Trade liberalization, environmental policy, and welfare

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Abstract

We analyze how trade liberalization affects environmental policies in the context of bilateral trade and imperfect competition. Instead of looking at the strategic distortions that trade introduces in environmental policies—the focus of most existing studies—we analyze how these distortions change in the face of a bilateral reduction in tariffs. The incentives to distort environmental protection may be reduced by this move. As a consequence, environmental policies may be more stringent. Also, welfare is likely (and for some instruments certain) to increase.

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1. Introduction

Environmentalists have generally considered international trade flows a threat to adequate environmental regulation. This has become clear in the discussions surrounding moves towards free trade, like NAFTA. As Kennedy [8, p. 49] points out, it has been argued and feared that “freer trade will lead governments to relax their environmental standards in order to gain a competitive edge over their trading partners”. This paper examines this key policy issue, asking what is the effect of a reduction in trade barriers on welfare and the level of environmental protection when governments have an incentive to use environmental policy as a substitute for a trade barrier.

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With the same concerns, a literature has developed which studies how strategic environmental policies differ from efficient policies, usually under the assumption of free trade (see, for instance, [2,8,12,14]; [15] provides a good review of the literature). The main conclusion is that a rent-shifting or trade-related incentive distorts environmental policies. When competition among firms is modeled as a Cournot game, these incentives imply that environmental policies will be weaker than is efficient. This result is a straightforward application of theories of strategic behavior. By committing to a less restrictive environmental policy the government reduces the marginal costs of domestic firms and makes them more aggressive competitors in international markets.

However, the conclusion that trade-related incentives tend to reduce environmental protection does not really address the policy question posed above. Indeed, a trade agreement is a move from one scenario with trade (and trade related incentives for environmental protection) to another, rather than a move from autarky to trade. Thus, the relevant questions are how trade liberalization affects those trade-related incentives for environmental protection, and what are the overall welfare consequences. These are the questions we aim to address here.

We study these issues in a model of imperfect competition and bilateral trade. Both ingredients, but primarily imperfect competition, appear to be necessary if “gaining a competitive edge over trade partners” is singled out as the main strategic motivation at work.2

Thus instead of looking at the trade-off between trade-related incentives and environmental considerations, we analyze how this trade-off changes when the level of tariff protection is reduced. As a result of a reduction in tariffs one would expect total output in each country to increase. This means higher marginal damage to the environment and lower prices. Both these effects actually reduce the incentives of governments to use environmental policies strategically as a way to gain a competitive edge over trading partners, and thus increase the incentives for environmental protection. On the other hand, lower tariffs also mean lower tariff revenue from imports (and lower cost of exports). From the government’s point of view, this reduces the appeal of imports, and increases that of exports, and thus reduces the incentives for environmental protection. These two opposite forces are the main factors determining how environmental policies change as a result of a bilateral reduction in tariffs.3 We will see that either effect can dominate.

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1Strategic trade considerations may strengthen environmental policies when competition is in prices [2]; when tougher environmental policies soften competition among domestic firms [2]; when tougher standards induce firms to reduce their unit costs—R&D—[15]; and also, when political economy considerations, rather than welfare, determine the goal of governments [3]. Without strategic considerations, [10,12] obtain the result for countries that export pollution intensive goods.

2Walz and Wellish [16] show that reductions in export subsidies will lead to less environmental protection in a model without bilateral trade. Kennedy [9] analyzes how environmental policies are affected by trade incentives when governments also tax or subsidize domestic output. Also related, in a series of papers, Copeland and Taylor [5–7] and Antweiler et al. [1] study how trade affects the environment as compared to autarky. Turunen-Red and Woodland [13] analyze Pareto improving reforms of trade and environmental policies. Ludema and Wooton [11] assume perfect competition when only one country pollutes, and only one (the other) cares about pollution. Trade liberalization makes it impossible for the second to affect pollution through tariffs.

3To this, one should add the possible effect that changes in output has on how the policy instrument affects environmental damage and/or cost of production, and how it affects marginal social surplus, as we will see below.
This may resemble another well known trade-off: Weaker environmental protection substitutes for tariff protection, but increased pressure on the environment due to higher output tends to strengthen environmental policies.\(^4\)

Note, however, that a bilateral reduction in tariffs does not mean less protection for domestic firms. Indeed, while domestic firms face tougher competition in the domestic market, they also enjoy a better competitive position in the foreign market. Thus, the change in the level of domestic trade protection is itself ambiguous, and we should look rather at how the relative surplus from exports and imports conditions the trade-off between higher consumption and a cleaner environment.

