Foreign Direct Investment and the Choice of Environmental Policy

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Abstract

We use a simple two-country oligopoly model of intra-industry trade to examine the implications of foreign direct investment for the pollution haven hypothesis and environmental policy. Countries which lower environmental standards to be more competitive in world markets generate pollution havens if environmental policy is fixed. However, if FDI is a viable option as a mode of entry, profit-shifting considerations weaken in favour of environmental considerations and FDI-recipients tighten environmental policy, weakening the pollution haven hypothesis by reducing incentives to relocate production. Interestingly, FDI may still occur in spite of the stricter standards in order to level the playing field. We derive conditions under which the FDI-receiving country has an incentive to manipulate its environmental standard to prevent or attract FDI, potentially eliminating or creating pollution havens. Without manipulation of standards, FDI leads to improvements in world pollution levels. However, when countries do manipulate their standards, FDI can lead to a dirtier environment when the two countries are substantially different in their valuation of environmental damages.

Keywords: Environmental policy, Foreign Direct Investment, Pollution Haven Hypothesis.

JEL Classifications: F18, Q28, F12

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1 Introduction

As the global economy has become more integrated, flows of foreign direct investment (FDI) have increased significantly. In 2003, 64,000 multinationals controlled more than 870,000 foreign affiliates worldwide (UNCTAD, 2008) and their sales exceeded \$18 trillion (compared to world exports of \$8 trillion). Cognizant of this trend, policymakers and researchers have focused on the welfare implications of FDI and on identifying economic variables that are instrumental in FDI decisions. Opponents to international trade and investment flows frequently argue that globalization and the presence of multinationals cause too lax environmental policies and "pollution havens" to emerge (Newell, 2001; Cole et al., 2006). According to the Pollution Haven Hypothesis (PHH), differences in pollution regulation across countries constitute a significant determinant of trade patterns and FDI/capital flows as firms in highly pollution-intensive industries have incentives to relocate their operations in countries with less stringent environmental standards. In Eskeland and Harrison (2003), the PHH is best seen as a corollary to the theory of comparative advantage: if it is more costly to conform to more stringent environmental standards at home, profit-maximizing firms would want to relocate their production activities.

As noted in Taylor (2004), a necessary, although not sufficient, condition for the PHH is the presence of a "pollution haven effect" which results when a tightening of environmental regulation deters exports (or stimulates imports) of dirty goods. While support for the latter is provided in several empirical studies, the evidence for or against the former (that is, the PHH) is rather limited. Although there exists a growing body of evidence in support of a significant link between the stringency of pollution regulations and the location of foreign direct investment and the size of net trade flows in U.S. manufacturing industries (List and Co, 2000; Keller and Levinson, 2002; Ederington and Minier, 2003), thus suggesting a fairly strong response by firms to differences in environmental regulation, there is little evidence that regulatory differences constitute the most relevant determinant of trade flows as the PHH predicts. Various reasons why this is the case from an empirical viewpoint have been proposed (e.g., data, measurement of environmental stringency); however, reasons why the PHH may fail theoretically have not received much attention.

In the present paper, we aim at filling the gap in the literature by addressing how differences in environmental regulation across countries give firms in countries with more stringent standards incentives to engage in FDI in countries with less stringent standards, how these incentives affect local environmental policy and welfare in recipient countries, and the potential policy responses of an FDI-recipient country. In this way, we can also examine whether recipient countries would ever select environmental standards that are tighter than the standard of the source country (that is, would the recipient ever become more "green" than the originally green country) and the conditions under which a recipient country would manipulate its standard to prevent (or even induce) FDI. We also consider the impact of (potential) FDI on the state of the environment worldwide and in the FDI-recipient country.

Our focus is thus different from the existing theoretical and empirical literature, which primarily is concerned with the effects of local environmental policies on investment flows (List and Co, 2000; Keller and Levinson, 2002; Javorcik and Wei, 2004; Xing and Kolstad, 2002). Little formal work is available on the impact of foreign direct investment on environmental policies. Most closely related to our paper is Markusen et al. (1993, 1995). In the 1993 article, a single active regional government influences the plant location of a single firm with increasing returns to scale and local pollution; in the 1995 article, the plant location problem is extended to the case in which both regional governments are active in policy setting. A number of extensions to this framework have been examined, including zero transportation costs (Hoel, 1997). Other modifications include policy commitment/time consistency (Ulph and Valentini, 2001, and Petrakis and Xepapadeas, 2003) and asymmetric relocation information (Greaker, 2003).[1] Our analytical framework differs from these models in several important ways. First, rather than examining the impact of environmental policy on the location decision of production, we focus on the impact of the option for FDI (potential relocation of production) on the choice of environmental policy. Second, instead of a single firm choosing to locate in both regions (multi-plant), one region, or no region, we assume two independent firms producing for (and competing in) the two markets. Third, we do not rely on increasing returns to scale or shipping costs to influence the location (FDI) decision. Finally, instead of two symmetric regions selecting environmental policy, we rely on the two countries placing different weights on environmental damages to generate environmental policy differences in the absence of FDI (that is, to induce a PHH incentive for FDI). Another related paper is Cole et al. (2006), in which a model of political economy with lobbying and government corruption is employed to explicitly examine the relationship between FDI and environmental policy. While the effect on environmental policy of an additional (foreign) producer is considered, the entry decision of the foreign firm is exogenous; we, on the other hand, are interested in the choice of FDI and how this choice is manipulated through environmental policy, depending on the external benefits of FDI. The key proposition in Cole et al. that foreign entry results in stricter environmental policy (when corruption is low) is confirmed in most of the cases we cover, with an important exception, although we encounter cases in which FDI does not occur but environmental policy is still affected.

We use a two-country oligopoly model of intra-industry trade. As in the perfectly competitive model

[1] Although the threat is present, relocation never occurs in Greaker (2003).

employed in Copeland and Taylor (1994), we assume pollution to be purely local and allow for a technology that abates emissions of pollution. Both countries have the same production and abatement technologies. We assume that countries are bound by the national treatment rules of the WTO, and as such cannot discriminate on products produced in different locations or by different firms.[2] In order to examine the implications of FDI, we consider a three-stage game. In the first stage, countries simultaneously decide their environmental policy, choosing the emission standards for local firms that maximize welfare defined as the sum of consumer surplus and producer surplus less environmental damages. Each country takes into account environmental damages when setting environmental policy, but the two countries differ in the weight they assign to environmental damage.[3] The second stage of the game involves the firm's decision about whether to serve foreign markets through export or FDI. In this setup, the firm in the country with more stringent environmental standards could move production to the country with more lax standards, depending on the benefits of such a move relative to the cost of setting up a foreign plant.[4] Finally, firms engage in Cournot competition in the product markets. In order to maintain the focus of the analysis on the implications of asymmetric emission standards for foreign direct investment, we ignore trade policy.

In the absence of FDI, the country which places less emphasis on environmental damage has an incentive to lower environmental standards to become more competitive in world markets; however, once FDI is available as a mode of entry, the country is confronted with two conflicting effects of FDI. On one hand, FDI has a positive effect through greater local production/consumption associated with lower domestic prices (higher consumer surplus) and may generate external benefits. On the other hand, FDI has a negative effect through lower profits for the domestic firm due to a loss in competitive advantage (lower producer surplus) and additional environmental damages from greater local production. If the home country assigns a higher weight on environmental damage than the foreign country does, the former can be considered, in the absence of an FDI option, as the more environmentally friendly or "green" country while the latter is the less environmental friendly or "grey" country. As the home country becomes more environmentally sensitive (as its weight on environmental damage increases), it chooses more stringent emission standards while the foreign country chooses less stringent standards.

We first consider a traditional PHH case in which the foreign country does not alter its emission standard in response to FDI. Not surprisingly, we find that, as long as the fixed cost of having an additional plant

[2] For the impact of national treatment on environmental policy, see Gulati and Roy (2008) and Horn (2011).

[3] We consider two similar countries to avoid non-environmental policy related incentives for FDI. The model is thus best suited for the analysis of the impact of FDI on policy setting among equally industrialized countries rather than between North and South.

[4] We ignore the possibility of reciprocal FDI and focus on the FDI decision of the home firm.

is sufficiently low and abatement is costly, the home firm facing a less stringent environmental standard abroad has incentives to relocate its production to the foreign country (the traditional PHH case). We then allow for the possibility that the host country is able to respond to FDI. In such a case, when FDI occurs, the foreign country has two active producers within its borders, and the home firm faces the same standard set by the foreign country for the foreign firm. Thus, the profit-shifting motive disappears while the environmental damage effect widens; as a result, the foreign country tightens its emission standard. Interestingly, when the two countries are sufficiently similar in weighing environmental damages, the "grey" country (foreign country) can become greener than the originally "green" country (home country). More interestingly, there are cases in which the home firm chooses to engage in FDI (rather than to export) in the foreign country even though the foreign emission standard is stricter than its own standard under the export case. Intuitively, as countries become more asymmetric in their environmental friendliness, the gap between their standards increases under export; as long as the asymmetry is not too large, the home firm would prefer to relocate to the foreign country in order to *level the playing field* even if relocation entails facing a tighter standard.

When allowing the foreign country to respond to the home firm's FDI, we consider the question of whether the foreign country can induce export (FDI) via preventing (attracting) FDI by adjusting its standard and, if so, whether this move leads to higher welfare in the foreign country and a cleaner environment worldwide. Hence, we obtain that, when the extra weight the home country assigns to environmental damage is low and the benefit the foreign country derives from the home country's FDI is high, the foreign country is better off inducing the home firm to engage in FDI by increasing its emission standard above the level prevailing under export; when the extra weight is high and the benefit is low, the foreign country is better off inducing the home firm to export by lowering its standard below the level prevailing under FDI. The export (FDI) equilibrium without inducement ensues when the extra weight and benefit are both low (high). Relative to the case in which environmental policy is not adjusted, pollution havens that would have existed do not come about when FDI is prevented while other pollution havens that would have not existed are generated when FDI is attracted.

From a purely environmental perspective, we show that, relative to the export case, the home firm's FDI results in two counteracting effects in the foreign country: an *emission standard effect* which amounts to a reduction in emission standards and a *scale effect* which amounts to an increase in output. As the former effect dominates the latter, given the convexity of costs/damages, FDI leads to a cleaner environment in the foreign country (and thus worldwide) relative to the export case. However, when the foreign country takes into account the home firm's option to engage in FDI and responds by adjusting its standard to either prevent or induce FDI, we obtain that, when FDI is induced, a dirtier world environment can result if the two countries do not differ substantially in their valuation of environmental damage and that, as the home firm's cost of FDI increases, a dirtier environment becomes more likely to result. Relative to the FDI case, we also find that, when export is induced, a cleaner environment obtains if the two countries differ substantially in their valuation of environmental damage and that, as the home firm's cost of FDI decreases, a cleaner world environment becomes more likely to result.

2 Model

We develop an oligopoly model of trade with two countries (h for home and f for foreign) and two goods (x and y). Good y is the numeraire good produced under perfect competition with a constant-returns-to-scale technology. There is no pollution associated with the production of good y. Good x, the polluting (dirty) good, is produced by a single profit-maximizing firm in each country at zero marginal cost.[5] For convenience, we refer to home (foreign) country's monopolist as firm h (f).

We assume that preferences over the two goods are quasi-linear and the inverse demand for good x in each country is linear, that is,

$$p_i(x_i) = \alpha - \sum_{z=h,f} x_{zi}, \tag{1}$$

where x_i denotes the total quantity of good x sold in country i, p_i denotes the price of good x in country i, and x_{zi} denotes the output sold by country z's firm in country i. Firm i's total production is made of its sales in the domestic market denoted by x_{ii} and in the foreign market denoted by x_{ij} with $i \neq j$. Firms compete in quantities (Cournot) in each market. For simplicity, we assume that each unit of x produced generates one unit of pollution and that, as in Copeland and Taylor (1994), pollution is purely local. Moreover, abatement is possible but costly. Specifically, if a government imposes a cap on the emissions of firm i, denoted e_i, the cost of meeting this target is

$$C_i(a_i) = \frac{a_i^2}{2}, \tag{2}$$

where a denotes abatement which is equal to the difference between production and the appropriate emission standard or

$$a_i = \max\left(0, \sum_{j=h,f} x_{ij} - e_i\right). \tag{3}$$

[5] The gains from trade stem from reduced market power in the domestic industry. To this end, the monopoly assumption is not crucial but is the simplest way to represent market power.

