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Strategic Environmental Policies in the Presence of Foreign Direct Investment

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Abstract. We analyze strategic environmental standards in the presence of foreign direct investment. A number of foreign firms located in a host country compete with a domestic firm in another country to export a homogeneous good to a third country. When the number of foreign firms is exogenous, the host country applies a stricter environmental regulation than the other producing country. However, under free entry and exit of foreign firms, the host country may apply a less severe standard under both non-cooperative and cooperative equilibrium. We also find that the nature market structure does not affect the equilibrium values of total pollution if export subsidies are also used.

Key words: environment, emission permits, foreign direct investment, trade, pollution

JEL classification: F2, H2

1. Introduction

The volume of foreign direct investment (FDI) has been increasing rapidly for the last two decades. According to UNCTAD, the ratio of inward plus outward FDI stocks to global GDP is 21%, and the foreign affiliate exports now make up about one-third of total world exports. More and more countries are creating attractive conditions for FDI. During 1991–1997, 94% of the regulations regarding FDI were relaxed to promote FDI (see UNCTAD 1998).

It has been argued that long-term pollution restrictions may cause polluting activities to be relocated in countries with relatively lower pollution standards. Low and Yeates (1992) found that during the 1970s and 1980s many polluting industries migrated through FDI flows towards lower income countries with less strict environmental restrictions. The production of highly poisonous substances such as chemical pesticides and heavy metals like copper, zinc, and lead have also changed location (see Anderson et al. 1995, p. 66). Lucas et al. (1992) show that the stricter regulation of pollution-intensive production in the OECD countries has led to significant displacement of polluting activities. Xing and Kolstad (1998) found that the location of the US chemical industry was affected by the laxity of the host country's environmental standards. Thus, trade and investment liberalization are alleged to have created pollution havens by developing channels through which polluting industries shift to less developed countries.[1]

Given the extensive role being played by FDI in the globalization process and the ever increasing concern for environment throughout the globe, it is surprising that there is only a limited literature on the interface between FDI and the environment. Markusen et al. (1993) analyze the location decisions of two firms in a two region model where the government in one region is passive in the face of investment flows. In Markusen et al. (1995), the second government is brought into play and they then analyze the outcome of the competition between the two countries to encourage the entry of a foreign firm (or to discourage the entry of a foreign firm, if the disutility from pollution is sufficiently high). Lahiri and Ono (2000) develop a one country model in which they analyze the different effects of tax and quantity restrictions on pollution control in the presence of an endogenous number of foreign firms.

Under the World Trade Organization (WTO) rules, it is becoming more and more difficult to use trade policies for strategic purposes such as increasing market share of home-based firms. As a result, many countries are using environmental policies as strategic instruments in trade. For example, some believe that the environmental restriction in Denmark that beer should be sold in bottles rather than cans is in part a measure to protect domestic beer producers against German ones. It is therefore important to analyze the issue of strategic environmental policies, particularly in the presence of FDI. None of the above papers on the interface between environment and FDI consider strategic environmental policies. Barrett (1994) analyzes environmental policies in a model where two countries compete to export to a third country. However, the firms in his model are local and fixed in number, and his main concern is to compare the results under Cournot competition with that under Bertrand competition. The purpose of this paper is to fill an important gap in the literature by considering strategic environmental policies in the presence of FDI. In particular, we analyze the role of free entry and exit of FDI on strategic environmental policies.

In the benchmark version of our model there are two firms (one from each country) compete in a Cournot duopolistic fashion to export a homogeneous good to a third country.[2] That is, both groups of firms are assumed to be export-oriented. The benchmark model extends the well-known Brander and Spencer (1985) model of strategic trade policy in several ways.[3] First, the firm located in country 1 is owned by foreigners. Second, we introduce pollution and environmental policies as opposed to trade policy in Brander and Spencer (1985). Pollution arises during production by both types of firms, and both firms possess a technology for abating pollution they generate. We rule out cross-border pollution.[4] The policy available to the governments in the two countries is a quantity restriction on pollution.[5] In particular, the policy options available are assumed to be emission standards.[6] It is assumed that there is unemployment in both countries, and that the profits of FDI are repatriated to the source countries. Hence, country 1 benefits from FDI only through the employment generated by foreign firms, but can not exploit any rents from the profits of FDI. Country 2, on the other hand, benefits from the profit earned by the domestic firm as well as the employment created by export-oriented production. However, both countries dislike pollution that accompanies production.

We then extend the benchmark model to allow the number of FDI to be endogenous as in Lahiri and Ono (1998a). The number of foreign firms is affected by the government in country 1 (the host to FDI) by the use of emission standard, as the FDI equilibrium is determined by equating the profits of the foreign firms to an exogenous level representing the reservation level of profits which the foreign firms could obtain if they invested in other countries.

Using the above specification, we examine the equilibrium levels of pollution restrictions when the governments determine their policies cooperatively and non-cooperatively. We also compare the outcome of these policies for the general model with that of the benchmark one, i.e. we examine the effect of free entry and exit of FDI on policies.

Finally, we shall examine how the results change if the producing countries apply export subsidies on top of emission standards. This would allow us to examine the effects of WTO-imposed restrictions on the use of trade policies on the nature of optimal environmental policies and their relationship to market structure. For example, we find that while market structure in the form of endogenous number of foreign firms has no effect on environmental policies when trade policies are simultaneously applied, it has important implications for environmental policies when the countries are not allowed to use trade policies.

The benchmark model is spelt out in the following section. In Sections 3 and 4, we derive the properties of the non-cooperative and cooperative equilibrium respectively. Section 4 also includes a comparison between non-cooperative and cooperative equilibria. Section 5 compares the equilibria in the presence and absence of free entry and exit. Section 6 introduces an extra instrument, viz. export subsidy, and examine how the results are affected by it. Finally, Section 7 makes some concluding remarks.

