supply of the domestic firm may also be different for different tariff levels. The marginal unit imported is paid according to the marginal willingness to pay, but part of this price is kept by the government in the form of tariff (t_i). The marginal unit produced and sold at home leaves a surplus equal to the marginal willingness to pay (price) and the marginal (environmental) cost of production:

$$t_i \frac{\partial^2 q_j^*}{\partial c_i \partial t_i} + [P_i - h'] \frac{\partial^2 q_i}{\partial c_i \partial t_i}. \tag{12}$$

-4-- A change in the level of output. Higher tariffs are associated with lower output and consumption, which depresses both the marginal environmental damage and the marginal willingness to pay (and import revenues):

$$[P_i' - h''] \frac{\partial Q_i}{\partial t_i} \frac{\partial [q_i + q_i^*]}{\partial c_i}. \tag{13}$$

The sign of the effect on the environmental tax of bilateral reductions in tariffs depends on the sum of these four effects. The sign of the second and third effects is ambiguous. If demand is linear, for instance, both of them disappear (the cross derivative in each of them vanishes).The first is always positive, and then means weaker environmental policies associated with a move towards free trade. However, the sign of the fourth effect is unambiguously negative: lower tariffs imply higher supply (production and consumption) and thus both higher marginal environmental cost and lower marginal gains (consumer surplus or import prices). This means an enhanced incentive to set tougher environmental policies.

In general, neither of these last two effects dominates, and tthis indeterminacy is still present if one considers drastic reductions in tariffs (change of regime from tariff competition to free trade), as the following examples show. Assume that the demand function is $P(Q) = 1 - Q$. Equations (1) and (2) can be solved explicitly, so that , in this case

$$[P_i' - h''] \frac{\partial Q_i}{\partial t_i} \frac{\partial [q_i + q_i^*]}{\partial c_i} = [-1 - h''] \left(-\frac{1}{3}\right) \left(-\frac{4}{3}\right),$$

and $\frac{\partial q_i^*}{\partial c_i} - \frac{\partial q_j^*}{\partial c_i} = \frac{4}{3}$. If we take $h(Q) = \frac{1}{3} Q^{3/2}$ then we have a situation where a move towards free trade implies a lower environmental tax. However, if $h(Q) = \frac{2}{3} Q^3$ then a move towards free trade implies higher environmental taxes. (See Table 1.)

Table 1 approximately here

The example also illustrates a general result: In both cases the total environmental damage increases, since the output is larger in both cases under free trade. In other words, a move towards free trade always implies an enlarged market and therefore a tendency for output to grow. Governments may react to this larger output by setting more stringent environmental policies, but this is induced precisely by the larger environmental damage. Then the result in this case will be cleaner output but higher total damage. (See, however, the next section.)

This puts the discussion over the effects of free trade on the environment into perspective. It is true that higher environmental damage is likely to follow from freer trade. However, this is not because governments try to improve the competitive edge of their firms in the more competitive world, but rather because economic activity is expanded. That is, output is taxed more heavily, but there is more output, which results in greater damage to the environment. Then the trade-off that the countries face when liberating commercial flows is the classic, old one between higher consumption and a cleaner environment.

3.- A more general model of environmental damage and policy instruments

Most of what we have obtained in the previous section did not depend on the fact that environmental damages were directly related to output and so the only policy instrument open to the government was a tax on that output. In general, firms may have access to different technologies, each with a different impact on the environment, for producing the same commodity, or they may engage in abatement activities at a cost. Governments may also be able to impose standards, and to tax dirty inputs, etc. Many of these alternative instruments are not only a transfer from firms to governments, but also have a direct influence on the social cost of production of any given level of output. For instance, imposing a higher input standard may imply lower emissions per unit of output but higher input costs. We now turn to the analysis of a more general model that encompasses many of these cases. In order to keep the analysis at the same level of simplicity, we will assume that governments have access to only one environmental instrument and that this instrument represents linear costs for firms.[6]