We also look at the welfare consequences of trade liberalization. In our model imperfect competition and policy competition will generally move the equilibrium from a first best situation. This means that in general prices will not be equal to marginal social cost (the sum of private marginal costs and marginal environmental externalities). Since a lower tariff will typically expand output, welfare will improve if price (willingness to pay) is above marginal social cost, and fall if price is below marginal social cost. Tariff rent appropriation motives typically mean prices above marginal social cost, and then welfare will typically improve as a result of trade liberalization. But there are exceptions: the environmental instrument (one of the instruments to affect output in this imperfect competition world) may have a direct impact on the (social) unit cost of production. When (but only when) this impact is strong and positive, prices may actually be below social marginal cost in equilibrium, and then welfare will fall as a consequence of a reduction in tariffs. We show that this may indeed be the case when the environmental instrument is a direct regulation of standards.

The prediction is clearer when governments use more indirect instruments, like taxes on outputs, inputs, or emissions. In these cases we show that price is always above the social marginal cost. Thus, the effect of trade liberalization on welfare is unambiguously positive.

The rest of the paper is structured as follows. Section 2 presents the model. Section 3 contains the general analysis of the effects of bilateral reduction in tariffs on welfare and environmental policies. In Section 4 we specialize the model for four different instruments: taxes on output, input, and emissions, and environmental standards, and show how the general analysis applies to these cases. Finally, Section 5 offers some concluding remarks.

2. The model

Consider a symmetric, Brander-Spencer [4] reciprocal dumping model of bilateral trade. There is a single, tradable good produced by two firms, each located in a different country, Home (1) and Foreign (2). Each firm sells in both countries. In each of the countries, the demand for the good is given by an inverse demand function, \(P(Q)\), which is the same in each country. Firms compete (in quantities) both in their domestic and foreign markets. In each country there is a government whose goal is to maximize national welfare by setting the value of some environmental instrument, \(c_i\). Environmental regulation tackles local environmental damage, a by-product of production. In addition, imports to each country are subject to a tariff, \(t\) which, for simplicity, we assume exogenous and the same in both countries.

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\(^4\)See, for instance, [5].
We further simplify the analysis by assuming constant marginal costs of production. The marginal cost that firms face is affected by environmental regulation. We assume it coincides with the value of the environmental instrument.5

The game is a two stage game. In the first stage, the Home (1) and Foreign (2) governments simultaneously choose the value of their environmental instrument. In the second stage, and after observing the policy choices of the first stage (and the tariffs), firms choose their output for the Home market and their output for the Foreign market.

Second stage: Given \( c_i, i = 1, 2 \), firms decide their output for each of the markets. Let \( q_i \) be the output of firm \( i = 1, 2 \) for the Home market and \( q_i^* \) the output of firm \( i = 1, 2 \) for the Foreign market. Also, let \( Q = q_1 + q_2 \) and \( Q^* = q_1^* + q_2^* \), the total consumption in each of the markets. Note that \( q_1^* \) are exports from Home to Foreign, and \( q_2 \) are imports of Home from Foreign. The marginal cost of the local firm, firm 1, for the goods produced for the Home market is \( c_1 \), and the marginal cost for the goods produced for the Foreign market is \( c_1 + t \), considering the tariff as a cost. Similarly, the marginal cost of the foreign firm, firm 2, for the goods produced for the Home market is \( c_2 + t \), and the marginal cost for the goods produced for the Foreign market is \( c_2 \).

The constant marginal cost assumption implies that markets are separated: the output choice for one of the markets is independent of the output choice for the other. We assume the demand function to be well behaved, so that an interior, unique solution exists. The Cournot equilibrium outputs of firm 1 are \( q_1(c_1, c_2 + t) \) and \( q_1^*(c_1 + t, c_2) \), and those for firm 2 are \( q_2(c_1, c_2 + t) \) and \( q_2^*(c_1 + t, c_2) \).