Environmental damages are quadratic in unabated local emissions and equal to

$$\Psi_i = \frac{1}{2}e_i^2. \tag{4}$$

To examine the implications of FDI access, we consider a three-stage game. In the first stage, countries simultaneously decide over their environmental policy, choosing the welfare-maximizing emission standards for local firms. Welfare is defined as the sum of consumer surplus (CS) and producer surplus (PS) less environmental damages (Ψ). To differentiate between the two countries in terms of their environmental attitude so that they select distinct emission standards, we assume that the home country places heavier emphasis on environmental damages in its welfare.[6] Hence, the welfare of the home country is

$$W_h(\mathbf{e}) \equiv CS_h(\mathbf{e}) + \sum_{j=h,f} \pi_{hj}(\mathbf{e}) - (1+w)\Psi_h(\mathbf{e}) \tag{5}$$

whereas the welfare of the foreign country is

$$W_f(\mathbf{e}) \equiv CS_f(\mathbf{e}) + \sum_{j=h,f} \pi_{fj}(\mathbf{e}) - \Psi_f(\mathbf{e}), \tag{6}$$

where $\mathbf{e} = [e_h, e_f]$ is the vector of emission standards, w is a positive parameter which captures the additional value that the home country places on the environment, and π_{ij} denotes the profit of firm i in country j.

In the second stage of the game, firm h decides whether to serve the foreign market through export or FDI. In this setup, the firm in the country with a more stringent environmental standard could move production to the country with a more lax standard, depending on the benefit of such a move relative to the cost of setting up a foreign plant, which we assume to be fixed at F. As Ulph and Valentini (2001) and Petrakis and Xepapadeas (2003) have previously compared pre-commitment and time consistent policies, we will for the most part assume the latter (except when examining the benchmark of no policy reaction/adjustment). Finally, in the third stage, firms engage in Cournot competition in the two product markets. We obtain the subgame perfect Nash equilibrium (SPNE) by backward induction.

3 Environmental Policy and Welfare under Trade

For the time being, we assume that FDI is not an option for the firms and intra-industry trade takes place between countries. This case serves as a benchmark to study the implications of FDI for strategic environmental policy and social welfare. To this end, we modify our game into a two-stage non-cooperative

[6] We would have qualitatively similar results by assuming that the two countries have different weights on producer surplus. However, as our focus is on environmental policy, how it responds to FDI, and how it can be manipulated to attract or prevent FDI, we maintain the assumption that the two countries differ in their environmental awareness.

game between firms and governments. In the first stage, countries simultaneously choose the welfare-maximizing emission standards for local firms; in the second stage, firms compete *a la* Cournot in the product markets. Since each firm produces within its own country, it is subjected to the local emission standard. Hence, firm i faces an endogenously determined emission standard e_i and the amount of pollution it abates is

$$a_i = \sum_{j=h,f} x_{ij} - e_i, \tag{7}$$

so that its profit is

$$\pi_i = \sum_{j=h,f} p_j x_{ij} - \frac{1}{2}\left(\sum_{j=h,f} x_{ij} - e_i\right)^2, \qquad i = h, f. \tag{8}$$

It is immediate that the marginal cost of abatement is equal to abatement. We note that, in order to maintain the focus of our analysis on the implications of asymmetric emission standards for foreign direct investment, we ignore trade policy.[7] We also ignore local taxation of profits, unlike Greaker (2003), so profits return to country of firm ownership.

Given the emission standards e_h and e_f, the profit-maximizing output choices must satisfy

$$\begin{aligned} \frac{\partial \pi_i}{\partial x_{ii}} &= \alpha - 3x_{ii} - x_{ji} - x_{ij} + e_i = 0 \\ \frac{\partial \pi_i}{\partial x_{ij}} &= \alpha - 3x_{ij} - x_{jj} - x_{ii} + e_i = 0, \qquad i, j = h, f. \end{aligned} \tag{9}$$

We simultaneously solve the above conditions to obtain the Cournot Nash equilibrium in the export scenario, namely,

$$x_{ii} = x_{ij} = \frac{3\alpha + 4e_i - e_j}{15} \qquad \text{and} \qquad p_i = \frac{3\alpha - e_i - e_j}{5}, \tag{10}$$

and the following comparative statics

$$\frac{\partial x_{ii}}{\partial e_i} = \frac{\partial x_{ij}}{\partial e_i} = \frac{4}{15} > 0 \qquad \text{and} \qquad \frac{\partial x_{ii}}{\partial e_j} = \frac{\partial x_{ij}}{\partial e_j} = -\frac{1}{15} < 0, \tag{11}$$

for $i, j = h, f$. Thus, firm i's total output increases with its own emission standard while it decreases with its rival's emission standard. Moreover, the effect on own output dominates the effect on rival output so that total output sold (price) in a country rises (falls) as either country weakens its standard, that is,

$$\sum_{z=h,f} \frac{\partial x_{zi}}{\partial e_i} = \sum_{z=h,f} \frac{\partial x_{zj}}{\partial e_j} = \frac{1}{5} > 0 \qquad \text{and} \qquad \frac{\partial p_i}{\partial e_i} = \frac{\partial p_i}{\partial e_j} = -\frac{1}{5} < 0. \tag{12}$$

[7] Inclusion of tariffs would provide countries with an additional incentive for FDI (i.e., tariff jumping) that would cloud the analysis of FDI decisions resulting from differences in environmental policies.

With the equilibrium behavior of firms as above described, we next examine the first-stage welfare maximization problem governments face to determine the non-cooperative emission standards, that is,

$$\max_{e_h} W_h(\mathbf{e}) = \frac{x_h(\mathbf{e})^2}{2} + \sum_{j=h,f} p_j(\mathbf{e}) x_{hj}(\mathbf{e}) - \frac{1}{2}\left(\sum_{j=h,f} x_{hj}(\mathbf{e}) - e_h\right)^2 - \frac{(1+w)e_h^2}{2} \tag{13}$$

and

$$\max_{e_f} W_f(\mathbf{e}) = \frac{x_f(\mathbf{e})^2}{2} + \sum_{j=h,f} p_j(\mathbf{e}) x_{fj}(\mathbf{e}) - \frac{1}{2}\left(\sum_{j=h,f} x_{fj}(\mathbf{e}) - e_f\right)^2 - \frac{e_f^2}{2}. \tag{14}$$

The first-order conditions for the above problems yield

$$\frac{\partial W_i}{\partial e_i} = \theta + e_i \frac{\partial^2 W_i}{\partial e_i^2} + e_j \frac{\partial^2 W_i}{\partial e_i \partial e_j}, \qquad i,j = h,f \quad \text{and} \quad i \neq j, \tag{15}$$

where $\theta = \frac{38\alpha}{75} > 0$, and the second-order conditions are satisfied as

$$\frac{\partial^2 W_h}{\partial e_h^2} = \frac{\partial^2 W_f}{\partial e_f^2} - w = -\frac{313}{225} - w < 0. \tag{16}$$

We thus have that e_i and e_j are strategic substitutes as

$$\frac{\partial^2 W_i}{\partial e_i \partial e_j} = -\frac{23}{225} < 0. \tag{17}$$

Combining the above two first-order conditions, we obtain the negatively sloped reaction functions in emission standards, that is,

$$e_i = -\frac{\theta + e_j \dfrac{\partial^2 W_i}{\partial e_i \partial e_j}}{\dfrac{\partial^2 W_i}{\partial e_i^2}}, \qquad i,j = h,f \quad \text{and} \quad i \neq j, \tag{18}$$

and

$$\frac{\partial e_i}{\partial e_j} = -\frac{\dfrac{\partial^2 W_i}{\partial e_i \partial e_j}}{\dfrac{\partial^2 W_i}{\partial e_i^2}} < 0, \qquad i,j = h,f \quad \text{and} \quad i \neq j. \tag{19}$$

The negative relationship between home environmental policy and foreign environmental policy stems from the nature of Cournot competition and provides support for the presence of a profit-shifting motive. We also note that, while $\frac{\partial e_f}{\partial e_h}$ is independent of w, the absolute value of the slope of the home country's reaction function, $\left|\frac{\partial e_h}{\partial e_f}\right|$, falls with w,

$$\frac{\partial \left|\dfrac{\partial e_h}{\partial e_f}\right|}{\partial w} < 0, \tag{20}$$

implying that the choice of the home country's emission standard becomes less sensitive to the foreign country's choice as the home country becomes more environmentally conscious (or the additional weight it places on environmental damages increases).[8] Simultaneously solving the two conditions in (15), we can express the optimal emission standards in the export scenario (e_i^{ex}) as

$$e_i^{ex} = \frac{\theta\left(\dfrac{\partial^2 W_i}{\partial e_i \partial e_j} - \dfrac{\partial^2 W_j}{\partial e_j^2}\right)}{\dfrac{\partial^2 W_i}{\partial e_i^2}\dfrac{\partial^2 W_j}{\partial e_j^2} - \left(\dfrac{\partial^2 W_i}{\partial e_i \partial e_j}\right)^2}, \qquad i, j = h, f \quad \text{and} \quad i \neq j. \tag{21}$$

Since $\frac{\partial^2 W_h}{\partial e_h^2} - \frac{\partial^2 W_f}{\partial e_f^2} = -w < 0$, we have that

$$e_h^{ex} - e_f^{ex} = \frac{\theta\left(\dfrac{\partial^2 W_h}{\partial e_h^2} - \dfrac{\partial^2 W_f}{\partial e_f^2}\right)}{\dfrac{\partial^2 W_h}{\partial e_h^2}\dfrac{\partial^2 W_f}{\partial e_f^2} - \left(\dfrac{\partial^2 W_h}{\partial e_h \partial e_f}\right)^2} < 0, \tag{22}$$

so that standards are tighter in the home country than in the foreign country. Thus, in the absence of an FDI option, the home country can be considered as the more environmentally friendly or "green" country while the foreign country is the less environmentally friendly or the "grey" country. Accordingly, as the home country becomes more environmentally sensitive (as w increases), it chooses more stringent emission standards while the foreign country chooses less stringent standards,[9] that is,

$$\frac{\partial e_f^{ex}}{\partial w} > 0 > \frac{\partial e_h^{ex}}{\partial w}. \tag{23}$$

Using the optimal emission standards, we can write the profit functions of the two firms in terms of emission standards as

$$\begin{aligned} \pi_h^{ex}(e_h^{ex}, e_f^{ex}) &= \left(\frac{6\alpha + 8e_h^{ex} - 2e_f^{ex}}{15}\right)^2 - \frac{e_h^{ex^2}}{2} \\ \pi_f^{ex}(e_h^{ex}, e_f^{ex}) &= \left(\frac{6\alpha + 8e_f^{ex} - 2e_h^{ex}}{15}\right)^2 - \frac{e_f^{ex^2}}{2}. \end{aligned} \tag{24}$$

Similarly, welfare levels are

$$\begin{aligned} W_h^{ex}(e_h^{ex}, e_f^{ex}) &= \underbrace{\frac{1}{2}\left(\frac{2\alpha + e_h^{ex} + e_f^{ex}}{5}\right)^2}_{CS_h} + \underbrace{\left(\frac{6\alpha + 8e_h^{ex} - 2e_f^{ex}}{15}\right)^2 - \frac{(2+w)e_h^{ex^2}}{2}}_{PS_h - \Psi_h} \\ W_f^{ex}(e_h^{ex}, e_f^{ex}) &= \underbrace{\left(\frac{2\alpha + e_h^{ex} + e_f^{ex}}{20}\right)^2}_{CS_f} + \underbrace{\left(\frac{6\alpha + 8e_f^{ex} - 2e_h^{ex}}{15}\right)^2 - e_f^{ex^2}}_{PS_f - \Psi_f}. \end{aligned} \tag{25}$$

[8] See appendix.

[9] See appendix for more details on emission standards under export, FDI with accomodation, and environmental policy adjustment to induce or prevent FDI.

In the section that follows, we consider the case in which the home firm (facing a more stringent standard under export) is free to choose between export and FDI as a mode of entry into the foreign country. We thus endogenize the home firm's choice over the mode of entry by allowing the foreign country to manipulate its environmental policy to induce or prevent FDI. We illustrate a tree diagram of the game between the home firm and the foreign country in Figure 1. The game involves nature determining the level of the cost the home firm has to incur to move production to the foreign country. Hence, taking this cost information into account, the foreign country decides, when setting its environmental policy, whether or not to manipulate its standard in order to induce or prevent FDI: if it decides against manipulation when the relocation cost is low ($F < F^{FDI}$), it can either do nothing in response to FDI or respond to FDI. The home firm then chooses whether to export or engage in FDI given the relocation cost it faces and the environmental policy in place in the foreign country. As we show in the section that follows, when $F < F^{FDI}$, that is, when the home firm has an incentive to engage in FDI, the foreign country is always better off by responding to FDI; whether it manipulates its standard to induce export when the home firm wants to do FDI (i.e., $F < F^{FDI}$) and to induce FDI when the home firm wants to export (i.e., $F > F^{FDI}$) depends on the benefit it receives from FDI (B). When $B < \underline{B}$ (and $F < F^{FDI}$), it induces export; when $B > \overline{B}$ (and $F > F^{FDI}$), it induces FDI.

