Multilateral Environmental Agreements and Trade

Obligations: A Theoretical Analysis of the Doha Proposal*

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Abstract

Proposals at the WTO Doha round suggested economic integration only upon ratification of multilateral environmental agreements, and countervailing tariffs upon non-compliance. This paper demonstrates that such proposals can be subgame perfect when environmental policy and green tariffs are endogenous. Ratification along with free trade becomes the equilibrium outcome, where positive optimal tariffs work as a credible threat against deviation. Delocation to pollution havens hence does not occur and capital movements are due to non-pollution related factors. Besides their standard effects of reducing trade and production, tariffs discourage firms from delocation and induce them to instead engage in pollution abatement R&D.

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1. Introduction

The link between trade liberalization and environmental protection is increasingly gaining importance with the latter constituting a bigger part of WTO rounds in recent years. 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 to pollution havens, mainly developing countries (South), or close down altogether in response to foreign competition that faces less strict environmental regulation and hence lower production costs.

When it comes to enforcing environmental standards on a global level, the South has shown to be lagging behind regardless of rising international concern over the environment. 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.\(^1\) The notion of enforcing environmental standards globally is however moving closer to realization with the WTO devoting greater attention to environmental negotiations in recent rounds. A significant part of the Doha declaration in 2001 for instance dealt with trade and environment. In fact, there are about 200 multilateral environmental agreements (MEA) in place today, of which only 20 contain trade

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\(^1\) Neary (2004) addresses and analyzes the key issues of the Doha development agenda and obstacles that must be overcome for successful negotiations in future rounds of the WTO.
provisions.\textsuperscript{2} Loopholes currently allow non-signatories to use their WTO rights to protest trade restrictions put against them by a MEA. This has lead to suggestions to eliminate such free riding opportunities by only allowing WTO members that are also parties to a MEA to practice their WTO rights, or even more drastic measures such as harmonizing environmental regulations across countries. As a first step in the new Article 31 (i) of the Doha text, ministers have agreed to launch negotiations on the relationship between existing WTO rules and specific trade obligations set out in MEAs.\textsuperscript{3} WTO in this case could give a signatory country the choice to only accept greater economic integration with another country if the latter agrees to ratify and adopt more stringent environmental standards. In other words, it allows rivals of a non-signatory country to impose countervailing tariffs on its imports in case of non-compliance for having laxer environmental regulations. (http://www.wto.org/english/thewto_e/minist_e/min01_e/mindecl_e.htm) Can such tariffs be justified, and if so, what is their impact on the location of firms, innovation, environmental policies in the South and the environment itself?

When discussing a cleaner environment, growth and sustainable development in the South, two basic issues must be taken into account: (1) the decision of smokestack multinationals on where to locate and how much to invest in pollution abatement R&D, (2) the environmental policy in the South that can influence these decisions. Zannetti and Abate (1993) have carried

\footnote{Examples are 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)}

\footnote{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)}
out a business survey to find that big corporations in industrialized countries (North) indeed tend to respond to environmental policy measures primarily by technological and organizational innovation, and 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 policy.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 two “footloose” firms. Firms decide where to set up production by observing the plant and firm specific fixed costs, transport costs and environmental policy in the two regions. They could decide not to enter the market at all, serve both regions from a plant at home, or establish plants in both regions to serve each market locally. They show environmental policy to have a very strong impact on a firm’s decision about location. Motta and Thisse (1994) consider a different setting where firms are initially established in their country of origin and do not incur any fixed cost when operating at home. They examine the impact of a country’s environmental policy on the location and production choices of its firm.5 They show that a firm is less likely to relocate as a response to environmental policies because fixed costs of establishing a domestic plant are sunk when the game begins. 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 the 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 as this can create strategic rent-shifting incentives for governments. It is worth

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

5 In their model they also give the multinational firm the choice of closing down home production altogether and establishing a plant abroad to serve both markets. Additionally, they assume the other firm to be a local firm with its location (as well as the other country’s policy) as given.
mentioning that although the pollution haven hypothesis has received strong theoretical support, much of recent empirical literature such as Smarzynska and Wei (2001), Eskeland and Harrison (2003) and Grether and Melo (2003) have found little evidence to support it. On the innovation side, 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 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 of better products or cheaper processes, it is not clear if the benefits will pay off investments made in the necessary R&D. Simpson and Bradford (1996) for instance use this argument to challenge Porter 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 caused by the spurred 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 policies on the two issues in a framework with both present. This paper brings environmental harmonization, economic integration, delocation and pollution abatement R&D into a single model to investigate how they interact to shape the optimal environmental policy in the South. It endogenizes the decision of firms on location and R&D, and governments’ policies on trade and environment, to see whether proposals made at the Doha round can be effectively implemented. It shows that under certain plausible conditions, green tariffs can work as a successful credible threat to make environmental harmonization and free trade the unique subgame perfect equilibrium outcome. If a non-signatory country deviates, optimal green tariffs are positive eliminating multinationals’