First stage: Governments decide their policies to maximize national welfare, defined as total surplus net of social cost (plus any tariff revenue). The social cost \( h \) is the sum of the private cost born by firms and the environmental externality, and may depend on locally produced output and the environmental policy: \( h(c_1, q_1 + q_1^*) \), for Home, and, \( h(c_2, q_2 + q_2^*) \) for Foreign. In Section 4, we explicitly derive this function from primitives: production function, environmental instruments and damage functions. For now, we make the straightforward assumption that \( \frac{\partial h}{\partial Q} > 0 \). Also, we assume that \( h \) is convex in \( Q \). Thus, the Home government maximizes

\[
W_1(c_1, c_2, t) = \int_0^Q P(x) dx - h(c_1, q_1 + q_1^*) - P(Q)q_2 + P(Q^*)q_1^* - t(q_1^* - q_2),
\]

where \( q_1, q_1^*, q_2, \) and \( q_2^* \) are the second stage equilibrium outputs. The five terms on the right-hand side are, respectively, gross (domestic) consumer surplus, social cost of domestic output, the value of imports, export revenue, and net tariff revenue.

3. The effect of bilateral reductions of tariffs

Equilibrium (interior) policies will satisfy \( \frac{\partial W}{\partial c_1} = 0 \). The main goal of this paper is to analyze the effects of an exogenous reduction in \( t \) on this equilibrium and the welfare change associated with it. We will only consider symmetric equilibria of this all-symmetric model. In such symmetric equilibria (for any given value of \( t \)), the net tariff revenue is zero as is the difference between the

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5In fact, this is a reduced form of a model where the constant marginal cost is a function of one of several environmental instruments. See Section 4.
value of imports and the export revenue: indeed, \( q_1^* = q_2 \) and \( Q = Q^* \). Thus, in equilibrium,
\[
W_1(c_1, c_2, t) = \int_0^Q P(x) \, dx - h(c_1, Q),
\]
and differentiating with respect to \( t \), using the fact that \( \frac{\partial Q}{\partial c_2} = \frac{\partial Q}{\partial t} \), we have that
\[
\frac{\partial W_1}{\partial t} = \left[ P(Q) - \frac{\partial h}{\partial q} \frac{\partial Q}{\partial t} \left( 1 + \frac{dc_2}{dt} \right) \right].
\]
Since \( \frac{\partial Q}{\partial t} < 0 \), and unless \( \frac{dc_2}{dt} < -1 \), the welfare effect of a reduction in tariffs (freer trade) would then be positive if (but only if) \( P - \frac{\partial h}{\partial q} > 0 \) in equilibrium.

The intuition is straightforward. Compared to a first best situation, under imperfect competition between firms and policy competition between governments, price may not be equal to marginal (social) cost. In this case, since a lower tariff will expand output, welfare will improve if price (willingness to pay) is above marginal cost, and fall otherwise.\(^6\)

We now turn to the related issue of the effect of a reduction of \( t \) on the equilibrium values of \( c_i \), i.e., the effect of reductions in tariffs on environmental policies. Totally differentiating \( \frac{\partial W_i}{\partial c_i} = 0 \), we have that
\[
\frac{dc_1}{dt} = \frac{\frac{\partial^2 W_1}{\partial t \partial c_1}}{\frac{\partial^2 W_1}{\partial c_1}}.
\]
Second-order conditions for equilibrium include \( \frac{\partial^2 W_i}{\partial c_i} < 0 \). Then, a reduction in tariffs implies weaker environmental policies (lower \( c_i \)) if, but only if, \( \frac{\partial^2 W_i}{\partial c_i} \) is positive. We now study the sign of this cross derivative.

Differentiating \( \frac{\partial W_1}{\partial c_1} \) with respect to \( t \), and using symmetry again, we have
\[
\frac{\partial^2 W_1}{\partial t \partial c_1} = \left( P' - \frac{\partial^2 h}{\partial q^2} \frac{\partial (q_1 + q_1^*)}{\partial c_1} - \frac{\partial^2 h}{\partial q \partial c_1} \frac{\partial Q}{\partial t} + \frac{\partial (q_2 - q_1^*)}{\partial c_1} \right) \frac{\partial^2 h}{\partial q \partial c_1} \frac{\partial Q}{\partial t} \frac{\partial Q}{\partial c_1} + \left[ P - \frac{\partial h}{\partial q} \frac{\partial^2 (q_1 + q_1^*)}{\partial c_1 \partial t} + \frac{\partial^2 (q_2 - q_1^*)}{\partial c_1 \partial t} \right].
\]
The first term on the right-hand side is negative when \( \frac{\partial^2 h}{\partial q \partial c_1} < 0 \) (see below), since \( P' < 0 \), \( \frac{\partial^2 h}{\partial q^2} > 0 \), \( \frac{\partial (q_1 + q_1^*)}{\partial c_1} < 0 \), and \( \frac{\partial Q}{\partial t} < 0 \). The second term, on the other hand, is positive: tougher environmental policies at home mean lower exports and higher imports. The other two terms, however, do not have a definite sign. For instance, when demand is linear they vanish. Yet, the sign of \( \frac{\partial^2 W_1}{\partial c_i} \) can be positive or negative depending on which of the following two incentives associated with a reduction in tariffs is stronger: (a) higher output depresses the marginal value of output (marginal willingness to pay minus marginal cost), and this induces tougher environmental regulations