Thus, we now postulate an environmental damage function that has c as an argument. So let $h(q,c)$ be the environmental damage caused by a q level of output under c level of environmental instrument. Among the particular examples of this general model which have been considered in the literature, we have the following:

(i) There is a continuum $n \in [0,b]$ of possible, perfectly substitutable, inputs from which to produce the commodity q at constant returns to scale, where the index n is the (fixed, exogenously given) cost of input n. The higher n, the lower the level of emissions of

[6] There are important issues related to the strategic choice of instruments that will be omitted from the scope of this paper. We refer the reader to the good review and discussion of this and other issues in Ulph (1996).

any given output q, which is given by $(b-n)q$. Finally, the environmental damage of emissions increases more than proportionally with their level, and is given by $A[(b-n)q]^2$. Both b and A are positive constants. The instrument for governments is the setting of a standard on input, taken here as the setting of the admissible maximal polluting (cheapest) input c, which the firm will actually choose to use. Then, the firm's cost function is indeed given by cq and the environmental externality is $h(c,q) = A[(b-c)q]^2$.

(ii) The government can tax emissions directly, but firms can choose from among several constant marginal cost technologies with different degrees of pollution. This is the model analyzed by Kennedy (1994). Governments set tax rates τ on emissions which are given by the function $Z(\theta,q) = q/\theta$, where θ represents the technology chosen by the firm after observing the government's choice of τ. Technology θ also results in input unit costs θ for the firm. Hence cheaper technology results in higher pollution. Emissions cause damage given by the increasing convex function $e(Z)$. Profit maximization by a firm implies choosing $\theta = \tau^{1/2}$, independently of the level of production. That is, when the government chooses τ it is actually choosing θ. Then the total cost for the firm is given by

$$\theta q + \tau Z(\theta,q) = 2\,\theta q.$$

Also, the (environmental) tax revenue for the government is $\tau(q/\theta) = \theta q$. Thus, letting $c = 2\theta$, adding $(c/2)\,q$ to both the government's tax revenue and to the "environmental damage" function, we recover Kennedy's model with $h(c,q) = (c/2)\,q + e(2q/c)$. Emissions would be given by $Z = (2q/c)$.

<u>The effect of bilateral reductions in tariffs:</u>

Given C and T, the problem faced by firms in this more general setting has a solution which is again given by equation (1) and (2). In addition, the objective function for the government of country i is as stated in (3) except that now $h(\cdot)$ has c as an argument. Again, whether lower tariffs imply tougher or weaker policies (higher or lower values of c) depends on the sign of (4), and this again depends on the aggregation of the four effects stated in (10) through (13) (substituting $\frac{\partial h}{\partial q}$ for h'), except that (13) is now:

$$\left[P_i'\,\frac{\partial\left[q_i+q_i^*\right]}{\partial c_i}-\frac{d}{dc_i}\left(\frac{\partial}{\partial q}h(c,q)\right)\right]\frac{\partial Q_i}{\partial t_i}. \qquad (14)$$

That is, instead of only having the effects on $h(\,)$ of changes in output that appear in (13), we now also have to consider the direct effect of the policy instrument on the marginal social cost of production:

$$\frac{d}{dc_i}\left(\frac{\partial}{\partial q}h(c,q)\right) = \frac{\partial^2 h}{\partial q^2}\,\frac{\partial\left[q_i + q_i^*\right]}{\partial c_i} + \frac{\partial^2 h}{\partial q \partial c_i}.$$

The first term above is, as before, negative, and the sign of the second term depends on the particular case that we are analyzing: the marginal direct effect of the environmental variable may be lower or higher for higher levels of output. Still, a reduction in tariffs has both positive and negative effects on the incentives for governments to set tougher environmental policies, and the trade off of these effects could be resolved in either direction. Again for the demand function $P(Q) = 1 - Q$, and for particular examples of both cases (i) and (ii) above, a move towards free trade can result in weaker environmental policies, but can also result in stronger ones (see Table 2).