[Insert Figure 1 here]

4 Foreign Direct Investment

FDI occurs if it is profitable for the home firm to move production to the foreign country in order to take advantage of the higher emission standard in that country (or to level the playing field, as we discuss below). By relocating production to the foreign country, the home firm has to pay an exogenous plant-level fixed cost equal to F. We ignore the possibility of reciprocal FDI and focus on the FDI decision of the home firm. In addition, we allow for the possibility that the FDI-recipient or host country (i.e., the foreign country) benefits or suffers from the home firm's FDI. We denote the benefit (loss if negative) as B and, for simplicity, assume that it is exogenously given. In essence, B captures spillover effects of FDI in the host country. Although standard theory points to FDI-generated externalities which raise the productivity of host factors of production (Glass and Saggi, 1999 and 2002), the evidence about the presence of productivity spillovers is rather mixed. While a positive industry-level correlation between FDI and productivity is detected in Caves (1974), Blomström (1986), and Driffield (2000), the incidence of spillovers is found to be influenced by host industry's and host country's characteristics. At the micro-level, no evidence of higher levels of total factor productivity is found in sectors with higher foreign participation in Morocco (Haddad and Harrison, 1993), for Venezuelan manufacturing companies (Aitken and Harrison, 1999), and for low-technology Indian companies (Kathuria, 1998 and 2000).

When the home firm engages in FDI, the home and foreign firms' profits are

$$\pi_h = \sum_{j=h,f} p_j x_{hj} - \frac{1}{2}\left(\sum_{j=h,f} x_{hj} - e_f\right)^2 - F \tag{26}$$

and

$$\pi_f = \sum_{j=h,f} p_j x_{fj} - \frac{1}{2}\left(\sum_{j=h,f} x_{fj} - e_f\right)^2. \tag{27}$$

Given the foreign country's emission standard e_f, the profit-maximizing output choices must satisfy

$$\begin{aligned} \frac{\partial \pi_i}{\partial x_{ii}} &= \alpha - 3x_{ii} - x_{ji} - x_{ij} + e_f = 0 \\ \frac{\partial \pi_i}{\partial x_{ij}} &= \alpha - 3x_{ij} - x_{jj} - x_{ii} + e_f = 0, \qquad i,j = h,f \quad \text{and} \quad i \neq j. \end{aligned} \tag{28}$$

Hence, in equilibrium, firm i's output levels are

$$x_{ii} = x_{ij} = \frac{\alpha + e_f}{5}, \qquad i,j = h,f \quad \text{and} \quad i \neq j. \tag{29}$$

In the following discussion, we examine several cases which differ in how the FDI-recipient country (foreign country) reacts to FDI. First, we consider the case of no reaction to FDI: the foreign country selects the emission standard above derived for the export scenario regardless of whether FDI occurs. This corresponds to a traditional pollution haven hypothesis case. Then, we examine the case in which the foreign country endogenously determines its emission standard in response to FDI; we thus obtain conditions under which the home firm undertakes FDI and discuss the implications of FDI for the foreign country's welfare. Finally, we consider whether the foreign firm has incentives to modify its standard to prevent (attract) FDI when FDI yields higher (lower) profits to the home firm than exporting and discuss the welfare implications of such a strategy.

4.1 No response to FDI

In a typical pollution haven hypothesis case, firms facing weaker environmental standards in foreign countries shift production to those countries (in our model through FDI) without influencing local standards. With the foreign country choosing the emission standard prevailing under export, profit maximization by each firm yields identical output levels as

$$x_{ii}^{nr}(e_f^{ex}) = x_{ij}^{nr}(e_f^{ex}) = \frac{\alpha + e_f^{ex}}{5}, \qquad i,j = h,f \quad \text{and} \quad i \neq j. \tag{30}$$

where the superscript nr refers to no response levels. Each firm's profit is

$$\begin{aligned}
\pi_h^{nr}\left(e_f^{ex}\right) &= \frac{8\alpha\left(\alpha+2e_f^{ex}\right)-17e_f^{ex^2}}{50}-F \\
\pi_f^{nr}\left(e_f^{ex}\right) &= \frac{8\alpha\left(\alpha+2e_f^{ex}\right)-17e_f^{ex^2}}{50}
\end{aligned} \tag{31}$$

and foreign welfare is

$$W_f^{nr}\left(e_f^{ex}\right)=\frac{12\alpha\left(\alpha+2e_f^{ex}\right)-63e_f^{ex^2}}{50}+B. \tag{32}$$

We note that FDI only occurs if the home firm's profits are greater through FDI than through export. Specifically, if the fixed cost of relocating production to the foreign country is sufficiently low, the home firm prefers FDI to export as a mode of entry, that is,

$$\pi_h^{nr}\left(e_f^{ex}\right)-\pi_h^{ex}\left(e_h^{ex},e_f^{ex}\right)\geq 0 \quad \text{iff } F\leq F^{nr}, \tag{33}$$

where

$$F^{nr}=\frac{8\alpha\left(\alpha+2e_f^{ex}\right)-17e_f^{ex^2}}{50}-\left(\frac{6\alpha+8e_h^{ex}-2e_f^{ex}}{15}\right)^2+\frac{e_h^{ex^2}}{2}, \tag{34}$$

with

$$\frac{\partial F^{nr}}{\partial w}>0, \tag{35}$$

which says that the critical value of F (below which the home firm engages in FDI) increases in w. In other words, as the emission standards of the two countries become more asymmetric (as w increases), the home firm has greater incentives to engage in FDI in the foreign country. When production shifts from the home country to the foreign country, environmental damages in the home country fall to zero. Thus, as long as the home firm has an incentive to perform FDI, the home country is better off relative to the export case.

We now consider the foreign country's welfare. If there exists no benefit from FDI, the foreign country strictly prefers the home firm to export rather than to perform FDI. There are three distinct effects of FDI on the foreign country: (i) a decrease in the foreign firm's profits from a loss in competitive advantage; (ii) an increase in environmental damages from a rise in local production; (iii) an increase in consumer surplus from a decrease in the price. The first two effects of FDI outweigh the last effect and foreign welfare falls if there exists no benefit from receiving FDI. Hence, we can always identify a (positive) critical benefit level, denoted by B^{nr}, above which the foreign country prefers the home firm to engage in FDI rather than export, that is,

$$W_f^{nr}\left(e_f^{ex}\right) - W_f^{ex}\left(e_h^{ex}, e_f^{ex}\right) \geq 0 \quad \text{iff } B \geq B^{nr}, \tag{36}$$

where

$$B^{nr} = \left(\frac{2\alpha + e_h^{ex} + e_f^{ex}}{20}\right)^2 + \left(\frac{6\alpha + 8e_f^{ex} - 2e_h^{ex}}{15}\right)^2 - \frac{12\alpha\left(\alpha + 2e_f^{ex}\right) - 13e_f^{ex^2}}{50}. \tag{37}$$

From an environmental perspective, whenever the home firm engages in FDI and the foreign country does not change its environmental policy, environmental damages are higher in the foreign country (and therefore worldwide) relative to the export case.[10]

4.2 Optimum Response to FDI

Next, we consider the case in which the foreign country, in response to FDI, adjusts its emission standard. If FDI occurs, the foreign country has two active producers within its borders and the home firm faces the same standard set by the foreign country for the foreign firm. Thus, the profit-shifting motive disappears while the environmental damage effect widens. As a result, the foreign country has an incentive to lower its emission standard when faced with FDI, so that FDI acts as a disciplining device for governments wishing to exploit environmental standards to gain competitive advantage. Stage three of the game remains the same as in the no response case, so that output levels are given by (29). The foreign country, however, faces twice the environmental damages as in the export case; accordingly, it adjusts its emission standard to satisfy

$$\frac{\partial W_f}{\partial e_f} = \frac{12\alpha - 63e_f}{25} = 0, \tag{38}$$

which gives

$$e_f^{FDI} = \frac{4\alpha}{21} \tag{39}$$

as the optimal emission standard in the foreign country under FDI. Upon comparison of the above with (21), we obtain

Proposition 1: *The optimum emission standard in the foreign country is always more stringent when the foreign country responds to FDI optimally relative to the export and no response cases. Furthermore, the gap between the export and FDI standards in the foreign country widens as the home country becomes more environmentally conscious:*

$$e_f^{FDI} - e_f^{ex} < 0 \quad \text{and} \quad \frac{\partial\left(e_f^{ex} - e_f^{FDI}\right)}{\partial w} > 0. \tag{40}$$

[10] See appendix for details on critical F and B values under both no response and accomodation.

Since pollution is local, the foreign country not only takes into account the environmental damages generated by its own firm but also the damages generated by the home firm. In the absence of any adjustment in the emissions standard, consumer surplus is higher while producer surplus is lower since the protection of the domestic industry afforded by a weaker emission standard is lost as the home firm enters and receives the same protection. Moreover, emissions (thus environmental damages) rise significantly. Since the foreign country's benefit from FDI is exogenous, it does not affect the emission standard. In such a case, the negative effects of FDI on producer surplus and environmental damage dominate the positive effect on consumer surplus. Thus, as we illustrate in Figure 2, the foreign country has an incentive to reduce its emission standard relative to the export case.

More interesting is the comparison of the emission standard in the foreign country (originally the *grey* country) under FDI, which both the foreign and home firms face, with the emission standard in the home country (originally the *green* country) in the export scenario, that is,

$$e_f^{FDI} - e_h^{ex} \leq 0 \quad \text{if } w \leq \overline{w}, \tag{41}$$

where $\overline{w} = \frac{1015}{939} \approx 1.08$. Hence, we obtain

Proposition 2: *When the foreign country (originally the grey country) responds optimally to the home firm's FDI, its emission standard falls below the home country's (originally the green country) standard under export if w is sufficiently low.*

The above proposition implies that, when the home firm engages in FDI in the foreign country and the two countries' weights on environmental damage are very different, the *grey* country (the foreign country) selects an environmental standard that is weaker than the standard of the originally *green* country (the home country) under export. However, as we also show in Figure 2, the foreign country can become "greener" than the *green* country (the home country) when the two countries are sufficiently similar in weighing environmental damages.

[Insert Figure 2 here]

When the two countries are quite different, their export standards are quite different; specifically, the standard in the foreign country is much higher than that in the home country. While FDI generates additional environmental damages and takes away profit-shifting motives, thus inducing the foreign country to lower its standard, these effects are not sufficiently large to eliminate the policy gap resulting from a divergence in the two countries' environmental positions. However, when the two countries are similar (i.e., w is sufficiently low), the two countries' emission standards are not very different in the export scenario so that the damage effect and weakened profit-shifting effect under FDI outweigh the environmental weight differential effect.

From a purely environmental perspective, the home firm's FDI results in two counteracting effects in the foreign country: (i) an *emission standard effect*, according to which, when FDI is accommodated, the foreign country's emission standard falls (even below the *green* country's standard under export when $w < \overline{w}$); (ii) a *scale effect*, according to which FDI raises the production level in the foreign country relative to the export case and this, in turn, increases environmental damages for a given standard. The former effect dominates the latter and FDI leads to a cleaner environment in the foreign country (and thus worldwide) relative to the export case when the foreign country responds to the home firm's FDI by lowering its emission standard. The environmental improvement does depend on w; specifically, as w increases, the improvement gets larger or

$$\frac{\partial \left[\Psi_f^{ex}\left(e_f^{ex}\right) - \Psi_f^{FDI}\left(e_f^{FDI}\right)\right]}{\partial w} = e_f^{ex}\frac{\partial e_f^{ex}}{\partial w} > 0, \tag{42}$$

where

$$\Psi_f^{ex}\left(e_f^{ex}\right) - \Psi_f^{FDI}\left(e_f^{FDI}\right) = \frac{\left(e_f^{ex} - e_f^{FDI}\right)\left(e_f^{ex} + e_f^{FDI}\right)}{2} > 0. \tag{43}$$

Using the optimum emission standard e_f^{FDI}, we find the firms' profit levels to be

$$\begin{aligned} \pi_h^{FDI}\left(e_f^{FDI}\right) &= 23\left(\frac{2\alpha}{21}\right)^2 - F \\ \pi_f^{FDI}\left(e_f^{FDI}\right) &= 23\left(\frac{2\alpha}{21}\right)^2 \end{aligned} \tag{44}$$

and the foreign welfare level to be

$$W_f^{FDI}\left(e_f^{FDI}\right) = \frac{2\alpha^2}{7} + B. \tag{45}$$

As above mentioned, FDI only occurs if the home firm's profits are greater through FDI than through export. Again, if the fixed cost of relocating production to foreign country is sufficiently low, the home firm prefers FDI to export as a mode of entry, that is,

$$\pi_h^{FDI}\left(e_f^{FDI}\right) - \pi_h^{ex}\left(e_h^{ex}, e_f^{ex}\right) \geq 0 \quad \text{if } F \leq F^{FDI}, \tag{46}$$

where

$$F^{FDI} = 23\left(\frac{2\alpha}{21}\right)^2 - \left(\frac{6\alpha + 8e_h^{ex} - 2e_f^{ex}}{15}\right)^2 + \frac{e_h^{ex^2}}{2} \geq 0 \quad \text{if } w \geq \underline{w}, \tag{47}$$

where $\underline{w} \approx 0.43$. We thus have

Proposition 3: *The incentive to perform FDI increases in w. For $w < \underline{w}$, the home firm does not engage in FDI. For $w > \underline{w}$, the home firm engages in FDI even if it entails facing tighter standards than under export at values of w ranging between $\underline{w}$ and $\overline{w}$.*

As illustrated in Figure 3, the critical F value below which the home firm engages in FDI, F^{FDI}, increases in w. In other words, as the emission standards become relatively more asymmetric (as w increases), the home firm has greater incentives to perform FDI in the foreign country. Also, as $e_f^{FDI} < e_f^{ex}$ holds, $F^{FDI} < F^{nr}$ always obtains. For sufficiently small values of w ($w < \underline{w}$), the home firm does not have any incentive to perform FDI in a country which adjusts its standard optimally and thus $F^{FDI} < 0$ when $w < \underline{w}$. However, there are instances in which the home firm chooses to engage in FDI even though the foreign emission standard falls below its own standard under export (since $\overline{w} > \underline{w}$). As w increases, the gap between the two countries' standards widens under export. Provided that w is not too large ($w < \overline{w}$), the home firm prefers relocating to the foreign country, even if it ends up facing tighter standards, in order to *level the playing field*. Intuitively, if the home firm does not engage in FDI, its cost of abatement is higher than that of its competitor. By relocating to the foreign country, the home firm faces the same marginal abatement cost as the foreign firm so that it is no longer at a competitive disadvantage. When w is sufficiently high ($w > \overline{w}$), the home firm faces a lower marginal abatement cost in the foreign country under FDI relative to export. Hence, the home firm has two reasons to engage in FDI: (i) to take advantage of lower abatement costs and (ii) to remove the competitive advantage of the foreign firm resulting from differences in standards.