6 Green tariffs in this paper refer to trade barriers raised for environmental purposes, i.e. trade obligations in MEAs.
incorporates incentives to delocate. Therefore, the so-called escape to pollution havens never actually takes place in accordance with recent empirical findings, and all capital movements are due to other non-pollution related factors. Also, by discouraging delocation green tariffs induce firms to put more efforts into pollution abatement R&D. This occurs because green tariffs eliminate the advantages of delocation and encourage firms to use R&D as alternative means of reducing costs. It will be seen that total world R&D aimed at cleaner technologies is always at its highest level when environmental regulations are harmonized. Yet, tariffs can be a more useful tool for reducing world pollution when pollution related costs realistically constitute only a small component of firms’ total costs. When information about the dangers of pollution is introduced in the South, such system is no longer necessary as the South finds it optimal to voluntarily upgrade its environmental standards.

The Doha proposal is illustrated in the following game: in the first stage, the Southern government chooses whether or not to adopt standards taking into consideration that the North can impose a tariff against its imports in the second stage upon non-compliance. If the South chooses to harmonize its environmental standards, tariffs are abolished to allow for economic integration as a complement or a reward. The governments also anticipate firms’ decision on output, R&D and location. The Northern firm moves next by choosing location in the third stage, decides how much to invest in pollution abatement R&D in the fourth, and competes in production with the Southern firm in the final stage. The stages of the game are illustrated in figure 1. The rest of the paper is organized as follows: Section 2 describes the model and solves the final three stages of the game when environmental standards are not enforced in the South. Section 3 introduces the other branch of the game where the South

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7 Although all levels of pollution tax are examined in the paper, only very low tax levels reflect reality and are of relevance for the results. A wide range of studies such as Noerdstrom and Vaughan (1999) have confirmed that pollution related costs only account for a very small proportion of a firm’s total costs. These costs only come up to no more than 1% of production costs for the average industry in the North and at most 5% for the worst polluters. Accordingly, this paper emphasizes the results for low enough levels of pollution tax.
ratifies with the MEA and shows the outcome on output, R&D and location under harmonized standards. Section 4 analyzes the optimal tariff set by the North, the optimal environmental policy for the South and shows the possible equilibria of the Doha proposal. Section 5 concludes.

2. The Decision of Firms

2.1. The Model

There are two countries in the model: the North and the South. The regions are assumed to be symmetric in all aspects aside from their environmental regulations. The North is assumed to enforce environmental standards by imposing a pollution tax on emissions released by firms during production. The South in contrast can choose to adopt standards and enjoy trade liberalization or to keep its lax environmental regulations and pay tariffs. The latter option allows local as well as foreign firms operating in the South to produce without any additional charges for causing pollution. There is however a green tariff in this case set optimally by the North against all dirty imports produced in the South. The tariff also applies to dirty re-exports of the Northern firm back to the North and hence serves to discourage eco-dumping and delocation.

The model assumes two firms with one belonging to each country. They produce a homogeneous good and compete in an oligopolistic manner à la Cournot. Firms compete in segmented markets and choose the optimal output for each market separately. The Northern firm 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 delocate for pollution related purposes to serve both markets from the South. The Southern firm on the other hand is assumed to be a local firm for simplicity and only produces in its
domestic country.\textsuperscript{8} Firms are also capable of investing in pollution-abatement R&D to
innovate cleaner production technologies in order to reduce their expenses on pollution tax.

Demand is assumed to be linear and takes the familiar form

\[ p_N = a - Q_N, \quad p_S = a - Q_S, \]

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

\[ Q_N^E = q_{SN} + q_{NN} \quad Q_S^E = q_{SS} + q_{NS}, \]

\[ Q_N^F = q_{SN} + q_{NN} \quad Q_S^F = \tilde{q}_{SS} + \tilde{q}_{SS}^*, \]

\[ Q_N^D = \tilde{q}_{SN} + \tilde{q}_{SN}^* \quad Q_S^D = \tilde{q}_{SS} + \tilde{q}_{SS}^*, \]

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 relocates 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 pollution tax \( \tau \) paid on emissions that are released from
producing one unit of the good. Unit emission discharged by the Northern and the Southern
firm respectively is

\[ e_N = e_0 - \sqrt{x_N}, \]

\[ e_S = e_0 - \sqrt{x_S}, \]

where \( x_i \leq e_0^2 \). \( e_0 \) represents the basic pollution caused by the production of one good prior to
any pollution abatement efforts, and \( x_i \) is the amount of R&D investment carried out by each
firm to innovate cleaner technologies. Notice that investment takes a one-off form and
reduces emission at a decreasing rate.\textsuperscript{9}

\textsuperscript{8} This locational framework follows Motta and Thiesse (1994).