\(^6\) The exception would be a case where the environmental policy reaction of governments to reductions in tariffs is extreme in the direction of tougher regulation, i.e., when \( \frac{dc_2}{dt} < -1 \), as we mentioned above. This can make output drop as a result of lower tariffs.
(which reduce output) at least if tougher regulation does not imply higher marginal social cost \( \frac{\partial h}{\partial q c} < 0 \); (b) lower tariff rates reduce tariff revenue from imports and tariff cost on exports, and then reduce the incentive to substitute foreign output for domestic output by using tougher environmental policies.

We now turn to evaluate these two effects and also the welfare implications of a reduction in tariffs for different specifications of the environmental instrument.

4. Welfare, policy strength and instruments

We specialize the model in order to discuss how the effects of trade liberalization on environmental policy and welfare may depend on the environmental instruments used by governments. Thus, assume that the production of \( q \) requires the use of two inputs, 1 and 2. The production function is Cobb–Douglas, and for simplicity in the computations, we assume equal exponents for both inputs, i.e.,

\[
q = x_1^{1/2} x_2^{1/2}.
\]

Input 1 is a “clean” input traded in a competitive market at price 1. Input 2 is the “dirty” input, traded in a competitive market at price \( w \). Each unit of input 2 used generates as a by-product an amount of emissions \( y \). The value of \( y \) is determined by the abatement technology (or the intensity of its use) chosen by the firm. Thus, obtaining a level of emissions per unit \( \theta \in [\theta, \tilde{\theta}] \) requires a cost per unit of input of \( A(\theta) \), with \( A(\tilde{\theta}) = 0 \), where \( A' < 0, \ A'' > 0 \). Finally, emissions \( E \) create environmental damage \( G(E) \), where \( G', \ G'' > 0 \).

We will study four policy instruments: a tax on output \( t \), a tax on the dirty input \( m \), a tax on emissions \( d \), and a standard \( y \). The latter is the maximum acceptable amount of emissions per unit of input. \(^7\) Assume the firm has chosen (or has been imposed) a level \( \theta \) of emissions per unit of input. Then, from the firm’s vintage point, the unit “price” of input 2 is \( (w + \mu + A(\theta) + \delta\theta) \). The first term is the cost (after tax) of acquiring a unit of input, the second term is the cost of obtaining a level of emissions \( \theta \) for that unit of input, and the last one is the tax (on emissions) paid as a consequence of using that unit of input. Then, the demand for input 2 and the cost function for the firm are given by

\[
x_2(q) = [w + \mu + A(\theta) + \delta\theta]^{-1/2} q,
\]

\[
C(q) = (2[w + \mu + A(\theta) + \delta\theta]^{1/2} + \tau)q.
\]

Thus, we should define

\[
c \equiv (2[w + \mu + A(\theta) + \delta\theta]^{1/2} + \tau)
\]

to recover our abstract (linear private cost) model of previous sections. Public revenue is given by

\[
PR = \mu x_2 + \delta E + \tau q = q \left[ \frac{2}{c - \tau} (\mu + \delta\theta) + \tau \right],
\]

\(^7\) \( \theta \) may be the intensity of abatement activities (coal scrubbing, for instance). Equivalently, \( \theta \) may represent a choice of input type (coal with different levels of sulfur content) whose unit price is \( w + A(\theta) \).
and thus, the total social cost is

$$h(c, q) = cq - PR + G(E) = \left[ \frac{c - \tau}{2} + \frac{2(w + A(\theta))}{c - \tau} \right] q + G\left( \theta \frac{2q}{c - \tau} \right).$$

In the next subsections we will use the particular form of $h(\cdot)$ described above to analyze the welfare effects of tariff reductions and the effects of tariff reductions on environmental policies in the framework of the model described in Section 2.

