Foreign Direct Investment and Environmental Taxes

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Abstract

This paper discusses environmental policies in response to foreign direct investment (FDI) in a symmetric two-country setting, where firms' behavior affects government policy decisions. We show that two alternative equilibria with FDI are possible: (i) one with unilateral FDI, where one firm is a multinational firm, and the other firm is a national firm; (ii) and one with bilateral FDI, where both firms become multinational firms. With regard to strategic environmental policies, we show that the country attracting FDI introduces a Pigouvian environmental tax, whereas the country served by the local firm only levies a smaller tax rate. Hence, FDI does not lead to ecological dumping. With regard to welfare, we show that the impact on welfare is negative for the country hosting the national firm; positive for the country hosting the multinational firm, if FDI is unilateral; and ambiguous for both countries, if FDI is bilateral.

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1 Introduction

Recent years have been characterized by an unprecedented integration of commodity and factor markets in the world. The notion of globalization attempts to provide a catchword for this development. Since globalization seems to trigger substantial structural changes in each country, which is open to international competition, it is often not unanimously welcome. Some environmentalists, for example, are afraid that globalization can undermine public policies, which support environmental regulation. It is frequently argued that globalization might force governments in a locational competition process, in order to attract both domestic and foreign investment, often resulting in too lax environmental policies (i.e. "race to the bottom" or emergence of pollution "havens" are typical newspapers' headlines). These concerns led to the United Nations' international conferences in Rio de Janero in 1992 and in Kyoto in 1997 and, more recently, to the conference on the relationship between FDI and the environment organized by the OECD in the Hague in 1999 (OECD, 1999). The scientific community can help the debate move beyond polemics by answering the following questions: Is it strategically optimal for governments to employ unfriendly environmental policies in order to attract FDI? How would the firms' choice between FDI and exports be affected, if strategic environmental policies are introduced? How will welfare vary in the presence of FDI compared to trade? These are key questions that we try to answer with a noncooperative game-theoretical model, where firms choose the number and the regional location of their plants, and their behavior influences government environmental policy decisions. It is important to stress that we disregard from the analysis the problems associated with transfrontier pollution (i.e. global warming, acid rain), whilst we focus upon local pollution externalities, whose regulation affects

production locations' decisions of firms.

The economic literature on international integration and the environment started in the seventies and developed rapidly in the eighties and nineties. The link between trade and environment have been studied under perfect competition (Markusen, 1975, Krutilla, 1991) and imperfect competition (Conrad, 1993, 1996, Barrett, 1994; Kennedy, 1994). Another branch of the literature on trade and environment has examined the role of factor mobility within locational competition models (Rauscher, 1995) and when perfect capital mobility is postulated (Beladi, Chao, Frasca, 1999; section B.III in Scholz, Stähler, 1999).[1] In particular, the locational competition model of Rauscher (1995) determines the optimal policies when several governments interact strategically to attract one polluting industry. Conversely, in this paper, two firms decide whether or not to invest in the country where the other firm is located. Hence, both strategic effects between firms and governments are taken into account.

Regarding FDI, the literature distinguishes between horizontal FDI, which replaces trade, and vertical FDI, which is complementary to trade. In the horizontal case, a firm sets up a production plant in the foreign country to serve the foreign market. In the vertical case, this plant serves the foreign market as well as the domestic market. In this paper, we assume that FDI is horizontal, an hypothesis which is also supported by recent empirical evidence (see Brainard, 1997, Blonigen, 1999, Markusen and Maskus, 2000). Models which explain horizontal FDI as a result of strategic behavior of firms are those of Markusen (1984), Horstmann, Markusen (1992), Brainard (1993), Markusen, Morey and Olewiler (1993, 1995), Markusen, Venables (1998, 2000). In particular, Markusen, Morey and Olewiler (1993) set up a numerical model, which studies the

[1] An excellent overview of all these models can be found in Rauscher (1997).

effects of exogenous environmental policies introduced by one region on plant location and industrial structure in both regions; whereas Markusen, Morey and Olewiler (1995) extend their previous model to incorporate the strategic behavior of governments. They set up a two-stage non-cooperative game with trade and horizontal FDI, which links strategic environmental policies with a model of endogenous plant location and industrial structure. However, the model is solved numerically for a certain range of parameter values. Hence, the exhaustive characterizaton of all possible equilibria is not provided.

As pointed out by Markusen, Morey and Olewiler (1995), the discontinuity of the reaction curves due to the fact that firms can change the location and the number of their plants makes the analysis complex in an increasing returns to scale setting. In this paper, we tackle this analytical problem and we solve for the sub-game perfect Nash equilibrium of a three-stage game with trade and horizontal FDI, where governments and firms play Nash. The main difference from the numerical model suggested by Markusen, Morey and Olewiler (1995) is that at the first stage of the game we assume that firms decide their long-run investment policies and, as a result of this choice, strategic environmental policies of governments are influenced.

Since the intraindustry trade equilibrium is the benchmark for our analysis, firstly, we replicate some results already known in the literature. Regarding the environmental taxes, we show that the strategic tax rate is lower than its Pigouvian level, as governments have an incentive to correct domestic distorsions due to the duopoly and to shift profits to the local firm against the foreign competitor (see also Conrad, 1996). Regarding welfare, we show that intraindustry trade compared to autarky can lead to welfare losses as in Brander and Krugman (1983), also if governments pursue strategic environmental taxation policies.