\textsuperscript{9} The cost function containing pollution abatement R&D takes the same approach as in Ulph (1994).
Looking at the case of non-compliance in the rest of this section, the profit function for the Northern firm when all of its production takes place in the North is

\[ \pi_N^E = q_{NN} (a - Q_N^E - c - \pi_N) + q_{NS} (a - Q_S^E - c - \pi_N) - x_N. \]  

(5a)

This locational scenario implies 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:

\[ \pi_N^F = q_{NN} (a - Q_N^F - c - \pi_N) + \tilde{q}_{SS} * (a - Q_S^F - c) - x_N - \Gamma. \]  

(5b)

\( \Gamma \) is the fixed cost of setting up a plant abroad which is independent of output. If the firm completely delocates 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:

\[ \pi_N^D = \tilde{q}_{SN} * (a - Q_N^D - c - t) + \tilde{q}_{SS} * (a - Q_S^D - c) - x_N - \Gamma. \]  

(5c)

The profit of the Southern firm takes the form

\[ \pi_S^E = q_{SN} (a - Q_N^E - c - t) + q_{SS} (a - Q_S^E - c) - x_S \]

\[ \pi_S^F = q_{SN} (a - Q_N^F - c - t) + \tilde{q}_{SS} (a - Q_S^F - c) - x_S \]  

(6)

\[ \pi_S^D = \tilde{q}_{SN} (a - Q_N^D - c - t) + \tilde{q}_{SS} (a - Q_S^D - c) - x_S \]

for each scenario created by the Northern firm’s decision on production location. Recall that there is no environmental tax enforced in the South here, but a tariff is paid on Southern exports to the North.\(^{10}\) Adopting backward induction, section 2.2 first solves the problem of firms in the final stage where they compete in output.

2.2. Production

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

\[ q_{NN} = \frac{1 + t - 2\pi_N}{3}, \]  

(7)

\(^{10}\) Tariffs and pollution taxes have been normalized to the market size to allow for the elimination of \((a-c)\) from all upcoming equations.
\[ q_{NS} = \frac{1 - 2\tau N}{3}, \quad (8) \]

while the Southern firm produces

\[ q_{SS} = \frac{1 + \tau N}{3}, \quad (9) \]

\[ q_{SN} = \frac{1 - 2\mu + \tau N}{3}, \quad (10) \]

for the South and the North respectively.

In the case of FDI, \( q_{NV} \) 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

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

for both firms. When the Northern firm relocates, 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 the goods back to the North, production by both firms aimed at the North turns to

\[ \tilde{q}_{SN}^* = \tilde{q}_{SN} = \frac{1 - \mu}{3}. \quad (10') \]

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 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, \( \tau \) 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 Trade and Production of Dirty Goods in the South**

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

**2.3. R&D Investment**

In the fourth stage, firms decide how much to invest in R&D in order to reduce emissions and cut their costs of production. Replacing the relevant optimal quantities back into their corresponding profit functions and differentiating the latter with respect to \( x \), we can find the optimal amount of R&D investment by each firm for all locational scenarios. Looking at the Southern firm first, it is trivial that \( x^d = 0 \) at all times as there are no incentives to engage in R&D in the absence of a pollution tax in the South. If the Northern multinational keeps all production at home, optimal R&D investment is

\[
x^E_N = \left[ \frac{2\tau(2 + t - 4\pi_0)}{9 - 8\tau^2} \right]^2,
\]

where the condition \( t > 2(2\pi_0 - 1) \) 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

\[
x^F_N = \left[ \frac{2\tau(1 + t - 2\pi_0)}{9 - 4\tau^2} \right]^2
\]

(11b)
in R&D, where a more relaxed constraint \( t > 2\pi_0 - 1 \) is required for a positive R&D investment. Figure 2 shows the region where R&D is positive in a \( \tau, t \) 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 the case of exports unless pollution taxes are at a high enough level. Finally,
\[ x_N^D = 0 \]  
(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.

It can be seen from (11a) and (11b) that \( \frac{\partial x_N}{\partial \tau} \) is ambiguous in the feasible space of \( t \) and \( \tau \).

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 \( \tau \) 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 \( \tau \) 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.\(^\text{11}\) The pollution tax rate that gives the maximum pollution abatement R&D effort by the Northern firm in each scenario is found from the first order conditions of \( x_N \) with respect to \( \tau \) and is:
\[ \tau^{*E} = \frac{18e_0 - \sqrt{2[18e_0^2 - (2 + t)^3]}}{4(2 + t)} \]  
(12a)
\[ \tau^{*F} = \frac{3[3e_0 - \sqrt{(3e_0 + 1 + t)(3e_0 - 1 - t)}]}{2(1 + t)} \]  
(12b)
This level of pollution tax is drawn in figure 2 for both cases. It is easy to see that this level of \( \tau \) is increasing in tariffs showing that a higher level of green tariff must accompany higher

\(^{11}\) For clean industries with a low \( e_0 \), R&D is always increasing in \( \tau \), but never reaches a high level as a very small amount of R&D effort can put an end to all emissions released.
pollution tax rates to motivate the Northern firm to engage in the highest possible level of pollution abatement R&D.

\[
\frac{\partial x_N^E}{\partial t} > 0 \quad \text{and} \quad \frac{\partial x_N^F}{\partial t} > 0
\]

show that tariffs stimulate R&D efforts when 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 efforts to reduce pollution through a greener technology.

