

Environmental Standards, Wage Incomes and the Location of Polluting Firms*

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Abstract. The purpose of this paper is to study how the choice of environmental standards by governments is affected by the existence of wage incomes when firms' location is endogenous. In developed countries labor is unionized, which allows positive wage incomes to arise. Thus, each government has incentives to persuade firms to locate in its country since its social welfare depends on such incomes. But, as pollution damages the environment, each government will try to persuade polluting firms to locate in its country to obtain the wage incomes only when its valuation of environmental damage shows that it is low.

Key words: environmental standards, firms' location, wage incomes

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1. Introduction

In debates on the European Single Market and NAFTA some environmentalists raised the concern that free trade might damage the environment. They argued that firms would locate their polluting plants in countries with weak environmental policies, selling their products on the international market. Therefore, competition could arise between governments, by means of a strategic choice of environmental policy, to get polluting firms to locate in their countries because of the positive incomes that this would generate, e. g., the wage incomes of workers. But, on the other hand, as pollution damages the environment each government wants firms to locate in other countries and pollute there.

Given the above arguments, the purpose of this paper is to study how the existence of wage incomes influences the choice of environmental policy by governments when the location of polluting firms is endogenous. It must be noted that, in developed countries, workers are unionized and thus wages are the result of negotiation between firms and unions.

The effect that the environmental policy fixed by governments has on the choice of firms' location was analyzed first by Markusen *et al.* (1993), Motta and Thisse (1994) and Ulph (1994a). These studies do not consider any strategic interaction between governments because they assume that the environmental policy of a government is given or that environmental targets are exogenous. Strategic interaction between governments is an important question and, thus, subsequent papers focused on it.

Rauscher (1995), Markusen *et al.* (1995), Markusen (1997), Ulph and Valentini (1997) and Hoel (1997) assume that environmental policy is an endogenous variable and, thus, there is strategic interaction between governments. These studies consider taxes as the only environmental policy tool. The taxes chosen by governments affect not only to the location of firms but also environmental damage in their countries. Therefore, when each government

chooses its environmental policy a trade off is present. On the one hand, when firms locate in a country with a strict environmental policy they are less competitive in the international market because their marginal production costs increase. Therefore, firms might locate new plants in countries with a lax environmental policy, which would decrease social welfare in countries with a strict policy. On the other hand, when a government chooses a strict policy that protects the environment by reducing the pollution level, this improves its social welfare.

The aforementioned papers measure social welfare in each country as the sum of consumer surplus, firms' profits, quality of the environment and tax incomes. Nevertheless, in debates about environmental policy it is argued that social welfare is also affected by employment. Hoel (1997) and Markusen (1997) argue that the choice of environmental policy by a government affects the location of firms and, thus, the employment level in its country. However, they do not consider that the workers of those firms obtain positive wage incomes. In developed countries labor is usually unionized, and thus wages are the result of negotiation between firms and unions. Therefore, when labor is unionized there are positive wage incomes and governments have incentives to choose a lax policy to get firms to locate in their countries, since the welfare level in each country depends on such incomes.¹ We shall analyze this question in this paper.

The aforementioned studies consider that the policy tools that governments use are environmental taxes. However, in practice, environmental standards are the policy tools that governments use to control pollution.² Indeed, Ulph (1992) shows that, in a theoretical framework of strategic international trade, governments prefer to use standards rather than taxes as their environmental policy tool. Therefore, we shall consider that governments choose environmental standards to control environmental damage.

Empirical evidence shows that government environmental policy influences the decision of firms as to where to locate. Thus, Rowland and Feiock (1991) point out that

environmental regulations affect firms' location decisions in the chemical industry in the United States. Hettige *et al.* (1992), Lucas *et al.* (1992) and Low and Yeats (1992) conclude that there has been a long-term upward trend in industrial emissions for most countries, and that this upward trend is higher in lower income countries. This result is consistent with an industrial displacement effect on dirtier industries resulting from stricter environmental regulations in industrialized countries since 1970.³

An example illustrating this question is given by the case of the French chemical multinational Elf Atochem. This firm moved one of its production plants from Lyon to Spain, due to the more lax Spanish environmental policy. Greenpeace argued that the firm moved its production plant due to the pressure of French public opinion. The Spanish government, given its lower valuation of the environment, permitted the firm to locate in its country due to the positive effects on the employment level (*El Correo Español*, 7-10-93).