2. The Benchmark Model

In this model there are two exporting (or producing) countries (labelled as country 1 and country 2) and one consuming (importing) country. There is one foreign firm which operates in country 1 and one domestic firm in country 2 for the oligopolistic market of a homogeneous good in the consuming country. Implicitly, we assume that the government of country 1 allows only one foreign firm to operate in its territory and the government in country 2 does not allow any FDI and that the foreign firm makes more profits in the host country than what it would have made had it stayed in the home country. In Section 4 we shall consider the case of free entry and exit of foreign firms in country 1, but country 2 would continue to disallow any FDI both in and out of the country.[7] This way we shall be able to examine the effect of liberal entry policy on FDI in country 1 on strategic environmental policies. We assume the existence of unemployment in the two producing countries.[8] The inverse demand function for oligopolistic good is given by

$$p = \alpha - \beta D, \tag{1}$$

where p is price and D is the total demand for the good, which is equal to the sum of output produced by the foreign firm, x_1, and output produced by the domestic firm, x_2, in country 2. That is,

$$D = x_1 + x_2, \tag{2}$$

Profit of a firm, π_i, is given by

$$\pi_i = (p - \kappa_i)x_i, \quad i = 1, 2 \tag{3}$$

where κ_i is the constant average (marginal) cost of each i firm that is given by

$$\kappa_i = c_i + \mu(\theta_i - z_i), \quad i = 1, 2 \tag{4}$$

where c_i is a constant per unit cost determined by technological and factor market conditions, θ_i is the gross pollution (pollution before abatement), μ is the constant unit cost of abatement,[9] and $z_i \in (0, \theta_i)$ is the maximum quantity of pollution per unit of output that the firms are allowed to emit into the atmosphere.[10]

The firms are assumed to behave in a Cournot–Nash fashion. Hence, profit maximization yields

$$\beta x_i = p - \kappa_i, \quad i - 1, 2. \tag{5}$$

Given the policy decisions of the governments, the equilibrium output of foreign and domestic firms can be found from (5) as

$$x_1 = \frac{\alpha - 2\kappa_1 + \kappa_2}{3\beta}, \tag{6}$$

$$x_2 = \frac{\alpha + \kappa_1 - 2\kappa_2}{3\beta}. \tag{7}$$

As stated before, we assume that there is unemployment in countries 1 and 2. Following Brander and Spencer (1987), factor input costs are taken to be the income of the factors which would remain unemployed in the absence of the production of the oligopolistic good (see note 7). Hence, the welfare levels in country 1 and country 2 are given by W_1 and W_2 below:

$$W_1 = c_1 x_1 - \phi_1(x_1 z_1), \tag{8}$$

$$W_2 = c_2 x_2 + \pi_2 - \phi_2(x_2 z_2), \tag{9}$$

where $\phi_i(\cdot)$ is the disutility of pollution function in country i ($i = 1, 2$). We assume that the profits of FDI are repatriated to the source country. Hence, country 1 benefits from FDI only through the employment generated by foreign firms, but cannot exploit any rents from the profits of FDI. The employment benefit is given by the first term on the right hand side of (8). Country 2, on the other hand, benefits from the profits earned by the domestic firm as well as the employment created by export-oriented production. These benefits are given by the first and second terms on the right hand side of (9). However, both the countries dislike pollution that accompanies production, as given by the last terms in the two equations.[11] From now on we shall assume the damage functions to be linear, and denote the constant marginal disutilities ϕ_1' and ϕ_2' by ϕ_1 and ϕ_2, respectively. This assumption will need to be relaxed in Section 6.

Substituting (4) in (6) and (7), and totally differentiating the results we obtain

$$\mathrm{d}x_1 = \frac{2\mu}{3\beta}\mathrm{d}z_1 - \frac{\mu}{3\beta}\mathrm{d}z_2, \tag{10}$$

$$\mathrm{d}x_2 = -\frac{\mu}{3\beta}\mathrm{d}z_1 + \frac{2\mu}{3\beta}\mathrm{d}z_2. \tag{11}$$

The above equations state that each firm will increase (decrease) production if it is allowed to emit more (less) pollution or if the amount of pollution that the rival firm is allowed to emit is reduced (raised).[12]

Totally differentiating the welfare functions we get

$$3\beta\,\mathrm{d}W_1 = A_1\,\mathrm{d}z_1 + A_2\,\mathrm{d}z_2, \tag{12}$$

$$3\beta\,\mathrm{d}W_2 = A_3\,\mathrm{d}z_1 + A_4\,\mathrm{d}z_2, \tag{13}$$

where

$$A_1 = [2\mu c_1 - \phi_1(2\mu z_1 + 3\beta x_1)], \quad A_2 = \mu[\phi_1 z_1 - c_1],$$
$$A_3 = \mu[\phi_2 z_2 - c_2 - 2\beta x_2], \quad A_4 = [2\mu(2\beta x_2 + c_2) - \phi_2(2\mu z_2 + 3\beta x_2)].$$

We discuss first the effects of each government's environmental policy on the welfare of its own nationals. For example, when country 1 reduces z_1, total pollution in that country is reduced. The reduction in pollution benefits country 1, with the magnitude of this benefit depending on the marginal disutility of pollution in that country. This benefit is given by the last term in A_1 for country 1, while in country 2 it is the last term in A_4. A reduction in z_1 $(i = 1, 2)$ also reduces the amount of output produced in country i by increasing the unit costs of production. For country 1, this will increase unemployment. This is given by the first term in A_1. For country 2, a reduction in output will reduce employment and profits. These are given by the first term in A_4 respectively.

Second, we examine the external effects of each government's pollution regulations on the other country's welfare. A reduction in z_1 will create a competitive advantage for the firm in country 2, resulting in an increase in its production. This increase in production in country 2 will have three effects on country 2's welfare through increased level of pollution, employment and profits of the domestic firm, and these are given by the three terms in A_3. A reduction in z_2, on the other hand, has similar effects on country 1's welfare. However, since profits of the foreign firm are repatriated, there are only two effects here.

3. Non-Cooperative Solution

In this section, we consider the case where the governments behave in a non-cooperative fashion. We shall find the non-cooperative Nash pollution levels of emission standards, z_1^N and z_2^N, i.e. the amounts the firms are allowed to emit into atmosphere per unit of output.

Setting A_1 and A_4 in (12) and (13) equal to zero, we find the Nash equilibrium values of the two instruments

$$z_1^N = \frac{2\mu c_1 - 3\phi_1 \beta x_1}{2\phi_1 \mu}, \tag{14}$$

$$z_2^N = \frac{2\mu c_2 + 4\mu\beta x_2 - 3\beta x_2 \phi_2}{2\phi_2 \mu}. \tag{15}$$

It can be shown that at the non-cooperative equilibrium the welfare function is concave and the equilibrium stable if

$$3\phi_2 > 4\mu. \tag{16}$$

Since the firm in country 2 is domestically owned, the government in that country has to pay attention to the profits of this firm in deciding the optimal emission standards. If the marginal disutility of pollution ϕ_2 is not sufficiently larger than the unit abatement cost μ, this consideration will overshadow the consideration for disutility from pollution and government will choose a corner value for z_2, viz., the firm will not be required to abate any amount of pollution.

