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The role of green tariffs in environmental harmonization

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The Role of Green Tariffs in Environmental Harmonization

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The Role of Green Tariffs in Environmental Harmonization[#]

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Abstract

This paper investigates the link between trade and environment by exploring the effects of green tariffs on the location of firms, innovation and environmental policy. Besides the standard effect of reducing trade and production of dirty goods, green tariffs discourage firms from relocating to pollution havens and induce them to engage in pollution abatement R&D instead. With no concern about pollution among Southern residents, green tariffs can block delocation to serve as the only means of persuading the South to harmonize its environmental standards. When some concern exists, tougher environmental regulations are adopted for a wider range of standards.

JEL classifications: F13, F18, F23, H23, Q21, R38

Keywords: environmental standards; eco-dumping; multinationals; location of firms; pollution abatement R&D; WTO; green tariffs

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1. Introduction

The link between trade liberalization and environmental protection is increasingly gaining importance in recent years with environmental protection constituting an even bigger part of WTO rounds. The primary debate led by environmentalists is that trade liberalization damages the environment. This may occur as trade can increase pollution by increasing activity, i.e. opening the domestic market to or expanding the production of goods that are manufactured with environmentally damaging technologies. In the absence of trade policy instruments, governments may also be tempted to distort their environmental policies to protect their domestic economy. If allowed, they can impose a loose regime of environmental regulation for fear that tougher environmental policies may damage the competitiveness of their firms. Such policies may also cause domestic firms to relocate plants abroad or close down altogether in response to foreign competition that faces less strict environmental regulation and hence lower production costs. Low and Yeats (1992) show for instance that pollution-intensive industries are more prevalent in the developing world and that exports of these industries are declining in industrialized countries (North) while rising in developing countries (South) where the environment is to a large extent ignored.¹

While intellectual property rights have officially found their way onto the WTO agenda through the TRIPS agreement and labor standards have failed to make a convincing case for inclusion, environmental protection remains in a limbo state. The notion of enforcing environmental standards at a global level is however moving closer to realization step by step with the WTO devoting greater attention to environmental negotiations in recent rounds. For example, a significant part of the Doha declaration in 2001 dealt with trade and environment. Ministers have agreed to launch negotiations on the relationship between existing WTO rules

¹ There are arguments against this at the same time with empirical evidence showing that there is no strong evidence that environmental regulation per se leads to reduced international competitiveness and firm relocation abroad as the costs of complying are relatively small compared to total production costs. (Beghin et al. 1994)

and specific trade obligations set out in multilateral environmental agreements (MEAs).² The new Article 31(i) in the Doha text in particular attempts to clarify and codify the rules between the WTO and MEAs.³ It addresses how WTO rules are to apply to WTO members that are parties to approximately 200 MEAs in place today, of which only 20 contain trade provisions. But the text exempts any country that is not a signatory to an MEA. Free riding problems through such obvious loopholes have led to policy suggestions for a move towards harmonized environmental regulations across countries. WTO involvement in this case means that a country that has adopted stricter environmental standards may accept greater economic integration with another country only if the latter agrees to adopt more stringent environmental policies. The role of WTO would in case of non-compliance be to allow rivals of such countries to impose countervailing tariffs on their imports for having laxer environmental regulations. Can such tariffs be justified, and if so, what is their impact on the location of firms, innovation, environmental policies in the South and finally the environment itself?

When discussing a cleaner environment, growth and sustainable development in the South, two issues come to mind regarding multinationals: their decision on where to locate and how much they plan to invest in pollution abatement R&D in response to different environmental policies. Zannetti and Abate (1993) have carried out a business survey to find that big

² This involves, for example, the Montreal Protocol on substances that deplete the ozone layer, the Convention on Biological Diversity, and the Convention on International Trade in Endangered Species (CITES). Other MEAs include the Basel Convention on the international movement of toxic waste, and the United Nations Framework Convention on Climate Change, and its Kyoto Protocol, aimed at curbing emissions of greenhouse gases. (<http://www.ipsnews.net/interna.asp?idnews=20065>)

³ WTO ministerial conference in Doha set Jan. 1, 2005 as the deadline for negotiations on clarifying the relationship between WTO rules and the trade obligations established by the MEAs. The fifth WTO ministerial conference in Cancun however did not give much emphasis to green issues and no consensus was reached to produce a new mandate or reaffirm the existing timeframe. (http://www.wto.org/english/thewto_e/minist_e/min03_e/min03_e.htm)

corporations in industrialized countries tend to respond to environmental policy measures primarily by technological and organizational innovation, secondarily by re-localizing of plants and production. This has created two important branches of literature in environmental economics that study different aspects of the connection between each of these factors and environmental standards.⁴

Markusen, et al. (1993) was the first paper to investigate the relationship between firm location and environmental policy. In their model, the world is composed of two countries and one “footloose” firm. The firm decides where to set up production after having observed the actions of the two governments. It could stay at home, establish an extra plant in the foreign country, or close down home production altogether and establish a plant abroad to serve both markets. They show environmental policies to have a very strong impact on a firm’s decision about location. Motta and Thisse (1994) consider a different setting where the firm is initially located in its home country before the proposed changes in environmental regulation. They examine a firm’s choice of location as a response to stricter environmental policy in its home country and show that a firm is less likely to relocate as it already incurs fixed costs as sunk costs. Hoel (1997) extends the study to endogenize environmental policy demonstrating that governments have an incentive to choose loose environmental standards to attract firms as long as disutility from pollution is not high enough to promote a ‘Not In My Back Yard’ policy. Finally, Ulph and Valentini (2001) show on the contrary that environmental dumping is greater when plants are ‘not’ footloose if there are two firms in the model as opposed to only one as this can create strategic rent-shifting incentives for governments.