4.1. Welfare effects of tariff reductions

We start with the analysis of the welfare effects of reductions in tariffs. Recall that these effects will be positive if $P - \frac{\partial h}{\partial q} > 0$. Also, from the maximization problem of governments, we know that

$$\frac{\partial W_1}{\partial c_1} = 0,$$

where

$$\frac{\partial W_1}{\partial c_1} = \left[ P - \frac{\partial h}{\partial q} \right] \frac{\partial (q_1 + q_1^*)}{\partial c_1} + t \frac{\partial (q_2 - q_1^*)}{\partial c_1} - \frac{\partial h}{\partial c_1}.$$

The second term on the right-hand side is always positive. Thus, since $\frac{\partial (q_1 + q_1^*)}{\partial c_1} < 0$, it follows that $P - \frac{\partial h}{\partial q} > 0$ whenever $\frac{\partial h}{\partial c_1} \leq 0$. For tax instruments, the following proposition shows that this is indeed the case.

**Proposition.** If the environmental instrument is a tax (either on output, input, or emissions), a bilateral reduction in tariffs increases welfare.

**Proof.** We consider each instrument in turn.

(i) **Tax on output:** Notice that in this case the firm will choose $\theta = \tilde{\theta}$, $\tau$ is a function of $c$, and, from expression (1), satisfies

$$c - \tau = 2w^{1/2}.$$

That is, $h(c, q) = 2w^{1/2}q + G(\tilde{\theta} \frac{q}{w^{1/2}})$, independently of $c$. Therefore, $\frac{\partial h}{\partial c_1} = 0$, and a reduction in tariffs implies an increase in welfare.

(ii) **Tax on input:** Again, the firm will choose $\theta = \tilde{\theta}$. From expression (2), we can compute

$$\frac{\partial h}{\partial c} = \frac{2q}{c^2} (\mu - \partial G'),$$

and notice that, using the derivative of (2) with respect to $q$, we can rewrite this as

$$\frac{\partial h}{\partial c} = \frac{q}{c} \left( \frac{c - \partial h}{\partial q} \right).$$
Substituting in $\frac{\partial W_1}{\partial c} = 0$, we obtain

$$[P - c - t] \frac{\partial(q_1 + q_1^*)}{\partial c_1} + c \frac{\partial(q_2 + q_2^*)}{\partial c_1} + \frac{\partial h}{\partial c} \left[ \frac{\partial(q_1 + q_1^*)}{\partial c_1} - \frac{1}{q} \right] = 0.$$  

Rearranging the above expression, we can write

$$[P - c - t] \frac{\partial q_1^*}{\partial c_1} + [P - c] \frac{\partial q_1}{\partial c_1} + t \frac{\partial q_2}{\partial c_1} + \frac{\partial h}{\partial c} \left[ \frac{\partial(q_1 + q_1^*)}{\partial c_1} - \frac{1}{q} \right] = 0.$$  

The first term is negative, since $c + t$, the private cost of exports, should be lower than the price. Also, since $|\frac{\partial q_1}{\partial c_1}| > |\frac{\partial q_2}{\partial c_1}|$, the sum of the second and third terms is negative. Then, once again, $\frac{\partial h}{\partial c} < 0$, and this implies that lower tariffs will induce higher welfare.

(iii) **Tax on emissions**: The firm will choose $\theta$ to minimize $A(\theta) + \delta \theta$. The first order condition of this problem implies $\delta = -A'(\theta)$. Then, from (1), it follows that

$$\theta(c) = g \left( \left( \frac{c}{2} \right)^2 - w \right),$$

where $g$ is the monotonic function that satisfies $g^{-1}(x) = A(x) - x A'(x)$. Again, from (2), we can compute

$$\frac{\partial h}{\partial c} = \frac{2q}{c^2} [\theta - c \theta'] (\delta - G'),$$

and we also have

$$\frac{\partial h}{\partial c} = \frac{q}{c} \left( c - \frac{\partial h}{\partial q} \right).$$

Thus, what we said in case (ii) applies here, and welfare improves as a result of a reduction of tariffs.  

(iv) **Standard on emission per unit input**: Things are more ambiguous when the environmental variable is a standard. In this case $\theta = \theta'$ is chosen directly by the government, and public revenue is zero. The following example illustrates this ambiguity.