**Proposition 2  Green Tariffs and Pollution Abatement R&D**

\[
\frac{\partial x_N^E}{\partial t} > 0 \quad \text{and} \quad \frac{\partial x_N^F}{\partial t} > 0 \quad \text{imply that tariffs always stimulate pollution abatement R&D efforts by the Northern firm when at least part of its production takes place at home.}
\]

2.4. Location

In the third 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 the profits for each case, we can find the locational outcome that yields the most profits. Northern profits for each scenario are simply

\[
\pi_N^E = q_{NN} (x_N^E)^2 + q_{NS} (x_N^E)^2 - x_N^E = \frac{9(t^2 + 2t + 2) - 4t^2 - 36\pi_0 (2 + t - 2\pi_0)}{9(9 - 8\pi^2)}, \quad (13a)
\]

\[
\pi_N^F = q_{NN} (x_N^F)^2 + \bar{q}_{SS} * 2 - x_N^F - \Gamma = \frac{9(t^2 + 2t + 2) - 4t^2 - 36\pi_0 (1 + t - \pi_0)}{9(9 - 4\pi^2)} - \Gamma, \quad (13b)
\]

\[
\pi_N^D = \bar{q}_{SN} * 2 + \bar{q}_{SS} * 2 - x_N^D - \Gamma = \frac{t^2 - 2t + 2}{9} - \Gamma. \quad (13c)
\]

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 \(\Gamma\), a firm would always be
better off by serving each market through a local subsidiary. The critical level of fixed costs that makes $\pi_N^E = \pi_N^F$ is

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

(14)

When fixed costs are below this level, costs of relocation are sufficiently low making FDI the preferable choice of location. Otherwise, relocation is too costly anyway and the Northern firm would keep all production at home leaving no concern that environmental policies could further influence firm location. 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 continue to produce for the domestic market and export to the South respectively. This scenario reflects a situation where there is no threat of relocation due to very high plant-specific fixed costs, inflexible foreign investment laws in the host country, or political instability in the region. 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.

We can now concentrate on the comparison between profits under FDI and delocation to distinguish between the standard form of capital movement and relocation due to pollution related reasons. It is easy to see that a higher pollution tax in the North makes delocation to

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12 This also reflects the branch of literature on environment and firms’ location pioneered by Markusen et al. (1993) that assumes firms to be footloose. Thus, there are no extra costs for relocation as they incur a plant specific fixed cost regardless of whether they build a plant at home or in the other region. The number of plants would however matter in determining the total fixed costs in this case.

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

14 The dividing line between the export and the FDI case has been studied in Motta and Thiss (1994). It plays a more important role in their analysis, as they also look at differences in the market size between regions and changes in fixed costs of establishing a plant.
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:

\[
\bar{t} = 1 - \frac{3}{2\tau^2} (1 - \tau e_0)(3 - \sqrt{9 - 4\tau^2}).
\]

(15)

Figure 3 shows the locational choice of the Northern firm in the space of \( \tau \) and \( t \) for an
emission level of \( e_0=1 \). \( \frac{\partial \bar{t}}{\partial \tau} > 0 \) implies that tougher standards require a higher tariff on dirty
goods from the South to impede delocation.

When the Northern firm has a subsidiary in each country, \( \tau \leq \frac{t + 1}{2\nu_0} \) is a constraint for
\( q_{NN}(x^F_N) \geq 0 \) to hold. A pollution tax above this prohibitive level would make it unprofitable
for the Northern firm to maintain home production and serve its home market.\(^{15}\)

\[
t \leq \frac{3(1 + \tau e_0) - 2\tau^2}{2(3 - \tau^2)}
\]

is also a necessary condition for the Southern firm to maintain its exports
to the North, i.e. for \( q_{SN}(x^F_S) \geq 0 \). 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. Such prohibitive tariff rates denote a complete ban on imports from the
South making values of \( t \) above this level irrelevant for the analysis. The shaded areas in
figure 3 show the regions where these two conditions no longer hold.

By comparing (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
could result in complete delocation of multinationals to countries with lax environmental
regulations. As tariffs rise, delocation becomes less attractive for a larger range of Northern
pollution taxes. Tariffs in the case of asymmetric environmental standards are “green”

\(^{15}\) This case coincides with the scenario of complete delocation, where the Northern firm no longer pays
an emission tax making the level of the latter irrelevant.
because they discourage delocation to pollution havens in developing countries, and in turn induce pollution abatement R&D by firms in industrialized nations.

**Proposition 3  Green Tariffs and the location of Multinationals**

Tariffs make complete delocation 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.

