Environmental Regulation Induced Foreign Direct Investment

Abstract

The last decade has witnessed a renewed interest in the relationship between environmental regulations and international capital flows. However, empirical studies have so far failed to find conclusive evidence for this so-called pollution haven or race to the bottom effect where foreign direct investment (FDI) is assumed to be attracted to low regulation countries, regions or states. In this paper we present a simple theoretical framework to demonstrate that greater stringency in environmental standards can lead to a strategic increase in capital inflows which we refer to as environmental regulation induced FDI. Our result reveals a possible explanation for the mixed results in the empirical literature and provides an illustration of the conditions under which environmental regulations in the host country can affect the location decision of foreign firms.

Keywords: FDI, environmental regulations, pollution halo

JEL: F2, Q5

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1. Introduction

The last decade has witnessed a renewed interest in the relationship between environmental regulations and international capital flows. The early theoretical literature (Baumol and Oates 1988, Markusen *et al.* 1993, Chichilnisky 1994 and Motta and Thisse 1994) tends to focus on the impact of regulation differences on capital flows with capital predicted to move from higher to lower regulation countries. The political economy literature models show excessively lax environmental regulations can be generated endogenously in an open economy through the lobbying of agents and reaches similar conclusions (see e.g. Oates and Schwab 1988, Hillman and Ursprung 1992 and 1993, Rauscher 1995, Fredriksson 1997 and 1999 and Cole *et al.* 2006). However, empirical studies have so far failed to find conclusive evidence for this so-called pollution haven or race to the bottom effect where foreign direct investment (FDI) is assumed to be attracted to low regulation countries, regions or states (Levinson 1996a and 1996b, List and Co 2000, Keller and Levinson 2002, Xing and Kolstad 2002, Fredriksson *et al.* 2003, Eskeland and Harrison 2003 and Samarzynska-Javorcik and Wei 2005).[1]

More recently, a small number of papers has emerged that model the process by which more stringent environmental regulations may not deter FDI (Dijkstra *et al.* 2011) or induce local firms to relocate (Sanna-Randaccio and Sestini 2012). Dijkstra *et al.* (2011) demonstrate in a Cournot duopoly setting (with an exogenous duopoly market structure in the host country) that FDI is more likely if higher regulation costs raise the costs for the domestic firm over and above those for the foreign firm. Sanna-Randaccio and Sestini (2012) show that when the market size of the home country is large, more stringent environmental regulation does not necessarily induce firms to relocate to foreign countries with lax environmental regulations.[2]

It is to this growing literature that our paper contributes. Specifically, we present a simple theoretical framework of FDI and environmental regulations with an endogenous market structure and highlight the case where greater stringency in environmental standards can lead to an increase in strategic capital inflows which we refer to in this paper as environmental regulation induced FDI. The originality of our approach is that we model FDI as a strategic decision by the foreign firm that can be used to prevent entry by a domestic competitor. Our contribution is to

[1] Levinson and Taylor (2008) suggest a number of flaws in the existing empirical research including unobserved heterogeneity, omitted variable bias and the quality of the data.

[2] Sartzetakis (1997) use a duopoly setting to model tradable permits and shows that increasing the cost of permits can limit competition if one firm sets the permit price.

provide a plausible scenario whereby a tightening of domestic environmental regulation encourages capital inflows into the host country and hence improve total social welfare. Our main focus is to contribute to the understanding of how different levels of environmental regulation in a host country can affect a foreign firm's choice between direct investment and exporting as a mode of market entry. To simplify the analysis we abstract from the case where a firm can affect the level of environmental regulation (through lobbying) and assume away the possibility of reverse exporting and FDI into the sending country.[3]

Our results contribute to a possible explanation for the mixed evidence in the empirical literature and provide an illustration of the conditions under which environmental regulations in the host country can affect the location decision of foreign firms. Specifically, we examine the effect of a host government's environmental regulations on the entry decision of foreign and domestic firms and sheds light on the complex relationship between environmental regulations and the attractiveness of a host country to foreign investors.

At a broader level, our approach follows on from the large literature that examines the determinants of FDI and the much smaller but growing literature that focuses on the choice of firms to either engage in exports or invest directly in a country as a means of market entry. Using a standard game theoretic approach Smith (1987), Horstmann and Markusen (1987, 1992), Brainard (1992), Rowthorn (1992) and Motta (1992) demonstrate for certain market conditions that FDI rather than exporting is the optimal strategy.

One of the early theoretical models to introduce the environment into the FDI decision making process is Pearson (1987) who considers environmental services as an additional factor of production and demonstrates that a developing country with a low level of industrial activity would have low demand for environmental services and hence have a lower price. Hence, developing countries have a comparative advantage in producing and exporting environmental intensive goods, which in turn leads to excessive consumption of environmental resources. Baumol and Oates (1988) employ a partial equilibrium setting, with two-countries and one clean and one dirty-good sector, to show that the lack of environmental control in the developing country provides it with a comparative advantage in producing environmentally intensive goods.[4]

[3] Such an approach has also been referred to in the literature as a "pollution halo" effect (Zarsky 1999) although this assumes crucially that FDI from developed countries is inherently cleaner than domestic firm production and that foreign firms displace domestic firms (and do not contribute to additional global pollution through a scale effect).
[4] Pearson (1987) criticises the assumption that only developed countries control pollution.

By introducing exogenous environmental policy into a two-region, two-firm setting Markusen *et al.* (1993) show that a unilateral increase in the stringency of environmental regulation in one region could lead to firm(s) relocating to the other region. The same conclusion is reached by Motta and Thisse (1994) in a partial equilibrium model with similar assumptions. They show that the larger the market size of the region with the higher environmental regulation and the freer trade between the regions, the more likely relocation will take place.

Adopting a similar setting to Markusen *et al.* (1993), Sanna-Randaccio and Sestini (2012) pay particular attention to the impact of market size on the relocation decision of the firm when environmental taxes rise. Sanna-Randaccio and Sestini (2012), in contrast to Motta and Thisse (1994), allow both regions to alter environmental policy. They show that when both countries are symmetric, a unilateral increase in environmental tax always leads to a partial or full relocation of production to the lower regulation country. However, if the country with the larger market increases its environmental stringency, relocation might not occur if unit transport costs are sufficient high.

In a recent study, Dijkstra *et al.* (2011) assuming the host market structure is characterised by a duopoly and show that an increase in a per unit of output environmental tax can encourage the foreign firm to change its method of supply from exporting to FDI if the relocation cost is sufficiently small and the increase in environmental tax increases the cost of the domestic firm by at least twice that of the foreign firm. However, by assuming a duopoly market structure, Dijkstra *et al.* (2011) overlook the possibility of strategic behaviour by the foreign firm.