[Insert Figure 3 here]

Comparing the FDI regions of no response and optimal response in Figure 3, we can see that some FDI which would have occurred in the absence of accomodation is deterred when environmental standards are optimally adjusted (dark grey shaded area). This suggests that optimal response weakens the incentive to relocate production, thereby weakening the PHH (at least in the absence of manipulation of standards to induce FDI, as we show below).

We can easily show that, if there exists no benefit from FDI, the foreign country strictly prefers the home firm to export rather than to engage in FDI. The (positive) critical benefit level, denoted by B^{FDI}, above which the foreign country is better off under FDI relative to export satisfies

$$W_f^{FDI}\left(e_f^{FDI}\right) - W_f^{ex}\left(e_h^{ex}, e_f^{ex}\right) \geq 0 \quad \text{iff } B \geq B^{FDI}, \tag{48}$$

where

$$B^{FDI} = 8\left(\frac{2\alpha + e_h^{ex} + e_f^{ex}}{20}\right)^2 + \left(\frac{6\alpha + 8e_f^{ex} - 2e_h^{ex}}{15}\right)^2 - e_f^{ex^2} - \frac{2\alpha^2}{7}. \tag{49}$$

Since the foreign country determines its emission standard optimally, the critical benefit level is smaller than the one obtained under no response, that is, $B^{FDI} < B^{nr}$, as we illustrate in Figure 4.

[Insert Figure 4 here]

As the home firm's choice of whether to perform FDI is influenced, to some degree, by the foreign country's emission standard, we next consider the question of whether the foreign country can induce export (FDI) via preventing (attracting) FDI by adjusting its standard and, if so, whether this can lead to higher foreign welfare.[11]

4.3 Adjustment in Emission Standards

If standards can be tightened or relaxed to eliminate or generate incentives for the home firm to engage in FDI, the foreign country can select its emission standard such that the home firm is (at most) indifferent between export and FDI. For a given e_f , the home firm's profit under FDI is

$$\pi_h^{FDI}(e_f) = \frac{8\alpha(\alpha + 2e_f) - 17e_f^2}{50} - F \tag{50}$$

while its profit under export is

$$\pi_h^{ex}(e_f) = \left(\frac{6\alpha + 8e_h(e_f) - 2e_f}{15}\right)^2 - \frac{e_h^2(e_f)}{2}. \tag{51}$$

From (15), the home country's best response to a change in the foreign emission standard under export is

$$e_h(e_f) = \zeta_1 + \zeta_2 e_f, \tag{52}$$

where

$$\zeta_1 = -\frac{\theta}{\frac{\partial^2 W_h}{\partial e_h^2}} = \frac{114\alpha}{313 + 225w} \quad \text{and} \quad \zeta_2 = -\frac{\frac{\partial^2 W_h}{\partial e_h \partial e_f}}{\frac{\partial^2 W_h}{\partial e_h^2}} = -\frac{23}{313 + 225w}. \tag{53}$$

Using the expressions in (53), we obtain the emission standard in the foreign country (denoted by $\widetilde{e}_f$) that makes the home firm indifferent between export and FDI, that is, such that $\pi_h^{FDI}(e_f) = \pi_h^{ex}(e_f)$, as

$$\begin{aligned}\widetilde{e}_f \;=\; & -\frac{3\sqrt{1849\zeta_1^2 + 1024\alpha^2(1-\zeta_2)^2 - (1-\zeta_2)[50F(161 + 97\zeta_2) + 2752\alpha\zeta_1]}}{(1-\zeta_2)(161 + 97\zeta_2)} + \\ & + \frac{32\zeta_1 + 96\alpha(1-\zeta_2) + 97\zeta_1\zeta_2}{(1-\zeta_2)(161 + 97\zeta_2)}. \end{aligned} \tag{54}$$

[11] Industrial policy could be used here rather than environmental policy. Since the externality is environmental, it is not unreasonable to adjust environmental policy to induce or prevent FDI. Further, national treatment rules of the WTO (Article III) may prevent the use of industrial policy against foreign entrants.

Hence, the home firm strictly prefers export to FDI below $\widetilde{e}_f$ while it prefers FDI to export above $\widetilde{e}_f$, that is,

$$\begin{aligned} \pi_h^{FDI}(e_f) &< \pi_h^{ex}(e_f) \quad \text{when } e_f < \widetilde{e}_f \\ \pi_h^{FDI}(e_f) &> \pi_h^{ex}(e_f) \quad \text{when } e_f > \widetilde{e}_f. \end{aligned} \tag{55}$$

Additionally,

$$\frac{\partial \widetilde{e}_f}{\partial F} > 0 > \frac{\partial \widetilde{e}_f}{\partial w}, \tag{56}$$

that is, $\widetilde{e}_f$ rises in F and falls in w. Intuitively, as w increases, that is, the two countries become more asymmetric in their valuation of environmental damages, the home firm's incentive to engage in FDI increases as the gap between the emission standards of the two countries increases, so that the foreign country can induce or prevent FDI with a lower standard. To understand the intuition behind the positive effect of a change in F on the threshold standard $\widetilde{e}_f$, we note that $e_f^{FDI} < \widetilde{e}_f < e_f^{ex}$ for combinations of F and w values at which the foreign country may opt for environmental policy manipulation to induce or prevent FDI.[12] If the home firm has no incentive to engage in FDI under optimum standards ($F > F^{FDI}$) while the foreign country prefers FDI to export ($B > B^{FDI}$), the foreign country must increase its standard above e_f^{FDI} to make FDI attractive (or, equally, to make export unattractive); hence, $\widetilde{e}_f > e_f^{FDI}$. If the home firm has an incentive to engage in FDI under optimum standards ($F < F^{FDI}$) while the foreign country prefers export to FDI ($B < B^{FDI}$), the foreign country must lower its standard below e_f^{ex} to make export attractive or FDI unattractive; hence, $\widetilde{e}_f < e_f^{ex}$. We thus have that, as F increases, the home firm's incentive to perform FDI decreases so that the foreign country has to increase its emission standard above e_f^{FDI} by more to induce FDI in the first instance (that is, when the home firm does not want to engage in FDI but the foreign country prefers FDI to export) while it has to decrease it below e_f^{ex} by less to induce export in the second instance (that is, when the home firm wants to engage in FDI but the foreign country prefers export to FDI); in both cases, the threshold standard $\widetilde{e}_f$ increases as F increases.

When the foreign country prevents FDI by lowering its standard below e_f^{ex} and the home firm decides to export, the home country adjusts its emission standard as well. Given that the emission standards of the two countries are strategic substitutes, a lower emission standard in the foreign country implies a higher emission standard in the home country, that is,

$$\widetilde{e}_f < e_f^{ex} \Longrightarrow \widetilde{e}_h = \zeta_1 + \zeta_2 \widetilde{e}_f > e_h^{ex}; \tag{57}$$

[12] See appendix for more details on the relationships between e_f^{FDI} and $\widetilde{e}_f$ and between e_f^{ex} and $\widetilde{e}_f$.

we thus have that

$$e_h^{ex} < \widetilde{e}_h < \widetilde{e}_f < e_f^{ex} \Longrightarrow (\widetilde{e}_f - \widetilde{e}_h) < \left(e_f^{ex} - e_h^{ex}\right), \tag{58}$$

so that the gap in environmental policy between the two countries narrows, through a tightening of the foreign standard and a weakening of the home standard, when export is induced as opposed to being optimally chosen by the home firm.[13]

In the following subsection, we derive the conditions under which adjusting the emission standard to induce export or FDI is in the interest of the foreign country. To this end, we compare the foreign country's welfare levels in the FDI and export scenarios using the adjusted emission standard above given. We finally examine the environmental implications of adjusting emission standards to induce or prevent FDI from a global perspective as well as from the foreign country's perspective.

4.3.1 Attracting FDI

We first consider the case in which the home firm has no incentive to engage in FDI under optimum standards ($F > F^{FDI}$). In such a case, the foreign country can be better off by inducing FDI with $\widetilde{e}_f$ if the benefit from FDI is sufficiently large, that is, $W_f^{FDI}(\widetilde{e}_f) > W_f^{ex}\left(e_h^{ex}, e_f^{ex}\right)$ if

$$B > \overline{B} = \left(\frac{2\alpha + e_h^{ex} + e_f^{ex}}{20}\right)^2 + \left(\frac{6\alpha + 8e_f^{ex} - 2e_h^{ex}}{15}\right)^2 - e_f^{ex2} - \frac{3\,(2\alpha + 7\widetilde{e}_f)\,(2\alpha - 3\widetilde{e}_f)}{50}. \tag{59}$$

It follows immediately that the above critical benefit level ($\overline{B}$) rises in F and falls in w since the foreign country has to make larger adjustments in its emission standard (this is more costly from a welfare perspective) to induce FDI when F gets larger or w gets smaller. Also, as $W_f^{FDI}(\widetilde{e}_f) \leq W_f^{FDI}\left(e_f^{FDI}\right)$, we always obtain that $\overline{B} \geq B^{FDI}$.

In light of the above, we have

Proposition 4: *Suppose that $F > F^{FDI}$ holds. Then, the following equilibria result:*

(i) *when $B < \overline{B}$, the home firm exports and the home and foreign countries choose their optimum emission standards e_h^{ex} and e_f^{ex};*

(ii) *when $B > \overline{B}$, the foreign country induces the home firm to engage in FDI by adjusting its emission standard to $\widetilde{e}_f$ where $e_f^{FDI} < \widetilde{e}_f < e_f^{ex}$.*

We illustrate the equilibria for $F = 0.01$ and $\alpha = 1$ in Figure 5. For a given F, we use (47) to obtain the value of w ($\widehat{w}$) such that the home firm prefers export for $w < \widehat{w}$ and FDI for $w > \widehat{w}$. As F increases, $\widehat{w}$

[13] See section on emission standards in the appendix.

increases so that the home firm prefers export for a wider range of w values. Hence, in terms of Figure 5, the home firm prefers export for $w < 0.7159$. However, for $B > \overline{B}$, the foreign country prefers FDI and thus induces the home firm to engage in FDI by increasing its standard above e_f^{FDI}; for $B < \overline{B}$, the foreign country prefers export and the optimum export emission standards (e_f^{ex} and e_h^{ex}) prevail. Induced FDI results in a Pareto improvement over export: the home country is better off from higher producer surplus and consumer surplus and lower environmental damages; the foreign country is better off from the external benefits of FDI and higher consumer surplus that offset the additional environmental damages and reduced producer surplus.

[Insert Figure 5]

From an environmental perspective, when we compare worldwide environmental damages under export and under induced FDI, we obtain

Proposition 5: *For a given F, there exists a w_l such that $\Psi_f^{FDI}(\widetilde{e}_f) > \sum_{i=h,f} \Psi_i^{ex}\left(e_h^{ex}, e_f^{ex}\right)$ for $w < w_l$ and $\Psi_f^{FDI}(\widetilde{e}_f) < \sum_{i=h,f} \Psi_i^{ex}\left(e_h^{ex}, e_f^{ex}\right)$ for $w > w_l$, where $w_l = 0$ if $F = 0$ and $w_l > 0$ if $F > 0$; furthermore, w_l is increasing in F.*

When the home firm does not have any incentive to engage in FDI but the foreign country adjusts its standard to induce FDI, the environment is dirtier under FDI relative to export when the two countries are not substantially different in their valuation of environmental damages unless the fixed cost is zero. As the two countries become more asymmetric (w increases), the foreign country can induce FDI with a smaller upward adjustment in its standard (from e_f^{ex}) so that it becomes less likely for the environment to be dirtier under FDI. Conversely, as the cost of FDI the home firm faces increases, the foreign country has to adjust its standard upward by a larger amount in order to induce the home firm to engage in FDI; hence, the range of w values for which the environment is dirtier under FDI widens.