Emission standards here serve a number of opposing purposes. First, it reduces pollution. Second, it has strategic roles of employment and/or profit shifting, i.e. a stricter emission standard in a country increases the marginal costs for the firm operating in that country, giving competitive advantage to the other firm. This reduces employment and profits in the former country. Because of this, the optimal levels of the two instruments have both positive and negative terms, as can be seen from (14) and (15). Since profits of the firm in country 1 is repatriated, there is only one positive term in (14) as opposed to two positive terms in (15), the second one being due to the profit-shifting effect. In the absence of unemployment in country 1 the first term in (14) will disappear and we shall have $z_1^N = 0$.[13] It should be clear from the above discussion that, *ceteris paribus*, the host country of FDI applies a stricter emission standard than the other exporting country. This can be confirmed by setting $c_1 = c_2 = c$, $\theta_1 = \theta_2 = \theta$ and $\phi_1 = \phi_2 = \phi$, and then from (14), (15) and (16) deriving

$$z_1^N - z_2^N = -\frac{8(\phi\omega + \mu c)}{\phi(45\phi - 28\mu)} < 0,$$

where $\omega = (\alpha - \mu\theta - c) = 3\beta x_1|_{z_1=z_2=0} > 0$. Formally,

Proposition 1. In the absence of free entry and exit of foreign firms, when the countries do not cooperate, ceteris paribus the FDI-host country applies a more severe emission standard level than the other country.

It should be noted that the above proposition does not necessarily refute the pollution haven hypothesis. The emission standard in the host country could still be less severe than that in the home country of the foreign firm. What the proposition shows is that in the context of strategic interactions between two exporting countries and in the absence of endogenous mobility of foreign firms, foreign ownership at the margin relaxes emission standards.

Having characterized the non-cooperative equilibrium, we shall now carry out two exercises in the following two subsections. In Subsection 3.1, we shall conduct two comparative static exercises on the optimal emission standards, and in Section 3.2 we shall examine the welfare effect of a multilateral piecemeal reform of emission standards when the initial values of the emission standards are at their Nash optimal levels.

3.1. COMPARATIVE STATICS

Using the non-cooperative solutions above, we now examine the effects of changes in two parameters on the equilibrium emission levels. The parameters we focus on are the demand parameter α in the consuming country, which is used as a measure for market size, and the per unit gross pollution (pollution before abatement), θ_i $(i = 1, 2)$.

3.1.1. *Emission levels and market size*

From (14), (15) and (16) we get

$$\frac{\partial z_1^N}{\partial \alpha} = -3\frac{(5\phi_2 - 4\mu)}{\mu(45\phi_2 - 28\mu)} < 0,$$

$$\frac{\partial z_2^N}{\partial \alpha} = -5\frac{(3\phi_2 - 4\mu)}{\mu(45\phi_2 - 28\mu)} < 0.$$

A decrease in the market size will lead governments to impose less severe emission restrictions. This is because a decrease in market size will decrease the amount of goods produced by both firms. On the other hand, the marginal negative effect on welfare of relaxing the pollution standards is smaller when the amount of output is smaller. Therefore, a decrease in the market size decreases the negative marginal effect of relaxing pollution on welfare of both countries.[14]

Proposition 2. When there is a decrease in market size, the optimal non-cooperative level of pollution that the firms are allowed to emit will increase in both countries.

The above result suggests that bigger industries – the ones with larger size of the market – should be subject to more severe emission standards.

3.1.2. *Emission levels and gross pollution*

Differentiating the Nash solutions with respect to per unit gross pollution in country 1 we get

$$\frac{\partial z_1^N}{\partial \theta_1} = 3\frac{(7\phi_2 - 4\mu)}{(45\phi_2 - 28\mu)} > 0,$$

$$\frac{\partial z_2^N}{\partial \theta_1} = -2\frac{(3\phi_2 - 4\mu)}{(45\phi_2 - 28\mu)} < 0.$$

An increase in the level of gross pollution by the foreign firm will increase its marginal costs, and therefore reduce its output. To encourage foreign firm to produce more, the country 1 government will find it optimal to allow it to emit more pollution. As costs in country 1 are risen with an increase in gross pollution, the firm in country 2 receives a competitive advantage. Therefore, the government in country 2 can impose a stricter pollution restriction.

Proposition 3. An increase in the per unit gross pollution level in a country will increase the optimal non-cooperative level of pollution that the firm in that country is allowed to emit, and reduce the same for its rival in the other country.

The above results relate emission standards to gross pollution intensities of the foreign firms. In particular, it suggests that, *ceteris paribus*, the developing countries are likely to attract relatively polluting-intensive firms as these would face relatively less severe emission standards.

3.2. REFORM FROM A NON-COOPERATIVE EQUILIBRIUM

In this subsection we examine the effects on welfare in both countries of small reductions in emission standards when the initial levels are set at the non-cooperative level. This can be seen as a multilateral effort to coordinate environmental policies.

Substituting (14) in (12), (15) in (13), and using the property of the reform exercise ($\mathrm{d}z_1 < 0$ and $\mathrm{d}z_2 < 0$), we obtain

$$2\,\mathrm{d}W_1|_{z_1=z_1^N} = -\phi_1 x_1\,\mathrm{d}z_2 > 0, \tag{17}$$

$$2\,\mathrm{d}W_2|_{z_2=z_2^N} = -\phi_2 x_2\,\mathrm{d}z_1 > 0. \tag{18}$$

From above we have

Proposition 4. Starting from the non-cooperative equilibrium, a reduction in the emission standards in both countries is strictly Pareto-improving.[15]

Recall that the non-cooperative equilibrium levels are found by equating A_1 and A_4 to zero. Hence, all that remains are A_2 and A_3, which are the international externalities associated with environmental policies. Although, as explained before, these externalities are ambiguous in sign in general, when evaluated at the Nash equilibrium, these are unambiguously negative. This results points to the basic inefficiency of the non-cooperative equilibrium. That is, the "beggar thy neighbour" nature of the non-cooperative problem leads to a reduction in global welfare. Therefore any attempt at coordinated reductions in the Nash equilibriums levels of the emission standards ought to increase global welfare. The above result shows that such reductions not only increase global welfare but also individual welfare levels. Therefore, a multilateral reduction in emission standards in this case does not need any lump-sum transfers in order for it to be strictly Pareto improving.

4. Cooperative Equilibrium

Having analyzed some properties of the non-cooperative equilibrium, we shall now turn our attention to cooperative equilibrium. In order to focus on the foreign ownership of the firm in country 1, we shall henceforth assume that $c_1 = c_2 = c$, $\theta_1 = \theta_2 = \theta$ and $\phi_1 = \phi_2 = \phi$.