Then, we study strategic environmental policies in response

to FDI in a three-stage setting where two symmetric countries and two firms are involved, and where firms' behavior affects policy decisions. We find that two alternative Nash equilibria in the presence of FDI are possible: (i) one with unilateral FDI, where one firm is a multinational firm, and the other firm is a national firm, which does not longer exports; (ii) and one with bilateral FDI, where both firms become multinational firms. With regard to environmental policies, we show that the country attracting FDI introduces a Pigouvian environmental tax, whereas the country served by the local firm only, regardless if it is a national firm or a multinational firm, levies a smaller tax rate. Finally, regarding social welfare, we show that the impact on welfare is negative for the country hosting the national firm; positive for the country hosting the multinational firm, if FDI is unilateral; and ambiguous for both countries, if FDI is bilateral.

This paper is organized as follows. Section 2 introduces the model. Section 3 discusses strategic environmental policies under intraindustry trade. Section 4 explores the impact of FDI on strategic environmental policies, trade flows and welfare. Section 5 provides some concluding remarks.

2 The model

The theoretical model used in this paper is an extension of the two-stage non-cooperative numerical model used by Markusen, Morey and Olewiler (1995), used to study the effects of strategic environmental policies on market structure and plant location. Like the cited model, we assume that (i) an oligopolistic firm produces a good with increasing returns to scale, (ii) local pollution is generated as a by-product of the production of the oligopolistic good, (iii) both governments play strategically as their policies might change the international competitiveness of the firms. However, we also assume that firms' long run policy

decisions can influence taxation policies. We solve for a subgame-perfect Nash equilibrium of the three-stage theoretical game. By so doing, we provide the entire characterization of all possible equilibria regarding plant location and industrial structure, and we study the impact on social welfare.

We consider two countries, a domestic country and a foreign country. All terms associated with the foreign country are denoted by a star. Both countries are identical with respect to preferences, endowment and size. The resulting symmetry simplifies greatly the expressions for the solution of the game and reduces the total number of the equations to be shown since we consider the domestic country only whenever it is possible. There is only one production factor, L. In both countries, a homogeneous good Z is produced under perfect competition by using this production factor such that $L^Z = Z$, where the superscript denotes the sector in which the factor is used. The price of Z or the return on L is the numeraire of the model. There is no pollution associated with the production or consumption of Z. Exporting Z is assumed to raise no trade costs. In order to keep the structure of the model simple, the consumers' preferences in each country are given by the quadratic utility function $U(X, Z, D) = aX - bX^2/2 + Z - D$, where X denotes the consumption of the product produced by the oligopolistic industry and D the environmental damage, which is a public 'bad'. We assume an international duopoly for the oligopolistic industry, where one firm is located in each country.[2] By using the typical terminology in the literature, we will refer to a firm which serves the foreign market with exports as a *national firm*, and to a firm which does it with a plant set up abroad as a *multinational firm*.

Assume that the consumer structure is atomistic in the sense that consumers do not take into account the effects of their be-

[2]For an analytical model which can explain endogenously FDI, trade, and the equlibrium number of firms see De Santis, Stähler (1999).

havior on environmental damage. Namely, each individual views the total production of pollution as exogenous. In this context, market failure would occur, if the externality were not internalized via government intervention. Given the aggregate resource constraint $L + \Pi + T = pX + Z$, where Π denotes the profits of the domestic firm, T the domestic tax revenues and p the price of X in terms of the numeraire, maximization of U subject to the resource constraint yields the following inverse income inelastic demand function:

$$p = a - bX. \tag{1}$$

With regard to the equilibrium in the goods market, let $y(y^*)$ denote the production of the domestic (foreign) firm for the domestic (foreign) market, and $x(x^*)$ the production of the foreign (domestic) firm for the domestic (foreign) market.[3] Then, the equilibrium in the goods market is given by $X = x + y$ in the domestic country, and by $X^* = x^* + y^*$ in the foreign country. Note that $x(x^*)$ denotes exports of the foreign (domestic) firm, if the latter is a national firm, or FDI of the foreign (domestic) firm, if the latter is a multinational firm.

Regarding the environmental damage, we assume that pollution is not global, in the sense that international spillovers exist, and it depends linearly on the level of aggregate production within the domestic country, P: $D = \delta P$, where $\delta > 0$ reflects the constant marginal disutility from pollution. It is important to emphasise that $P = x^* + y$, if both firms are national firms; $P = x + y$, if both firms are multinational firms; $P = x + x^* + y$, if the domestic firm is a national firm and the foreign firm is a multinational firm; and $P = y$, if the domestic firm is a multinational firm and the foreign firm is a national firm. Needless to say that the strategically optimal environmental policies will depend on the type of firms serving the market.

[3]The superscript refers to the destination of the respective production.

The international duopoly is characterized by imperfect competition and Cournot behavior. Each firm faces a fixed set-up cost and produces one good, which is traded within the home market and may be exported or produced abroad. Exports and FDI are assumed to be perfect substitutes, which implies that we focus our analysis upon *horizontal* FDI. Firms' production decisions depend on the fixed costs, the marginal cost c, environmental taxes t and the trade costs s. Markets are segmented in the sense that each firm is able to regard each country as a separate market. Thus, each firm maximizes its profit function with respect to both the sales in the foreign market and the production for the domestic market, and chooses the profit-maximizing quantity for each country separately.