Michael Porter (1991) pioneered the conception of positive externalities being generated by environmental regulation on R&D. He pointed out that environmental policies can spur domestic industries to innovate greener technologies ahead of their rivals to enhance long-run

⁴ For a survey of traditional and strategic literature on environmental policy and international trade see Neary (1999).

profitability through this so-called competitive advantage. The idea did not live long as several arguments emerged to attack Porter's hypothesis. One argument states that although environmental regulation can motivate innovation in better products or cheaper processes, it is not clear if the benefits will repay the investment in the necessary innovation. Simpson and Bradford (1996) for instance challenge Porter using this argument by showing the two effects of tougher environmental policies on profits: the direct effect of increased production costs and the indirect effect of lower variable costs it causes by spurring innovation. They conclude that environmental regulation is unlikely to serve industrial advantage. While a lot of literature in environmental economics has been devoted to the two fields of location and R&D, no attempt has been made to show the effects of environmental standards on the two issues in a framework with both present.

This paper brings economic integration, environmental harmonization, firm relocation and pollution abatement R&D stimulation into a single model to investigate how they interact to shape the optimal environmental policy in the South. It builds a North-South model to show that trade policy and environmental standards can together reduce multinationals' incentives to escape to pollution havens and instead induce them to engage in pollution abatement R&D. Tariffs make relocation useless and encourage firms to use R&D as an alternative to reduce costs. Additionally, R&D is higher and the environment as a result cleaner if standards are harmonized accompanied by trade liberalization as a reward. It will be seen that the optimal policy for the South is to always adopt standards enforced in the North for lower levels of the pollution tax. With no environmental concern over pollution in the South however, environmental harmonization is only an option when green tariffs are positive. If the concern about pollution in the South is high enough, it is optimal to adopt standards also when stricter environmental regulations are required.

The Northern firm chooses location in the second stage, decides how much to invest in pollution abatement R&D in the third, and competes in production with the Southern firm in the fourth stage. Prior to the actions of firms, the Southern government anticipates firms' decision on output, R&D and location, and chooses whether or not to adopt standards in the

first stage. If the South chooses to harmonize its environmental standards, tariffs are abolished to allow for economic integration as a complement or a reward. The paper is organized as follows: Section 2 describes the model and solves the three stages of the game for the Northern multinational, where there are initially no environmental standards enforced in the South. Section 3 introduces standards and shows firms' decision on output, R&D and location in the case of harmonized standards. Section 4 analyzes the optimal environmental policy for the South and shows the outcome for different levels of trade costs and pollution tax. Section 5 concludes.

2. The Model

There are two countries in the model: the North and the South. The North is assumed to enforce environmental standards by imposing a pollution tax on emissions released by firms during production. The South in contrast has no environmental restrictions and local firms as well as foreign firms operating there can produce without any additional charges for causing pollution. The model assumes two firms with one belonging to each country. They produce a homogenous good and compete in an oligopolistic manner à la Cournot. They compete in segmented markets and choose the optimal output for each market separately.

The Southern firm is a local firm and only produces in its domestic country. The Northern firm on the other hand is a multinational and can decide on production location. It can stay at home and serve both markets from its Northern headquarters. It can also build a subsidiary in the South to serve the Southern market, but still maintain production in the North to serve its home interests. Alternatively, it can close down home production altogether and completely relocate to serve both markets from the South.⁵ The Northern firm is also capable of investing in pollution-abatement R&D to innovate cleaner production technologies in order to reduce its

⁵ This framework was used in a study by Barbier and Haltberg (2001) to show that a firm's decision to relocate in case of economic integration is influenced by the relative marginal cost of production between the regions, the cost of relocation, the cost of exporting its good across borders and the relative size of the two regions.

expenses on pollution tax. It is assumed that the Southern firm is less developed than the Northern firm and has no R&D capabilities.⁶ Hence, it always produces using a dirty technology.

The Southern government chooses whether to adopt standards and enjoy trade liberalization or to keep its lax environmental regulations and pay tariffs. Green tariffs are imposed against all imports produced in the South with a dirty technology if the latter does not adopt environmental standards. Note that this includes re-exports of the Northern firm back to the North and hence serves to discourage eco-dumping and delocation.

Demand is assumed to be linear and takes the familiar form

$$\begin{aligned} p_N &= a - Q_N \\ p_S &= a - Q_S \end{aligned} \tag{1}$$

where Q is the total consumption in each region, and subscripts N and S represent the North and the South. Total consumption in each region is

$$\begin{aligned} Q_N^E &= q_{SN} + q_{NN} & Q_S^E &= q_{SS} + q_{NS} \\ Q_N^F &= q_{SN} + q_{NN} & Q_S^F &= \tilde{q}_{SS} + \tilde{q}_{SS}^* \\ Q_N^D &= \tilde{q}_{SN} + \tilde{q}_{SN}^* & Q_S^D &= \tilde{q}_{SS} + \tilde{q}_{SS}^* \end{aligned} \tag{2}$$

where the first subscript indicates where the good is produced and the second denotes where it is consumed. Superscript E represents the case where the firm produces only in the North and exports to the South, F when it undertakes FDI to serve the Southern market locally, and D when it delocates and re-exports back to the North. The tilde above q denotes a situation where both firms produce in the South, while a star distinguishes Northern foreign production from local output by the Southern firm. The costs of production are divided between non-pollution related costs c and the pollution tax τ paid on the emissions that are released from producing one unit of the good. Unit emission discharged by the Northern and the Southern firm respectively is