For characterizing the cooperative equilibrium, we obtain changes in total welfare by adding (12) and (13)

$$3\beta\,\mathrm{d}W = (A_1 + A_3)\,\mathrm{d}z_1 + (A_2 + A_4)\,\mathrm{d}z_2 \tag{19}$$

Setting the coefficients of $\mathrm{d}z_1$ and $\mathrm{d}z_2$ equal to zero, and solving simultaneously for z_1 and z_2, we find the cooperative solutions as

$$z_1^C = \frac{\mu c - \phi(2\beta x_1 + \beta x_2)}{\phi\mu}, \tag{20}$$

$$z_2^C = \frac{\mu c + 2\beta x_2 \mu - \phi(2\beta x_2 + \beta x_1)}{\phi\mu}. \tag{21}$$

As in the case of non-cooperative equilibrium (see (14) and (15)), here also the expression for optimal z_2 has an extra positive term as compared to that for optimal z_1. This is because, country 2 shifts profits from the foreign firm located in country 1. Since the foreign firm repatriates its profits to its home country, the profit shifting does not adversely affect country 1 and therefore does not cancel out in the global (cooperative) exercise. So, as before, it can be shown here that $z_1^C < z_2^C$. That is, even in the cooperative equilibrium, the host country of FDI sets a more severe emission standard than the other exporting country.

We now compare the magnitudes of optimal emission restrictions for the two countries under the cooperative and non-cooperative equilibria. Since the international externalities on emission standards are negative as shown in (17) and (18), it can also be shown that the governments apply stricter environmental standards when they cooperate than when they act non-cooperatively, i.e. $z_1^N > z_1^C$ and $z_2^N > z_2^C$. The results of this section shows the mechanism via which cooperation in the setting of emission standards benefits both countries. To be more specific, a cooperative approach leads to lower emission standards in *both* exporting countries and this benefits them both.

5. Free Entry and Exit of FDI

In this section we extend the model developed in the previous sections by allowing the number of foreign firms to be endogenous. We assume that there are now n identical foreign firms from the rest of the world which operate in country 1.[16] It is assumed that country 1 is small in the market for FDI. Hence, the foreign firms will move into (out of) country 1 if the profits they make in country 1 are larger (smaller) than the reservation profit, $\bar{\pi}$, that they can make in the rest of the world. Therefore, in the FDI equilibrium we must have

$$\pi_1 = \bar{\pi}. \tag{22}$$

The total output in this case is defined as

$$D = nx_1 + x_2. \tag{23}$$

Some of the key variables can be solved as

$$n = \frac{\alpha - 2\kappa_1 + \kappa_2}{\sqrt{\bar{\pi}}\sqrt{\beta}} - 2, \tag{24}$$

$$x_1 = \frac{\alpha - 2\kappa_1 + \kappa_2}{\beta(2+n)} = \frac{\sqrt{\bar{\pi}}}{\sqrt{\beta}}, \tag{25}$$

$$x_2 = \frac{\sqrt{\bar{\pi}}\sqrt{\beta} + \kappa_1 - \kappa_2}{\beta}. \tag{26}$$

From the above we obtain

$$\mathrm{d}n = \frac{2\mu}{\sqrt{\bar{\pi}}\sqrt{\beta}}\mathrm{d}z_1 - \frac{\mu}{\sqrt{\bar{\pi}}\sqrt{\beta}}\mathrm{d}z_2, \tag{27}$$

$$\mathrm{d}x_1 = 0, \tag{28}$$

$$\mathrm{d}x_2 = -\frac{\mu}{\beta}\mathrm{d}z_1 + \frac{\mu}{\beta}\mathrm{d}z_2. \tag{29}$$

Equation (27) states that since there is free entry and exit of FDI, a reduction in the number of emission permits allocated to the the domestic firm in country 2 or an increase in emission permission allocated to the foreign firm will encourage more foreign firms to enter country 1. The domestic firm in country 2 will increase (decrease) production if it is allowed to emit more (less) or if the amount of pollution that the foreign firm is allowed to emit is reduced (raised) (Equation (29)). Because of free entry and exit and the linearity of demand, the output of a foreign firm does not change with the policy instruments.

Substituting x_1 in country 1's welfare function (Equation (8)) by nx_1 and totally differentiating the resulting equation and country 2's welfare function (Equation (9)), we get

$$\beta\,\mathrm{d}W_1 = A_5\,\mathrm{d}z_1 + A_6\,\mathrm{d}z_2, \tag{30}$$

$$\beta\,\mathrm{d}W_2 = A_7\,\mathrm{d}z_1 + A_8\,\mathrm{d}z_2, \tag{31}$$

where

$$A_5 = [2\mu c - \phi(2\mu z_1 + \beta x_1 n)], \quad A_6 = \mu[\phi z_1 - c],$$
$$A_7 = \mu[\phi z_2 - c - 2\beta x_2], \quad A_8 = [\mu(2\beta x_2 + c) - \phi(\mu z_2 + \beta x_2)].$$

The direct and external effects of each government's environmental policy on the welfare of the two countries are similar to those in the case where there is no entry and exit. However, the effects on the FDI production of a reduction in per unit pollution allowance will be due to the changes in the number of foreign firms. For example, a reduction in z_i $(i = 1, 2)$ reduces total output produced in country i: there will be less foreign firms in country 1, while the firm in country 2 will produce less.

Setting A_5 and A_8 equal to zero, we find

$$\hat{z}_1^N = \frac{2\mu c - \phi\beta x_1 n}{2\phi\mu}, \tag{32}$$

$$\hat{z}_2^N = \frac{\mu c + 2\mu\beta x_2 - \beta x_2\phi}{\phi\mu}. \tag{33}$$

It should be noted that that the concavity of the welfare function and the stability of the equilibrium hold if $\phi > 2\mu$. The economic intuition for this restriction has been explained in Section 3 (see the discussion after (15)).[17]

As in case of fixed number of foreign firms (see (14) and (15)), there is once again an extra positive term in the expression for the optimal value of z_2. Therefore, from (32) and (33) it should be clear that $\hat{z}_2^N > \hat{z}_1^N$ as long the value of $\bar{\pi}$ is such that $x_2 < nx_1/2$. That is, if the the reservation profit is sufficiently small so that the number of foreign firms in country 1 large, the FDI host country will apply a more severe emission standard than the other exporting country. However, if the reservation profit is large so that the number of foreign firms is small, then it is possible that the FDI host country will employ a less severe emission standard than the other country. In particular, if the value of $\hat{\pi}$ is such that $n = 1$ and $\phi > 4\mu$, it can be shown that $\hat{z}_2^N < \hat{z}_1^N$. Formally,

Proposition 5. When the. governments set non-cooperative policies, in the presence of free entry and exit in the FDI market, the FDI host country will impose stricter pollution restrictions than the other country if the reservation profit is sufficiently small. If the reservation profit is very high, the FDI host country may apply a less severe emission standard.