The profits of a firm with headquarters located in the domestic country depend on the firm's type. The profits of the domestic national firm, Π_n, are given by (2), whilst the profits of a domestic multinational firm, Π_m, are given by (3):

$$\Pi_n = (p - c - t)y + (p^* - c - t - s)x^* - F - G, \qquad (2)$$

$$\Pi_m = (p - c - t)y + (p^* - c - t^*)x^* - F - 2G, \qquad (3)$$

where F denotes the firm-specific fixed costs for headquarters and G the plant-specific fixed costs for setting up a production plant. A national firm has to carry trade costs s, which depend linearly on exports. This variable collects all costs associated with cross-border activities. Conversely, the multinational firm saves the variable trade costs s, but has to carry the additional fixed costs G to set up a second plant in the other country.[4]

Note that if the firm serves the foreign market by exporting goods, these exports will be subject to the domestic environmental tax t; by contrast, if the firm serves the foreign market

[4]As argued by Horstmann, Markusen (1992), the fixed costs can be assumed to be so high that only two firms are active in each of the two markets.

with FDI, the production in the foreign country will be subject to the foreign environmental tax t^*.[5]

Similarly, (4) and (5) give the respective profit structure of the national, Π_n^*, and multinational foreign firm, Π_m^*:

$$\Pi_n^* = (p^* - c - t^*)y^* + (p - c - t^* - s)x - F - G, \qquad (4)$$

$$\Pi_m^* = (p^* - c - t^*)y^* + (p - c - t)x - F - 2G. \qquad (5)$$

Given the quasi-linear structure of the utility function, we can measure welfare by the sum of firms' profits, $\Pi = \Pi_n + \Pi_m$, consumer surplus, CS, tax revenues, the disutility of pollution, and labor income.[6] That is,

$$W = \Pi + CS + (t - \delta)P + L. \qquad (6)$$

Given the linear inverse demand function (1), consumer surplus is determined by $CS = bX^2/2$. For simplicity, (6) assumes that taxation is not distortionary. The advantage of (6) is that we can derive a simple measure for the internalization of the environmental damage. If the environmental tax rate is such that $t = \delta$, then perfect internalization occurs, because the marginal damage is equal to the marginal tax rate. This case will be referred to as the Pigouvian tax rate. If, instead, the environmental tax rate is such that $t < \delta$, then the tax rate falls short of its Pigouvian level and internalization is incomplete. It is important to emphasize that this categorization does not allow us to draw any conclusion concerning welfare, because imperfect competition implies market distortions, which also have to be taken into account.

[5]Note that indirect taxation follows the origin principle if production is taxed, and the destination principle if consumption is taxed. In this paper, (2) and (4) apply the origin principle, whereas (3) and (5) apply the destination principle. The welfare effects of these alternative tax principles under trade and imperfect competition have been examined by Keen, Lahiri (1998) and Haufler, Schjelderup, Stähler (2000).

[6]The entire profits of the multinational firm belong to the country where its headquarters are located.

3 Environmental policy under trade

For the time being, assume that FDI is banned and that intraindustry trade takes place among countries. The results of the intraindustry trade model will serve as a benchmark to study the impact of FDI liberalization on firms' location and production, and on strategic environmental taxes and social welfare.

In this section, we set up a simple two stage non-cooperative game between firms and governments: in the first stage, both governments decide simultaneously on environmental taxation; in the second stage, both firms compete á la Cournot. This game structure acknowledges that competition in the output market is based on short-run decisions by firms, whereas environmental taxation is based on medium-run decisions by governments. The game is solved in the backward induction fashion under the full information assumption.

By using (1), (2) and (4), the f.o.c.'s describing firms' behavior imply the following equilibrium output levels in the intraindustry trade equilibrium:

$$\begin{aligned} y_I &= \frac{a-c-2t+t^*+s}{3b}, \\ x_I &= \frac{a-c-2t^*+t-2s}{3b}, \\ x_I^* &= \frac{a-c-2t+t^*-2s}{3b}, \end{aligned} \tag{7}$$

which can then be used to compute the consumer surplus and the profits of the domestic firm as follows:

$$\widetilde{CS}_I = \frac{(2(a-c)-s-t-t^*)^2}{18b}, \tag{8}$$

$$\tilde{\Pi}_I = \frac{(a-c-2t+t^*+s)^2+(a-c-2t+t^*-2s)^2}{9b} - F - G. \tag{9}$$

The maximized terms are denoted by a tilde. Similarly, the equilibrium output levels can be used to determine the tax revenues corrected by the environmental damage as follows:

$$\tilde{T}_I - \tilde{D}_I = (t - \delta)\frac{2(a-c) - s - 4t + 2t^*}{3b}. \tag{10}$$

Social welfare (6) in the intraindustry trade equilibrium, W_I, is then the sum of (8), (9) and (10). Differentiation of domestic welfare with respect to t yields

$$\frac{dW_I}{dt} = 2(2(a-c) - 6\delta - s) + 7t + t^*. \tag{11}$$

The strategic tax rates can be determined by setting (11) equal to zero. Given the symmetry assumption of the intraindustry trade model, then

$$\tilde{t}_I = \tilde{t}_I^* = -\frac{a-c-\delta}{4} - \frac{a-c-s-\delta}{4} + \delta. \tag{12}$$

Expression (12) collects three incentives for government intervention. Firstly, the government of each country wishes to correct the distortion existing in its own market, due to the presence of the duopoly. This incentive alone implies a subsidy (see the first term in (12), which we refer as the *domestic correction* incentive). Secondly, the government can subsidize exports of its home firm in order to shift profits from the foreign country to the home country (see the second term in (12), which we refer as the *profit shifting* incentive). This is the classic incentive already analyzed by Brander and Spencer (1984). Thirdly, the government has to take into account the externality which is caused by its own firm in producing goods to be supplied internally and exported (see the third term in (12), which we refer as the *environmental protection* incentive). The first two incentives imply a negative tax, whereas the third incentive leads to a positive tax. Although the aggregate effect

is ambiguous in sign, the strategic environmental tax rate is lower than the marginal damage. Lemma 1 summarizes and proves this result:

Lemma 1: *In the case of intraindustry trade, the strategic environmental tax rate is lower than the Pigouvian tax rate.*

Proof: The proof of Lemma 1 can be given by contradiction. By inserting (12) into (7), we can determine the necessary condition for exports, x_I^*, to be positive. This is the case if

$$2(a-c) - 2\delta - 3s \geq 0. \tag{13}$$

If $\tilde{t}_I = \tilde{t}_I^* > \delta$, by using (12), $2(a-c) - 2\delta - 3s < -2s < 0$, which given (13) would imply $x_I^* < 0$. ■

A similar result can be also found in Conrad (1996). Note that Lemma 1 does not necessarily warrant a negative tax. On the contrary, $\tilde{t}_I > 0$ implies $-2(a-c) + s + 6\delta > 0$ which does not violate condition (13). Note also that the negative *profit shifting* incentive weakens as s increases. This is because high trade costs make profit shifting more costly, as the home firm finds itself in a substantial cost disadvantage in the foreign country. The positive effect of δ on the tax rate can be easily interpreted. Since the *domestic correction* incentive and the *profit shifting* incentive lead to an output expansion of the domestic firm, the resulting increase in environmental damage ought to be corrected to maximize consumer's welfare. In particular, if δ is in the range $[(a-c)/3 - s/6, a - c - 3s/2]$, then the *environmental protection* incentive would dominate the other two incentives, and the strategic environmental tax rate would be positive. However, if $\delta < (a-c)/3 - s/6$ and $\delta < s/2$, then the *environmental protection* incentive is too weak, and the strategic tax rate would be negative.

Regarding welfare, we can compute the reduced form of welfare, denoted by a hat, by inserting (12) into (8), (9) and (10). That is,

$$\hat{W}_I = \hat{W}_I^* = \frac{(a-c-\delta)^2}{2b} - \frac{s(4(a-c-\delta)-5s)}{8b} - F - G + L. \tag{14}$$

Let us now explore the welfare implications of trade compared to autarky, observing that autarky would be an equilibrium if (13) is violated. That is, if $s > 2(a-c-\delta)/3$. Lemma 2 demonstrates that the welfare implications of trade are ambigous.

Lemma 2: *In the intraindustry trade setting, welfare is convex in trade costs, s. It decreases (increases) with s, if s is lower (larger) than* $2(a-c-\delta)/5$.

Proof: Since only the second term in (14) depends on s, we can concentrate our analysis on its behaviour:

$$\Sigma(s) := \frac{s(4(a-c)-4\delta-5s)}{8b}, \Sigma' = \frac{4(a-c)-4\delta-10s}{8b}, \Sigma'' < 0. \tag{15}$$

Σ has a maximum at $\bar{s} = 2(a-c-\delta)/5$. Since exports are profitable only if $s \leq 2(a-c-\delta)/3$, then $\bar{s}$ is within the relevant range. The maximum of the function Σ is given by

$$\Sigma(\bar{s}) = \frac{(a-c-\delta)^2}{10b}. \tag{16}$$

This implies that the value of the function $\hat{W}_I(\bar{s}) = \hat{W}_I^*(\bar{s})$ is a minimum. ■

The potential welfare losses of intraindustry trade with a fixed market structure have already been demonstrated by

Brander and Krugman (1983) in a model without any policy intervention. Lemma 2 shows that this result holds also if governments pursue strategic environmental policies.

It is also interesting to note that (12) into (9) yields the reduced form of profits

$$\hat{\Pi}_I = \hat{\Pi}_I^* = \frac{(a-c-\delta)^2}{2b} - \frac{s(4(a-c-\delta)-5s)}{8b} - F - G, \tag{17}$$

which coincides with the first four terms in (14). This implies that consumer surplus and the difference between tax revenues and the environmental damage offset each other. In the subsequent section, we relax the assumption that FDI are banned and we take (14) as the benchmark for welfare analysis.

4 Environmental policy under trade and FDI

How do strategic environmental taxation and welfare change when FDI can be made? If FDI is liberalized, the game presented in the previous section becomes more elaborated, because firms can decide on their long-run investment policies. In other words, they have to decide whether to remain national firms or to become multinational firms. Since investment is a long-run decision with a high degree of commitment by firms, we employ the following three stage game: in the first stage, firms decide simultaneously on their type; in the second stage, governments decide simultaneously on environmental taxation; and in the third stage, firms compete in the usual Cournot-Nash fashion. Table 1 summarizes the game structure of this section, which is solved by backward induction. Three alternative market structure equilibria ought to be distinguished in the last stage: intraindustry trade, where both the domestic and the foreign firm are national firms; bilateral FDI, where both firms are multinational firms;

Table 1: Game structure of the model incorporating FDI

Stage I: Both firms decide simultaneously whether or not to make FDI.
Stage II: Both governments decide simultaneously on environmental taxes.
Stage III: Both firms decide simultaneously on their production levels in both markets.

and unilateral FDI, where one firm is a multinational firm and the other firm is a national firm. Strategic environmental taxes, profits and welfare levels have been already computed for the intraindustry trade case in the previous section. These variables will be determined for both the bilateral and the unilateral FDI equilibria respectively in the next two sub-sections.