Crucially, Markusen *et al.* (1993), Motta and Thisse (1994) and Sanna-Randaccio and Sestini (2012) assume that environment policy is exogenous. This enables them to measure the local impact of a firm's location decision in response to changes in regulations. Markusen *et al.* (1995), Hoel (1997), Ulph and Valentini (2001), Kayalica and Lahiri (2005), Cole *et al.* (2006) and De Santis and Stahler (2009) take the opposite approach and assume that the environmental policy is endogenous and focus on the possible effect of foreign firm(s) on environmental policy formation. Dijkstra *et al.* (2011) assume that environmental taxes are chosen to maximise social welfare. As the main concern of this paper is on the effect of more stringent environmental regulations on FDI inflows we do not discuss endogenous environmental policy further. With the exception of Sanna-Randaccio and Sestini (2012) and Dijkstra *et al.* (2011), the remaining

theoretical literature on environmental regulation and FDI uniformly points to the conclusion that greater stringency in environmental policies would in one form or another induce the relocation of local firms or discourage FDI.

To summarise, the contribution of this paper is to provide a framework whereby the market is assumed to be endogenous to provide a motivation for environmental regulation induced FDI (Dijkstra *et al.* 2011 assume an exogenous (duopoly) market structure and Sanna-Sandaccio and Sestini 2012 study the effect of environmental regulations on domestic firms instead of foreign firms). We also show that higher lump-sum environmental permit costs can promote FDI complementing Dijkstra *et al.* (2011) and Sanna-Sandaccio and Sestini (2012) who model per unit environmental taxes. In this paper we consider a home country with an established firm looking to enter a foreign market through FDI or exporting. The foreign market contains a domestic firm that is considering entry into the local market. The firm in the home country is assumed to have first-mover advantage. The argument put forward in this paper is that the established home country firm may choose to invest in a high environmental regulation country as a way of deterring domestic entry in that country and hence increase profits. For example, a US firm may choose to enter China through exporting or FDI. We show that under certain circumstances that the preferred market entry choice is FDI rather than exporting when environmental regulations are higher. Intuitively one would expect the opposite. Such an approach is useful when considering the existing empirical literature that has tended to be cross-sectional in nature and compares foreign firm FDI in relation to differences in regulations across countries. It would explain why FDI is not always positively correlated with low regulations after controlling for other country specific differences (wages, skills, capital, infrastructure etc.) with the result that foreign firms choose to invest in the country with strict regulations and export to the country with lax regulations.

2. The Model

We present a game-theoretic model of firm entry in the tradition of Smith (1987), Motta (1992) and Motta and Thisse (1994). We assumes a host country, A with an inverse demand for a homogenous good that can be written as $P = Z - Q$ where P is price, Z is market size and Q is total output. Country B is a foreign country and is assumed to have an established domestic producer and supplier of good with a constant marginal cost of C^* per unit of output. The firm

in Country *B* (a foreign firm from the prospective of Country *A*) then has to decide, first, whether to enter market *A* and second, if it chooses to enter what should they enter as an exporter or through direct investment (FDI). In Country *A* we assume that there is a domestic producer who would incur a constant marginal cost of *C* per unit of output if it decided to enter the domestic market. For simplicity we assume that $C=C^*$ (identical factor costs) although the key results hold when $C \neq C^*$. Results are available from the authors upon request. Moreover, it is assumed that the variable cost $C<Z$, otherwise no output would be supplied in country *A*.

We now introduce environmental regulations. Assume that any new production in Country *A* requires an environmental permit with price *T* to be purchased from the government of the host country. The assumption of a lump-sum environmental permit cost is equivalent to a direct fee required by the government which could represent the cost that a firm is required to pay in order to satisfy the conditions for environmental certification. Such a lump-sum cost can also be interpreted as the investment in technology needed to upgrade part of the production process required in order for the firm to meet regulatory standards. Lump-sum payments of this type are common. For example, the most widely adopted international environmental standard, ISO14000 certification, specifies the procedures and requirements for environmental protection and pollution abatement. A firm must expend resources in order to obtain certification which can also be considered a form of lump-sum sunk cost required to meet environmental regulation standards of a particular industry.[5] As the costs of certification are likely to be fairly similar for firms in the same industry we believe our assumption that the same environmental permit *T* is required for both the foreign and domestic firms is reasonable. An alternative to the lump sum permit costs approach to modelling environmental regulations is to use abatement costs per unit of output (Markusen *et al.* 1993, Motta, Thisse 1994 and Dijkstra *et al.* 2011). Our key results do not change when we replace *T* with a per unit of output abatement cost measure. This topic is discussed in more detail later in the paper and results are available from the authors.[6]

[5] Although ISO14000 is not a mandatory standard in all countries, in most developing countries it has been used as a *de facto* regulation for new firms entering the market. See http://www.iso.org for details. In addition to internationally accepted environmental certification such as ISO14000, individual countries also impose their own regulation standards. In the UK, Pollution Prevention and Control (PPC) and Waste Management Licensing (WML) regulations need to be followed by all companies and clearly specify the abatement and environmental conditions producers need to meet. Similar regulation regimes exist in developing countries. For example, China is currently experiencing considerable environmental damage from its rapid industrialisation and has put in place environmental standards that need to be satisfied by both domestic and foreign firms before any production can take place. See http://www.environment-agency.gov.uk and http://www.cenews.com.cn/xwzx/yz/yzqt/200907/t20090722_619874.html for a detailed description of the UK and China's regulations respectively.

[6] Throughout this paper the stringency of the environmental policy (equivalent to the price of environmental permit *T*) can be considered a measure of the attitude of the host government towards environmental damage. As such it can be thought of as a measure of the "greenness" of a government and hence the willingness of the host

In addition to the permit cost T we assume that any domestic firm that decides to begin production in Country A must incur a fixed plant set-up cost G and a fixed enterprise start-up cost F to establish itself as an operating company. F can be thought of as the cost of registering the company and paying for example the associated legal costs whilst G is the cost of building the plant itself to enable production to begin. Hence, the total costs of beginning production in Country A for the domestic firm are $G+F+T$.