**Example.** Assume $P(Q) = 2 - Q$, $A(\theta) = (1 - \theta)^2$ (i.e., $\theta = 1$), and $G(E) = m E^2$. Also, let $w = 0.25$ and $t = 0.2$. Then, we can solve the model above for $m = 1/2$, and obtain that governments choose in equilibrium a standard $\theta \approx 0.3$ (cost $c \approx 1.12$). This implies a price $P = 1.48$ and $\frac{\partial h}{\partial q} \approx 0.2$. On the other hand, if $m = 1/16$ governments choose in equilibrium a standard $\theta \approx 0.5$ (cost $c \approx 1$). This implies a price $P = 1.4$ and $\frac{\partial h}{\partial q} \approx 1.29$. That is, in the first case welfare would be lower following a reduction in $t$, but in the second welfare would be higher.

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9 We use subscripts whenever the lack of them could lead to confusion.

10 Notice that the elasticity of demand is higher and the marginal damage lower in the second case. These two factors are important to determine the final effect on welfare of a reduction of tariffs when the instrument is a standard. Indeed, if the demand is very elastic and tariffs negligible, and recalling that in a symmetric duopoly the difference between price and marginal cost is half the inverse of the elasticity of demand, then $P - c$ is very small. Thus, $\frac{\partial h}{\partial q} (= c + \frac{w}{2} G')$ would be above $P$ and we would expect welfare to be lower after a reduction in tariffs.
The results above are not merely an artifact of this model. Indeed, in the case of a tax on output the positive result generalizes (under linear private costs and symmetry). Also, when the instrument is either a tax on input or on emissions, our result hinges only on the relationship between $\frac{\partial h}{\partial q}$ and $\frac{\partial h}{\partial c}$. The key is (convexity and) the relationship between social marginal cost ($\frac{\partial h}{\partial q}$) and the marginal direct effect of private cost on social cost ($\frac{\partial h}{\partial c}$). Recall that when the instrument is indirect (taxes on input and on emissions), the government can control the social costs only through the optimizing behavior of the firm. Thus, the government can only hope to induce the firm to choose the cost minimizing technology or input ($\frac{\partial h}{\partial c} = 0$) when private incentives are perfectly aligned with social ones ($\frac{\partial h}{\partial q} = c$). Conversely, if the firm does not fully internalize the social cost of production ($\frac{\partial h}{\partial q} > c$), we should also expect that the technology used by the firm (the mix of inputs, when $\theta$ cannot be controlled with policy, or the abatement effort and mix of inputs, when emissions can be taxed) is too cheap (dirty) relative to the cost-minimizing one, and then $\frac{\partial h}{\partial c} < 0$. And this is what drives our results.

This also explains the difference between the unambiguous results when the instrument is a tax and the ambiguous result when the instrument is a standard. In the case of a standard there is no public revenue, and the private cost is always lower than the social cost (there is no instrument to make the firm internalize the effect of emissions). And this is so whether the standard is set too high or too low from the point of view of the minimization of social costs. Indeed,

$$\frac{\partial h}{\partial q} = c + \frac{2\theta}{c} G'.$$

Thus, $\frac{\partial h}{\partial c}$ could be negative even when the price is smaller than the marginal social cost, explaining the possibility that welfare is lower under freer trade.

4.2. Effects of tariff reductions on environmental policies

Next, we turn to the effect of a reduction of tariffs on the strength of environmental policies; that is, on $c$. The answers here are necessarily less clear cut. Indeed, ambiguity is pervasive. In short, a reduction in tariffs induces an increase in output, and then an increase in the marginal social cost. This represents an incentive for tougher environmental regulations. However, a reduction in tariffs also reduces the tariff revenues associated with negative commercial balances. This represents an incentive for less strict regulations (lower cost for domestic firms). The relative strength of these two incentives is ambiguous and depends on such factors as the convexity of the damage function, the emissions per unit of output, and the level of output itself. When the convexity of the damage function, the level of emissions per unit of output, and this output are large, then we should expect more stringent environmental regulations as a consequence of moves towards freer trade. Finally, the instrument used affects both the level of output and the emissions per unit of output. However, instruments that induce higher emissions per unit of output also induce lower level of output. Thus, the type of environmental instrument used does

11 Note that increases on $\tau$, $\mu$, or $\delta$, and reductions in $\theta^d$ all imply increases in $c$. 

not help predicting the environmental policy response of governments to bilateral reductions in tariffs.