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 a successful implementation of policies discussed in the WTO round in Doha where the WTO members can only integrate to liberalize trade when they have ratified a MEA and raised their level of environmental standards to that in force in a signatory country. Here the South upgrades its standards to the level imposed in the North, namely $\tau$, 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 $\tau$ on the emissions they release during production, while trade is liberalized. The profit functions of the two firms are now

\begin{equation}
\pi^H_N = q_{NN}(a - Q^N_N - c - \omega_N) + q_{NS}(a - Q^N_S - c - \omega_N) - x_N,
\end{equation}

\begin{equation}
\pi^H_S = q_{SN}(a - Q^H_N - c - \omega_S) + q_{SS}(a - Q^H_S - c - \omega_S) - x_S,
\end{equation}

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 identical:

\begin{equation}
q_{NN}^H = q_{NS}^H = q_{SN}^H = q_{SS}^H = \frac{1 - \tau(e_0 - \sqrt{x})}{3}.
\end{equation}

The research undertaken by each firm in the second stage to abate pollution is now
\[ x_N^H = x_S^H = \left[ \frac{4\tau(1 - \varpi_0)}{9 - 2\tau^2} \right]^2. \] (19)

For R&D to be positive in the case of harmonized standards it is necessary that \( \tau < \frac{1}{\varpi_0} \).

Comparing (19) with (11b), it can be seen that total pollution abatement R&D is always higher when standards are harmonized as \( x_N^H + x_S^H > x_N^F \) at all times.

**Proposition 4  Environmental Harmonization and R&D Efforts**

*Introducing standards in the South creates a stimulus for the South to also engage in pollution abatement R&D. Total world R&D is hence always higher when the South upgrades its environmental standards to the level in force in the signatory country.*

Finally, profits for each firm are equal under harmonized standards and are

\[ \pi_i^H = q_{iH}^N + q_{iS}^N - x_i^H = \frac{2(1 - \varpi_0)^2}{9 - 2\tau^2} \] (20)

for \( i = N, S \). Profits are lower for both firms the more stringent are the standards required in the MEA. We now turn to the first two stages of the game where the South decides whether or not to comply with environmental harmonization and the North chooses an optimal countervailing tariff in the case of non-compliance. 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 delocate production using the approach explained in section 2.4.

4. Optimal Policy by Governments

4.1. The Environment

Total pollution in each region varies depending on where the Northern multinational chooses to locate production. Pollution in this model is assumed to be of the non-transboundary type. Looking at the case with no standards, when the multinational has a local subsidiary in each country total emission in each region is
\[ E_N^e = (e_0 - \sqrt{x_N^e})q_{NN}(x_N^e) = \frac{3(1 - 2\pi_0 + t)[9e_0 - 2\tau(1 + t)]}{(9 - 4\tau^2)} \]

\[ E_S^e = (e_0 - \sqrt{x_S^e})q_{SS}(x_S^e) = \frac{9e_0(\pi_0 + 3 - 2t) - 2\tau^3e_0(5 - 3t) - 2\tau(1 + t)}{3(9 - 4\tau^2)} \]  

(21a)

Note that as knowledge has a public good character and can be transferred across borders easily, the Northern firm uses its enhanced technology also in its facilities in the South. When the multinational completely delocates, total emissions in the each region becomes

\[ E_N^D = 0 \]

\[ E_S^D = e_0(q_{SN} + \tilde{q}_{SS} + \tilde{q}_{SN} + \tilde{q}_{SS}) = \frac{2e_0(2 - t)}{3} \]  

(21b)
as all production takes place in the South and neither firm has any incentives to engage in R&D. Under harmonized standards, each firm remains in its home country and emissions in both regions are identical:

\[ E_i^H = e_0(q_{IN}^H + q_{IS}^H) = \frac{6(9e_0 - 2\tau)(3 - 4\tau^2)}{(9 - 2\tau^2)^2} \]  

(21c)

for \( i=\text{N,S} \). Comparing (21a) and (21b) with (21c) reveals that for all feasible positive value of pollution tax, total emissions suffered by the population in the South (North) always decrease (increase) when standards are adopted in the South. With no standards, the most (least) pollution in the South (North) is created when the Northern firm moves all production to the South to take advantage of weaker environmental policies there.

The first order conditions of emissions released in the North and 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 \( \tau \) implying that green tariffs are beneficial (harmful) and pollution taxes harmful (beneficial) for the environment in the South (North). When standards are adopted globally on the other hand, the derivative of emissions with respect to \( \tau \) is negative implying that tougher environmental regulations can improve the environment in both regions because there are no incentives for relocation.
It is worth making a final remark regarding total world pollution. In the absence of any green tariffs \( (\tau=0) \), adding up emissions in the two regions for each case in (21a), (21b) and (21c) tells us that total world emissions always decrease when standards are harmonized across regions. When green tariffs are put into effect in case of non-compliance however, total world pollution is lower with green tariffs than with environmental harmonization and trade liberalization up to a threshold value of \( \tau \). If the sole reason for a MEA is to reduce world pollution, green tariffs are hence a more effective tool for modest values of pollution tax, and harmonization if pollution costs amount to a large proportion of firms’ total costs.