The intuition is simple. When the reservation profit is very small, there will be many foreign firms investing in country 1 as they have less profitable opportunities in the rest of the world. Since there is a large supply of FDI, the government in country 1 will be able to impose more severe environmental regulations. On the other hand, when the reservation profit is sufficiently large, there will be few foreign firms entering country 1. With a small supply of FDI, the government in country 1 will try to attract the foreign firms by imposing less severe environmental regulation. Recall that in the absence of free entry and exit country 1 unambiguously imposes more severe environmental standards than country 2, as pollution is the main concern for country 1. Under free entry and exit of foreign firms, however, country 1 is more concerned with attracting FDI, particularly when the supply of FBI is small. In particular, it imposes less severe policies when the supply of FDI is small. To summarize, free entry and exit of foreign firms *per se* is not sufficient for FDI host countries to be more lenient with regard to emission standard. A host country will be more lenient only if the number of foreign firms located on its soil is very small.

We now turn to cooperative equilibrium. In order to find the cooperative equilibrium, we obtain a change in total welfare by adding (30) and (31);

$$\beta\, \mathrm{d}W = (A_5 + A_7)\, \mathrm{d}z_1 + (A_6 + A_8)\, \mathrm{d}z_2. \tag{34}$$

Setting the coefficients of $\mathrm{d}z_1$ and $\mathrm{d}z_2$ equal to zero in (34) and solving them simultaneously, we find the cooperative solutions as

$$\hat{z}_1^C = \frac{\mu c - \phi(\beta x_2 + \beta x_1 n)}{\phi\mu}, \tag{35}$$

$$\hat{z}_2^C = \frac{\mu c - 2\beta x_2(\phi - \mu) - \phi\beta x_1 n}{\phi\mu}. \tag{36}$$

It is to be noted that for total welfare to be concave in the two instruments, it is sufficient that $\phi > \mu$. The economic intuition for this restriction has been explained in Section 3.

Subtracting (35) from (36) we get

$$\hat{z}_1^C - \hat{z}_2^C = \frac{\beta x_2(\phi - 2\mu)}{\phi\mu}. \tag{37}$$

From (37) it is clear that $\hat{z}_1^C > \hat{z}_2^C$ if and only if $\phi > 2\mu$. When the two countries cooperate the difference between the two emission standards depends on the magnitude of marginal disutility of pollution relative to the marginal private cost of abatement. If the disutility from pollution, ϕ, is very large the government in country 2 applies more severe emission standards than country 1. Since there is no entry and exit in country 2, when the two governments cooperate the government in country 2 will be able to impose more severe environmental standards. In this case, the government of country 2 applies more (less) severe policies if the marginal disutility of pollution is sufficiently large (small).

Proposition 6. When the two countries cooperate, in the presence of free entry and exit in the FDI market, the FDI-host country applies a less severe emission standard than the other country if the marginal disutility of pollution is sufficiently small. Otherwise, the FDI host country will apply a more severe emission standard.

From the last two proposition, it follows that inefficiencies of the non-cooperative equilibrium is not the reason why a FDI host country may apply a less severe emission standard than the other exporting country without any FDI in it. This is because, with free entry and exit of foreign firms, a FDI host country may apply a less severe emission standard under both non-cooperative and cooperative equilibrium. However it should be pointed out that with fixed number of foreign firms, the FDI host country always applies a more severe emission standard than the other country.

6. Export Subsidy and Emission Standards

In the analysis above, we assumed that the only instrument at the disposal of the governments of the two producing countries were emission standards. Thus, optimal emission standards in each country had other roles than just dealing with pollution emission. This was done to capture the reality that because of restrictions imposed by the WTO, countries cannot use trade policies for strategic purposes and often use emission standards strategically to achieve ends other than just pollution reduction.[18] In this section, we shall assume that each government has an additional instrument, viz. export subsidy and see how some of the results of the preceding sections change. This will allow us to examine the effects of WTO-imposed restrictions on the choice of instruments on the nature of optimal environmental policies. This analysis will also enable us to compare the effects of market structure, viz. free entry and exit of foreign firms, on optimal environmental policies for the case when the governments can use trade policies with the case when they cannot.

6.1. BENCHMARK CASE

Profit of a firm, π_i, is given by

$$\pi_i = (p - \kappa_i + s_i)x_i, \quad i = 1, 2. \tag{38}$$

Profit maximization yields

$$\beta x_i = p - \kappa_i + s_i, \quad i = 1, 2. \tag{39}$$

Given the policy parameters of the governments, the equilibrium output of foreign and domestic firms can be found from (39) as

$$x_1 = \frac{\alpha + 2(s_1 - \kappa_1) - s_2 + \kappa_2}{3\beta}, \tag{40}$$

$$x_2 = \frac{\alpha - s_1 + \kappa_1 + 2(s_2 - \kappa_2)}{3\beta}. \tag{41}$$

Totally differentiating (40) and (41), we find

$$\mathrm{d}x_1 = \frac{2\mu}{3\beta}\,\mathrm{d}z_1 - \frac{\mu}{3\beta}\,\mathrm{d}z_2 + \frac{2}{3\beta}\,\mathrm{d}s_1 - \frac{1}{3\beta}\,\mathrm{d}s_2, \tag{42}$$

$$\mathrm{d}x_2 = -\frac{\mu}{3\beta}\,\mathrm{d}z_1 + \frac{2\mu}{3\beta}\,\mathrm{d}z_2 - \frac{1}{3\beta}\,\mathrm{d}s_1 + \frac{2}{3\beta}\,\mathrm{d}s_2. \tag{43}$$

The welfare levels in country 1 and 2 are

$$W_1 = c_1x_1 - s_1x_1 - \phi_1(x_1z_1), \tag{44}$$

$$W_2 = c_2x_2 + \pi_2 - s_2x_2 - \phi_2(x_2z_2), \tag{45}$$

where the pollution disutility functions $\phi(\cdot)$'s are assumed to satisfy[19]

$$\phi_i' > 0, \quad \phi_i'' > 0, \qquad i = 1, 2.$$

That is, there is positive and increasing marginal disutility from pollution.