We now turn to the foreign firm. If it chooses to supply Country A's demand by exporting it will face a constant tariff rate S per unit of exports which is exogenously determined. If the foreign firm chooses to become a multinational and set up a production plant in Country A it does not have to incur an enterprise start-up cost F as the firm is already operating in Country B and will have previously incurred these costs. However, it would still need to pay the same fixed sunk plant set-up cost G and the same lump-sum environmental permit cost T.[7]

In our entry game the foreign and domestic firms make their entry and production choices simultaneously. Hence they play *à la* Cournot as in Markusen *et al.* (1993) and Motta and Thisse (1994). To simplify our analysis we assume that the foreign firm acts as the first mover and chooses the option that leads to a higher profit for itself when multiple equilibria arise. This assumption mimics the familiar practice of multinationals being given preferential treatment in foreign markets (usually in a developing country context). For example foreign firms being given faster project approval than competing domestic firms.

Possible Equilibria

There are six possible states of the economy which are: an export monopoly (the domestic firm does not enter and the foreign firm supplies Country A through exports); export duopoly (the domestic firm enters and the foreign firm exports); FDI monopoly (the domestic firm stays out and the foreign firm invests in Country A); FDI duopoly (the domestic firm enters and the

government to reduce environmental damage by restricting production. Alternatively, it can be viewed as a measure of the ability of the host government to deal with environmental damage.

[7] The assumption that the foreign firm is already established and hence does not have to incur the firm specific fixed set-up cost F follows the common practice in foreign firm entry literature. See e.g. Horstmann and Markusen (1987, 1992), Brainard (1992), Markusen *et al.* (1993) and Motta and Thisse (1994). Dropping this assumption does not affect our main results.

foreign firm invests in Country *A*); domestic monopoly (the domestic firm enters and the foreign firm does not invest or export) and No supply to Country *A* (neither the foreign nor the domestic firm supplies Country *A*). The possible equilibria and the payoffs (profits) for the foreign and domestic producers are listed below. Π_j^i represents profit and superscript *i* relates to the entry mode ($i \in \{E, F\}$, where *E* represents exporting and *F* represents FDI). Subscript *j* refers to the eventual market structure ($j \in \{M, D\}$, where *M* represents a monopolistic and *D* represents a duopolistic market structure. An asterisk * represents the foreign firm.

Case 1 **Export monopoly:** $(\Pi_M^{*E}, 0)$

Case 2 **Export duopoly:** (Π_D^{*E}, Π_D^E)

Case 3 **FDI monopoly:** $(\Pi_M^{*F}, 0)$

Case 4 **FDI duopoly:** (Π_D^{*F}, Π_D^F)

Case 5 **Domestic monopoly:** $(0, \Pi_M)$

Case 6 **No supply in country *A*:** $(0, 0)$

We now consider each case in turn. The payoffs for each outcome and the conditions under which a firm is able to break even are stated below. The sales of the domestic and foreign firm are q_j^i and q_j^{*i} respectively such that $Q_j^i = q_j^i + q_j^{*i}$. A hat (^) above a variable represents the optimal output and maximum profit level for the firm. As a reminder, *Q* is output, *S* is the tariff rate per unit of output, *Z* is the market size and *C* is the marginal cost of production. Each case is represented in Figure 1 with market size *Z* on the vertical axis and tariff rate *S* on the horizontal axis.

[Figure 1 about here]

Case 1 export monopoly: In a market characterised by a foreign exporting monopolist, the profit of the domestic firm is zero and the profit of the foreign firm can be written as:

$$\Pi_M^{*E} = (Z - Q_M^{*E})Q_M^{*E} - (C + S)Q_M^{*E}.$$

From which we derive the optimal output and profit for the foreign firm as the follows:

$$\hat{Q}_M^{*E} = \frac{(Z - C - S)}{2},$$
$$\hat{\Pi}_M^{*E} = \frac{(Z - C - S)^2}{4}.$$

Exporting as a monopolist in the host country would be profitable for the foreign firm if:

$$S \leq Z - C. \qquad (1)$$

Condition (1) is represented by the area to the left of the upward sloping line $\Pi_M^{*E} = 0$ in Figure 1. The area to the right of the line represents negative profits for the foreign firm.

Case 2 export duopoly: When the market is characterised by an exporting duopoly, the profits of the foreign firm can be written as:

$$\Pi_D^{*E} = (Z - q_D^{*E} - q_D^E)q_D^{*E} - (C + S)q_D^{*E}.$$

The optimal output and profit for the foreign firm in this case is:

$$\hat{q}_D^{*E} = \frac{(Z - C - 2S)}{3},$$
$$\hat{\Pi}_D^{*E} = \frac{(Z - C - 2S)^2}{9}.$$

and the condition for the foreign firm to be profitable when it chooses exporting and the market is characterised by a duopoly is:

$$S \leq \frac{Z - C}{2}. \qquad (2)$$

Condition (2) is represented by the area to the left of the upward sloping line $\Pi_D^{*E} = 0$ in Figure 1. It is to the left of and has twice the slope of the $\Pi_M^{*E} = 0$ line which indicates that for any given level of tariff, the market size of Country *A* need to be larger in order for the foreign firm to break even and that the foreign firm is twice as sensitive to tariff increases as an exporting duopolist as a monopolist.

The profit for the domestic firm in this case would be:

$$\Pi_D^E = (Z - q_D^{*E} - q_D^E)q_D^E - Cq_D^E - G - F - T.$$

The optimal output and profit for the domestic firm when the foreign firm enters as an exporting duopolist is:

$$\hat{q}_D^E = \frac{(Z - C + S)}{3} > \hat{q}_D^{*E},$$

$$\hat{\Pi}_D^E = \frac{(Z - C + S)^2}{9} - G - F - T.$$

The condition for the domestic firm to be profitable in this case is:

$$Z \geq 3\sqrt{G + F + T} + C - S. \qquad (3)$$

In Figure 1, this condition is represented by the area to the right of the downward sloping line labelled $\Pi_D^E = 0$. The area to the left represents the range of parameter values that generate negative profits for the domestic firm when the foreign firm chooses to enter the market via exporting.

Case 3 FDI monopoly: When the market is characterised by a foreign FDI monopolist, the profit of the domestic firm would be zero. The profit for the foreign firm is:

$$\Pi_M^{*F} = (Z - Q_M^{*F})Q_M^{*F} - CQ_M^{*F} - G - T.$$

The optimal output and profit for the foreign firm when it is the FDI monopolist is:

$$\hat{Q}_M^{*F} = \frac{(Z - C)}{2},$$

$$\hat{\Pi}_M^{*F} = \frac{(Z - C)^2}{4} - G - T.$$

And the condition for the foreign firm to be profitable in this case is:

$$Z \geq Z_1 = 2\sqrt{G + T} + C. \qquad (4)$$

This condition is represented by the area above the horizontal line labelled $\Pi_M^{*F} = 0$ in Figure 1, which intersects the vertical axis at Z_1. The area below the line indicates the range of parameter values where the foreign firm would make a negative profit.