⁶ If R&D by the Southern firm were allowed, it would not have any incentives to engage in R&D as it faces no restrictions as long as the government in the South does not adopt environmental standards.

$$e_N = e_0 - \sqrt{x} \quad (3)$$

$$e_S = e_0 \quad (4)$$

where $x \leq e_0^2$. e_0 represents the basic pollution caused by the production of one good prior to any pollution abatement research, and x is the amount of R&D investment carried out by the Northern firm to innovate cleaner technologies. Notice investment takes a one-off form and reduces emission at a decreasing rate.⁷ The profit function for the Northern firm when all of its production takes place in the North is

$$\pi_N^E = q_{NN}(a - Q_N^E - c - \tau_N) + q_{NS}(a - Q_S^E - c - \tau_N) - x \quad (5a)$$

This locational scenario entails that the Northern firm must pay a pollution tax on its entire production. When the firm builds a subsidiary in the South to serve each market locally, it only pays a pollution tax on the goods it produces in the North for the domestic market:

$$\pi_N^F = q_{NN}(a - Q_N^F - c - \tau_N) + \tilde{q}_{SS}^*(a - Q_S^F - c) - x - \Gamma \quad (5b)$$

Γ is the fixed cost of setting up a plant abroad which is independent of output. If the firm completely relocates to serve both markets from the South, it avoids paying pollution taxes altogether, but is bound to pay tariffs on its exports back to the North:

$$\pi_N^D = \tilde{q}_{SN}^*(a - Q_N^D - c - t) + \tilde{q}_{SS}^*(a - Q_S^D - c) - x - \Gamma \quad (5c)$$

The profit of the Southern firm takes the form

$$\begin{aligned} \pi_S^E &= q_{SN}(a - Q_N^E - c - t) + q_{SS}(a - Q_S^E - c) \\ \pi_S^F &= q_{SN}(a - Q_N^F - c - t) + \tilde{q}_{SS}^*(a - Q_S^F - c) \\ \pi_S^D &= \tilde{q}_{SN}^*(a - Q_N^D - c - t) + \tilde{q}_{SS}^*(a - Q_S^D - c) \end{aligned} \quad (6)$$

for each scenario created by the Northern firm's decision on production location. Recall that there is no environmental tax enforced in the South, but a tariff is paid on Southern exports to

⁷ The cost function containing pollution abatement R&D takes the same approach as in Ulph (1994).

the North.⁸ Adopting backward induction, section 2.1 first solves the problem of the firms in the third stage where they compete in output.

2.1. Production

In case of exports, production by the Northern firm in the North for each market takes the form

$$q_{NN} = \frac{1+t-2\tau_N}{3} \quad (7)$$

$$q_{NS} = \frac{1-2\tau_N}{3} \quad (8)$$

while the Southern firm produces

$$q_{SS} = \frac{1+\tau_N}{3} \quad (9)$$

$$q_{SN} = \frac{1-2t+\tau_N}{3} \quad (10)$$

for the South and the North respectively.

In case of FDI, q_{NN} and q_{SN} remain similar to (7) and (10) as the Northern firm keeps producing for its home market from a local plant. The firm however builds a subsidiary in the South to serve the latter locally making the output aimed at the South by both firms

$$\tilde{q}_{SS}^* = \tilde{q}_{SS} = \frac{1}{3} \quad (9')$$

In case of delocation, production for the Southern market by both firms remains the same as (9'). As the Northern firm also produces for its domestic market in the South and re-exports back to the North, production by both firms aimed at the North turns to

$$\tilde{q}_{SN}^* = \tilde{q}_{SN} = \frac{1-t}{3} \quad (10')$$

If the Northern firm produces at home for the domestic market, the direct effect of tariffs is to increase local production in the North and reduce imports from the South. Stricter standards

⁸ Tariffs and pollution taxes have been normalized to the market size to allow for the elimination of (a - c) from all upcoming equations.

per se have the reverse effect of reducing Northern production and encouraging production by the Southern firm. When the Northern firm exports to the South, τ affects the entire production by both firms, whereas with FDI only goods targeted at the Northern market are influenced. As under FDI both firms produce in the South for the Southern market where no pollution tax exists, the optimal quantity produced by both firms resembles that in a typical Cournot case. Finally, if the firm completely closes down production in the North and establishes a plant in the South to serve both markets, pollution taxes become irrelevant and tariffs reduce the exports of both firms to the North. The multinational has no production cost advantage in this case and the quantity produced by the two firms is always the same.

Proposition 1 Green Tariffs and Production of Dirty Goods in the South

As $\frac{\partial q_{SN}}{\partial t}$, $\frac{\partial \tilde{q}_{SN}}{\partial t}$ and $\frac{\partial \tilde{q}_{SN}^*}{\partial t} < 0$ at all times, tariffs always reduce production of environmentally unfriendly goods in the South in the exports sector. Total production of such goods also fall as $\frac{\partial q_{SS}}{\partial t} = \frac{\partial \tilde{q}_{SS}}{\partial t} = \frac{\partial q_{SS}^*}{\partial t} = 0$.