Totally differentiating the welfare functions we get

$$3\beta\,\mathrm{d}W_1 = E_1\,\mathrm{d}z_1 + E_2\,\mathrm{d}z_2 + E_3\,\mathrm{d}s_1 + E_4\,\mathrm{d}s_2, \tag{46}$$

$$3\beta\,\mathrm{d}W_2 = E_5\,\mathrm{d}z_1 + E_6\,\mathrm{d}z_2 + E_7\,\mathrm{d}s_1 + E_8\,\mathrm{d}s_2, \tag{47}$$

where

$$E_1 = [2\mu(c_1 - s_1) - \phi_1'(2\mu z_1 + 3\beta x_1)], \quad E_2 = \mu[\phi_1' z_1 + s_1 - c_1],$$
$$E_3 = 2(c_1 - s_1 - \phi_1' z_1) - 3\beta x_1, \quad E_4 = \phi_1' z_1 + s_1 - c_1,$$
$$E_5 = \mu[\phi_2' z_2 + s_2 - c_2 - 2\beta x_2], \quad E_6 = [2\mu(2\beta x_2 + c_2 - s_2) - \phi_2'(2\mu z_2 + 3\beta x_2)],$$
$$E_7 = \phi_2' z_2 + s_2 - c_2 - 2\beta x_2, \quad E_8 = \beta x_2 - 2(\phi_2' z_2 + s_2 - c_2).$$

Substituting (39) to (41) in (46) and (47) and setting E_1, E_3, E_6 and E_8 equal to zero, we find the Nash equilibrium values of the two instruments. In particular, the optimal values of the emission standards in the two countries are found to satisfy

$$\phi_1'(z_1^N x_1) = \mu, \quad \phi_2'(z_2^N x_2) = \mu. \tag{48}$$

The above equations say that at the optimum, the marginal disutility of pollution – which is also the marginal willingness to pay for pollution abatement – in each country is equal to the marginal (unit) cost of private abatement. This is parallel to the Pigouvian rule on optimum emission taxation to the present context. One interesting point about (48) is worth noting. If the disutility functions are the same in the two countries, the equilibrium amount of pollution in the two countries will be the same, even though the efficiency levels of the two firms in the two countries are different and the host country's welfare does not include profits of the firm operating from its territory. This is because in the present case, export subsidies take care of the distortions/motives such as the employment- and/or profit--shifting one, leaving emission standards to deal only with the distortion of pollution emission.

6.2. FREE ENTRY AND EXIT CASE

Having analyzed the case where there are restrictions on the number of foreign firms, we shall now discuss the case of free entry and exit of foreign firms in the host country. Some of the key equations in this case are:

$$x_1 = \frac{\alpha + 2(s_1 - \kappa_1) - s_2 + \kappa_2}{\beta(2+n)} = \frac{\sqrt{\pi}}{\sqrt{\beta}}, \tag{49}$$

$$x_2 = \frac{\sqrt{\pi}\sqrt{\beta} + \kappa_1 - s_1 - \kappa_2 + s_2}{\beta}, \tag{50}$$

$$n = \frac{\alpha - 2(\kappa_1 - s_1) + \kappa_2 - s_2}{\sqrt{\pi}\sqrt{\beta}} - 2. \tag{51}$$

Totally differentiating (50) and (51), we obtain

$$\mathrm{d}x_2 = -\frac{\mu}{\beta}\,\mathrm{d}z_1 + \frac{\mu}{\beta}\,\mathrm{d}z_2 - \frac{1}{\beta}\,\mathrm{d}s_1 + \frac{1}{\beta}\,\mathrm{d}s_2, \tag{52}$$

$$\mathrm{d}n = \frac{2\mu}{\sqrt{\pi}\sqrt{\beta}}\,\mathrm{d}z_1 - \frac{\mu}{\sqrt{\pi}\sqrt{\beta}}\,\mathrm{d}z_2 + \frac{2}{\sqrt{\pi}\sqrt{\beta}}\,\mathrm{d}s_1 - \frac{1}{\sqrt{\pi}\sqrt{\beta}}\,\mathrm{d}s_2. \tag{53}$$

Replacing x_1 in country 1's welfare function (Equation (44)) by nx_1 and totally differentiating the resulting equation and country 2's welfare function, we get

$$\beta\,\mathrm{d}W_1 = R_1\,\mathrm{d}z_1 + R_2\,\mathrm{d}z_2 + R_3\,\mathrm{d}s_1 + R_4\,\mathrm{d}s_2, \tag{54}$$

$$\beta\,\mathrm{d}W_2 = R_5\,\mathrm{d}z_1 + R_6\,\mathrm{d}z_2 + R_7\,\mathrm{d}s_1 + R_8\,\mathrm{d}s_2, \tag{55}$$

where

$$R_1 = [2\mu(c_1 - s_1) - \phi_1'(2\mu z_1 + 3\beta x_1 n)], \quad R_2 = \mu[\phi_1' z_1 + s_1 - c_1],$$
$$R_3 = 2(c_1 - s_1 - \phi_1' z_1) - 3\beta x_1 n, \quad R_4 = \phi_1' z_1 + s_1 - c_1,$$
$$R_5 = \mu[\phi_2' z_2 + s_2 - c_2 - 2\beta x_2], \quad R_6 = [\mu(2\beta x_2 + c_2 - s_2) - \phi_2'(\mu z_2 + \beta x_2)],$$
$$R_7 = \phi_2' z_2 + s_2 - c_2 - 2\beta x_2, \quad R_8 = \beta x_2 - \phi_2' z_2 - s_2 + c_2.$$

Setting R_1, R_3, R_6 and R_8 in (54) and (55) equal to zero, and substituting (49) to (51) in the results gives the Nash equilibrium values of the two instruments.

$$\phi_1'(nz_1^N x_1) = \mu, \quad \phi_2'(z_2^N x_2) = \mu. \tag{56}$$

Comparing (48) for the case of exogenous number of foreign firms with (56), it is interesting to note that the equilibrium amount of pollution emission in the two countries are not affected at all by the free entry and exit of foreign firms as long as export subsidies are simultaneously applied with emission standards. The important policy conclusions from the analysis of this section is that market structure has no role in the determination of optimal emission standards as long as the set of policy instruments contain an element that is best suited to deal with market structures, leaving emission standards to deal with what it is supposed to target. In other words, the fact that often environmental policies are employed for strategic reasons has important implications for the nature of optimal environmental policies. Since the scope for using trade policies is limited in WTO member countries, it is important that institutions such as the WTO look hard at environmental policies and try to extricate the strategic components from the pure environmental ones.