**Proposition 5**  
**The Effects of Green Tariffs and Harmonization on the Environment**

As \( \frac{\partial E^I_j}{\partial t} > 0 \) and \( \frac{\partial E^I_j}{\partial t} < 0 \) for \( j=F,D \), tariffs always decrease (increase) pollution in the South (North). Having \( \frac{\partial E^S_N}{\partial \tau} < 0 \) and \( \frac{\partial E^S_N}{\partial \tau} > 0 \) for \( j=F,D \) and \( \frac{\partial E^H_i}{\partial \tau} < 0 \) for \( i=N,S \) implies that pollution taxes on the other hand only reduce pollution in both regions when standards are harmonized. In the case of no standards, they increase (decrease) pollution in the South (North) by shifting production to the South. For low enough values of \( \tau \) as observed in the world, total world pollution is lower with green tariffs than with harmonization.

### 4.2. Welfare

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 each region, plus the tariff revenue for the North.

Consumer surplus is the area under the demand curve and can be written as half of the total output intended for each region squared:

\[
CS^j_i = \frac{Q^j_i}{2},
\]

where \( i=N,S \) and \( j=F,D \) for FDI and delocation respectively. Consumer surplus with no environmental standards is
\[ CS_N^F = \frac{[3(2-t-n_0) - 2\tau^2(1-t)]^2}{2(9 - 4\tau^2)^2} , \]
\[ CS_S^F = \frac{2}{9} , \]
\[ CS_N^D = \frac{2}{9}(1-t)^2 , \]
\[ CS_S^D = \frac{2}{9} , \]  
(22a)

for FDI and delocation respectively. When standards are adopted, consumer surplus turns to
\[ CS^{i''}_i = 18 \frac{(1-n_0)^2}{(9 - 2\tau^2)^2} , \]  
(22c)

where \( i = N, S \). Comparing (22a) and (22b) with (22c), we can see that Southern consumer surplus is always lower when environmental standards are harmonized. Northern consumer surplus on the other hand is higher with harmonized standards up to a threshold value of \( \tau \), which increases with \( t \).

Producer surplus with no standards in the North is the profits derived in (13b) and (13c) for FDI and delocation respectively. Producer surplus in the South on the other hand equals Southern profits from (6) using the appropriate output and R&D for each case:
\[ \pi_S^F = q_SN(x^F)^2 + \bar{q}_SN^2 \]
\[ = 4\tau^4(9\tau^2 - 18t + 13) - 108\tau^2\xi_0(1-t) - 9\tau^2(24t^2 - 9\xi_0^2 - 36t + 20) + 162(1 + \xi_0 - 2t + 2t^2 - 2t\xi_0) + \frac{9(9 - 4\tau^2)^2}{9(9 - 4\tau^2)^2} , \]  
(23a)

\[ \bar{q}_SN^2 + \bar{q}_SS^2 = \frac{t^2 - 2t + 2}{9} . \]  
(23b)

Finally, equation (20) represents the producer surplus for both regions with harmonized standards. For any positive tariff there is a threshold \( \tau \) under which the Southern firm is better off when standards are harmonized in the two regions. This range of \( \tau \) 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 \( \tau \), and the tariff savings on its exports with a move to free trade. However, the quantity produced by the Southern firm for both markets and hence its profit drops sharply in \( \tau \) when standards are enforced. With no Southern
standards, \( \pi_s^D \geq \pi_S^F \) for \( t > \frac{(9\epsilon_0 - 2\tau)}{9 - 2\tau^2} \) implies that the interests of the Southern firm are always in conflict with the Northern firm’s preferences on location.\(^{16}\)

The third component of welfare is the disutility caused by pollution in each region. This is parameterized as \( D_i \) and contains total emissions in each region and a parameter \( d_i \), which measures the concern of the population of a country about local pollution:\(^{17}\)

\[
D_i = \frac{d_i^2}{2} E_i^i.
\]

The welfare function for each country is

\[
W_N^j = \pi_N^j + CS_N^j - D_N^j + T
\]

\[
W_S^j = \pi_S^j + CS_S^j - D_S^j
\]

for \( j = F, D, H \), where \( T \) is the tariff revenue and equals unit tariff rate \( t \) times the total quantity exported to the North. Another interpretation for parameter \( d_i \) is the relative importance of the disutility caused by emissions against the utility gained from consumer and producer surplus.

Note from (22a), (22b) and (25) that as \( CS_S^j \) is always a constant, the higher Southern producer surplus brought about by standards for low values of \( \tau \) also makes harmonization optimal in terms of welfare. This occurs even when there is no concern about pollution in the South and therefore no disutility brought about by emissions. Naturally, standards become preferable for a higher range of \( \tau \) as \( d_S \) increases.

4.3. Optimal Northern Tariff

The welfare function derived in the previous section can now be used to see if it is optimal for the North to impose a punishing tariff on the South if the latter refuses to adopt the standards required in a MEA. The Northern government sets an optimal tariff that maximizes its welfare in the second stage for each scenario. It then compares the Northern welfare functions for FDI

\(^{16}\) This threshold value of \( t \) approximately coincides with \( \bar{t} \).

\(^{17}\) Concern and hence disutility here increases in an increasing rate. Other functional forms can be used to describe disutility, but the merits of the results remain the same.
and delocation using the respective optimal tariff. Taking the decision of its firm on location into consideration, it chooses the optimal tariff that results in a higher Northern welfare.