Case 4 FDI duopoly: When the market is characterised by a duopoly and the foreign firm engages in FDI, the profit of the foreign firm can be written as:

$$\Pi_D^{*F} = (Z - q_D^{*F} - q_D^F)q_D^{*F} - Cq_D^{*F} - G - T.$$

The optimal output and profit for the FDI foreign firm when the domestic firm also enters the market is:

$$\hat{q}_D^{*F} = \frac{(Z-C)}{3},$$

$$\hat{\Pi}_D^{*F} = \frac{(Z-C)^2}{9} - G - T.$$

The condition for the foreign firm to be profitable in this case is:

$$Z \geq Z_3 = 3\sqrt{G+T} + C. \qquad (5)$$

Similarly, condition (5) is represented by the area above the line labelled $\Pi_D^{*F} = 0$ and intersects the vertical axis at Z_3 in Figure 1.

The profit for the domestic firm in this case can be written as:

$$\Pi_D^F = (Z - q_D^{*F} - q_D^F)q_D^F - Cq_D^F - G - F - T.$$

The optimal output and profit for the domestic firm when the foreign firm enters the market via FDI is:

$$\hat{q}_D^F = \frac{(Z-C)}{3},$$

$$\hat{\Pi}_D^F = \frac{(Z-C)^2}{9} - G - F - T.$$

The condition for the domestic firm to be profitable in this case is:

$$Z \geq Z_4 = 3\sqrt{G + F + T} + C. \qquad (6)$$

Condition (6) is represented by the area above the line labelled $\Pi_D^F = 0$ and intersects the vertical axise at Z_4.

Case 5 domestic monopoly: When the market is characterised by a domestic monopolist the profit of the foreign firm would be zero and the profit of the domestic firm is:

$$\Pi_M = (Z - Q_M)Q_M - CQ_M - G - F - T.$$

If the foreign firm acts as the first mover in the game, the market structure of domestic monopoly would not be realised, however diverting from this does not affect the main result. The optimal output and profit of the domestic firm when it is the monopolist in the market is:

$$\hat{Q}_M = \frac{(Z - C)}{2},$$
$$\hat{\Pi}_M = \frac{(Z - C)^2}{4} - G - F - T.$$

The condition for the domestic firm to be profitable in this case is:

$$Z \geq Z_2 = 2\sqrt{G + F + T} + C. \qquad (7)$$

Condition (7) is represented by the area above the line labelled $\Pi_M = 0$ and intersects the vertical axise at Z_2. The area below this line represents parameter values that lead to negative profit for the domestic firm if the market is characterised by an domestic monopolist. It is assumed that the sunk cost is not too high (i.e. $F < \frac{5}{4}(G + T)$) hence $Z_3 > Z_2$. The alternative assumption (i.e. $Z_3 \leq Z_2$) will not affect our main results.

Case 6 no supply or production in Country *A*: If all the conditions above fail to be satisfied, then there will be neither production nor exporting to country *A*. This case is represented by the white area labelled (0, 0) in Figure 1.

Finally, given the entry decision of the domestic producer, for the foreign firm to favour FDI over exporting we require the profit generated from FDI to be at least as high as from exporting. Specifically, if the domestic firm chooses not to enter the foreign firm will prefer FDI if:

$$\Pi_M^{*F} \geq \Pi_M^{*E}.$$

from which we derive the condition:

$$Z \geq \frac{S^2 + 4(G+T)}{2S} + C. \qquad (8)$$

which is represented by the area to the right of the downward sloping curve labelled $\Pi_M^{*F} = \Pi_M^{*E}$ in Figure 1.

Similarly, if the domestic firm chooses to enter the market the foreign firm will prefer FDI over exporting if:

$$\Pi_D^{*F} \geq \Pi_D^{*E}.$$

from which we can derive the condition:

$$Z \geq \frac{4S^2 + 9(G+T)}{4S} + C. \qquad (9)$$

which is represented by the area to the right of the downward sloping curve labelled $\Pi_D^{*F} = \Pi_D^{*E}$ in Figure 1.

The slope of the curve $\Pi_M^{*F} = \Pi_M^{*E}$ in Figure 1 (representing condition 8) equals $\frac{1}{2} - \frac{2(F+T)}{S^2}$. Assuming S is small relative to F and T, it is reasonable to assume that $\frac{1}{2} - \frac{2(F+T)}{S^2} < 0$ and is steeper than the slope of $\Pi_D^E = 0$ (i.e. $\frac{\partial Z}{\partial S} = -1$). Dropping this assumption does not change our main results. If S was large relative to F and T the only difference would be an enlarged area

for the FDI monopoly equilibrium. For simplicity, we assume that the slope of $\Pi_D^{*F} = \Pi_D^{*E}$ (i.e.$1 - \frac{9(G+T)}{4S^2}$) is steeper than the slope of $\Pi_M^{*F} = \Pi_M^{*E}$ $(i.e.\frac{1}{2} - \frac{2(F+T)}{S^2})$.[8]

Figure 1 provides a diagrammatical representation of the range of parameter values that support different market equilibriums. The area with dark grey represents case 1(i.e. exporting monopoly) where the domestic firm chooses not to enter and the foreign firm enters via exporting. The area marked with horizontal lines represents case 2 (i.e. exporting duopoly) where the domestic firm chooses to enter and the foreign firm enters via exporting. The light grey region represents case 3 (i.e. FDI monopoly) where the domestic firm chooses not to enter and the foreign firm enters via FDI. The area marked by grey and white checks represents case 4 (i.e. FDI duopoly) where the domestic firm enters the market and the foreign firm chooses to enter via FDI. Finally, the blank region represent the case 6 (i.e. no supply) where the market in country *A* is too small and both the domestic and the foreign firms choose not to enter. It is worth noting as we assume that the foreign firm has first move advantage case 5 (domestic monopoly) will not be realised.

We now introduce environmental regulations into our framework.