The above example illustrates the question that we want to analyze in this paper. Thus, we consider a single market made up of two countries and one polluting firm that has to decide its location. The firm produces a good whose productive process pollutes only in the country in which the firm locates. We consider that workers are unionized, so there are positive wage incomes in the country in which the firm locates. The existence of these incomes gives each government a stronger incentive to compete for the firm. We show that each government can choose strategically its environmental standard to get the firm to locate in its country even if this damages the environment. In this way, the country in which the firm locates obtains the wage incomes paid by the firm. In the absence of competition by governments, they could choose a stricter standard.

To show the relevance of considering positive wage incomes we compare this case with that in which there are no wage incomes. We obtain that, in equilibrium, the environmental

standard chosen by governments, and thus the pollution level and the location of the firm, differ depending on whether there are wage incomes or not.

The paper is organized as follows. Section 2 presents the model. Section 3 studies the case in which there are wage incomes. Section 4 analyzes the case in which there are none. Section 5 compares the two cases, and finally, conclusions are drawn in section 6.

2. Model

We consider a single market comprising two countries, A and B , and one firm that has to decide in which of these two countries to locate. The firm produces a good whose productive process pollutes, and sells it in the single market. There are no transportation costs, and no possibility of discriminating between consumers from different countries.

In country i , the inverse demand function for the product is:

$$p = a - 2q_{ik}, \quad i, k = A, B, \quad (1)$$

where p is the price in force in the single market for the product, a is a positive parameter and q_{ik} is the amount of the product consumed in country i when the firm is located in country k .

The single market inverse demand function for the product is then:

$$p = a - y_k, \quad k = A, B, \quad (2)$$

where y_k is the total output produced by the firm when it is located in country k . Therefore,

$$y_k = q_{Ak} + q_{Bk}.$$

Consumers from both countries can buy the product independently of the location of the firm. Therefore, when the firm is located in country k , the consumer surplus in country i , denoted by CS_{ik} , is:

$$CS_{ik} = (q_{ik})^2, \quad i, k=A, B. \quad (3)$$

The only factor used in the production process is labor. When the firm is located in country k it contracts L_k workers with a uniform wage rate w_k . The wage incomes in country k are thus $R_k(w_k, L_k) = w_k L_k$; in the other country the wage incomes paid by the firm are zero.⁴ All workers are unionized and there is no labor mobility between countries. The technology used by the firm exhibits constant returns to scale such that: $y_k = L_k, k=A, B$.

We consider a variant of the “right-to-manage” model of Nickell and Andrews (1983), where the employer and the union bargain over the wage while employment is set unilaterally by the firm. The union and the firm are both risk neutral and there is no uncertainty. The firm aims to maximize its profit while the union aims to maximize wage incomes.

Each government has the environmental standard (emission quantity) per unit of output as a decision variable. It is assumed that the government may implement a maximum level of pollution which can be achieved through domestic environmental policies. When the firm locates in country k it has to take into account the standard set in this country, e_k , which affects its cost function. When the government sets a strict standard (a low e_k), the firm has to use a production technology with a high variable cost.⁵ This effect is shown in the variable cost function of the firm:

$$C_k(y_k) = c_k y_k = (1 + w_k - e_k) y_k, \quad c_k > 0, \quad k=A, B. \quad (4)$$

The marginal production cost, c_k , depends positively on the wage set in the country k , w_k , and negatively on the domestic environmental standard, e_k . The firm takes an optimum decision on how much to pollute. This is precisely the maximum level of pollution per unit of output that the government of the country k permits, because the greater the pollution the smaller the marginal cost.

We consider that environmental damage is local.⁶ We use a quadratic functional form to measure the environmental damage generated in country k , denoted by D_k , by the productive process when the firm locates in this country; there is no environmental damage in the other country:⁷

$$D_k = \frac{1}{4} (y_k e_k)^2, \quad k=A, B. \quad (5)$$

The social welfare function considered by government of country i comprises the workers' incomes and the consumer surplus minus the environmental damage caused by the production process:⁸

$$W_{ik}(e_k) = CS_{ik} - g_i D_k + R_k, \quad i, k=A, B, \quad (6)$$

where D_k and R_k are positive if $k=i$, and are zero if $k \neq i$. The positive parameter g_i measures the valuation of the environment by the government i : it can be interpreted as willingness to pay to decrease environmental damage in one unit.