<u>Table (2) approximately here</u>

Perhaps more surprisingly, in this more general model the results regarding total damage are less conclusive. Indeed, even though total output is larger under free trade, as before, the fact that this output may be obtained using cleaner technology implies that it is possible that a cut in tariffs is associated with less damage to the environment. This is the case, for instance, in the particular specification of the model in Kennedy (1994) that we consider in Table 2b (first specification), where emissions were given by q/θ (remember that, in this case, $\theta = c/2$). Not only is the environmental policy more stringent under free trade (higher c); total emissions (and marginal emissions) are also lower.

4.-Concluding remarks

In this paper we have analyzed the effect on environmental protection that should be expected from bilateral reductions in trade protection. Thus, we have compared the strategic interaction of governments when they can influence production and environmental damage with two instruments, tariffs and environmental variables (standards, taxes on output, taxes on emissions, etc.), and when they can only use environmental policies. Weaker policies can be expected when the effect of environmental protection on the marginal social cost of production and the marginal willingness to pay for consumption is not great. However, if this effect is large and negative enough, the reduction in tariffs resulting from a free trade agreement will give rise to tougher environmental policies.

We have argued that instead of looking at the trade-off between rent appropriation and pollution shifting, what one should consider is how this trade-off changes when the level of tariff protection is lower. As it turns out, this change takes us back to the traditional trade-off between higher consumption and a cleaner environment. Thus, whether one considers freer trade desirable or not will in general depend on how desirable one considers increasing the consumption standards at the cost of greater damage to the environment.

We have also shown cases in which even the total damage to the environment is reduced as a consequence of trade liberalization: greater output makes the option of inducing cleaner technologies a more attractive one. Then greater output will be obtained with cleaner technologies, and the result may be a cut in total damage to the environment. [7]

We have assumed symmetric countries for simplicity. Relaxing this assumption could change the balance of the effects of changes in tariffs on environmental policies. However the same incentives that we have analyzed in the symmetric model would also appear in the asymmetric one and so we also expect the issues raised in this paper to be relevant in that case.

[7] This case and the incentives behind it (excluding the strategic ones) would be supported by the empirical evidence presented in Antweiler, Copeland, and Taylor (1998).

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Table 1

	Tariff competition	Free trade
$h(q)=\frac{1}{3}q^{3/2}$		
Env. Tax (c)	.16	.09
Tariff (t)	.22	--
Total output (Q_i)	.48	.60
Domestic sales (q_i)	.35	.30
Exports (q_i^*)	.13	.30
$h(q)=\frac{2}{3}q^{3}$		
Env. Tax (c)	.23	.25
Tariff (t)	.20	--
Total output (Q_i)	.44	.50
Domestic sales (q_i)	.32	.25
Exports (q_i^*)	.12	.25

Table 2a

Case (i)	Tariff competition	Free trade
A= 10, b = .2		
Env. Tax (c)	.088	.089
Tariff (t)	.203	--
Total output (Q_i)	.54	.61
Domestic sales (q_i)	.37	.30
Exports (q_i^*)	.17	.30
A= 10, b = .88		
Env. Tax (c)	.627	.626
Tariff (t)	.047	--
Total output (Q_i)	.23	.25
Domestic sales (q_i)	.14	.12
Exports (q_i^*)	.09	.12

Table 2b

Case (ii)	Tariff competition	Free trade
$e(Z) = .05\ Z^2$		
Env. Tax (c)	.548	.556
Tariff (t)	.127	--
Total output (Q_i)	.295	.296
Domestic sales (q_i)	.193	.148
Exports (q_i^*)	.066	.148
$e(Z) = .01\ Z^{3/2}$		
Env. Tax (c)	.264	.257
Tariff (t)	.22	--
Total output (Q_i)	.417	.495
Domestic sales (q_i)	.31	.248
Exports (q_i^*)	.107	.248

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