7. Conclusion

We develop a model of FDI and analyze the interaction between environmental standards and FDI. We begin with two firms (one from each country) which compete to export a homogeneous good to a third country. The firm located in country 1 is foreign owned while that in country 2 is domestically owned. We then extend the model to allow the number of foreign firms to be endogenous. The FDI equilibrium is determined by equating the profits of the foreign firms to an exogenous level representing reservation profits which the they could obtain if they invested in alternative countries. Pollution occurs during production by all firms, and both firms possess a technology for abating pollution. The governments in the two countries can force the firms to decrease the level of emission through restrictions on pollution in the form of emission standards. Any emission standard affects country 1 welfare through effects on employment and pollution, while country 2 is affected through change in the profits of the domestic firm, employment and pollution.

We examine the equilibrium levels of emission standards on pollution when the governments act non-cooperatively and cooperatively. We find that the non-cooperative equilibrium always generates a higher level of pollution per unit of output. Furthermore, it is found that starting from the non-cooperative equilibrium, a small reduction in emission standards is strictly Pareto-improving.

When there is no entry and exit in the FDI market, the FDI host country always sets more severe policy than the other country, as the government in the former does not have to consider the effect on the outflow of FDI and the level of profits. However, the relative magnitude of quantity restrictions on pollution between the two countries is ambiguous in the presence of free entry and exit of FDI. In particular, we find that when the pollution policies are set non-cooperatively, and the number of foreign firms is endogenous, the FDI-host country will set a higher pollution allowance if the reservation profit is large (i.e. if there are few foreign firms). In the cooperative equilibrium (with endogenous number of foreign firms), our results suggest that country 2 sets a lower (higher) pollution allowance than country 1 if the marginal disutility of pollution is sufficiently high (low).

Finally, we find that the equilibrium amount of pollution in a country is independent of whether the firm operating from its soil is foreign or domestically owned and whether there is free entry and exit of foreign firms, as long as the countries apply optimally export subsidies along with emission standards.

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Notes

1. Becker and Henderson (2000), Gray (1997), Henderson (1996), Kahn (1997), Keller and Levinson (1999), and List et al. (1999) also find evidences in favour of the hypothesis that environmental regulations affect the location decision of firms. However, there are others who find the opposite (see, for example, Bartik 1988, 1989; Duffy-Deno 1992; Friedman et al. 1992; Levinson 1996; McConnell and Schwab 1990). Jeppesen et al. (2002) provides an excellent survey on this subject.
2. The benchmark model in which the location decisions are exogenous, is developed to examine later on the marginal effect of free entry and exit of foreign firms on strategic and cooperative policies.

3. The Brander and Spencer (1985) model of strategic trade policy has had extensively applications in the literature. See, for example, Ishikawa and Spencer (1999) and Qiu (1995) for two recent applications.
4. Since we rule out cross-border pollution, the only link between the two producing countries is via oligopolistic interdependence in the product market. Alternatively, one could have considered imperfect competition in the labour markets in the two countries which would have also implications for capital movements and unemployment. However, in order to have policy externalities between the two producing countries, one needs some interdependence between the two countries. We have chosen interdependence via product market – rather than via labour markets – as restrictions on commodity trade across countries are lot less severe than restrictions on labour movements.
5. In Section 6 we consider an additional instrument, viz., export (production) subsidy.
6. As Helfand (1991) points out an emission standard itself can take a variety of forms such as an emission quantity restriction per unit of output, an emission restriction per unit of certain input, restrictions on the use of a particular input, or mandated use of a particular pollution-control technology. In this paper we shall consider a quantity restriction on emission in the form of a restriction on emission *per unit of output*, and for expositional simplicity call the latter simply an emission standard. An emission standard is typically not marketable, i.e. it is imposed by environmental authorities as a command.
7. Although FDI is getting more and more popular over time, it is still not the case that the mobility of capital is perfect, particularly in the developing world. There is still a strong political force in those countries that opposes FDI, and government policies on FDI get influenced by lobbying from such interest groups.
8. There is a numeraire good at the background and this good is produced using labour and a sector specific factor unelastically supplied. Labour is freely mobile between the two sectors (within a country) and the wage rate in terms of the numeraire good is rigid. Labour is the only factor of production in the oligopolistic sectors. Production technologies are of the constant returns to scale type everywhere. Given this framework, for our welfare analysis, we can ignore the numeraire good sector.
9. For simplicity, we assume μ to be the same for the two firms.
10. Both θ_i's and z_i's are implicitly assumed to be above the level which the World Health Organization considers to be harmless.
11. We only consider the case of local pollution. That is, pollution harms only the country where it is generated. Hence, we rule out transboundary pollution. See, for example, Copeland (1996), Copeland and Taylor (1995) and Hatzipanayotou et al. (2002) for analysis of transboundary pollution.
12. Note that we assume the demand function to be linear for analytical simplicity. However, our qualitative results are robust under a more general demand functions. Let $p = f(D)$ be a general inverse demand function. Solving for Cournot–Nash type first-order profit maximization conditions, and totally differentiating the results one can obtain ($\mathrm{d}x_i = -(\mu/f')\mathrm{d}z_i - \Delta_i \mathrm{d}D$), where ($\Delta_i = 1 + f'' x_i/f'$), and ($i = 1, 2$). In the literature Δ_i is normally assumed to be positive. This assumption correspond to the 'normal' case in Seade (1980) and to the strategic substitutes in Bulow et al. (1985). The stability of the Cournot equilibrium is guaranteed when ($1 + \Delta_1 + \Delta_2$) is positive.
13. Note that if z_1^N in (14) is negative, the optimal policy would be to impose the strictest restriction, i.e. $z_1^N = 0$.
14. There are no cross effects on welfare of relaxing the pollution standards through employment in country 1, and through employment and domestic profits in country 2 because of the linear specification of the model.

15. By strict Pareto improvement, we mean that the welfare levels in country 1 and 2 are higher: we do not take into account the consuming country's welfare.
16. Unfortunately, it is not possible to endogenize the numbers of firms in both countries as then one group of firms – the ones with higher marginal costs – will be forced out of the market. One way out could be to relax the assumption that the goods produced by the two group of firms are homogeneous as was done in Lahiri and Ono (1998b).
17. The exact condition is however different here because the model structure is somewhat different.
18. For example, a proposal has been introduced in the U.S. congress, so called Green Bill, which would authorize the administration to impose eco-dumping duties against lower environmental standards abroad. See Bhagwati (1995) for further discussion on this proposal. According to Bhagwati, the actual motivation for the bill is not the improvement of world environment, but it is simply a protectionist measure.
19. For the analysis in this section we need the marginal disutility in each country to be increasing. If they were constants, we would only get corner solutions for emission standards. In particular, there would be the strictest emission standards in country i if $\phi_i' > \mu$ and the firm in country i would be allowed not to abate any pollution if $\phi_i' < \mu$ $(i = 1, 2)$.