2.2. R&D Investment

In the third stage, the Northern multinational decides how much to invest in R&D in order to reduce emissions and cut its costs of production. Replacing the relevant optimal quantities back into their corresponding profit function and differentiating the latter with respect to x , we can find the optimal amount of R&D investment by the Northern firm for each locational scenario. If the multinational keeps all production at home, optimal R&D investment is

$$x^E = \left[\frac{2\tau(2+t-4\tau e_0)}{9-8\tau^2} \right]^2 \tag{11a}$$

where the condition $t > 2(2\tau e_0 - 1)$ must hold for R&D investment to take place. If tariffs are below this constraint, the Northern firm does not find it profitable to invest in R&D and stops pollution abatement efforts altogether. When the Northern firm partly moves production to the South, it invests

$$x^F = \left[\frac{2\tau(1+t-2\tau e_0)}{9-4\tau^2} \right]^2 \quad (11b)$$

in R&D, where a more relaxed constraint $t > 2\tau e_0 - 1$ is required for a positive R&D investment. Figure 1 shows the region where R&D is positive in τ, t space for $e_0=1$ and illustrates the $x^E = x^F$ locus to show which scenario brings a higher R&D effort. It can easily be seen that R&D is higher in case of exports unless pollution taxes imposed are at a high enough level. Finally,

$$x^D = 0 \quad (11c)$$

as no R&D is undertaken when the Northern firm moves all production to the South in order to fully exploit the pollution haven. If the Northern firm at least keeps a part of its production in the North, $\frac{\partial x}{\partial \tau}$ is ambiguous in the feasible space of t and τ . R&D investment increases

with a higher pollution tax burden as long as $e_0 < \frac{(8\tau^2 + 9)(2+t)}{72\tau}$ for the export case and

$e_0 < \frac{(4\tau^2 + 9)(1+t)}{36\tau}$ for the FDI case. R&D is always increasing in τ for low emissions and

low pollution taxes as the cost advantage absorbed by R&D always outweighs the R&D investment costs. By contrast, when emissions and pollution taxes are both high, a higher τ increases the costs of production to a point that benefits from extra R&D can no longer serve industrial advantage. As a result, when emissions released from production are not very low, R&D first increases with a higher pollution tax until it reaches a maximum level and starts falling thereafter.⁹ The pollution tax that gives the maximum pollution abatement R&D effort by the Northern firm in each scenario is found from the first order conditions of x with respect to τ and is:

$$\tau^{*E} = \frac{18e_0 - 3\sqrt{2[18e_0^2 - (2+t)^2]}}{4(2+t)} \quad (12a)$$

⁹ For clean industries with a low e_0 R&D is always increasing in τ , but never reaches a high level as a very small amount of R&D effort can put an end to all emissions released.

$$\tau^{*F} = \frac{3[3e_0 - \sqrt{(3e_0 + 1 + t)(3e_0 - 1 - t)}]}{2(1 + t)} \quad (12b)$$

This level of pollution tax is drawn in figure 1 for both cases. It is easy to see that this level of τ is increasing in tariffs showing that a higher level of green tariff must accompany higher pollution taxes to motivate the Northern firm to engage in the highest possible level of pollution abatement R&D.

$\frac{\partial x^E}{\partial t} > 0$ and $\frac{\partial x^F}{\partial t} > 0$ show that tariffs stimulate R&D efforts as long as the Northern firm does not completely relocate to the South. Tariffs discourage the import of dirty products, motivate local production and hence create the incentives to innovate cleaner technologies to pay less pollution tax. Results show that whether the Northern firm exports to the South or serves the latter via FDI, green tariffs induce R&D to decrease pollution through a greener technology.

Proposition 2 Green Tariffs and Pollution Abatement R&D

$\frac{\partial x^E}{\partial t} > 0$ and $\frac{\partial x^F}{\partial t} > 0$ imply that tariffs always stimulate the pollution abatement R&D effort

by the Northern firm as long as part of its production takes place at home.

2.3. Location

In the second stage of the game, the Northern multinational must choose where to locate to serve each market. By substituting the optimal R&D investment back into the Northern firm's profit function and comparing profits from each case, we can find the locational outcome that yields the most profits. Northern profits for each scenario are simply

$$\pi_N^E = q_{NN}(x^E)^2 + q_{NS}(x^E)^2 - x^E = \frac{9(t^2 + 2t + 2) - 4t^2\tau^2 - 36\tau e_0(2 + t - 2\tau e_0)}{9(9 - 8\tau^2)} \quad (13a)$$

$$\pi_N^F = q_{NN}(x^F)^2 + \tilde{q}_{SS}^{*2} - x^F - \Gamma = \frac{9(t^2 + 2t + 2) - 4\tau^2 - 36\tau e_0(1 + t - \tau e_0)}{9(9 - 4\tau^2)} - \Gamma \quad (13b)$$

$$\pi_N^D = \tilde{q}_{SN}^{*2} + \tilde{q}_{SS}^{*2} - x^D - \Gamma = \frac{t^2 - 2t + 2}{9} - \Gamma \quad (13c)$$

Looking first at profits of keeping all production in the North and establishing an extra plant in the South, we can see that in the absence of relocation costs I , a firm would always be better off by serving each market through a local subsidiary.¹⁰ The critical level of fixed costs that makes $\pi_N^E = \pi_N^F$ is

$$\bar{\Gamma} = \frac{4\tau[18t\tau(2\tau_0 - 1) + 81e_0(1 - \tau_0) + 4\tau^3(2 - t^2) - 27\tau]}{9(9 - 8\tau^2)(9 - 4\tau^2)} \quad (14)$$