3. Environmental regulations and a foreign firm's entry decision

Proposition 1: *A marginally more stringent environmental regulation will lead the foreign firm to prefer exporting rather than FDI given the entry choice of the domestic firm.*

Proof: The stronger a government's environmental preferences, the higher would be the price of environmental permit fee (*T*) imposed. If the domestic firm chooses not to enter the market and Country *A* is characterised by a foreign monopoly, the additional profit for the foreign firm from switching from exporting to FDI in country *A* can be represented by:

[8] If the opposite was true, the area for the existence of an export duopoly would be narrowed, which would make environmental regulation induced FDI less likely although the possibility for higher environmental regulations to induce FDI is not excluded. Hence, a change to the assumption regarding to the slope of the curves $\Pi_D^{*F} = \Pi_D^{*E}$ and $\Pi_M^{*F} = \Pi_M^{*E}$ in Figure 1 does not change the main result of this paper except in the extreme case where the parameter values do not support an exporting duopoly in equilibrium in Country *A*.

$$\Delta\Pi_{\mathrm{M}}^{*} = \widehat{\Pi}_{M}^{*F} - \widehat{\Pi}_{M}^{*E} = \frac{2S(Z-C)-S^2}{4} - G - T.$$

If we differentiate with respect to *T* we get:

$$\frac{\partial \Delta\Pi_{\mathrm{M}}^{*}}{\partial T} = -1 < 0.$$

Hence, if the domestic firm stays out of the market, the higher *T* the less likely the foreign firm is to engage in FDI if it was a monopolist. When the domestic firm enters the market, the additional profits for the foreign firm from choosing FDI over exporting is given by:

$$\Delta\Pi_{\mathrm{D}}^{*} = \widehat{\Pi}_{D}^{*F} - \widehat{\Pi}_{D}^{*E} = \frac{4S(Z-C)-S^2}{9} - G - T.$$

Differentiating with respect to *T* gives:

$$\frac{\partial \Delta\Pi_{\mathrm{D}}^{*}}{\partial T} = -1 < 0.$$

Hence, if the domestic firm enters the market, a higher *T* means the foreign firm is less likely to engage in FDI. This is the standard result.■

The preceding discussion shows that taking the entry choice of the domestic firm as given, more stringent environmental regulations reduces the incentive for the foreign firm to invest. However, the choice of the domestic firm is not fixed. Instead it is conditional on the environmental regulation imposed. In particular, we observe that when environmental regulations become more stringent, it can force the domestic firm to change its entry choice and hence alter the investment incentives for the foreign firm.

Proposition 2: *A marginally more stringent environmental regulation and hence a higher permit cost T in the host country will induce the foreign firm to switch from exporting to FDI if it can pre-empt market entry by the domestic firm.*

Proof: A change in the level of environmental regulation in the host country caused by a change in the host government's attitude towards environmental issues can be represented by an increase or decrease in the price of the environmental permit *T*. Assume that the host government implements a more stringent environmental regulation $T' = T + \varepsilon$, where $\varepsilon > 0$ and marginally small. The local effect of the change from T to T' could change the foreign firm's incentive to engage in FDI rather than exporting. Everything else remaining equal, the more stringent the regulations, the higher are the fixed costs for both foreign and domestic firms. Hence, revenues must increase for both firms to break even which requires the market size of Country *A* to increase accordingly. In this case higher environmental regulations cause the right hand side of inequality (3)-(9) to increase. This is represented by the upward shift in the lines and curves corresponding to inequality (3)-(9) in Figure 1. In Figure 2 we use *'* to represent the condition after the increase in regulatory stringency. For example, Z_4' represents the upward move from Z_4 following a more stringent regulations. The original line Z_4 is not labelled in Figure 2 for reasons of space. In the cases where the foreign firm exports (conditions 1 and 2) an increase in *T* has no effect. Note that we consider a marginally more stringent environmental regulation (i.e. a marginally higher *T*) and the results in Figure 2 are local effects. The supply decisions of the foreign and domestic firms that are located at the boundary of their entry choices are changed following a marginal higher *T*. Depending on the market conditions under lax environmental regulation, such a change could increase or decrease FDI from the foreign firm.

[Figure 2 about here]

Of primary interest is Area 1 highlighted in Figure 2. Area 1 represents a case of market equilibrium of an exporting duopoly under lax environmental regulation (*T*) and an FDI monopolist under a more stringent environmental regulation (T') when the domestic firm is at the boundary between breaking even as an FDI duopolist and reporting negative profits under the lax environmental regulation. Such a switch of market structure could happen locally because stricter environmental regulations raise the overall cost structure of setting up for the domestic firm who is no longer able to break even as an FDI duopolist but could still break even as an exporting duopolist.[9] If we assume prefect information, the rational foreign firm would

[9] Because the output supplied by the foreign firm via exporting is less than via FDI, the domestic firm is still able to break even as an exporting duopolist even under more stringent environmental regulation.

know the domestic firm's reaction function and hence, for given parameter values, the foreign firm can make a higher profit as an FDI monopolist rather than as an exporting duopolist and choose FDI in order to pre-empt market entry by the domestic firm under more stringent environmental regulation.[10] The rational domestic firm would foresee this move and hence stay out of the market. In this case, we observe that a more stringent environmental regulation T' can have the local effect of inducing the market equilibrium from an exporting duopoly (Case 2) under a lax environmental regulation to an FDI monopoly (Case 3).■

Hence, a more stringent environmental regulation can result in a strategic switch in a foreign firm's mode of entry from exporting to FDI. The result is similar in spirit to the concept of strategic FDI caused by an increase in the tariff rate that is discussed by Smith (1989) and Motta (1992). They show that when demand is large enough to cover the fixed-cost of setting up a plant for either the domestic or the foreign firm, but it is too small to allow either the foreign or the domestic firm to break even as a duopolist, the domestic firm will choose to stay out if the foreign firm enters. For parameter values where the foreign firm can earn a higher profit as an FDI monopolist than by staying out or as an exporting monopolist, the foreign firm would enter the market via FDI and deter the entry of the domestic firm. In this case, FDI is motivated not only by achieving a lower marginal cost than by exporting, but also by the foreign firm's incentive to pre-empt and prevent entry by the domestic firm.

In this case, a foreign firm choosing FDI instead of exporting can be viewed as strategic because to do so would mean a higher output supplied by the foreign firm, hence lower revenue for the domestic firm than under an exporting equilibrium which in turn deters the domestic firm from entering the market. Intuitively, a tightening of environmental regulations in a developing country could deter the development of domestic industry while promoting entry from foreign firms from more developed countries.[11]

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[10] The appendix provides a derivation for the feasible range of the marginally more stringent environmental regulation that could lead to strategic FDI by the foreign firm.