To analyze the choice of environmental policy when there are positive wage incomes and the firm's location is endogenous, we propose a four stage game with the following timing. First, the two governments decide their environmental standards simultaneously and independently; they can commit themselves to these policy variables, which are common knowledge. In the second stage, the firm chooses its location and a technology to comply with the environmental policy. In the third stage, the firm bargains wages with its workers. Finally, the firm takes its production decision. The equilibrium concept used is the subgame perfect equilibrium solved by backward induction.

3. Results

In the fourth stage the firm chooses the output level that maximizes its profit given the environmental standard and the wages set in country k . Therefore, when the firm is located in country k it will produce:

$$y_k = L_k = \frac{a - 1 - w_k + e_k}{2}, \quad k=A, B. \quad (7)$$

Output level decreases with wages since it increases the marginal production cost. Output level increases with the standard since a higher level of e_k , implies a more polluting technology and, thus, a lower marginal production cost.

Using (7) it is easy to see that the firm's profit, π_k , the output sold in each country, q_{ik} , the wage incomes obtained by the workers of the firm, R_k , the consumer surplus in country i , CS_{ik} , and the environmental damage, D_k , as a function of the wage and the environmental standard are, respectively:

$$\pi_k = \left(\frac{a-1-w_k+e_k}{2} \right)^2 - F_k, \quad q_{ik} = \frac{a-1-w_k+e_k}{4}, \quad R_k = \frac{w_k(a-1-w_k+e_k)}{2}, \quad (8)$$

$$CS_{ik} = \left(\frac{a-1-w_k+e_k}{4} \right)^2, \quad D_k = \left(\frac{e_k(a-1-w_k+e_k)}{4} \right)^2, \quad i, k=A, B,$$

where F_k is the fixed cost of locating the firm in country k .⁹

In the third stage, given e_k , the firm bargains wages with the union. The result of this negotiation is given by:

$$w_k(e_k) = \underset{w_k}{\operatorname{argmax}} (\pi_k - d_k) R_k, \quad k=A, B, \quad (9)$$

where the wage incomes and the profit of the firm are given by (8). By d_k we denote the disagreement payoff of the firm: $d_k = -F_k$; when the firm does not produce it loses the fixed cost. The disagreement payoff of the union is zero given that there is “one to one” bargaining. Solving the first order conditions of problem (9) we obtain the equilibrium wage, w_k^* :

$$w_k^* = \frac{a-1+e_k}{4}, \quad k=A, B. \quad (10)$$

Expression (10) shows that the higher the environmental standard chosen by the government k , the higher the wages that the firm will pay. This is because the higher the standard, the lower the marginal production cost of the firm (c_k) and, thus, the higher the output level and the profit of the firm. As a result, the union demands a greater wage and the firm can pay it.

Using (10) we get that the profit of the firm, its output level, the wage incomes of its workers, the consumer surplus and the environmental damage when the firm is located in country k ($k=A, B$) are, respectively:

$$\pi_k^* = \frac{9(a-1+e_k)^2}{64} - F_k, y_k^* = \frac{3(a-1+e_k)}{8}, R_k^* = \frac{3(a-1+e_k)^2}{32}, \quad (11)$$

$$CS_{ik}^* = \frac{9(a-1+e_k)^2}{256}, D_k^* = \frac{9(e_k)^2(a-1+e_k)^2}{256}.$$

Hereafter, we shall denote the government k by k ($k=A, B$). To simplify the analysis we assume that the government of each country can choose either a strict environmental policy ($e_k=0$) to achieve a low pollution level, or a lax one ($e_k=e$) to permit a higher pollution level.

In the second stage of the game, given e_k and F_k , the firm has to decide its location. We assume, without loss of generality, that $F_A=0$ and $F_B=F$, where F is a positive parameter. Thus, the fixed cost of locating the firm in country B is higher than for country A : $F_B-F_A=F$.

We can distinguish three cases. First, when $e_A=e_B$, given that both governments choose the same policy, the marginal production cost is the same in both countries, $c_A=c_B$; therefore, as $F_A < F_B$, the firm will locate in country A . Second, when $e_A=e$ and $e_B=0$, given that A allows a higher pollution level than B , we have that $c_A < c_B$; as $F_A < F_B$ the firm will locate in country A . Thirdly, when $e_A=0$ and $e_B=e$, there is a trade off: the marginal production cost is lower in country B ($c_A > c_B$ since $e_A < e_B$) but the fixed cost is higher ($F_A < F_B$). As a result, the firm will locate in country B if and only if $F \leq F_o$. By F_o we denote the value of the fixed cost such that, given these environmental policies, the firm obtains the same profit in the two

countries; that is, $F_o = \frac{9e(e + 2a - 2)}{64}$.¹⁰ When $F \leq F_o$ the firm will locate in country B since its smaller marginal production cost offsets its greater fixed cost.