When the fixed costs are below this level, costs of relocation are sufficiently low compared to the environmental costs at home making FDI the preferable location choice.¹¹ Otherwise the Northern firm would keep all production at home and there is no concern relating firm location to environmental protection. In that case, a green tariff rate of $t > \frac{9(2\tau_0 - 1)}{9 - 4\tau^2}$ and

$t > \frac{9(2\tau_0 - 1)}{4\tau^2}$ is required for the Northern firm to keep producing for the domestic market

and exporting to the South respectively. As we are interested in a case where relocation is at least partly an option, this paper focuses on a situation where costs of relocation are sufficiently low. The export scenario where the Northern firm keeps all production in the North is therefore eliminated from the rest of the analysis.

Comparing profits under FDI and delocation next, it is easy to see that a higher pollution tax in the North makes relocation to the South more attractive. The threshold tariff rate, below which the firm completely delocates, is the t that makes the profits under the two options equal:

$$\bar{t} = 1 - \frac{3}{2\tau^2}(1 - \tau_0)(3 - \sqrt{9 - 4\tau^2}) \quad (15)$$

¹⁰ This also reflects the branch of literature on environment and the location of firms pioneered by Markusen et al. (1993) that assumes firms to be footloose. Thus, they incur no relocation costs and simply decide where to locate their operation depending upon environmental policies.

¹¹ Note that $\frac{\partial \bar{\Gamma}}{\partial \tau} > 0$.

When the Northern firm has a subsidiary in each country, $t \geq 2\tau e_0 - 1$ is a constraint for $q_{NN}(x^F) \geq 0$ to hold. A lower tariff rate would give the Southern firm such a large competitive advantage that the Northern firm no longer finds it profitable to serve its home market and closes down home production altogether.¹² $t \leq \frac{3(1 + \tau e_0) - 2\tau^2}{2(3 - \tau^2)}$ is also a necessary condition for the Southern firm to maintain its exports to the North, i.e. for $q_{SN}(x^F) \geq 0$. This threshold value of t stops the importation of all dirty products to the North by blocking trade and gives the Northern firm a monopoly position in its home market.

By observing (13b) and (13c), we can see that in case of free trade profits of completely delocating to the South are always higher than having local facilities in each country. This reinforces the concept of economic integration and environmental standards being complements by showing that without a trade policy, the smallest amount of pollution tax results in complete relocation of multinationals to countries with lax environmental regulations. As tariffs rise, delocation becomes less attractive for a larger range of Northern pollution taxes. In other words as $\frac{\partial \bar{t}}{\partial \tau} > 0$, a higher level of tariff on dirty goods from the South is needed to impede delocation when tougher standards are desired in the North. Tariffs in the case of asymmetric environmental standards can be called green tariffs because they discourage delocation to pollution havens in developing countries, which in turn induces pollution abatement R&D by firms in industrialized nations. Figure 2 shows the locational choice of the Northern firm in the space of τ and t for an emission level of $e_0=1$.

Proposition 3 Green Tariffs and the location of Multinationals

Tariffs make complete relocation to pollution havens less attractive by working as a force to keep Northern firms near their domestic consumers. This compels them to pay pollution taxes, which in turn encourages more effort towards pollution abatement R&D.

¹² This case coincides with the scenario of complete delocation.

3. Environmental Harmonization and Trade Liberalization

This section of the paper analyzes the consequences of policies that suggest global harmonization of environmental regulations. This can be interpreted as policies discussed in the WTO round in Doha where the WTO members can only integrate to liberalize trade when they have harmonized their level of environmental standards to that in force in MEA signatory countries (http://www.wto.org/english/thewto_e/minist_e/min01_e/mindecl_e.htm). Here the South upgrades its standards to the level imposed in the North, namely τ , and at the same time enjoys free trade as a reward with tariffs t abolished.

There is only one possible scenario in the case of harmonized standards as liberalized trade and symmetry in environmental policies make the multinational indifferent about location. As there are no incentives for relocation in such situation, it is assumed that each firm remains in its home country. Both firms now pay the pollution tax τ on the emissions they cause during production, while trade is liberalized. The profit functions of the two firms are now

$$\pi_N^H = q_{NN}(p_N^N - c - \tau e_N) + q_{NS}(p_S^N - c - \tau e_N) - x \quad (16)$$

$$\pi_S^H = q_{SN}(p_N^N - c - \tau e_S) + q_{SS}(p_S^N - c - \tau e_S) \quad (17)$$

where superscript H stands for harmonized environmental standards. In this case, the quantity produced by each firm for the domestic and the foreign market is the same. Yet production by the Northern and the Southern firm are different as they still face different technologies:

$$q_{NN}^H = q_{NS}^H = \frac{1 - \tau e_0 + 2\tau\sqrt{x}}{3} \quad (18a)$$

$$q_{SN}^H = q_{SS}^H = \frac{1 - \tau e_0 - \tau\sqrt{x}}{3} \quad (18b)$$

The research undertaken by the Northern firm in the second stage for abating pollution is now

$$x^H = \left[\frac{4\tau(1 - \tau e_0)}{9 - 8\tau^2} \right]^2 \quad (19)$$

For R&D to be positive in the case of harmonized standards it is necessary that $\tau < \frac{1}{e_0}$.