The optimal tariff for each case can easily be found by differentiating Northern welfare in (25) with respect to \( t \) using its appropriate components from (13b), (13c), (21a), (21b), (22a) and (22b) to get

\[
\tau^* F = \frac{4\tau^3(2\tau - e_0) - 4\tau^2(3d_N^{-2}e_0 + 10) + 12d_N^{-2} + 27(2 - d_N^{-2}e_0)}{2(12\tau^2 - 64\tau^2 - 12\pi N + 81)}, \tag{26a}
\]

\[
\tau^* D = 0 , \tag{26b}
\]

for FDI and delocation respectively. Note that unless concern about pollution is very high in the North, the optimal tariff is strictly positive with FDI for all feasible values of \( t \) and \( \tau \).\(^{18}\)

When the Northern firm delocates on the other hand, the optimal trade policy for the North is always free trade.

After obtaining the optimal tariffs, the Northern government uses (26a) and (26b) to compare its welfare for each case and manipulate its firm to make the socially optimal locational decision. Northern welfare is higher with FDI for realistic low values of \( \tau \) and \( d_N \), namely when\(^{19}\)

\[
d_N < \sqrt{\frac{24d_0(\tau^2 + 3) - 4\tau(5 + 27e_0^2) - 2\sqrt{(9\tau^2 - 12\pi_0 + 5)(4\tau^2[5 + 6e_0^2] - 144\pi_0 + 243e_0^2)}}{3e_0}} . \tag{27}
\]

Otherwise, very high concern about local pollution tempts the North to implement a ‘Not in My Back Yard’ policy by removing tariffs in order to motivate the delocation of its dirty industries.\(^{20}\) Subsequently, no standards would be adopted in the South. The Northern optimal tariff is illustrated in figure 4 for several values of \( d_N \). Thicker lines characterize the level of \( \tau \)

\(^{18}\) This threshold value of \( d_N \) is not binding and is therefore kept out of the analysis.

\(^{19}\) When \( e_0 \) is set to unity, this implicit value of \( \tau \) is at its maximum level of approximately 0.1 when \( d_N=0 \) and is decreasing in the latter. Other emission levels give the same results as all outcomes change in the same proportion.

\(^{20}\) This result is caused by the non-transboundary nature of pollution in this model.
up to which it is optimal for the North to set a positive tariff to induce FDI over delocation, namely when condition (27) is satisfied. A higher \( d_N \) causes a discontinuous jump from \( t^{*F} > 0 \) to \( t^{*D} = 0 \). The results also imply that FDI for motives other than pollution is the only form of capital movement to the South in this region. Delocation to pollution havens hence does not occur even upon non-compliance by the South, reinforcing empirical studies that have found weak or no evidence for the pollution haven hypothesis.

**Proposition 6  Green Tariffs and the Pollution Haven Hypothesis**

As a positive Northern tariff is optimal for a realistic range of \( \tau \) and \( d_N \), standard FDI would be the equilibrium locational outcome if the South deviates and does not ratify. Pollution related delocation hence does not take place, discrediting the pollution haven hypothesis also in theory.

To summarize, optimal tariffs by the North are positive when its firm establishes a plant in each region and zero when it completely delocates to the South. The North commits to a positive green tariff if its concern over pollution is not so high to instigate a ‘Not in My Back Yard’ policy. Taking that into consideration, the Southern government moves in the first stage to commit to its optimal environmental policy.

**4.4. Optimal Southern Environmental Policy**

We turn to the first stage of the game to analyze the Southern government’s decision whether to adopt standards and enjoy trade liberalization, or to continue to ignore environmental policies and pay punishing green tariffs. Looking at the Southern welfare function (25) again after substituting for its components from the appropriate equations, it is easy to demonstrate whether adopting standards would be beneficial for the South. Figure 4 gives a preview of the optimal Southern environmental policy for different values of \( t \) and \( \tau \) when there is no concern about pollution in the South (\( d_N = 0 \)). This represents the worst case scenario, namely when ratification is least likely to occur. The curves on the left of the figure show the loci where Southern welfare with ratification is equal to each of the two scenarios without standards. \( W^H = W^F \) is the relevant locus if \( t > \overline{t} \) and \( W^H = W^D \) corresponds to the region
where \( t < \bar{t} \).\(^{21}\) The area to the left of these curves is the region where the South is better off by adopting standards. The curves clearly shift to the right increasing this area as \( d_s \) increases. 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 equilibrium 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 \( \tau \). It must be taking into account however that the South anticipates the Northern optimal tariff when making its choice over environmental policy. Therefore, it is only optimal for the Southern government to harmonize its environmental standards with those enforced in the North when \( W^{d_s} > W^{f} \) and (27) hold.