4.1 The bilateral FDI equilibrium

Assume that bilateral FDI is the Nash equilibrium.[7] At the third stage, given the inverse demand function (1), the maximisation of (3) and (5) yield the following equilibrium output levels in the domestic country

$$y_B = x_B = \frac{a - c - t}{3b}, \tag{18}$$

which are then used to compute the domestic damage function

$$\tilde{D}_B = \delta(y_B + x_B) = \delta\frac{2(a - c - t)}{3b}, \tag{19}$$

[7]Its proof is given in sub-section 4.3.

and, given the symmetry assumption, the domestic profits

$$\tilde{\Pi}_B = \frac{(a-c-t)^2 + (a-c-t^*)^2}{9b} - F - 2G. \qquad (20)$$

Finally, the welfare function (6) in the bilateral FDI case is equal to

$$W_B = \frac{(a-c-t)^2}{3b} + \frac{(a-c-t^*)^2}{9b} + (t-\delta)\frac{2(a-c-t)}{3b} \qquad (21)$$
$$-F - 2G + L.$$

At the second stage, the social planner has to compute the strategic environmental tax rate, which maximizes social welfare. The solution is summarized by Proposition 1.

Proposition 1: *In the case of bilateral FDI, the strategic environmental tax rate coincides with the Pigouvian tax rate in both countries.*

Proof: Maximization of (21) with respect to t leads to $\tilde{t}_B = \delta$. ■

Proposition 1 is a surprising result because strategic incentives are not absent in this setting. The government has the incentive to correct the market distortions with a subsidy (*domestic correction* incentive). But, at the same time, it wishes to tax the production in the domestic country of the foreign multinational firm. Clearly, the *profit shifting* incentive is different from that discussed in the intraindustry trade case, because it is not domestic exports but foreign "imports" (which are produced in the domestic country) which are subject to environmental taxation. To a certain extent, the *profit shifting* incentive is similar to the tariff argument of Brander, Spencer (1984). Proposition 1 shows that the *domestic correction* incentive and the *profit shifting incentive* offset each other, leaving

effective only the *environmental protection* incentive.[8] Clearly, FDI does not lead to ecological dumping, as one might believe in the first place.

Given the symmetry of the bilateral FDI case, the reduced forms of profits and welfare turn out to be respectively equal to

$$\hat{\Pi}_B = \hat{\Pi}_B^* = \frac{2(a-c-\delta)^2}{9b} - F - 2G, \tag{22}$$

$$\hat{W}_B = \hat{W}_B^* = \frac{4(a-c-\delta)^2}{9b} - F - 2G + L. \tag{23}$$

4.2 The unilateral FDI equilibrium

Assume that unilateral FDI is the Nash equilibrium.[9] For convenience, assume also that the foreign firm is the multinational firm and the domestic firm is the national firm. Under this scenario, the appendix can substantiate the following Lemma 3.

Lemma 3: *In the case of unilateral FDI, the national firm no longer exports to the home country of the multinational firm.*

Proof: See appendix.

The proof of Lemma 3 is tedious and lengthy. Therefore, it is relegated to the appendix. However, the basic intuition behind this result is that three types of environmentally harmful activities within the domestic country (these are, the output produced by the domestic firm for the domestic and the foreign market and the output produced by the foreign firm in the domestic market) may imply substantial environmental

[8] We should emphasize that this result depends crucially on the assumption of linear demand. For the influence of consumer preferences on the sign of commodity tax rates, see Haufler, Schjelderup, Stähler (2000).

[9] Its proof is given in sub-section 4.3.

damage. Clearly, the domestic country's *profit shifting* incentive to tax the multinational firm harms the potential exports of the domestic firm. As a result, the tax would be comparably high, since the *environmental protection* incentive becomes important. Furthermore, the *domestic correction* incentive in the foreign country deteriorates the competitive position of the domestic firm in the foreign market. Lemma 3 suggests that these effects are so strong that exports are not longer profitable.

Given Lemma 3, the national firm is producing only for the home market and faces competition by the multinational firm, whilst the foreign multinational firm is a monopolist in its home market. The profit maximizing f.o.c.'s allow us to determine the following production and consumption levels in the domestic market:

$$x_U = y_U = \frac{a-c-t}{3b}, P_U = X_U = \frac{2(a-c-t)}{3b}, \qquad (24)$$

which can be used to determine the maximized profits of the domestic national firm

$$\tilde{\Pi}_U = \frac{(a-c-t)^2}{9b} - F - G, \qquad (25)$$

and the domestic social welfare

$$\tilde{W}_U = \frac{(a-c-t)^2}{3b} + (t-\delta)\frac{2(a-c-t)}{3b} - F - G + L, \qquad (26)$$

which depends only on the domestic tax rate. Proposition 2 derives the strategically optimal environmental policy for the domestic country.

Proposition 2: *In the case of unilateral FDI, the country hosting the national firm introduces a strategic environmental tax rate, which coincides with the Pigouvian tax rate.*

Proof: Differentiating (26) with respect to t yields $\tilde{t}_U = \delta$. ■

Proposition 2 and Proposition 1 give the same solution for the domestic country, because the effects are similar. The *domestic correction* incentive and the *profit shifting* incentive compensate each other for the same reasons already discussed in the previous subsection, such that only the *environmental protection* incentive is left.

What happens to the foreign country? Without facing any competition from the national firm, the equilibrium output of the foreign firm for the foreign market is given by the monopoly output

$$y_U^* = P_U^* = \frac{a - c - t^*}{2b}. \tag{27}$$

By using (24) and (27), the profits of the foreign multinational firm are equal to

$$\tilde{\Pi}_U^* = \frac{(a - c - t)^2}{9b} + \frac{(a - c - t^*)^2}{4b} - F - 2G. \tag{28}$$

Note that the first term gives the profits realized in the domestic country and the second term gives the monopoly profits realized in the foreign country. Finally, by collecting consumer surplus, profits and the difference between tax revenues and environmental damage, aggregate welfare in the foreign country adds up to

$$W_U^* = \frac{3(a - c - t^*)^2}{8b} + \frac{(a - c - t)^2}{9b} + (t^* - \delta)\frac{a - c - t^*}{2b} - F - 2G + L. \tag{29}$$

Proposition 3 draws the environmental policy conclusion for the foreign country.