Northern profits under harmonized standards are

$$\pi_N^H = q_{NN}^{H^2} + q_{NS}^{H^2} - x^H = \frac{2(1 - \tau e_0)^2}{9 - 8\tau^2} \quad (20)$$

Comparing (19) with (11b), it can be seen that $x^H > x^F$ at all times. Pollution abatement R&D by the Northern firm is therefore always higher when the South adopts environmental standards.

Proposition 4 Environmental Harmonization and R&D Efforts

Pollution abatement R&D effort by the Northern firm is always stimulated when the South upgrades its environmental standards to the level in force in the North.

Now we turn to the first stage of the game where the South decides whether or not to comply with environmental harmonization. By choosing to adopt standards, the South makes relocation redundant for the Northern firm and forces the latter to keep all production at home. When the South disagrees to adopt standards on the other hand, the Northern firm can decide whether to undertake FDI or completely relocate as explained in section 2.3 depending on the values of t and τ .

4. Welfare Implications

As the welfare implications of adopting tougher environmental regulations for South are the focus of this paper, this section seeks out the welfare consequences of a move from no standards toward economic integration and environmental harmonization. Economic welfare in this setting is the sum of consumer surplus and producer surplus, minus the disutility caused by pollution in the South.

Consumer surplus in the South can be written as half of the total output by the two firms intended for the South squared:

$$CS_S^i = \frac{Q_S^i{}^2}{2} \quad (21)$$

where $i=F,D$ for FDI and delocation respectively. Consumer surplus with no environmental standards in the South for both cases is

$$CS_S^F = CS_S^D = \frac{2}{9} \quad (21a)$$

as residents in the South only consume goods produced at home using an environmentally damaging technology. When standards are adopted consumer surplus turns to

$$CS_S^H = 2 \left[\frac{(1 - \tau e_0)(3 - 2\tau^2)}{9 - 8\tau^2} \right]^2 \quad (21b)$$

Comparing (21a) with (21b), we can see that Southern consumer surplus is always lower when environmental standards are harmonized.

Producer surplus with no standards in the South equals Southern profits from (6) using the appropriate output and R&D for each case, and (17) when standards are adopted. The profit of the Southern firm in each case is

$$\begin{aligned} \pi_S^F &= q_{SN} (x^F)^2 + \tilde{q}_{SS}^2 \\ &= \frac{4\tau^4(9t^2 - 18t + 13) - 108\tau^3 e_0(1-t) - 9\tau^2(24t^2 - 9e_0^2 - 36t + 20) + 162(1 + \tau e_0 - 2t + 2t^2 - 2t\tau e_0)}{9(9 - 4\tau^2)^2} \end{aligned} \quad (22a)$$

$$\pi_S^D = \tilde{q}_{SN}^2 + \tilde{q}_{SS}^2 = \frac{t^2 - 2t + 2}{9} \quad (22b)$$

$$\pi_S^H = q_{SN}^{H^2} + q_{SS}^{H^2} = 2 \left[\frac{(1 - \tau e_0)(3 - 4\tau^2)}{9 - 8\tau^2} \right]^2 \quad (22c)$$

For any positive tariff there is a threshold τ under which the Southern firm is better off when environmental standards are harmonized in the two regions. The range of τ under which the Southern firm prefers standards expands with higher tariffs against eco-dumping. Higher profits with standards in this range are due to the higher total production by the Southern firm for low enough τ , and the tariff savings on its exports with a move to free trade. However, the sum of quantity produced by the Southern firm for the home and the foreign market and hence its profit drops sharply in τ when standards are enforced while it remains unchanged with no standards. In case of no Southern standards, $\pi_S^D \geq \pi_S^F$ for $t > \frac{\tau(9e_0 - 2\tau)}{9 - 2\tau^2}$ implies that the interests of the Southern firm are always in conflict with the Northern firm's preferences on location.¹³

¹³ This threshold value of t approximately coincides with \bar{t} .

The third component of Southern welfare is the disutility caused by pollution. This is parameterized as the total emission in the South times a linear parameter d , which represents the concern of Southern residents about pollution:

$$D = dE \quad (23)$$

D is the disutility and E the aggregate emission in the South. Total pollution varies depending on where the Northern multinational chooses to locate. It is assumed that there is no trans-boundary pollution in this case. Looking at the case with no standards, when the multinational has a local subsidiary in each country, total emission in the South is

$$E_S^F = (e_0 - \sqrt{x^F})\tilde{q}_{SS}^* + e_0[\tilde{q}_{SS} + q_{SN}(x^F)] = \frac{2\tau(1+t) + 3e_0(3\tau e_0 - 6\tau^2 + 2t\tau^2 - 6t + 9)}{3(9 - 4\tau^2)} \quad (24a)$$

Note that the Northern firm uses the enhanced technology obtained through its R&D efforts also for its production in the South. When the multinational completely delocates, it has no incentives to engage in R&D and total emissions in the South become

$$E_S^D = e_0(\tilde{q}_{SN} + \tilde{q}_{SS} + \tilde{q}_{SN}^* + \tilde{q}_{SS}^*) = \frac{2e_0(2-t)}{3} \quad (24b)$$

Under harmonized standards, each firm remains in its home country and the only emissions in the South are those released by the Southern firm with its dirty technology:

$$E_S^H = e_0(q_{SS}^H + q_{SN}^H) = \frac{2e_0(1-\tau e_0)(3-4\tau^2)}{9-8\tau^2} \quad (24c)$$

For any positive pollution tax, total emissions suffered by the population in the South are always at their lowest level when environmental policies are harmonized in the two regions. The most pollution comes when the Northern firm moves all production to the South to take advantage of weaker environmental policies in the South. The first order conditions of emissions released in the South with respect to pollution taxes and tariffs show how the environment can be affected through government policies. When standards are not adopted, these derivatives are negative with respect to t and positive with respect to τ implying that green tariffs are beneficial and pollution taxes harmful for the environment in the South. When standards are adopted globally on the other hand, the derivative of emissions with

respect to τ is negative implying that tougher environmental regulations can improve the environment when there are no incentives for relocation.