References

Andersson, T., C. Folke and S. Nyström (1995), *Trading with the Environment*. London: Earthscan Publications.

Barret, S. (1994), 'Strategic Environmental Policy and International Trade', *Journal of Public Economics* **54**, 325–338.

Bartik, T. J. (1988), 'The Effects of Environmental Regulation on Business Location in the United States', *Growth and Change* **19**, 22–44.

Bartik, T. J. (1989), 'Small Business Start-ups in the United States: Estimates of the Effects of Characteristics of States', *Southern Economic Journal* **55**, 1004–1018.

Becker, R. and J. V. Henderson (2000), 'Effects of Air Quality Regulation on Polluting Industries', *Journal of Political Economy* **108**, 379–421.

Bhagwati, J. (1995), *Free Trade, 'Fairness' and the New Protectionism: Reflections on an Agenda for the World Trade Organization*. Wincott memorial lecture, 24th Occasional paper, Institute of Economic Affairs, 96. London: Institute of Economic Affairs for the Wincott Foundation.

Brander, J. A. and B. J. Spencer (1985), 'Export Subsidies and International Market Share Rivalry', *Journal of International Economics* **18**, 83–100.

Brander, J. A. and B. J. Spencer (1987), 'Foreign Direct Investment with Unemployment and Endogenous Taxes and Tariffs', *Journal of International Economics* **22**, 257–279.

Bulow, J. I., J. D. Geanakoplos and P. D. Klemperer (1985), 'Multimarket Oligopoly: Strategic Substitutes and Complements', *Journal of Political Economy* **93**, 488–511.

Copeland, B. R. (1996), 'Pollution Content Tariffs, Environmental Rent Shifting, and the Control of Cross-border Pollution', *Journal of International Economics* **40**, 459–476.

Copeland, B. R. and M. S. Taylor (1995), 'Trade and Transboundary Pollution', *American Economic Review* **85**, 716–737.

Duffy-Deno, K. (1992), 'Pollution Abatement Expenditures and Regional Manufacturing Activity', *Journal of Regional Science* **32**, 419–436.

Friedman, J., D. A. Gerlowski and J. Silberman (1992), 'What Attracts Foreign Multinational Corporations? Evidence from Branch Plant Location in the United States', *Journal of Regional Science* **32**, 403–418.

Gray, W. B. (1997), 'Manufacturing Plant Location: Does State Pollution Regulation Matter?' Clark University.

Hatzipanayotou, P., S. Lahiri and M. S. Michael (2002), 'Can Cross-Border Pollution Reduce Pollution?', *Canadian Journal of Economics* **35**, 805–818.

Helfand, G. (1991), 'Standards Versus Standards: The Effect of Different Pollution Restrictions', *American Economic Review* **81**, 622–634.

Henderson, J. V. (1996), 'Effects of Air Quality Regulation', *American Economic Review* **86**, 789–813.

Ishikawa, J. and B. J. Spencer (1999), 'Rent-shifting Export Subsidies with an Imported Intermediate Product', *Journal of International Economics* **48**, 199–232.

Jeppesen, T., J.A. List and H. Folmer (2002), 'Environmental Regulations and New Plant Location Decisions: Evidence from a Meta-Analysis', *Journal of Regional Science* **42**(1), 19–49.

Kahn, M. E. (1997), 'Particulate Pollution Trends in the United States', *Regional Science and Urban Economics* **27**, 87–107.

Keller, W. and A. Levinson (1999), 'Environmental Regulations and FDI Inflows to U.S. States: The Potential for a "Race to the Bottom" of Environmental Stringency', Paper prepared for the ISIT99 Conference, June 4–5.

Lahiri, S. and Y. Ono (1998a), 'Foreign Direct Investment, Local Content Requirement, and Profit Taxation', *Economic Journal* **108**, 444–457.

Lahiri, S. and Y. Ono (1998b), 'Tax Competition in the Presence of Cross-hauling', *Weltwirtschaftliches Archiv* **134**, 263–279.

Lahiri, S. and Y. Ono (2000), 'Protecting Environment in the Presence of Foreign Direct Investment: Tax Versus Quantity Restriction', Discussion Paper, Department of Economics, University of Essex.

Levinson, A. (1996), 'Environmental Regulations and Manufacturer's Location Choices: Evidence from the Census of Manufactures', *Journal of Public Economics* **61**, 5–29.

List, J. A., W. McHone, J. Lee and M. Soskin (1999), 'Effects of Air Quality Regulation on Manufacturing Births: Evidence from a Panel of Counties in New York State', Working Paper AREC, University of Maryland.

Low, P. and A. Yeats (1992), 'Do Dirty Industries Migrate?', in P. Low, ed., *International Trade and the Environment:* The World Bank, Washington, DC, pp. 89–103.

Lucas, R. E. B., D. Wheeler and H. Hettige (1992), 'Economic Development, Environmental Regulation and the International Migration of Toxic Industrial Pollution: 1060–1988', in P. Low, ed., *International Trade and the Environment*, pp. 89–103. Washington DC: The World Bank.

Markusen, J. R., E. R. Morey and N. Olewiler (1993), 'Environmental Policy when Market Structure and Plant Locations are Endogenous', *Journal of Environmental Economics and Management* **24**, 69–86.

Markusen, J. R., E. R. Morey and N. Olewiler (1995), 'Competition in Regional Environmental Policies When Plant Locations are Endogenous', *Journal of Public Economics* **56**, 55–57.

McConnell, V. D. and R. M. Schwab (1990), 'The Impact of Environmental Regulation on Industry Location Decisions: The Motor Vehicle Industry', *Land Economics* **66**, 67–81.

Qiu, L. D. (1995), 'Strategic Trade Policy under Uncertainty', *Review of International Economics* **3**(1), 75–85.

Seade, J. (1980), 'On the Effects of Entry', *Econometrica* **48**, 479–489.

UNCTAD (1998), *World Investment Report 1998*: *Trends and Determinants*, United Nations Publications.

Xing, Y. and C. Kolstad (2002), 'Do Lax Environmental Regulations Attract Foreign Investment?', *Environmental and Resource Economics* **21**, 1–22.