As the condition for positive tariffs falls right within the region where the South is better off with standards (see figure 4), the South always ratifies the MEA when positive tariffs upon non-compliance are optimal. This makes harmonization the unique equilibrium outcome for low combinations of \( \tau \) and \( d_s \). Here tariffs work successfully as a credible threat to motivate environmental harmonization without actually being put into practice. The proposals at the Doha round of the WTO can hence be deemed effective in this region as they create a subgame perfect equilibrium outcome. Note that this region resembles the situation in the real world as only fairly low values of \( \tau \) are consistent with data, tariffs above this region are suboptimal, and a Northern Not in My Back Yard Policy uncommon. In the unlikely case of a higher \( \tau \) and \( d_s \), standards would not adopted and the equilibrium outcome turns to delocation with free trade (see section 4.3). Free trade is therefore always the equilibrium trade policy both inside and outside the region where the South harmonizes its standards.

As the South is educated about the dangers of pollution and concern about the latter grows, the pollution externality in the Southern welfare function causes it to voluntarily upgrade its standards for a larger range of \( \tau \), leaving no need for trade obligations in a MEA.

\(^{21}\) Calculations of these threshold values are tedious and therefore not included in the text. They can be obtained from the author upon request.
**Proposition 7  Green Tariffs and the Optimal Environmental Policy**

Environmental harmonization is the unique subgame perfect equilibrium outcome for realistic low values of $\tau$ and $d_N$. Green tariffs work as a credible threat to persuade the South to ratify a MEA that requires it to upgrade its standards. Growing concerns in the South increases the range of $\tau$ along which the South finds it optimal to ratify voluntarily, eliminating the necessity for having trade and environmental measures as complementary policies.

**5. Conclusion**

This paper studies the importance of MEA trade obligations for a successful round of international environmental negotiations. It particularly emphasizes on the proposals made at the Doha round of the WTO regarding the formation of conditional consent for economic integration only upon compliance with certain MEAs. Non-cooperation in this case allows for countervailing tariffs against a country with environmental standards laxer than those set out in the MEA. Using this framework, the paper shows that in equilibrium it could be optimal for a non-signatory country to upgrade its standards according to the MEA. With no concern about pollution in the South, trade obligations in the MEA work *only* as a credible threat to deter delocation and motivate environmental harmonization. If the Southern government deviates, Northern optimal tariffs are positive so pollution motivated delocation never occurs.

The paper also analyzes the roles of tariffs on production, pollution abatement R&D, and hence the quality of the environment in each region. Green tariffs are shown to indeed serve the purpose of environmentalists to discourage trade and production of goods manufactured under environmentally unfriendly techniques. In addition, by discouraging delocation of multinationals to countries with weaker environmental policies, they spur innovation in search of cleaner technologies to serve as an alternative source of cost reduction. Comparing the impact of such trade policy with environmental harmonization (along with trade liberalization) on total world pollution reveals that the former is a more useful instrument when pollution costs are modest.
It was found in the light of Carraro and Siniscalco (1994) that unlike conventional environmental policy recommendations, a policy to control pollution can only be optimal when it is a mix of complementary measures. Since a pollution tax alone may not be an effective policy tool, its role must be reassessed and trade obligations must be considered when reaching out for environmental targets.\textsuperscript{22} If green tariffs can serve as a successful threat against delocation and eco-dumping policies, they may at times be the only means of a move towards more successful international environmental negotiations. Yet, the paper shows that positive tariffs never turn up in equilibrium. Finally, creating concern in the South about the dangers of pollution by disseminating information about the latter makes it optimal for the South to voluntarily adopt standards, eliminating the need for complementary policies.

The model in the paper is only a cornerstone to highlight the basic roles of green tariffs and the potential need for trade obligations to achieve the outcomes desired in a MEA. It can easily be extended to investigate a situation with transboundary pollution, an optimal emission tax rate for each region, or one with an international body determining a world optimal tariff to induce environmental harmonization when the latter is globally optimal. It is also important to look into other more direct measures of improving the environment such as abatement R&D subsidies to avoid creating a distortion. This could indeed be more beneficial for the North as neither green tariffs nor environmental harmonization always serve the interests of the latter, especially in the case of non-transboundary pollution. It must however be taken into account that such subsidy must be financed from costly taxation. Extending the model to include more countries is a next step to see the impact of the number of signatories on the decision of a non-signatory in regards to ratification. Another interesting line of research is to study the issue into a multi-firm, multi-sector general equilibrium framework.

\textsuperscript{22} 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 CO\textsubscript{2} at the level of the year 1990 in order to combat global warming.
References


Figure 1: R&D investment by the Northern Firm

I. Southern Government: environmental standards ($\tau$)

II. Northern Government: green tariffs ($t$)

III. Northern Firm: location

IV. Firms: pollution abatement R&D ($x$)

V. Firms: production ($q$)

Figure 2: R&D investment by the Northern Firm

$x^E > x^F$  
$x^F > x^E$  
$\max R&D \quad \tau^{SE}$  
$\max R&D \quad \tau^{SF}$  
$t^E = 0$  
$t^F = 0$  
$\tau^E$  
$\tau^F$
Figure 3: Location of the Northern Firm

Figure 4: Optimal Government Policies