[11] It is worth noting that because the choice of FDI by the foreign firm is not based on the cost advantage it has over the domestic firm regarding the firm set-up cost *F*, the result is unchanged if we assume there is no firm set-up cost *F*. What is more, the result does not change if a per unit pollution abatement cost (*t*) is used instead of a lump-sum environment permit (Dijkstra *et al.* 2011). The rationale is as follows. When the level of per unit abatement cost (*t*) increases, it forces the domestic firm located at the border to break-even and the FDI duopolist to exit the market. This means that if the foreign firm enters via FDI, the market would be characterised by a FDI monopoly. However, the domestic firm would still be able to make positive profit as an exporting duopolist. This means if the foreign firm choose to enter via exporting it would have a lower market share and revenue; hence there exists a combination of fixed plant set-up cost (*G*) and per unit abatement cost (*t*) that makes FDI a more attractive option for the foreign firm. Therefore, instead of a lump-sum permit fee as assumed here, when per unit abatement cost is

Proposition 3: *A marginally more stringent environmental regulation could increase the local profitability of the foreign firm from investing in Country A.*

Proof: Consider the possible local profit improving effect of a marginally more stringent environmental regulation for the foreign firm. In Area 1 of Figure 2 we observe that under a marginally stringent environmental regulation T' the market equilibrium could change from an exporting duopolist under a lax environmental regulation to an FDI monopolist, if the domestic firm is initially at the break even boundary as a FDI duopolist. In this case for the parameter values that make area 1 in figure 2 to be feasible, the difference in the foreign firm's profit under lax and more stringent environmental regulation can be written as follows:[12]

$$\Delta\Pi_1^{*\prime} = \widehat{\Pi}_M^{*F\prime} - \widehat{\Pi}_D^{*E} = \widehat{\Pi}_M^{*F} - \widehat{\Pi}_D^{*E} - \varepsilon > 0. \quad (11)$$

Area 2 in Figure 2 demonstrates that a marginal more stringent environmental regulation can induce the host market to change from an FDI duopolist under a lax environmental regulation to an FDI monopolist if the domestic firm is initially located at the boundary between break even as an FDI duopolist. The difference in the foreign firm's profit under lax and more stringent environmental regulation can be written as follows:

$$\Delta\Pi_2^{*\prime} = \widehat{\Pi}_M^{*F\prime} - \widehat{\Pi}_D^{*F} = \widehat{\Pi}_M^{*F} - \widehat{\Pi}_D^{*F} - \varepsilon. \quad (12)$$

For the parameter values that makes area 2 in figure 2 feasible, the above condition would be positive if:[13]

$$0 < \varepsilon < \widehat{\Pi}_M^{*F} - \widehat{\Pi}_D^{*F}. \quad (13)$$

This means as long as condition (13) holds for the parameter values that supports area 2 in figure 2, the foreign firm will get a higher profit as FDI monopolist under more stringent

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used the case where an increase in the per unit abatement cost (*t*) induces the foreign firm to change its mode of entry from exporting to FDI is still plausible. Hence our results are robust to changes in the definition of *T*.

[12] Appendix shows that given the range of ε for area 1 in figure 2 to be feasible as indicated by inequality (A3) (i.e. $0 < \varepsilon \leq \widehat{\Pi}_M^{*F} - \widehat{\Pi}_M^{*E}$) and $\Pi_M^{*E} > \Pi_D^{*E}$ we know that ε is small enough to ensure that $\Delta\Pi_1^{*\prime} > 0$.

[13] Because area 2 of figure 2 represents the case where the domestic firm would not be able to break even as an FDI duopolist under more stringent environmental regulation (i.e. $T' = T + \varepsilon$), therefore we know that $\varepsilon > \Pi_D^F$. However, the domestic firm still can break even as an exporting duopolist, which means $\varepsilon < \Pi_D^E$. Same as in area 1 of figure 2 as discussed in the appendix for the foreign firm to enter via FDI rather than exporting it is required that $0 < \varepsilon \leq \widehat{\Pi}_M^{*F} - \widehat{\Pi}_M^{*E}$. These three conditions together provides the range of more stringent environmental regulation that would make area 2 in figure 2 feasible (i.e. $\Pi_D^E < \varepsilon < \Pi_D^E$ and $0 < \varepsilon \leq \widehat{\Pi}_M^{*F} - \widehat{\Pi}_M^{*E}$).

environmental regulation. In both cases a more stringent environmental regulations can increase profits of the foreign firms through FDI.■

Area 2 of figure 2 shows that a marginal more stringent environmental regulation T' can increase the foreign firm's profit from FDI, because the foreign firm does not have to pay the fixed enterprise set-up cost F to establish a presence. In particular this means the parameter values that put the domestic firm at a boundary between breaking even and negative profit under lax environmental regulation would not put the foreign firm at the same boundary. This in turn enables the foreign firm to continue to produce as an FDI supplier in the country with a more stringent environmental regulation T' even when the domestic firm cannot. It is the marginal more stringent environmental regulations that make the saving from enterprise set-up costs F significant enough to benefit the foreign firm and make it a monopolist in the host market. As a result, in these cases discussed above, marginally more stringent environmental regulation can actually increase rather than reduce the profitability of the foreign firm from FDI.

The discussion shows that when market structure is endogenous, a more stringent environmental policy does not necessarily reduce the profitability of foreign firms from FDI. Instead, when such increase in environmental regulation deters the entry of domestic firms, the profit of foreign firms from FDI can be increased as demonstrated by Areas 1 and 2 in Figure 2. The implication is that the attractiveness of FDI as mode of entry into a host country is not automatically reduced as a result of higher environmental regulation leading to a potential pollution halo effect from regulation increases.

4. Environmental regulations and social welfare

Following Motta (1992), Markusen *et al.* (1993) and Dijkstra *et al.* (2011) we assume that social welfare in Country A is equal to the sum of consumer surplus, domestic producer surplus, the host government's tariff revenue and the environmental license revenue minus the environmental damage. For Area 1 in Figure 2 the market structure is characterised by an

exporting duopoly under a lax environmental regulation. Hence, the level of social welfare can be written as[14]:

$$SW_D^E = \frac{(2Z-2C-S)^2}{18} + \frac{S(Z-C-2S)}{3} + \frac{(Z-C+S)^2}{9} - G - F - D\left[\frac{(Z-C+S)}{3}\right].$$

where all the parameters have the same meaning as before and D represents the level of per unit output environmental damaged caused by the domestic firm in the host country and $D\left[\frac{(Z-C+S)}{3}\right]$ represents the total level of environmental damage caused by the domestic firm at its optimal output level.

As shown in Area 1 of Figure 2 a marginal more stringent environmental regulation T could induce the market structure to change to that of an FDI monopoly. In this case total social welfare would be:[15]

$$SW_M^F = \frac{(Z-C)^2}{8} + T - D^*\left[\frac{(Z-C)}{2}\right].$$

where D^* represents the level of per unit output environmental damage caused by the foreign firm in Country A and $D^*\left[\frac{(Z-C)}{2}\right]$ represents the total level of environmental damage caused by the foreign firm at its optimal output.