Proposition 3: *In the case of unilateral FDI, the country*

hosting the multinational firm introduces a strategic environmental tax rate which falls short of the Pigouvian tax rate.

Proof: Differentiation of (29) with respect to t^* yields $\tilde{t}_U^* = -(a - c - \delta) + \delta$. This tax rate is larger than δ if, and only if, $\delta > a - c$, which would imply $y_U^* < 0$. ■

Since the domestic firm is no longer active in the foreign country and the foreign activities of the foreign multinational firm are subject to domestic taxation, the foreign government balances only two incentives: on the one hand, it has to correct the market imperfections due the monopoly power (*domestic correction* incentive); on the other hand, it has to internalize the environmental damage (*environmental protection* incentive). This is the reason why the strategic tax rate is lower than the Pigouvian level. Note that Proposition 3 does not necessarily imply a subsidy.[10] A positive tax rate requires $a - c < 2\delta$, which does not violate the necessary condition $y_U^* > 0$. More precisely, a strategic environmental tax rate is positive if $\delta < a - c < 2\delta$, but negative if $a - c > 2\delta$. In other words, $\tilde{t}_U^* > 0$, if the disutility of pollution is sufficiently large compared to the size of the market. Note that $\tilde{t}_U^* = -(a - c - \delta) + \delta$ is also the tax rate which we would observe in autarky. Since the foreign firm faces no competition in its home market, business conditions for the foreign firm in the home market do not differ between unilateral FDI and autarky. Note also that $\tilde{t}_U^* < \tilde{t}_I^*$, because only one type of environmental harmful activity is carried out in the foreign country (that is, the production of the multinational firm for the foreign country).

The reduced form of domestic and foreign profits can be ob-

[10] Note also that the tax structure described by Proposition 2 and Proposition 3 is consistent with Lemma 3 since $x_U^* = (a - c - 2t + t^* - 2s)/3b$ (see (A.1) in the appendix) would be equal to $-2s/3b$ and, hence, exports are not profitable.

tained by inserting the results of Propositions 2 and 3 respectively into (25) and (28):

$$\hat{\Pi}_U = \frac{(a-c-\delta)^2}{9b} - F - G. \tag{30}$$

$$\hat{\Pi}^*_U = \frac{10(a-c-\delta)^2}{9b} - F - 2G. \tag{31}$$

Whereas the reduced forms of the welfare levels in the domestic and the foreign country can be obtained by inserting the results of Propositions 2 and 3 respectively into (26) and (29):

$$\hat{W}_U = \frac{(a-c-\delta)^2}{3b} - F - G + L, \tag{32}$$
$$\hat{W}^*_U = \frac{11(a-c-\delta)^2}{18b} - F - 2G + L.$$

4.3 FDI as a Nash equilibrium

In the two previous sub-sections, we have only considered the effects of bilateral and unilateral FDI on environmental taxation. But we have not shown whether and under which conditions FDI is a Nash equilibrium. Basically, the first stage of the game described in Table 1 has not yet been solved. To calculate the Nash equilibrium, we have to examine the best responses of firms to various strategy choices. Suppose that the foreign firm wishes to make FDI. Then, it would have an incentive to go for this long run investment decision policy if, and only if, its profits under intraindustry trade are not larger than its profits under unilateral FDI. Namely, a foreign firm has an incentive to become a multinational firm if (17) $\leq$ (31). The equality between these two expressions allows us to compute a critical G:

$$G' = \frac{11(a-c-\delta)^2}{18b} + s\frac{4(a-c-\delta)-5s}{8b}, \tag{33}$$

such that if the factual G is lower than G', then the foreign firm becomes a multinational firm. However, $G \leq G'$ does not describe a complete equilibrium behavior, because the domestic firm can react with its own maximizing strategy. The first Nash equilibrium is summarized in Proposition 4.

Proposition 4: *An asymmetric industry equilibrium characterized by asymmetric strategic environmental tax rates can be a Nash equilibrium.*

Proof: The proof can be shown by considering the one-shot deviation property of an asymmetric equilibrium. Suppose that G is not larger than G', so that the foreign firm is not better off by not investing abroad, given that the other domestic firm is a national firm. Then, the domestic firm has also an incentive in becoming a multinational firm if (30) is not larger than (22). The equality between these two expressions gives a critical G'':

$$G'' = \frac{(a-c-\delta)^2}{9b}. \tag{34}$$

If the factual G is larger (less) than G'', then the domestic firm will refrain from (go for) an FDI policy. If, however, $G \leq G''$, the domestic firm is not worse off by making FDI, given that the foreign firm is a multinational firm. Hence, the proof for the existence of an asymmetric equilibrium is complete if $G' > G''$. The latter disequality means that a non-empty range for G exists so that the foreign firm becomes a multinational firm and the domestic firm remains a national firm. The difference between G' and G'' proves that this is in fact true:

$$G' - G'' = \frac{4(a-c-\delta)^2 + s(4(a-c-\delta) - 5s)}{8b} > 0 \qquad \blacksquare \tag{35}$$

Although countries are symmetric, a Nash equilibrium with an asymmetric industry structure and asymmetric environmental tax rates may exist. Proposition 4 is by no means a trivial conclusion, especially if one considers the fact that an asymmetric equilibrium can never exist, if tax rates are exogenously fixed and symmetric (see the appendix for a proof). This implies that firms can anticipate the effects of alternative strategic tax rates on market structure equilibria. These anticipated effects imply different profitability conditions and the possibility for an asymmetric equilibrium.