In order to identify the effects most directly related to the relationship between environment and trade, let us assume that the demand function is linear, so that the second derivatives of this function vanish. Then, a reduction in tariffs will induce a tougher environmental stance, i.e., a higher $c$, if and only if

$$\frac{\partial^2 W_1}{\partial t \partial c_1} = \left[ P' - \frac{\partial^2 h}{\partial q^2} - \frac{\partial^2 h}{\partial q \partial c_1} \left( \frac{\partial(q_1 + q_1^*)}{\partial c_1} \right)^{-1} \right] \frac{\partial(q_1 + q_1^*)}{\partial t} \frac{\partial Q}{\partial c_1} + \frac{\partial(q_2 - q_1)}{\partial c_1} < 0. $$

The first term on the right-hand side is related to the effect of a change in output on the difference between willingness to pay and (social) marginal cost. When tariffs are reduced, output and consumption are larger. This alters how a change in domestic cost affects the difference $[P - \partial h/\partial q]$. At least if the environmental instrument is a tax (either on output, input or on emissions), this term is negative and represents an incentive for tougher environmental regulations following reductions in tariffs.\( ^{12} \) That is, when output is larger, the incentive to tighten environmental regulation is higher. The second term, on the other hand, represents the effect on the net commercial flow into the country of an increase in the domestic cost. A reduction in tariffs also reduces the attractiveness of imports (and increases the appeal of exports), and therefore lowers the incentives of the government to increase the private cost in order to attract these imports. This second term is unambiguously positive, and represents an incentive for governments to relax their environmental policies in response to a bilateral reduction of tariffs. Thus, even though the higher output associated with a reduction in tariffs will foster the incentives to protect the environment, the reduced incentive to cash in on imports (and save revenue from exports) may outweigh this effect. The result may then be a lower valuer of $c$.

When demand is linear, $P'$, $\frac{\partial(q_1 + q_1^*)}{\partial c_1}$, and $\frac{\partial(q_2 - q_1)}{\partial c_1}$ are all constant (the first three are negative and the last one is positive). Thus whether $\frac{\partial^2 W_1}{\partial t \partial c_1}$ is positive or negative depends on

\( ^{12} \) Both $P'$, $\frac{\partial(q_1 + q_1^*)}{\partial c_1}$, and $\frac{\partial Q}{\partial t}$ are negative, and

$$\frac{\partial^2 h}{\partial q^2} = \left( \frac{2 \theta}{c - \tau} \right)^2 G'' > 0$$

in all four cases. $\frac{\partial^2 h}{\partial q \partial c_1}$ vanishes when the instrument is a tax on output. When the instrument is a tax on inputs, and applying again the relationship between $\frac{\partial h}{\partial t}$ and $\frac{\partial h}{\partial q}$,

$$\frac{\partial^2 h}{\partial q \partial c_1} = \frac{1}{c} \left( c - \frac{\partial h}{\partial q} \right) - q \left( \frac{2 \theta}{c} \right)^2 G'' \left( A' - 2 \theta \left( A' - q \frac{2 \theta}{c} G'' \right) \right) < 0,$$

since we have seen that $(c - \frac{\partial h}{\partial q}) < 0$. Also, in case the instrument is a tax on emissions,

$$\frac{\partial^2 h}{\partial q \partial c_1} = \frac{1}{c} \left( c - \frac{\partial h}{\partial q} \right) - q \left( \frac{2 \theta}{c} \right)^2 G'' - 2 \theta \left( A' - q \frac{2 \theta}{c} G'' \right) \left( A' - q \frac{2 \theta}{c} G'' \right) < 0,$$

since both $\theta'$ and $A'$ are negative.
whether
\[ \frac{d \frac{\partial l(c, q(c))}{\partial q}}{dc} = \frac{\partial^2 h}{\partial q^2} \frac{\partial (q_1 + q_1')}{\partial c_1} + \frac{\partial^2 h}{\partial q \partial c_1} \]
is (negative and) large or small.\(^{13}\) That is, a reduction in tariffs will imply a higher private cost for firms (tougher environmental policies) if the marginal social cost is very responsive to the private marginal cost (a function itself of the environmental instrument). In other words, and considering the equilibrium inverse relationship between output and private cost, if the marginal social cost is very responsive to output then a reduction in tariffs will imply tougher environmental regulations.