In the first stage, each government chooses the environmental standard that maximizes its social welfare. Therefore, when the firm locates in country k , the social welfare obtained by the government of country i is:

$$W_{ik}(e_k) = CS_{ik}^* - g_i D_k^* + R_k^*, \quad i, k=A, B, \quad (12)$$

where D_k^* and R_k^* are positive if $k=i$, and are zero if $k \neq i$, and where CS_{ik}^* , D_k^* and R_k^* are given by (11). We assume that $g_i < \frac{11}{3e^2} = \bar{g}$ ($i=A, B$), to assure that social welfare is always positive. Let us denote by $W_{ik}^{e_A e_B}$ ($i, k=A, B$) the social welfare of government i when the firm locates in country k , given that A chooses environmental standard e_A and B chooses standard e_B .

In this stage, given that we consider two countries, the following cases arise: both governments chooses the strict standard ($e_A=e_B=0$) or the lax one ($e_A=e_B=e$); A chooses the lax standard ($e_A=e$) whereas B chooses the strict one ($e_B=0$); and, A chooses the strict standard ($e_A=0$) and B the lax one ($e_B=e$).

The first case is that in which both countries choose the same standard: the strict one ($e_A=e_B=0$) or the lax one ($e_A=e_B=e$). As we have seen, in this case the firm locates in country A . Therefore, the social welfare in countries A and B is given by the following expressions:

$$W_{AA}^{00} = \frac{33(a-1)^2}{256}, \quad W_{BA}^{00} = \frac{9(a-1)^2}{256},$$

$$W_{AA}^{ee} = \frac{3(a-1+e)^2(11-3e^2g_A)}{256}, \quad W_{BA}^{ee} = \frac{9(a-1+e)^2}{256}.$$

The second case is that in which A chooses the lax standard ($e_A=e$) and B chooses the strict one ($e_B=0$). In this case, the firm locates in country A ; therefore, the social welfare in countries A and B is $W_{AA}^{ee} = W_{AA}^{e0}$ and $W_{BA}^{ee} = W_{BA}^{e0}$.

The third case is that in which A chooses the strict standard ($e_A=0$) and B the lax one ($e_B=e$). When $F \leq F_o$ the firm will locate in country B , and the social welfare in countries A and B is: $W_{AB}^{0e} = W_{BA}^{ee}$, $W_{BB}^{0e} = \frac{3(a-1+e)^2(11-3e^2g_B)}{256}$. When $F > F_o$ the firm will locate in country A and the social welfare in each country is $W_{AA}^{0e} = W_{AA}^{00}$ and $W_{BA}^{0e} = W_{BA}^{00}$.

To simplify the exposition of the results, we will show first the equilibrium of the game assuming that $F > F_o$, the case in which the firm locates in country A independently of the environmental standards chosen by the governments. Secondly, we will solve the game assuming that $F \leq F_o$, the case in which the firm can locate in either country.

3.1. The choice of the environmental standard on the grounds of efficiency

In this section we assume that the fixed cost of setting up the firm in country B is greater than F_o . Therefore, the firm will locate in country A independently of the environmental policies chosen by the governments.

Let $g_1 = \frac{11(2(a-1)+e)}{3e(a-1+e)^2}$ denote the level of g_A such that $W_{AA}^{ee_B} = W_{AA}^{0e_B}$, ($e_B=0, e$); the parameter g_A measures the valuation of the environment by A. Comparing social welfare levels in each country in these cases, we obtain the following result.

Proposition 1. *When $F > F_o$, in equilibrium, the firm locates in country A. Government A chooses the lax standard if its valuation of the environment is low enough ($g_A < g_1$). If its valuation of the environment is high enough ($g_A \geq g_1$) government A chooses the strict standard. Government B is indifferent to the two standards.*

This proposition shows that A chooses the environmental standard on grounds of efficiency. As $F > F_o$ firm locates in country A independently of the governments' environmental policies because location in country B is too expensive. B is indifferent between the lax and the strict standard, since neither of the two standards can get the firm to locate in its country.