The effect of marginally more stringent environmental regulations on the host country's total social welfare depends on the tariff rate S, fixed firm and plant set-ups costs (G and F), the level of environmental license fee T and the relative cleanness of the foreign firm's production process compared to the domestic firm (D and D^*). If the domestic production process is sufficiently dirty as shown below:

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14 If the market equilibrium was an exporting duopoly the customers' surplus will be $\frac{(2Z-2C-S)^2}{18}$, domestic producer's surplus equals $\frac{(Z-C+S)^2}{9} - G - F - T$, tariff revenue equals $\frac{S(Z-C-2S)}{3}$, government's environmental license fee revenue equals T and the environmental damage equals $D\left[\frac{(Z-C+S)}{3}\right]$.

15 If the market equilibrium is an FDI monopoly the consumer surplus will be $\frac{(Z-C)^2}{8}$, as the domestic firm does not enter the market hence domestic producer surplus equals 0, as the foreign firm enters the market via FDI rather than exporting hence the tariff revenue for the host government is 0, the government's environmental license fee revenue equals T and the environmental damage equals $D^*\left[\frac{(Z-C)}{2}\right]$.

$$D \geq \frac{6\left[\frac{(2Z-2C-S)^2}{18}+\frac{S(Z-C-2S)}{3}+\frac{(Z-C+S)^2}{9}-\frac{(Z-C)^2}{8}-G-F-T\right]+D^*[3(Z-C)]}{2(Z-C+S)}.$$

the result will be that a marginally more stringent environmental regulation encourages FDI into the host country and can improve social welfare. This can even hold when per unit environmental cost of the foreign firm equals the domestic firm (i.e. $D^*=D$). This is the well-known result described by Buchanan (1969) and Solow (1974) that competition between producers can lead to pollution above the social optimal and greater than the pollution emitted by a monopolist.[16] As a result, a FDI monopoly induced by more stringent environmental regulations might lead to higher social welfare than the exporting duopolist equilibrium. This result is consistent with the pollution halo hypothesis.

Similarly, for Area 2 in Figure 2, under lax environmental regulations the market in Country *A* is characterised by an FDI duopoly and the level of total social welfare is given by:

$$SW_D^F = \frac{(Z-C)^2}{3}+T-G-F-D\left[\frac{Z-C}{3}\right]-D^*\left[\frac{Z-C}{3}\right].$$

When the level of environmental regulation become more stringent, the market structure shifts to an FDI monopoly (with the social welfare shown earlier), which means that when the domestic production process is sufficiently dirty, more stringent environmental regulation improves social welfare although it deters the entry of the domestic producer. The environmental damage caused by the domestic firm should satisfy the condition:

$$D \geq \frac{\frac{5(Z-C)^2}{28}-3G-3F+D^*\left[\frac{(Z-C)}{2}\right]}{Z-C}.$$

If this condition fails, as in Dijkstra *et al.* (2011), although more stringent environmental regulations do not deter FDI it would still reduce total social welfare.

[16] Buchanan (1969) argues that concentrated industries are already producing below the socially optimal level so any first best policy designed to internalise external damages should be used with case so that reductions in producer and consumer surplus and not greater than any gains from a falls in emissions. Likewise, Solow (1974) shows how competition in product market can lead to a higher rate of exploitation of natural resources than under monopoly. Hence, a monopolist can help to conserve resources that would otherwise be extracted under a competitive environment.

Conclusions

Despite a large increase in the empirical literature that investigates the link between environmental policy and FDI the results remain inconclusive. In this paper we provide a formal model that may go some way to explain this lack of robust evidence. We provide an alternative approach to recent Dijkstra *et al.* (2011) and in doing so we provide a plausible scenario in where a more stringent environmental regulatory policy can induce FDI inflows. If foreign firms are assumed to be cleaner (which is usually the case in a developing-developed country story) this in turn provides support for the pollution halo hypothesis. Our model can therefore be considered as an extension to the existing research in this area. We have shown our result is plausible within a certain range of parameter values for the fixed plant and firm set-up costs (G and F), the tariff rate S and a marginally higher environment permit fee T. Furthermore, we show that a tightening of environmental regulation does not necessarily reduce the profitability of foreign firms and the probability of choosing FDI as the preferred mode of entry, especially when such an increase deters the entry of domestic firms. Finally, when the production process of the domestic firm is sufficiently dirty, marginally more stringent environmental regulations could also improve total social welfare even when foreign firms replace domestic producers.

The framework in this paper may help us interpret the mixed evidence found in the FDI and environmental regulation literature. Many of these papers are cross-sectional in nature and tend to try and measure the FDI decision of foreign firms when faced with differences in environmental regulations between developing countries. If, under certain circumstances, FDI is attracted to higher regulation regions it would explain the lack of compelling evidence that countries are engaged in a "race to the bottom" to attract foreign firms. In future research it would be useful to try and identify regulation induced FDI ideally through a natural experiment where different regions perhaps within a country (e.g. China) have different permit costs but are otherwise very similar (wage rates, infrastructure, access to markets, population etc.).