In Figure 6, we plot the critical F (F^{FDI}), as a function of w, below which the home firm prefers FDI over export and two isovalues curves. The isovalue curve labelled D^{FDI} shows the combinations of w and F such that the world's environmental damage under induced FDI is exactly the same as that under export. Above the D^{FDI} curve, damages are higher under induced FDI; below the curve, they are higher under export. For a given F, the F^{FDI} curve gives the critical w ($\widehat{w}$) such that the home country prefers export over FDI for $w < \widehat{w}$. If $B > \overline{B}$, the foreign country induces FDI by raising its standard above e_f^{FDI} to $\widetilde{e}_f$; the resulting worldwide environmental quality is worse for $w < w_l$ and better for $w_l < w < \widehat{w}$.

[Insert Figure 6]

The positive environmental implications of inducing FDI hold true, although for a smaller range of w values, when we only consider the foreign country's pollution level. In Figure 7, we have isovalue curves for foreign pollution level differences between induced FDI and export (D_f^{FDI}) and between FDI and induced export (D_f^{ex}), in addition to the isovalue curves given in Figure 6 (D^{FDI} and D^{ex}) and the threshold level of F above which the home firm prefers export (F^{FDI}). In Figure 7, we also show the contour of the set of feasible F values for given w values ($F \leq \overline{F}$) as derived in the Appendix. Hence, the pollution level in the foreign country is lower under induced FDI than under export for $w_{fl} < w < \widehat{w}$, with $w_l < w_{fl}$ implying that, for $w_l < w < w_{fl}$, environmental quality worsens in the foreign country but improves worldwide.[14]

[Insert Figure 7 here]

4.3.2 Preventing FDI

We next consider the case in which the home firm has an incentive to engage in FDI under optimum standards ($F < F^{FDI}$). The foreign country can then be better off by inducing export with $\widetilde{e}$ if the benefit from FDI is sufficiently small or negative, that is, $W_f^{ex}(\widetilde{e}_h, \widetilde{e}_f) > W_f^{FDI}\left(e_f^{FDI}\right)$ if

$$B < \underline{B} = 8\left(\frac{2\alpha + \widetilde{e}_h + \widetilde{e}_f}{20}\right)^2 + \left(\frac{6\alpha + 8\widetilde{e}_f - 2\widetilde{e}_h}{15}\right)^2 - \widetilde{e}_f^2 - \frac{2\alpha^2}{7}. \tag{60}$$

Since the foreign country is able to induce export with a smaller adjustment in its emission standard (this is less costly from a welfare perspective) as F goes up or w falls down, $\underline{B}$ rises in F and falls in w. Also, as $W_f^{ex}(\widetilde{e}_h, \widetilde{e}_f) \leq W_f^{ex}\left(e_h^{ex}, e_f^{ex}\right)$, we always obtain that $\underline{B} \leq B^{FDI}$. We thus have

Proposition 6: *Suppose that $F < F^{FDI}$ holds. Then, the following equilibria obtain:*

(i) *when $B > \underline{B}$, the home firm engages in FDI and the foreign country chooses its optimum emission standard e_f^{FDI};*

(ii) *when $B < \underline{B}$, the foreign country induces the home firm to export by adjusting its emission standard to $\widetilde{e}_f$ while the home country uses $\widetilde{e}_h$ where $e_h^{ex} < \widetilde{e}_h < \widetilde{e}_f < e_f^{FDI} < e_f^{ex}$.*

We illustrate the above equilibria in Figure 5 as well for a given positive F and α. The home country prefers FDI for $w > 0.7159$. However, for $B < \underline{B}$, the foreign country prefers export and thus induces the home firm to export by decreasing its standard below e_f^{FDI}; for $B > \underline{B}$, the foreign country prefers FDI and thus the optimum emission standard under FDI (e_f^{FDI}) prevails.

[14] For $F = 0.02$, the home firm may be induced to engage in FDI for $w < \widehat{w} \approx 1.09$. If FDI is induced, the pollution level increases in the foreign country for $w < w_{fl} \approx 1.01$ and worldwide for $w < w_l \approx 0.81$. Hence, environmental quality improves in the foreign country for $1.01 < w < 1.09$ and worldwide for $0.81 < w < 1.09$.

From an environmental perspective, when we compare worldwide environmental damages under FDI and induced export, we have

Proposition 7: *For a given F, there exists a w_u such that* $\Psi_f^{FDI}\left(e_f^{FDI}\right) < \sum_{i=h,f} \Psi_i^{ex}\left(\widetilde{e}_h, \widetilde{e}_f\right)$ *for* $w < w_u$ *and* $\Psi_f^{FDI}\left(e_f^{FDI}\right) > \sum_{i=h,f} \Psi_i^{ex}\left(\widetilde{e}_h, \widetilde{e}_f\right)$ *for* $w > w_u$; further, w_u *is increasing in* F.

When the home firm does have an incentive to engage in FDI but the foreign country adjusts its standard to induce export, the environment is dirtier under FDI relative to export when the two countries are substantially different in their valuation of environmental damages. As the two countries become more symmetric (w decreases), the foreign country can induce export with a smaller downward adjustment in its standard (from e_f^{ex}) so that it becomes less likely for the environment to be dirtier under FDI. As the cost of FDI the home firm faces increases, the foreign country has to adjust its standard downward by a smaller amount in order to induce the home firm to export; hence, the range of w values for which the environment is dirtier under FDI narrows.

In Figure 6, the isovalue curve labelled D^{ex} gives the combinations of w and F such that the world's environmental damage under FDI is exactly the same as that under induced export. Above the D^{ex} curve, damages are lower under FDI; below the curve, they are higher under induced export. For a given F (e.g., $F = 0.01$), the F^{FDI} curve gives the critical w ($\widehat{w}$) such that the home country prefers FDI over export FDI for $w > \widehat{w}$. If $B < \overline{B}$, the foreign country induces export by lowering its standard below e_f^{ex} to $\widetilde{e}_f$; the resulting worldwide environmental quality is worse for $\widehat{w} < w < w_u$ and better for $w > w_u$.

As in the induced FDI case, we find that it is possible for the foreign pollution level under FDI to be lower than the pollution level under induced export. In terms of Figure 7, we have that environmental quality improves both in the foreign country and worldwide for $\widehat{w} < w < w_{fu}$ but improves only worldwide for $w_{fu} < w < w_u$.[15]

5 Conclusion

An important question that has largely been ignored in the literature on the relationship between FDI and environmental policy is about strategic considerations countries entertain in setting their environmental standards under the threat of increased production from FDI, particularly when pollution is local. According to the standard PHH argument, as it relates to FDI, production shifts from countries with stringent standards to countries with weaker standards, presumably to benefit from lower production or

[15] For $F = 0.02$, the home firm may be induced to engage in export for $w > \widehat{w} \approx 1.09$. If export is induced, the pollution level increases in the foreign country for $w > w_{fu} \approx 1.26$ and worldwide for $w > w_u \approx 1.71$. Hence, environmental quality improves in the foreign country for $1.09 < w < 1.26$ and worldwide for $1.09 < w < 1.71$.

abatement costs. Although there are many other factors determining plant location, the idea that firms would chase lower standards is not unreasonable and could lead to a "race to the bottom" in environmental policy. Surprisingly, the empirical evidence on the PHH is limited and, while empirical reasons have been suggested why the PHH may not hold (e.g., data, measurement of environmental stringency), theoretical explanations for the possible failure of the PHH have not been thoroughly explored. In this paper, we attempt to provide one of such theoretical explanations by examining the relationship between FDI and endogenous standards, leaving the empirical investigation of the implications of FDI for environmental policy to future work. Aside from considering the question of whether and when differences in environmental policies trigger firms in countries with stringent standards to move production to countries with less stringent standards, we also examine the impact that FDI has on the global pollution level as well as on the state of the environment in FDI-recipient countries.

In an oligopoly model of trade which involves two countries differing in their environmental friendliness, with the home country exhibiting greater concern for the environment (and thus labelled "green"), and local pollution, we show that standards can become tighter in the face of FDI and, although unlikely, may even become stricter in the originally *grey* country than in the originally *green* country (this would happen in instances in which the two countries are not very different in how they value environmental damages). Thus, when environmental policy is endogenous, the PHH is weakened by the fact that the tightening of standards in FDI-recipient countries creates weaker incentives for FDI. The standard in the *grey* (FDI-recipient) country is in fact always stricter under FDI, when the country responds optimally to FDI, than under export. As the incentive for the *green* (FDI-source) country to engage in FDI increases with its incremental environmental consciousness, the greater the extent to which the two countries differ in their valuation of the environment is, the more stringent the foreign standard is under FDI than under export.

Hence, when the *grey* country adjusts its environmental policy in response to FDI, the differential in environmental standards between the two countries is smaller, for a given divergence in environmental friendliness between the two countries, than it would be without a reaction to increased domestic production and pollution and decreases as the two countries become more divergent. The adjustment amounts to a reduction in the likelihood that firms in the *green* (home) country engage in FDI in the *grey* (foreign) country; the greater the environmental concern gap between the two countries is (or the smaller the environmental policy gap between the two countries under FDI with optimal response), the less likely the firm in the *green* country is to prefer FDI over export. In this way, FDI acts as a disciplining device for countries considering weakening their environmental standards for competitive gain. At the same time, the strenghtening of standards under FDI serves to reduce incentives for relocation of production, so that less relocation occurs due to differences in environmental standards. This amounts to a weakening of the traditional pollution haven hypothesis: firms may not choose to relocate in response to differences in environmental policy as, by so doing, they would face stricter standards in the new location.

We then derive conditions under which the foreign country has incentives to manipulate its standard to induce FDI when the home country prefers export (that is, when the fixed cost of FDI is above its threshold level) or to induce export when the home country prefers FDI (that is, when the fixed cost of FDI is below its threshold level). Whenever manipulation is optimal, the foreign standard is weaker in the first instance (that is, when FDI is induced) than under FDI when it is not induced and stricter in the second instance (that is, when export is induced) than under export when it is not induced. The possible manipulation of environmental policy by the foreign country to induce or prevent FDI, depending on whether the benefit from FDI exceeds or falls short of its threshold level, has important implications for the overall effect of FDI on the state of the environment. In fact, while FDI always results in a cleaner environment in the foreign country (and thus worldwide) in the absence of manipulation as the *emission standard effect* (tightening of foreign standard) always dominates the *scale effect* (increase in production in the foreign country) due to the convexity of the damage function, whether FDI yields a cleaner or dirtier environment in the presence of manipulation depends on how different the two countries are in their valuation of the environment. Specifically, FDI worsens (improves) the environment when the two countries are quite similar (different) and FDI is induced or when the two countries are quite different (similar) and FDI is not induced.

That differences in environmental awareness play an important role in how FDI affects the environment stems from the fact that incentives to engage in FDI increase with the home country's environmental awareness over and above that of the foreign country; the more different the two countries are, the larger the gap in their environmental standards and the greater the benefits the home country can derive from FDI. When FDI is induced, the foreign standard is less stringent than in the absence of manipulation but the gap between the two standards decreases as the home country's incentives for FDI increase (that is, as the home country becomes more environmentally conscious); hence, the more similar the two countries are, the larger the gap and the dirtier the environment. On the other hand, when FDI is not induced, the foreign standard is more stringent than under export but the gap between the foreign standard under FDI and the foreign standard under induced export decreases as the home country becomes more environmentally conscious (or the incentives for FDI increase); hence, the more different the two countries are, the smaller the gap and the dirtier the environment. Overall, whenever FDI occurs with or without inducement, pollution is likely to decrease in FDI-recipient countries and worldwide whenever there exist neither trivial nor substantial differences in environmental attitude between the FDI-recipient and the FDI-source countries. As the cost of engaging in FDI increases, pollution is less likely to decrease under FDI, particularly in less divergent countries; in other words, the more costly FDI is, the less similar the two countries have to be in their environmental awareness for pollution to decrease under FDI.

The presence of external benefits of FDI has thus additional implications for the pollution haven hypothesis: if FDI provides significant external benefits to the recipient nation, we would expect to see more PHH-induced relocation of production as countries weaken standards to attract investment (light grey area in Figure 5); if the spillover effects of FDI are small or negative, countries may tighten standards to prevent PHH-driven relocation of production (dark grey area in Figure 5). Equilibrium outcomes ultimately depend on the fixed costs of relocation and how differently countries weigh environmental damages. Nonetheless, we show that, in most cases, FDI results in a tightening of environmental policy and is likely to improve the quality of the world environment (at least among countries similar in production and abatement technology that account for environmental damages when setting policy).