Proposition 5 Green Tariffs and the Environment

As $\frac{\partial E^F}{\partial t} < 0$ and $\frac{\partial E^D}{\partial t} < 0$, tariffs always reduce pollution in the South by discouraging the

production of goods manufactured with a dirty technology in the South. $\frac{\partial E^F}{\partial \tau} > 0$,

$\frac{\partial E^D}{\partial \tau} > 0$ and $\frac{\partial E^H}{\partial \tau} < 0$ show that pollution taxes on the other hand only reduce pollution in

the South when standards are harmonized. In the case of no standards, they have the adverse effect of actually increasing pollution by shifting production to the South.

The sum of consumer surplus and producer surplus minus the disutility caused by pollution gives total welfare for each case. Welfare for the three possible cases is:

$$W^i = \pi_S^i + CS_S^i - dE_S^i \quad \text{for } i = F, D, H \quad (25)$$

Parameter d weighs the importance of the disutility caused by emissions against the utility from consumer and producer surplus. Higher producer surplus in the case of standards at a low τ makes standards preferable also in terms of welfare up to a certain value of τ . This occurs even when there is no concern over pollution and therefore no disutility brought about by emissions. Naturally, standards become preferable for a higher range of τ as d increases.

Figure 3 illustrates the optimal Southern environmental policy for different values of t and τ when there is no concern and some concern about pollution in the South. The curves on the right hand side of the figure show the locus where Southern welfare under standards are equal to each of the two cases without standards. $W^H = W^F$ is the relevant locus where $t > \bar{t}$ and $W^H = W^D$ corresponds to the region where $t < \bar{t}$.

With no concerns about pollution in the South, the Southern government never finds it optimal to adopt environmental standards if tariffs are at a low enough level for delocation to be the locational outcome. When trade costs are higher so that the Northern firm decides to keep part of its production in the North, standards are adopted up to a threshold value of τ

after which it is optimal to ignore the call for harmonization of standards. Note that in this locational outcome, it is optimal to adopt standards for a low enough pollution tax rate even when there is no concern about pollution. Therefore, tariffs can act as an instrument to block delocation and as a result make the South agree to harmonize its standards.

If there is some concern about pollution among the residents in the South, the optimal policy in both locational scenarios is to harmonize standards up to a threshold level of pollution tax. The upper limit τ up to which standards are adopted is higher in the case of delocation as the latter creates more pollution than when the Northern firm only partially relocates. Comparing figures 2 and 3, it is clear that more concern about pollution in the South shifts both curves to the right increasing the area in which standards are adopted.

The above results reinforce the need for tariffs as an instrument to encourage developing countries to harmonize their environmental standards even when no concern about pollution exists in the South. This shows yet again another role tariffs can play as a green policy in order to stimulate a move to a cleaner environment.

Proposition 6 Green Tariffs and Harmonization of Environmental Standards

In the absence of concern about pollution in the South, tariffs can make it optimal for the South to harmonize its environmental standards by blocking the complete relocation of Northern firms to the South.

5. Conclusion

This paper emphasizes the importance of trade policy measures such as green tariffs for a successful attempt at global harmonization of environmental standards. It introduces and analyzes the roles of green tariffs in a framework where both R&D and location have a part in decisions by firms and governments. It shows in the light of Carraro and Siniscalco (1994) that an optimal policy to control pollution can be a mix of complementary measures different from conventional environmental policy recommendations. Since a pollution tax alone may

not be an effective policy tool, its role must be reconsidered and trade policy measures must account for environmental targets as they have clear consequences.¹⁴

Green tariffs are shown to indeed serve the purpose of environmentalists to discourage relocation of multinationals to countries with weaker environmental policies. This in turn spurs innovation in search of cleaner technologies to serve as an alternative to relocation for reducing production costs. In addition to its contribution to the environment by inducing R&D, green tariffs reduce pollution by discouraging trade and production of goods manufactured under environmentally unfriendly techniques. While seeking an optimal environmental policy for the South, the paper finds green tariffs to be a necessary complement to a pollution tax if an environmentally indifferent South is to adopt tougher standards.

This paper can serve as a good starting point by demonstrating the basic roles of tariffs and the need for them as a complementary policy to emission taxes to achieve the desired outcomes. It is however important to also look into other more direct measures of improving the environment such as R&D subsidies to avoid creating a distortion. This could indeed be more beneficial for the North as environmental harmonization may not always serve the interest of the latter, especially in the case of non-transboundary pollution.