In summary, if $G \leq G''$, the unique Nash equilibrium is given by bilateral FDI. However, if $G'' < G \leq G'$, the unique Nash equilibrium is represented by unilateral FDI.

4.4 FDI and welfare

With regard to welfare in the unilateral FDI case, an asymmetric equilibrium is likely to imply also an asymmetric distribution of welfare effects. We can explore the welfare impact of unilateral FDI by using (32).

Proposition 5: *In an asymmetric FDI equilibrium, the welfare of the country hosting the headquarters of the multinational firm improves, whereas the welfare of the country hosting the national firm deteriorates.*

Proof: Compare (32) with (14). The switch from intraindustry trade to unilateral FDI is welfare improving for the domestic country if, and only if, $\hat{W}_U$ in (32) is larger than $\hat{W}_I$ in (14), which implies that

$$s\frac{4(a-c-\delta)-5s}{8b} - \frac{(a-c-\delta)^2}{6b} > 0. \qquad (36)$$

However, we know from (15) and (16) that $s[4(a-c-\delta)-5s]/8b$ is smaller than or equal to $(a-c-\delta)^2/10b$, which is in contradiction with (36). Similarly, the foreign country is worse off if, and only if, $\hat{W}^*$ in (32) is less than $\hat{W}^*$ in (14), which implies that

$$G > \frac{(a-c-\delta)^2}{9b} + s\frac{4(a-c-\delta)-5s}{8b}. \tag{37}$$

This requirement, however, contradicts the necessary condition (33), for the unilateral FDI to be a Nash equilibrium. ■

We observe from Proposition 5 that one country gains, whereas the other country loses if unilateral FDI is the Nash equilibrium. This is because the profits of the domestic firm decline due to the lack of exports, whereas the profits of the foreign firm increase because it does not longer face competition at home. In addition, the dumping effect of transport costs for the foreign consumer is annulled, whereas the domestic consumer has to carry an additional plant-specific fixed cost. Note that the country which imposes the Pigouvian environmental taxation internalizes the environmental damage, but is worse off in terms of social welfare. Conversely, the other country chooses a lower tax rate, but is better off. Hence, each country would rather prefer its own firm to become a multinational firm, even at the cost of insufficient environmental regulation.

What about the welfare effects of bilateral FDI? Proposition 6 summarizes the results.

Proposition 6: *In a symmetric FDI equilibrium, the welfare effects of FDI are ambiguous.*

Proof: Bilateral FDI compared to intraindustry trade does not lead to welfare losses, if (23) is larger than or equal to (14).

This is the case if,

$$G \leq s\frac{4(a-c-\delta)-5s}{8b} - \frac{(a-c-\delta)^2}{18b}, \qquad (38)$$

which, however, does not contradict the necessary condition (34) for bilateral FDI to be a Nash equilibrium. ■

Note that under bilateral FDI, the strategic tax rates are always positive. Due to these high rates, firms produce less and make less profits affecting social welfare negatively, despite the fact that the detrimental reciprocal dumping effect would not materialize. However, if the plant-specific fixed costs are sufficiently small, then FDI liberalization would result in mutual welfare gains because the lack of the reciprocal dumping effect would dominate the negative aggregate fixed costs effect.

We may now collect together our results. Let G''' denote the critical level of plant-specific fixed costs, at which the welfare levels of bilateral FDI and intraindustry trade equalize. G''' can be obtained from the equality constraint of (38). Table 2 summarizes the effects of FDI liberalization on environmental taxation and welfare, taking the intraindustry trade scenario as the point of reference.

5 Concluding remarks

This paper has discussed strategic environmental taxation policies in a noncooperative model of potential intraindustry trade and FDI. We have assumed that FDI requires a long-run commitment by firms to run a production plant in a foreign country. Hence, we assumed that firms decide to make FDI before governments introduce environmental regulation. This strategy may also reflect the understanding that governments are, to a certain extent, the hostages of potential multinational enterprises in a

Table 2: The impact of FDI on environmental taxation and welfare

$G > G'$ *Intraindustry trade* Both countries: Environmental taxes lower than Pigouvian rates
$G'' < G \leq G'$ *Unilateral FDI* Country hosting FDI: Pigouvian taxation and welfare loss Other country: Lower taxes and welfare improvement
$G''' < G \leq G''$ *Bilateral FDI* Both countries: Pigouvian taxation and welfare loss
$0 < G \leq G'''$ *Bilateral FDI* Both countries: Pigouvian taxation and welfare improvement

globalized economy. As a result, firms anticipate the reaction of governments to their investment decisions. Environmental policies are then no longer taken as given by firms, since firms' behavior can affect government policy decisions.

We have taken the case of intraindustry trade as the point of departure of our analysis. Due to imperfect competition, intraindustry trade implies taxes which fall short of the Pigouvian level, because governments have the incentive to correct domestic distortion and to promote exports with lower taxes. If FDI is liberalized, we show that two alternative Nash equilibria can occur: unilateral FDI, where one firm becomes a multinational firm and the other remains a national firm; bilateral FDI where both firms become multinational firms.

With regard to the impact on environmental taxation and welfare, the first important finding is that FDI does not lead to ecological dumping. On the contrary, we show that the country hosting FDI would introduce a Pigouvian tax rate. This result holds for both Nash equilibria. However, if FDI is unilateral, the country attracting FDI loses in terms of welfare although its tax is at the Pigouvian rate. Conversely, the other country gains unambiguously, despite insufficient internalization of the negative externality. Hence, each country would rather prefer its own firm to become a multinational firm such that aggregate production in the country where the multinational firm is located declines, environmental tax rates can be reduced and welfare increased. If FDI is bilateral, the welfare effects are identical for both countries but ambiguous. In this case, the results support environmentally friendly policy strategies. However, they do not allow us to draw precise conclusions about the implications for social welfare because larger aggregate fixed costs have to be carried by consumers, although the dumping effect of transport costs in annulled. Therefore, the second important finding is that FDI does not necessarily lead to welfare improvement, even if envi-

ronmental policies react endogenously to firms' behavior.