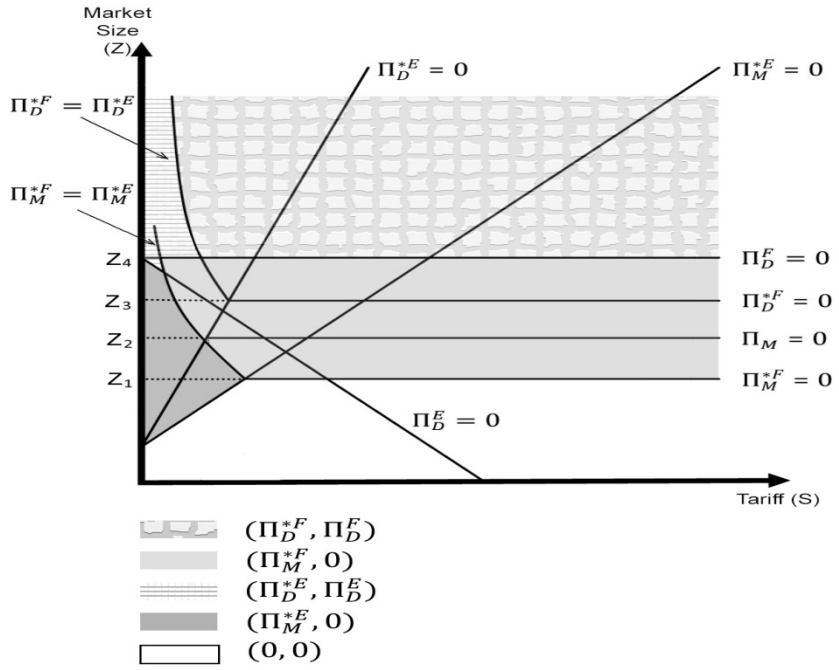

Figure 1: Market structure and firm choice

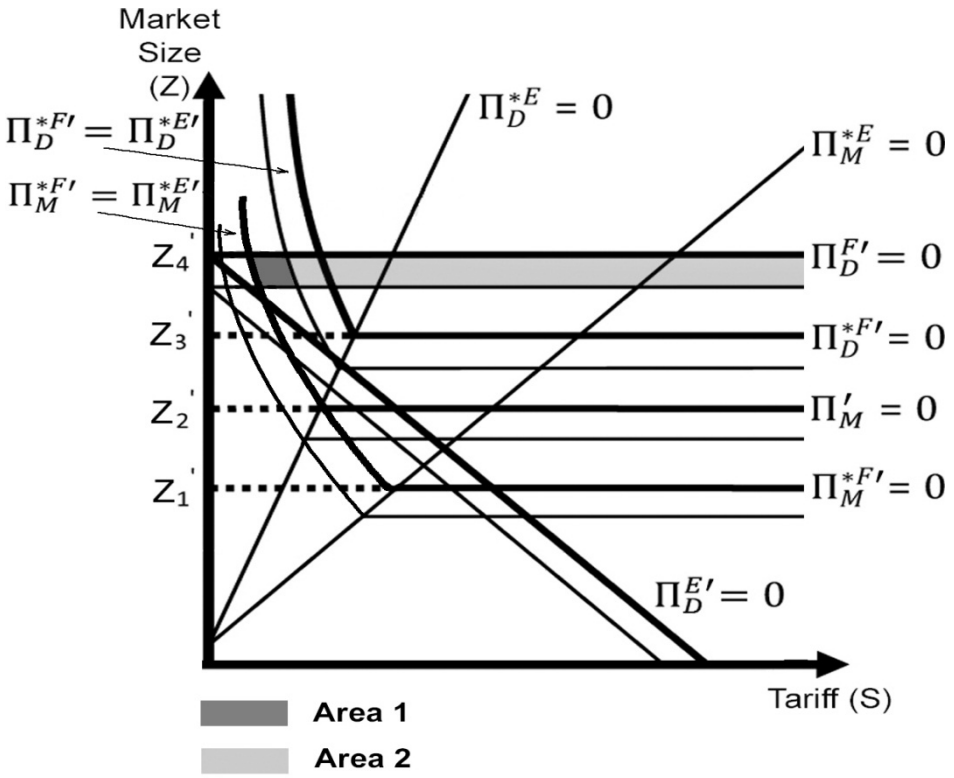

Figure 2: The effect of a marginally more stringent environmental regulation on entry choice

Appendix

Derivation of the range for marginally more stringent environmentally induced FDI

If the government's environmental regulation becomes more stringent with a higher environmental permit fee $T' = T + \varepsilon$, where ε>0 and marginally small, then from the discussion in the main text we know that area 1 in figure 2 represents the case with the assumption of lax environmental regulations that the market equilibrium will be an exporting duopoly and under marginally more stringent environmental regulation the market equilibrium would be an FDI monopoly. This section provides the derivation of the range for the marginally more stringent environmental policy that could induce such pattern.

As shown by area 1 in figure 2, under marginally more stringent environmental regulation the market equilibrium (i.e. Nash equilibrium outcome) would be an FDI monopoly, which that given the domestic firm does not enter the market it would be optimal for the foreign firm to enter with FDI. This requires profits from FDI be higher than both exporting and not entering, which means:

$$\widehat{\Pi}_M^{*F'} = \widehat{\Pi}_M^{*F} - \varepsilon \geq \widehat{\Pi}_M^{*E}, \quad (A1)$$

and

$$\widehat{\Pi}_M^{*F'} = \widehat{\Pi}_M^{*F} - \varepsilon \geq 0\,. \quad (A2)$$

Since with lax environmental regulation (i.e. *T*) the market equilibrium is an exporting duopoly, we know that $\widehat{\Pi}_D^{*E} \geq 0$. Because the foreign firm can always make a higher profit as an exporting monopolist than exporting duopolist (i.e. $\widehat{\Pi}_M^{*E}$>$\widehat{\Pi}_D^{*E}$), therefore $\widehat{\Pi}_M^{*E} > 0$. This means condition (A2) would be automatically satisfied if condition (A1) holds. This means, given the domestic firm chooses not to enter that FDI would be the optimal choice for the foreign firm if the more stringent environmental regulation is not too high such that:

$$0 < \varepsilon \leq \widehat{\Pi}_M^{*F} - \widehat{\Pi}_M^{*E}. \quad (A3)$$

Similarly, for FDI monopoly to be the market equilibrium under marginally more stringent environmental policy, given the foreign firm chooses FDI, not entering must be the optimal choice for the domestic firm. This requires:

$$\widehat{\Pi}_D^{F'} = \widehat{\Pi}_D^{F} - \varepsilon < 0,$$

$$\varepsilon > \widehat{\Pi}_D^{F}. \quad (A4)$$

Furthermore, given the market equilibrium is within the area 1 in figure 2, from the discussion in the main text we know that although the domestic firm would not be able to break even as an FDI duopolist but it could still break even as an exporting duopoly. This means the condition below must hold:

$$\widehat{\Pi}_D^{E'} = \widehat{\Pi}_D^E - \varepsilon \geq 0.$$

$$0 < \varepsilon \leq \widehat{\Pi}_D^E. \quad (A5)$$

We can combine the inequalities (A4) and (A5) above, it can be written as the inequality below:[17]

$$0 \leq \widehat{\Pi}_D^F < \varepsilon \leq \widehat{\Pi}_D^E. \quad (A6)$$

From discussion in the main text and this appendix we know that given perfect information and a rational domestic firm, when the more stringent environmental regulation ($T' = T + \varepsilon$) is in the range represented by conditions (A3) and (A6) simultaneously it would be optimal for the foreign firm to pre-empt the domestic firm by entering via FDI. This means a more stringent environmental regulation satisfies conditions (A3) and (A6) and could induce FDI from the foreign firm compared to the case under lax environmental regulation.

[17] Under lax environmental regulation (T) the area 1 in figure 2 is above the line $\widehat{\Pi}_D^F = 0$, which means condition (A2) is feasible.

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