6 Appendix

6.1 Emission standards

Using the first-order conditions for welfare maximization with respect to the standards, we can write the two countries' reaction functions as

$$e_h = \frac{114\alpha - 23e_f}{313 + 225w}$$

and

$$e_f = \frac{114\alpha - 23e_h}{313};$$

we thus have that the absolute value of the slope of the home country's reaction function is decreasing in w, that is,

$$\frac{\partial \left| \frac{\partial e_h}{\partial e_f} \right|}{\partial w} = -\frac{23\,(225)}{(313 + 225w)^2} < 0,$$

while the slope of the foreign country's reaction function is independent of w.

Letting $\beta = \frac{1}{112+75w}$, $\gamma = \frac{1}{698+525w}$, and $\delta = \frac{1}{6496+4695w}$, we can express the export standards as

$$e_h^{ex} = 2204\alpha\delta \qquad \text{and} \qquad e_f^{ex} = 38(58 + 45w)\alpha\delta,$$

so that

$$e_f^{ex} - e_h^{ex} = 1710\alpha\delta w > 0,$$

and the marginal effects of w on the standards as

$$\frac{\partial e_h^{ex}}{\partial w} = -4695\delta e_h^{ex} < 0 \qquad \text{and} \qquad \frac{\partial e_f^{ex}}{\partial w} = 345\delta e_h^{ex} > 0.$$

The foreign standard prevailing under FDI in the absence of any response by the foreign country is the same as that under export, that is, e_f^{ex}.

With accommodation, that is, when the foreign country adjusts its standard in response to FDI, $e_f^{FDI} = \frac{4\alpha}{21} < e_f^{ex}$, with the difference in standards increasing in w. We in fact have that

$$e_f^{FDI} - e_f^{ex} = -10\left(\frac{290}{3} + \frac{571}{7}w\right)\alpha\delta < 0$$

and

$$\frac{\partial\left(e_f^{ex} - e_f^{FDI}\right)}{\partial w} = 760380\alpha\delta^2 > 0.$$

Furthermore,

$$e_f^{FDI} - e_h^{ex} = 20\left(-\frac{145}{3} + \frac{313}{7}w\right)\alpha\delta$$

which is positive for $w > \overline{w} = \frac{1015}{939}$.

Under environmental policy adjustment by the foreign country to induce or prevent FDI, we have that

$$\widetilde{e}_f = \frac{1}{23}\left[2\left(610201 + 824400w + 270000w^2\right)\alpha - 5(313 + 225w)M\right]\beta\gamma$$

and

$$\widetilde{e}_h = \left[2\left(12287 + 8775w\right)\alpha + 5M\right]\beta\gamma,$$

where

$$M = \sqrt{2}\sqrt{450\left(13 + 16w\right)^2\alpha^2 - \frac{23}{\beta\gamma}F} > 0,$$

which gives the range of feasible F values for the system to yield a real solution as

$$F < \overline{F} = \frac{450}{23}\alpha^2\left(13 + 16w\right)^2\beta\gamma;$$

hence, we have that

$$\widetilde{e}_f - \widetilde{e}_h = \frac{15}{23}\left[\left(390 + 480w\right)\alpha - M\right]\gamma > 0.$$

We can then readily see that

$$\frac{\partial\widetilde{e}_f}{\partial F} = \frac{5}{23}(313 + 225w)\beta\gamma\frac{\partial\widetilde{e}_f}{\partial M}\frac{\partial M}{\partial F} > 0 < \frac{\partial\widetilde{e}_h}{\partial F} = 5\beta\gamma\frac{\partial\widetilde{e}_h}{\partial M}\frac{\partial M}{\partial F}$$

as $\frac{\partial \widetilde{e}_f}{\partial M} < 0 < \frac{\partial \widetilde{e}_h}{\partial M}$ and $\frac{\partial M}{\partial F} < 0$. The effect of w on $\widetilde{e}_f$ is not as straightforward; however, noting that

$$\frac{\partial^2 \widetilde{e}_f}{\partial w \partial F} = -2250\left[4166\alpha^2(13+16w)+115(173+160w)F\right]\frac{1}{M^3} < 0$$

and

$$\left.\frac{\partial \widetilde{e}_f}{\partial w}\right|_{F=0} = -2850\alpha\beta^2 < 0,$$

we can conclude that $\frac{\partial \widetilde{e}_f}{\partial w} < 0$ for $F > 0$.

When comparing $\widetilde{e}_f$ with e_f^{ex} and $\widetilde{e}_h$ with e_h^{ex}, we have that $\widetilde{e}_f - e_f^{ex} = \widetilde{e}_h - e_h^{ex} = 0$ for $F = F_{ind}^{ex}$, where

$$F_{ind}^{ex} = 342\,(7540+6957w)\,\alpha^2\delta^2 w = F^{nr},$$

$\widetilde{e}_f - e_f^{ex} < 0$ for $F < F_{ind}^{ex}$ as $\frac{\partial\left(\widetilde{e}_f - e_f^{ex}\right)}{\partial F} > 0$, and $\widetilde{e}_h - e_h^{ex} > 0$ for $F < F_{ind}^{ex}$ as $\frac{\partial\left(\widetilde{e}_h - e_h^{ex}\right)}{\partial F} < 0$ We then obtain that, for $F < F^{FDI} < F_{ind}^{ex}$, that is, whenever export may have to be induced as the home firm would engage in FDI, $\widetilde{e}_f - e_f^{ex} < 0$ and $\widetilde{e}_h - e_h^{ex} > 0$. As $e_h^{ex} < \widetilde{e}_h < \widetilde{e}_f < e_f^{ex}$, the gap in standards under export is narrower when export is induced than when it is optimally chosen by the home firm, that is, $\widetilde{e}_f - \widetilde{e}_h < e_f^{ex} - e_h^{ex}$ for $F < F^{FDI}$.

When we compare $\widetilde{e}_f$ with e_f^{FDI}, we have that $\widetilde{e}_f - e_f^{FDI} = 0$ for $F = F_{ind}^{FDI}$ where

$$F_{ind}^{FDI} = \frac{50}{441}\frac{(5581+5082w)\,(-7+6w)\,\alpha^2}{(313+225w)^2}$$

and $\widetilde{e}_f - e_f^{FDI} > 0$ for $F > F_{ind}^{FDI}$ given that $\frac{\partial\left(\widetilde{e}_f - e_f^{FDI}\right)}{\partial F} > 0$. Upon comparison of F_{ind}^{FDI} with F^{FDI}, we obtain that

$$F^{FDI} - F_{ind}^{FDI} = \left(\frac{313003322}{3} + \frac{1397089165}{7}w + \frac{851024400}{7}w^2 + \frac{161064000}{7}w^3\right)\left[\frac{e_f^{ex} - e_f^{FDI}}{(313+225w)^2}\right]\alpha\delta > 0;$$

hence, for any $F > F^{FDI} > F_{ind}^{FDI}$, that is, whenever FDI may have to be induced as the home firm would not engage in FDI, $\widetilde{e}_f - e_f^{FDI} > 0$.

6.2 Critical F and B values

Upon comparison of F^{FDI} with F^{nr}, that is, the threshold levels of F below which the home firm engages in FDI when the foreign country adjusts its standard in response to FDI and when it does not, we obtain that

$$F^{nr} - F^{FDI} = 42\left(\frac{290}{3} + \frac{571}{7}w\right)\left(\frac{13630}{3} + \frac{21593}{7}w\right)\alpha^2\delta^2 > 0,$$

where

$$F^{nr} = 342\,(7540+6957w)\,\alpha^2\delta^2 w > 0 \quad \text{iff } w \geq 0$$

and

$$F^{FDI} = 40\left(-\frac{197635}{9} + \frac{651572}{21}w + \frac{2298155}{49}w^2\right)\alpha^2\delta^2 > 0 \quad \text{iff } w > 0.43;$$

furthermore, we know that

$$\overline{F} - F^{nr} = \frac{18}{23}\left(422240 + 519829w + 146175w^2\right)^2 \alpha^2\beta\gamma\delta^2 > 0,$$

where $\overline{F}$ is the largest feasible value of F, as above defined, when we consider the possibility of policy manipulation to induce or prevent FDI. We thus derive the marginal effects of w on the two critical F values as well as their difference as

$$\frac{\partial F^{nr}}{\partial w} = 18\left(422240 + 474009w\right)\alpha\delta^2 e_h^{ex} > 0,$$

$$\frac{\partial F^{FDI}}{\partial w} = 60\left(123337 + 140250w\right)\alpha\delta^2 e_h^{ex} > 0,$$

and

$$\frac{\partial\left(F^{nr} - F^{FDI}\right)}{\partial w} = 138\left(1450 + 849w\right)\alpha\delta^2 e_h^{ex} > 0,$$

respectively.

Similarly, upon comparison of B^{FDI} with B^{nr}, that is, the threshold levels of B above which the foreign country is better off when FDI occurs when it adjusts its standard in response to FDI and when it does not, we have that

$$B^{nr} - B^{FDI} = \frac{2}{7}\left(2030 + 1713w\right)^2 \alpha^2\delta^2 > 0,$$

where

$$B^{nr} = 4408\left(551 + 945w + 423w^2\right)\alpha^2\delta^2 > 0$$

and

$$B^{FDI} = \frac{6}{7}\left(1459976 + 2541560w + 1197225w^2\right)\alpha^2\delta^2 > 0.$$

Hence, we can express the marginal effects of w on the two critical B values and their difference as

$$\frac{\partial B^{nr}}{\partial w} = 6\left(321610 + 352947w\right)\alpha\delta^2 e_h^{ex} > 0,$$

$$\frac{\partial B^{FDI}}{\partial w} = 18780\left(58 + 75w\right)\alpha\delta^2 e_h^{ex} > 0,$$

and

$$\frac{\partial\left(B^{nr} - B^{FDI}\right)}{\partial w} = 414\left(2030 + 1713w\right)\alpha\delta^2 e_h^{ex} > 0,$$

respectively.

References

[1] Aitken, B. and A. Harrison (1999), "Do Domestic Firms Benefit from Foreign Investment? Evidence from Venezuela,"*American Economic Review*, 89(3), 605-618.

[2] Antweiler, W., B. R. Copeland, and M. S. Taylor (2001), "Is Free Trade Good for the Environment?," *American Economic Review* 91(4), 877-908.

[3] Blomström, M. (1986), "Foreign Investment and Productive Efficiency: The Case of Mexico," *Journal of Industrial Economics*, 35(1), 97-110.

[4] Bommer, R. (1999), "Environmental Policy and Industrial Competitiveness: The Pollution Haven Hypothesis Reconsidered," *Review of International Economics*, 7(2), 342-355.

[5] Caves, R.E. (1974), "Multinational Firms, Competition and Productivity in Host-Country Markets," *Economica*, 41(162), 176-193.

[6] Cole, Matthew A., Robert J. R. Elliott, Per G. Fredriksson (2006), "Endogenous Pollution Havens: Does FDI Influence Environmental Regulations?," *Scandinavian Journal of Economics*, 108(1), 157–178.

[7] Copeland, B. R., and M. S. Taylor (1994), "North-South Trade and the Environment," *Quarterly Journal of Economics*, 109(3), 755-787.

[8] Donnenfeld, S. (2003), "Regional Blocs and Foreign Direct Investment," *Review of International Economics*, 11(5), 770–788.

[9] Driffield, Nigel (2001), "The Impact of Domestic Productivity of Inward Investment in the UK," *Manchester School*, University of Manchester, 69(1), 103-119.

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

[11] Ederington, J., A. Levinson, and J. Minier (2004), "Trade Liberalization and Pollution Havens," *Advances in Economic Analysis and Policy*, 4(2), Article 6.

[12] Eskeland, G., and A. Harrison (2003), "Moving to Greener Pastures? Multinationals and the Pollution Haven Hypothesis," *Journal of Development Economics*, 70(1), 1-23.

[13] Glass, A., and K. Saggi (1999), "FDI Policies under Shared Factor Markets," *Journal of International Economics*, 49(2), 309-332.

[14] Glass, A., and K. Saggi (2002), "Multinational Firms and Technology Transfer," *Scandinavian Journal of Economics*, 104(4), 495-513.

[15] Gulati, S. and D. Roy (2008) "National Treatment and the Optimal Regulation of Environmental Externalities," *Canadian Journal of Economics*, 41(4), 1445-1471.

[16] Greaker, M. (2003), "Strategic environmental policy when the governments are threatened by relocation," *Resource and Energy Economics* 25, 141-154.

[17] Haddad, M., and A. Harrison (1993), "Are there Positive Spillovers from Direct Foreign Investment? Evidence from Panel Data for Morocco," *Journal of Development Economics*, 42(1), 51-74.

[18] Henderson, D. J., and D. L. Millimet (2007), "Pollution Abatement Costs and Foreign Direct Investment Inflows to U.S. States: A Nonparametric Reassessment," *Review of Economics and Statistics*, 89(1), 178-183.