The paper also leaves room for more work on games between governments regarding environmental policies. Endogenous tariffs by governments in the North or the WTO aiming for a cleaner environment can for instance manipulate the South to harmonize its standards. It would be interesting to find the optimal green tariff for different levels of pollution tax taking into consideration its impact on the location of firms and Southern policies. If green tariffs can serve as a credible threat against relocation to pollution havens and eco-dumping policies

¹⁴ This reinforces evidence presented by the European Commission in case of the European carbon tax that showed that a ‘very high’ carbon tax achieves only about one half of the required reduction target (Cararro and Siniscalco, 1994). The European carbon tax was designed to stabilize the emissions of CO₂ at the level of the year 1990 in order to combat global warming.

by the South, they may be the only means of a successful move towards environmental harmonization. Another interesting line of research is to explore the issue in a multi-firm, multi-sector framework to see the dynamics of capital movement according to the pollution intensity of firms.

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Figure 1: R&D investment by the Northern Firm

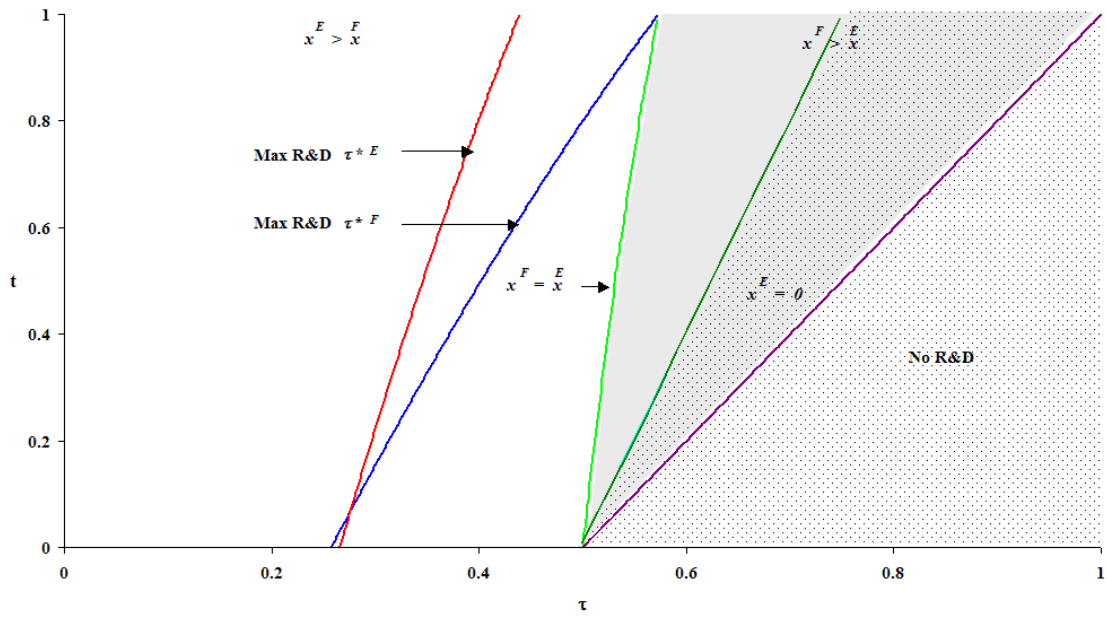


Figure 2: Location of the Northern Firm

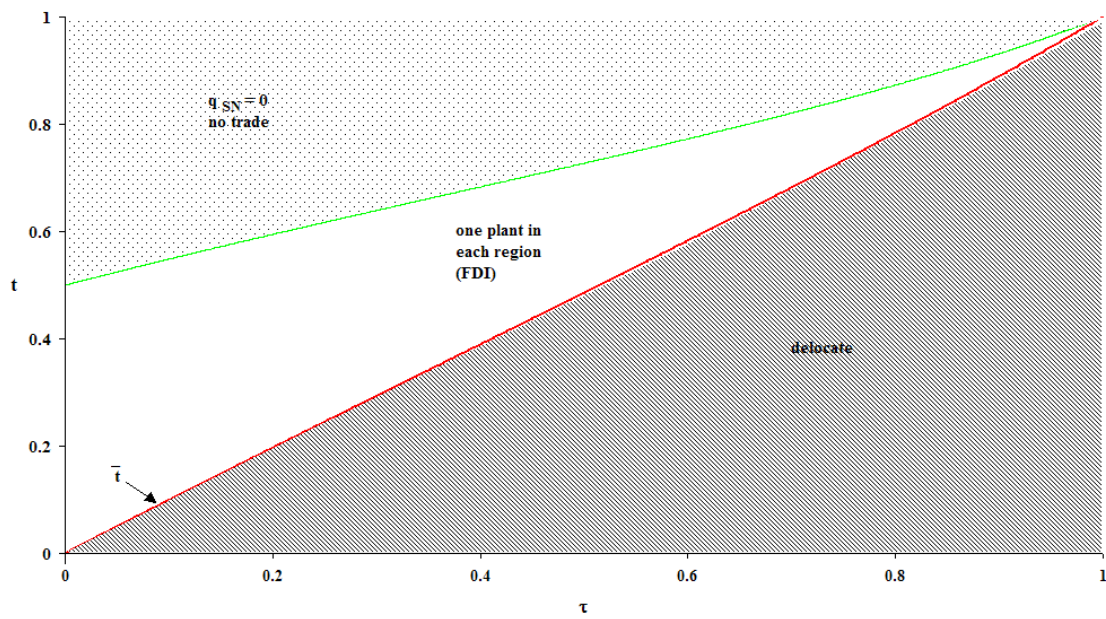


Figure 3: Optimal Environmental Policy in the South