In summary, the impact of FDI on strategic environmental policies seems to imply a tendency to higher rather than lower environmental taxes. The reason is that the strategic profit shifting incentive is different in the presence of FDI. Ecological dumping is more likely to occur in absence of FDI because the strategic profit shifting incentive implies a temptation to subsidize exports with lower environmental taxes. If, by contrast, a plant of the foreign firm is subject to an environmental tax, the strategic profit shifting motive implies an incentive to tax production of the foreign firm with higher environmental taxes.

Appendix

Proof of Lemma 3

Contrary to Lemma 3, suppose that exports of the national firm are positive. In this case, given the f.o.c.'s, the production which takes place in the domestic country is given by

$$y_U = x_U = \frac{a-c-t}{3b}, x_U^* = \frac{a-c-2t+t^*-2s}{3b}, \tag{A.1}$$

leading to

$$P_U = \frac{3(a-c)-4t+t^*-2s}{3b}. \tag{A.2}$$

Welfare can then be easily computed as

$$\begin{aligned} \tilde{W}_U = {} & \frac{2(a-c-t)^2}{9b} + \\ & \frac{(a-c-t)^2+(a-c-2t+t^*-2s)^2}{9b} \\ & +(t-\delta)\frac{3(a-c)-4t+t^*-2s}{3b} \\ & -F-G+L, \end{aligned} \tag{A.3}$$

where the first term represents the consumer surplus, the second term collects the profits of the national firm, and the third term gives the difference between tax revenues and environmental damage. Differentiation of (A.3) with respect to t yields

$$a - c - 12\delta - 2s + 10t + t^* = 0. \tag{A.4}$$

With regard to the the foreign country, the f.o.c. yields

$$y_U^* = P_U^* = \frac{a - c - 2t^* + t + s}{3b}. \tag{A.5}$$

Given (A.1) and (A.5), the sum of consumer surplus, profits, tax revenues, the disutility of pollution and labor income is equal to

$$\begin{aligned} \tilde{W}_U^* = \frac{(2(a-c) - s - t - t^*)^2}{18b} + \\ \frac{(a-c-t)^2 + (a-c-2t^*+t+s)^2}{9b} \\ +(t^* - \delta)\frac{a - c - 2t^* + t + s}{3b} \\ -F - G + L. \end{aligned} \tag{A.6}$$

Differentiation of (A.6) with respect to t^* yields

$$\tilde{t}_U^* = -(a - c) + 2\delta, \tag{A.7}$$

The reduced form of the equilibrium tax rate in the domestic country can be calculated by inserting (A.7) into eq. (A.4) as follows:

$$\tilde{t}_U = \delta + s/5. \tag{A.8}$$

Note, however, that the tax rates (A.7) and (A.8) imply an export level of

$$x_U^* = -\frac{4s}{5b} < 0, \tag{A.9}$$

which is in contradiction to the initial assumption that national firms export. ■

Bilateral FDI in the case of exogenous tax rates

Let the environmental taxes be fixed exogenously so that $t = t^* = \bar{t}$. From (7), intraindustry trade is profitable if $a-c-\bar{t}-2s \geq 0$, and from (9) the maximized profits of a national firm are equal to

$$\frac{(a-c-\bar{t}+s)^2+(a-c-\bar{t}-2s)^2}{9b} - F - G. \qquad \text{(B.1)}$$

By contrast, in the case of unilateral FDI, the multinational firm cannot gain a monopoly position in its home market, because tax rates are fixed and exports are guaranteed to be positive. Hence, the profits of a multinational firm, which unilaterally makes FDI, are equal to the second term in (A.6) evaluated at $t = t^* = \bar{t}$.

$$\frac{(a-c-\bar{t}+s)^2+(a-c-\bar{t})^2}{9b} - F - 2G. \qquad \text{(B.2)}$$

Expression (B.2) compared to (B.1) suggests that net revenues in the home market remain unchanged and that FDI decreases the variable costs of producing for the other market. Similarly, the profits of a national firm in the unilateral FDI case are equal to the second term in (A.3) evaluated at $t = t^* = \bar{t}$:

$$\frac{(a-c-\bar{t})^2+(a-c-\bar{t}-2s)^2}{9b} - F - G. \qquad \text{(B.3)}$$

The national firm loses its competitive advantage in the home market, whilst net revenues in the other market remain unchanged. By contrast, if this firm makes also for FDI, then the profits of both competing firms are equal to

$$\frac{2(a-c-\bar{t})^2}{9b} - F - 2G. \qquad \text{(B.4)}$$

There is an incentive to go for FDI unilaterally if (B.2) is not less than (B.1), followed by the condition that (B.4) is not less than

(B.3). The comparison between (B.2) and (B.1), and between (B.4) and (B.3) suggests that these incentives coincide so that FDI will take place only bilaterally if $G \leq \bar{G}$, where

$$\bar{G} = 4s\frac{a - c - \bar{t} - s}{9b}. \tag{B.5}$$

The reason is that both firms - the potential multinational firm and the potential follower - face the same variable costs. Thus, net revenues remain unchanged in each market. This implies that, if the plant-specific fixed cost is sufficiently smaller, then both firms are more profitable in making FDI.

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