[19] Hoel, M. (1997), "Environmental policy with endogenous plant locations," *Scandinavian Journal of Economics* 99, 241-259.

[20] Horn, H. (2011), "The burden of proof in trade disputes and the environment," *Journal of Environmental Economics and Management*, 62(1), 15-29.

[21] Jaffe, A. B., S. R. Peterson, P. R. Portney, and R. N. Stavins (1995), "Environmental Regulations and the Competitiveness of U.S. Manufacturing: What does the Evidence Tell Us?," *Journal of Economic Literature*, XXXIII, 132-163.

[22] Jaumotte, F. (2004), "Foreign direct investment and regional trade agreements: The market size effect revisited," *International Monetary Fund Working Paper* 04/206.

[23] Javorcik, B. S., and S-J. Wei (2005), "Pollution Havens and Foreign Direct Investment: Dirty Secret or Popular Myth?," *Contributions in Economic Analysis and Policy*, 3(2), Article 8.

[24] Kahn, M. E., and Y. Yoshino (2004), "Testing for Pollution Havens Inside and Outside of Regional Trading Blocs," *Advances in Economic Analysis and Policy*, 4(2), Article 4.

[25] Kayalica, M. O., and S. Lahiri (2005), "Strategic Environmental Policies in the Presence of Foreign Direct Investment," *Environmental and Resource Economics*, 30, 1-21.

[26] Kathuria, V. (1998), "Foreign Firms and Technology Transfer Knowledge Spillovers to Indian Manufacturing Firm," *INTECH Discussion Paper Series* No. 9804, United Nations University, January.

[27] Kathuria, V. (2000), "Productivity Spillovers from Technology Transfer to Indian Manufacturing Firms," *Journal of International Development*, 12(3), 343-369.

[28] Keller, W., and A. Levinson (2002), "Pollution Abatement Costs and Foreign Direct Investment Inflows to U.S. States," *Review of Economics and Statistics*, 84(4), 691-703.

[29] Levinson, A. (2000), "The missing pollution haven effect: exaiming some common explanations," *Environmental and Resource Economics*, 15, 343-364.

[30] List, J. A., and C. Co (2000), "The Effects of Environmental Regulations on Foreign Direct Investment," *Journal of Environmental Economics and Management*, 40(1), 1-20.

[31] Markusen, J. R., E. R. Morey, and N. D. Olewiler (1993), "Environmental Policy when Market Structure and Plant Locations are Endogenous," *Journal of Environmental Economics and Management,* 24(1), 69-86.

[32] Markusen, J. R., E. R. Morey, and N. D. Olewiler (1995), "Competition in regional environmental policies when plant locations are endogenous," *Journal of Public Economics*, 56(1), 55-77.

[33] Newell, P. (2001), Managing Multinationals: The Governance of Investment for the Environment, *Journal of International Development*, 13, 907-919.

[34] Ornelas, E. (2005), "Rent Destruction and the Political Viability of Free Trade Agreements," *Quarterly Journal of Economics*, 120(4), 1475-1506.

[35] Petrakis, E. and A. Xepapadeas (2003), "Location decisions of a polluting firm and the time consistency of environmental policy," *Resource and Energy Economics* 25, 197-214.

[36] Taylor, M. S. (2004), "Unbundling the Pollution Haven Hypothesis," *Advances in Economic Analysis and Policy*, 4(2), Article 8.

[37] Ulph, A., and L. Valentini (1997), "Plant location and strategic environmental policy with intersectoral linkages," *Resources and Energy Economics*, 19, 363-383.

[38] UNCTAD (2008), *World Investment Report 2008: Transnational Corporations and the Infrastructure Challenge*, New York and Geneva, United Nations.

[39] Wu, X. (2004), "Pollution Havens and the Regulation of Multinationals with Asymmetric Information," *Contributions in Economic Analysis and Policy*, 3(2), Article 1.

[40] Xing, Y., and C. Kolstad (2002), "Do Lax Environmental Regulations Attract Foreign Investment?," *Environmental and Resource Economics*, 21(1), 1-22.

[41] Yu, Z. (2002), "A Theory of Strategic Vertical DFI and the Missing Pollution-Haven Effect," *FEEM Working Paper* 46.2002.

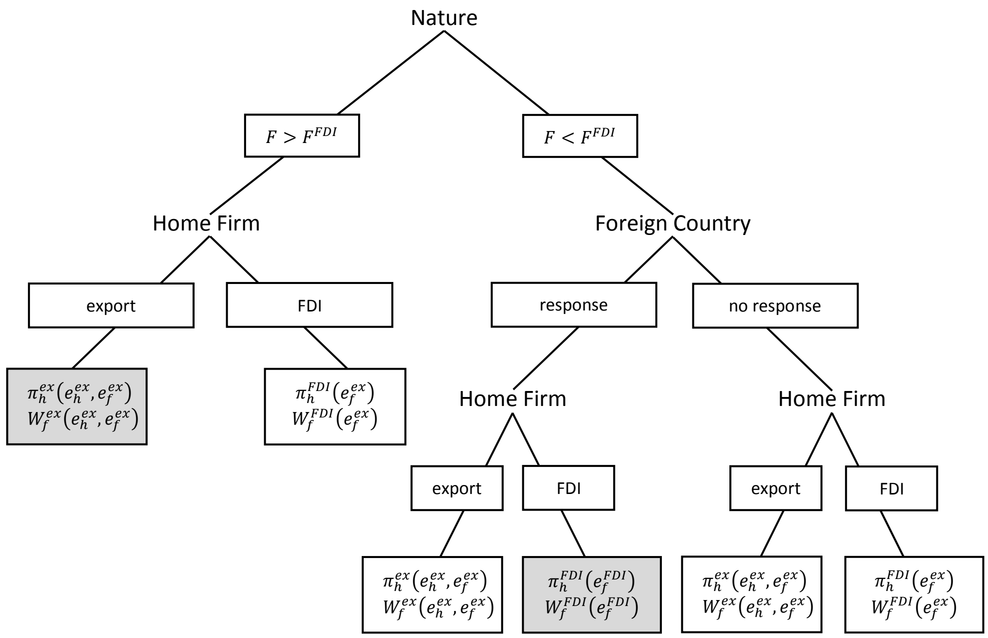

Figure 1a: Tree diagram of the game between the foreign country and the home firm under the assumption that the foreign country does not manipulate its standard to induce firms to perform FDI when the cost of relocation is high or induce firms to export when the cost of relocation is low. Shaded boxes represent SPNE depending on *F*.

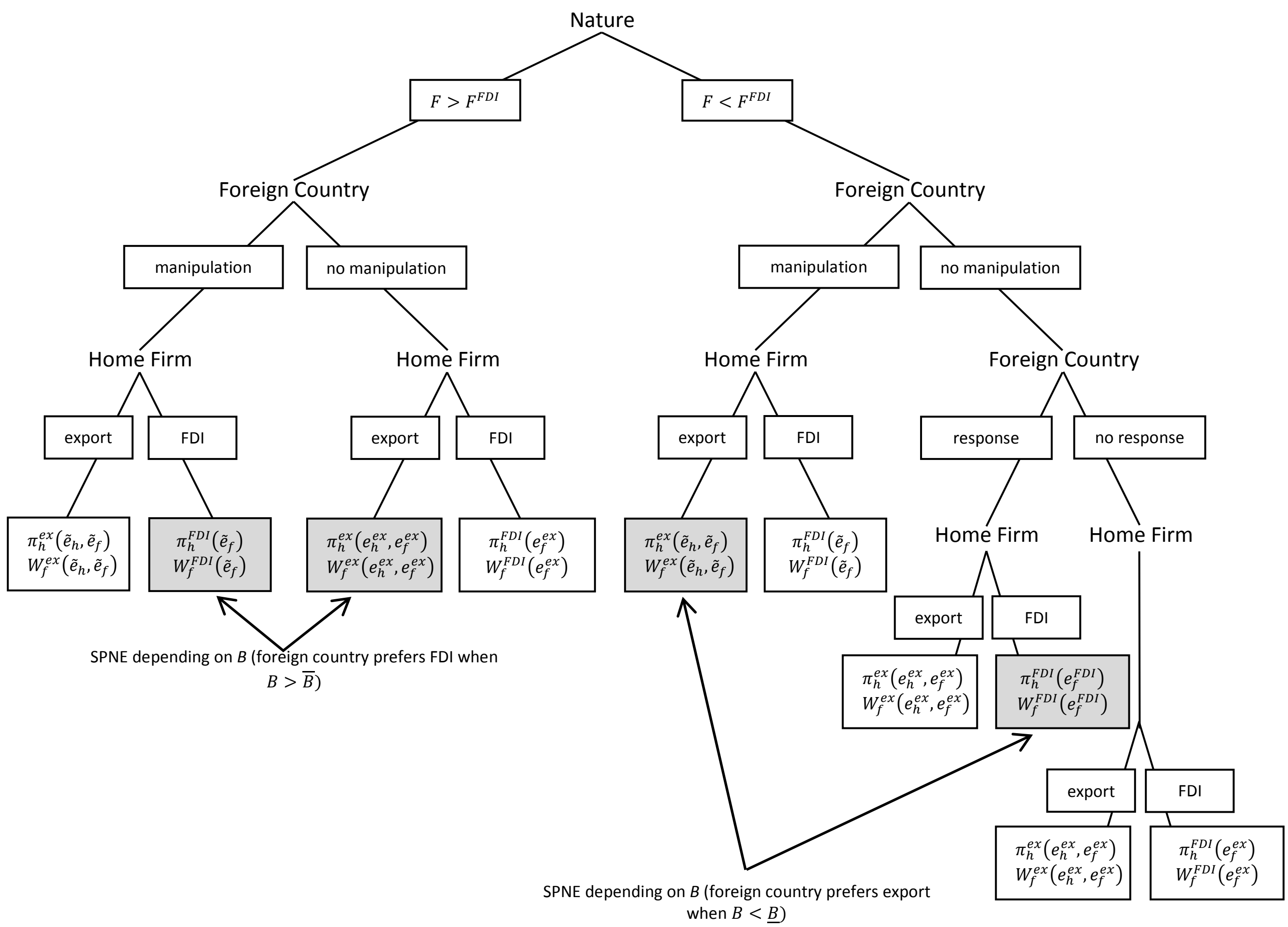

Figure 1b: Tree diagram of the game between the foreign country and the home firm when foreign country has the option to manipulate standards to induce or deter FDI. The foreign country manipulates its standard to induce FDI when $F > F^{FDI}$ and $B > \overline{B}$ and to induce export when $F < F^{FDI}$ and $B < \underline{B}$, but does not manipulate standards when $F > F^{FDI}$ and $B < \overline{B}$, or when $F < F^{FDI}$ and $B > \underline{B}$.

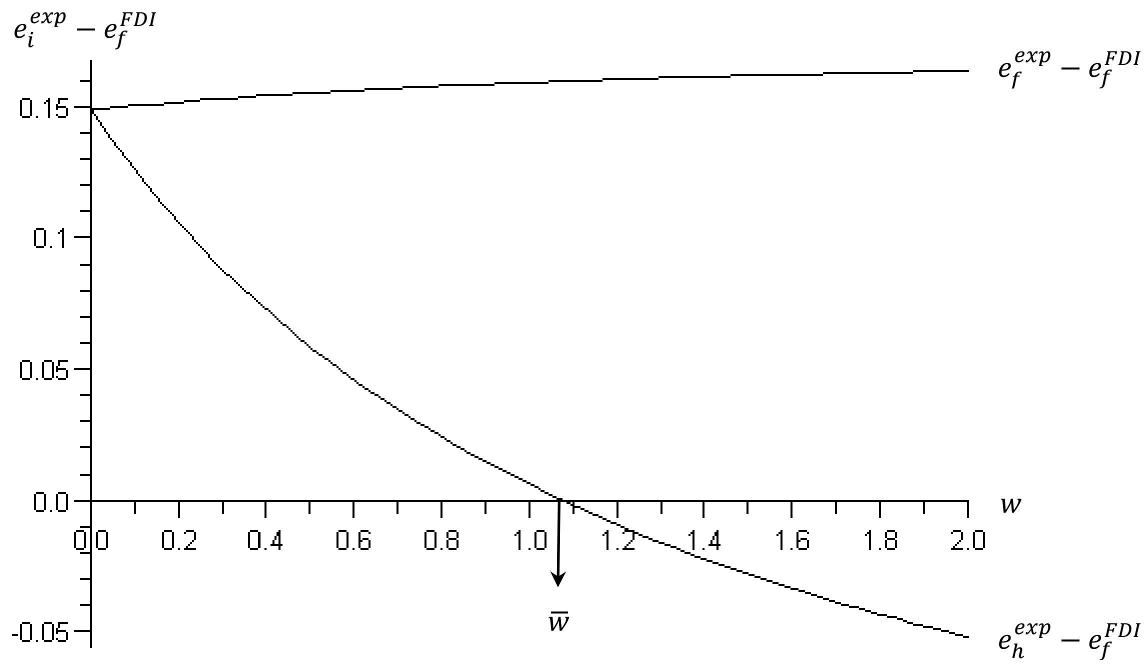

Figure 2: Emission standards under export and FDI for the home and foreign firms ($\alpha = 1;\ i = h, f$).