The direct impact of output on social cost is
\[ \frac{\partial^2 h}{\partial q^2} = \left( \frac{\theta}{(c - \tau)/2} \right)^2 G'' . \]

Thus, the degree of convexity of the damage function affects positively this direct impact. Intuitively, when the damage function is very convex, the increase in output that follows a reduction in tariffs increases the marginal social cost of production substantially. This is an incentive for governments to tighten their environmental policies. Emissions per unit of output, \( \frac{\theta}{c^{1/2}} \), (and output itself) have a more ambiguous effect. But this ambiguity disappears if \( G'' \) is also positive (i.e., if the degree of convexity of \( G \) is increasing with emissions). In this case, the higher the level of emissions per unit of output, and the higher the level of output (emissions), the more likely it is that environmental policies are tougher after the reduction in tariffs.\(^{14}\) Nevertheless, one can easily find examples of both toughening and relaxation of policies following a reduction of tariffs.

How does the instrument affect the responsiveness of marginal social cost to output? First, for the same value of private cost \( c \) (and output), different instruments will induce different levels of emissions per unit of output. The ranking here is clear: taxes on output induce the highest level of emissions per unit of output, \( \frac{\theta}{c^{1/2}} \), followed by taxes on input, \( \frac{\theta}{c^{1/2}} \) and taxes on emissions, \( \frac{\theta(\delta)}{c^{1/2}} \), where \( \theta(\delta) < \theta \). Also, for any standard \( \theta' \) the same value of \( \theta \) could be induced by a tax on emissions only at a higher private cost.\(^{15}\) That is, the same private cost induces a higher value of \( \theta \) when the instrument is a tax on emissions. Hence, emissions per unit of output are lowest when the instrument is a standard.\(^{16}\)

\(^{13}\)For linear demand, solving the Cournot model we can check that
\[ P_r \frac{\partial (q_1 + q_1')}{\partial c_1} \frac{\partial Q}{\partial t} + \frac{\partial (q_2 - q_1')}{\partial c_1} = -\frac{5}{9} P > 0 . \]

\(^{14}\)To this impact, we should add the indirect effect: output changes only as a result of changes in the private cost, which then affects (unless the instrument is a tax on output) the responsiveness of social cost to output. Here, again, the convexity of \( G \), the level of output, and the level of emissions per unit of output (if \( G'' > 0 \)) all make it more likely that the response to a reduction in tariffs is a toughening of environmental policies. The marginal cost of abatement activities would also make this result more likely.

\(^{15}\)When the instrument is a tax on emissions, the private cost includes the tax revenue \( \delta \theta \), which is not a (private) cost when the instrument is a standard.

\(^{16}\)This ranking is for a single regulated firm and will not necessarily extend to the case with several asymmetric firms.
However, different instruments induce different equilibrium values for the private cost, $c$, and therefore different levels of output. In fact, one can show that the ranking for private costs follows the same ranking as before, with the possible exception of standards: it is highest for output tax, lower for input tax and even lower for tax on emissions.\footnote{Proof of this can be obtained from the authors upon request.} Hence, since emissions per unit of output and output itself are inversely proportional to private cost, one cannot make a general ranking of instruments in terms of the induced value of $\frac{\partial^2 h}{\partial q \partial c}$\footnote{Things are further complicated by the fact that the indirect effect of output through private cost, $\frac{\partial^2 h}{\partial q \partial h_c}$, cannot be generally ranked, this time with the exception of a tax on output, for which this effect vanishes.}

Thus, and as opposed to our results regarding welfare, knowing the particular environmental instrument used does not help to predict the direction of the change in environmental policy that follows from trade liberalization.

5. Concluding remarks

In this paper we have analyzed the impact of bilateral reductions in trade protection on environmental policies and welfare. 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 as the level of tariff protection is reduced. In summary, we conclude that there is no special reason to expect environmental regulation to be less stringent as a result of trade agreements. Welfare implications of a move towards freer trade are easier to predict. We should expect higher welfare whenever governments use taxes as their environmental policy instrument. However, if the instrument is a direct setting of standards, and if demand is very elastic and the damage function very steep, welfare could be lower after this move.

We have assumed symmetric countries for simplicity. Relaxing this assumption should introduce new strategic considerations. However, the incentives that we have described in this symmetric model should also be important factors in a more general case.

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References

Further reading