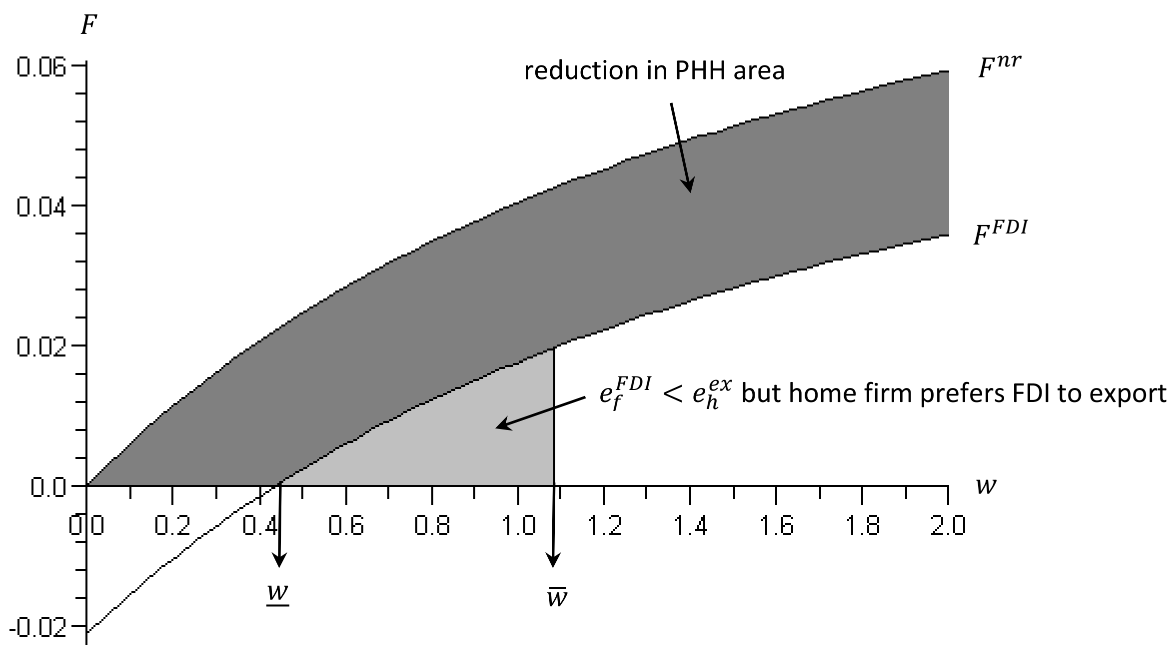

Figure 3: Critical F values and mode of entry of the home firm ($\alpha = 1$).

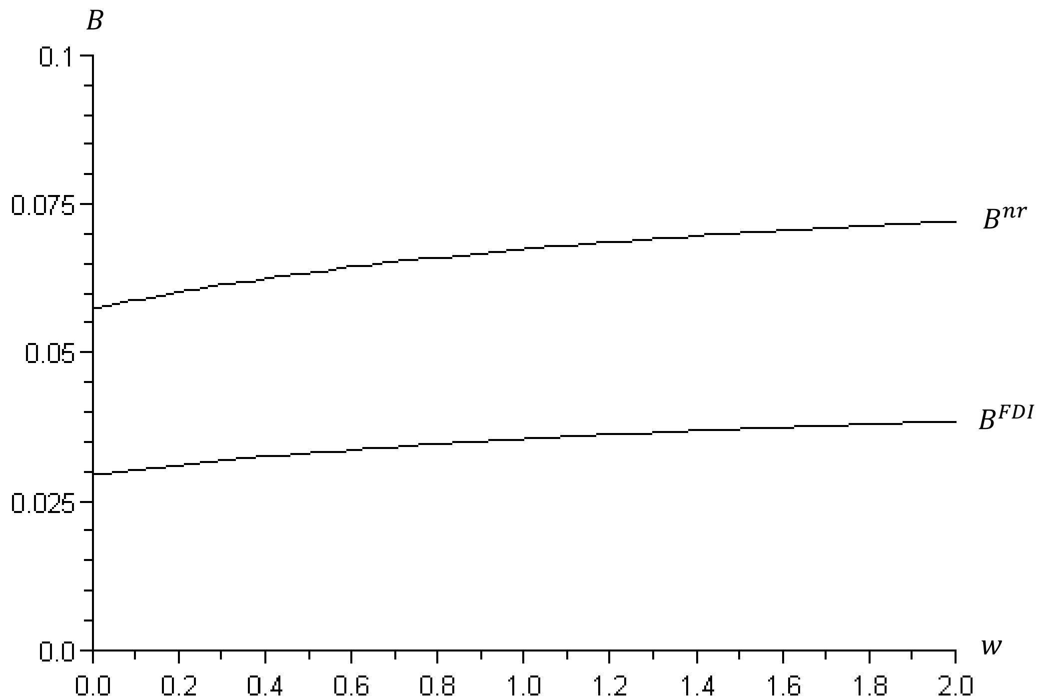

Figure 4: Critical benefit levels ($\alpha = 1$).

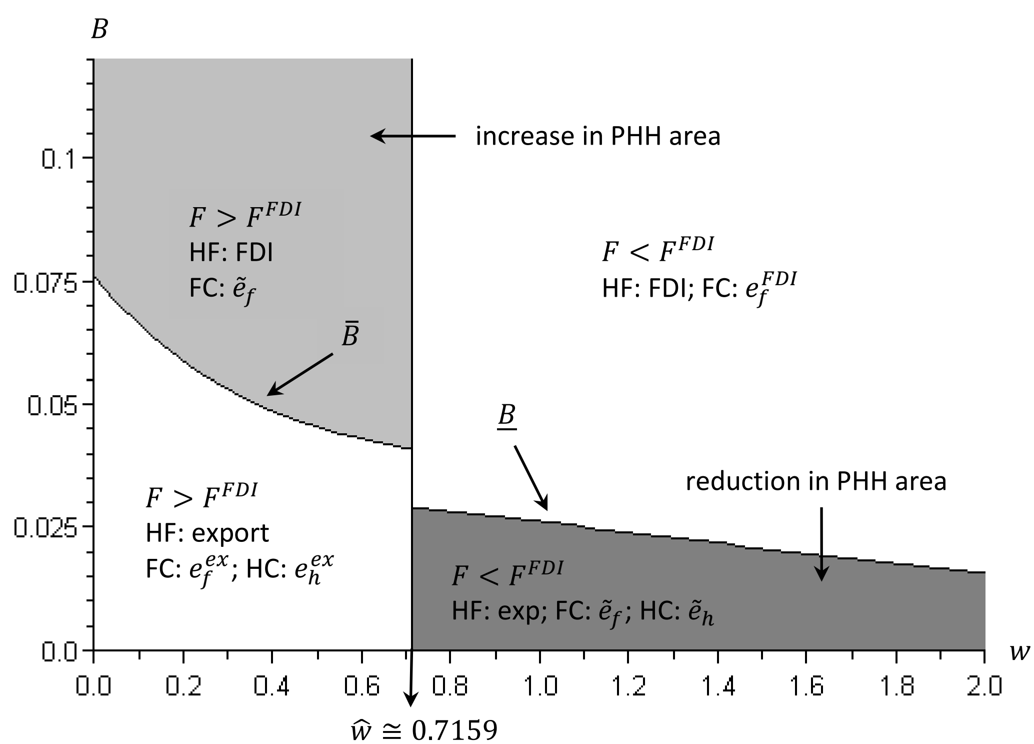

Figure 5: Possible equilibria ($F = 0.01;\ \alpha = 1$).

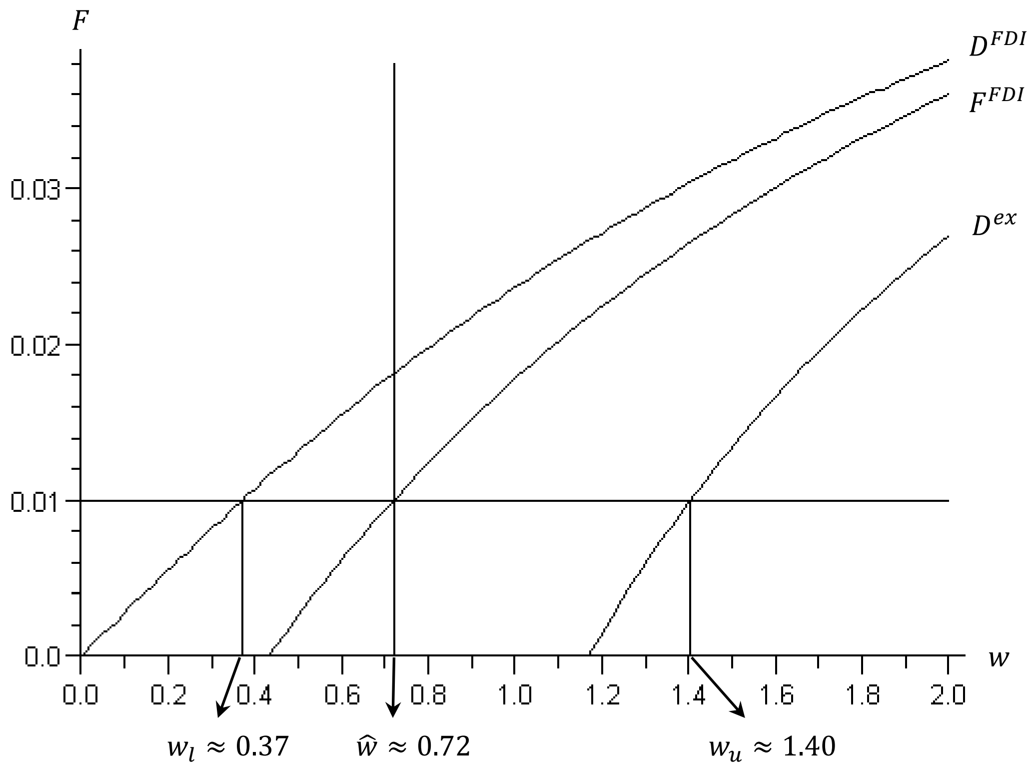

Figure 6: Critical w values for environmental considerations ($\alpha = 1$).

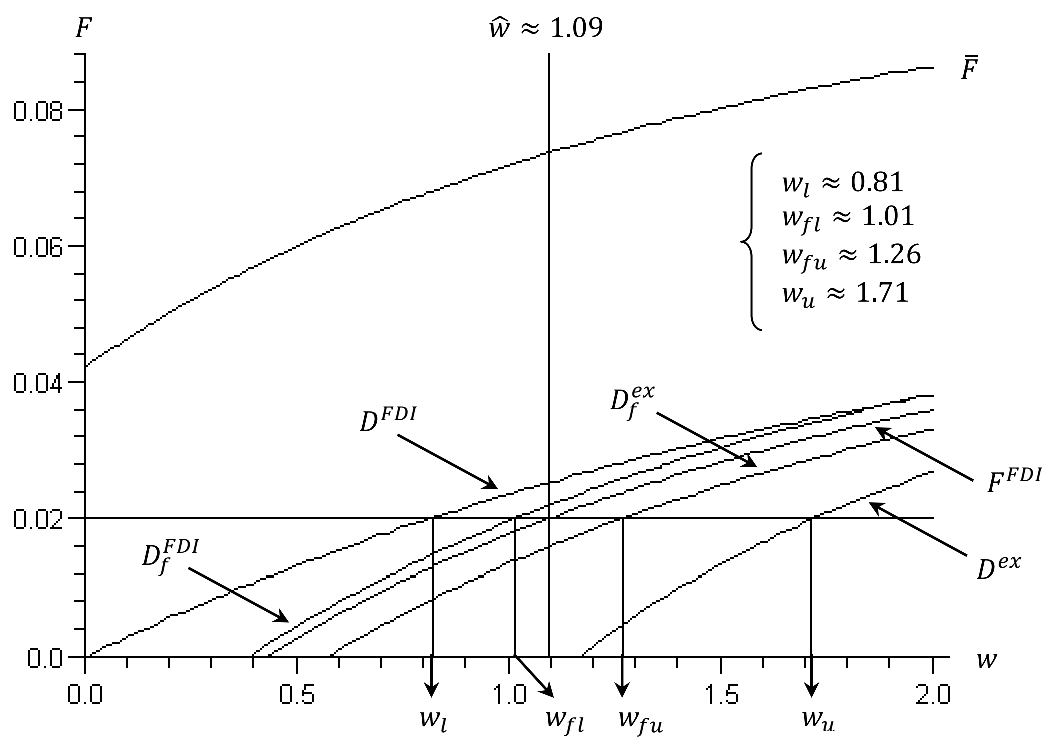

Figure 7: Critical w values for environmental considerations in the foreign country ($\alpha = 1$).