The standard chosen by A does not affect the location of the firm. It affects the wage paid by the firm and its marginal cost and, therefore, A's social welfare. The lax standard implies a higher wage but a lower marginal cost than the strict standard. Thus, the first policy generates higher consumer surplus and wage incomes. However, this policy causes a greater environmental damage. When A's valuation of the environment is low ($g_A < g_1$) it is a dominant strategy for A to choose the lax standard, because the greater consumer surplus and wage incomes offset the greater environmental damage. If $g_A \geq g_1$ the result is reversed.

3.2. Strategic interaction between governments

In this section we assume that $F \leq F_o$; i. e., the fixed cost of locating the firm in country B is low. Therefore, depending on the governments' standards, the firm could decide to locate in country B .

Let $g_2 = \frac{8}{3e^2}$ denote the level of g_A such that $W_{AB}^{0e} = W_{AA}^{ee}$, and $g_3 = \frac{11(a-1+e)^2 - 3(a-1)^2}{3e^2(a-1+e)^2}$ denote the level of g_B such that $W_{BA}^{00} = W_{BB}^{0e}$. Comparing the social welfare levels obtained in the cases analyzed above we can identify the following three zones. Zone *I* groups the values of g_A and g_B such that $g_A \leq g_2$ when $g_B \leq g_3$ and $g_A \leq g_1$ when $g_B > g_3$. Zone *II* is formed by the values of g_A and g_B such that $g_1 < g_A$ and $g_3 < g_B$. Finally, zone *III* groups the values of g_A and g_B such that $g_2 < g_A$ and $g_B \leq g_3$.¹¹ These three zones are shown in figure 1, which illustrates the following result.

Proposition 2. When $F \leq F_o$, in equilibrium, in zone *I* the firm locates in country A , whose government chooses the lax standard. In zone *II* both governments choose the strict standard and the firm locates in country A . Finally, in zone *III* the firm locates in country B , government A chooses the strict standard and government B the lax one.

[INSERT FIGURE 1]

As figure 1 shows, in zone *I*, the firm locates in country A , since its government chooses the lax standard. This standard implies a higher wage and a lower marginal production cost than the strict one. As a result, the lax standard generates higher consumer surplus and workers' incomes than the strict one. But, on the other hand, the lax standard causes greater

damage to the environment. In this zone, A prefers the lax standard. Therefore, even if B chooses the lax standard too, as the cost of locating the firm in this country is positive, the firm will always locate in country A .

In zone I , when $g_A \leq g_1$ there is no strategic interaction between the governments. As A 's dominant strategy is to choose the lax standard, the firm will never locate in country B . When $g_1 < g_A \leq g_2$ there is strategic interaction between the governments. In this case, given that g_A is high enough, A would prefer the strict policy. Nevertheless, if A set $e_A=0$, B would choose $e_B=e$, given that g_B is low, and thus the firm would locate in country B . Therefore, A would choose the lax standard to avoid the firm's locating in country B . In this way, the firm locates in country A , generating positive wage incomes in this country. As A chooses the lax standard, these incomes are high since the equilibrium output level increases with standards. The problem is that it implies that the environmental damage is the highest possible in this country.

In zone II , in equilibrium, both governments choose the strict standard. But, as it is more expensive to locate the firm in country B , the firm will always locate in country A . In this zone, when $g_1 < g_A \leq g_2$ there are two equilibria: in one of them both governments choose the strict standard, and in the other both choose the lax one. However, for A the first equilibrium Pareto dominates the second one. If A chooses $e_A=0$ the firm locates in its country since, as g_B is high enough ($g_3 \leq g_B$), B will never choose the lax standard. Thus, as in both equilibria the firm always locates in country A , its government chooses $e_A=0$ since the strict standard generates higher social welfare. In this zone, A gets the firm to locate in its country, which implies that there are wage incomes in this country (although they are low), and this is obtained with the lowest environmental damage possible. However, in zone I , when $g_1 < g_A \leq g_2$, A has to choose the lax standard to avoid the firm's locating in the other country.

In zone *II*, when $g_A > g_2$, there is only one equilibrium: both governments choose the strict standard, because the valuation of the environment by both governments is high. If *B* chooses the lax standard when *A* chooses the strict one, the firm will locate and pollute in country *B*. Thus, although by choosing the lax standard the consumer surplus is higher and the wage incomes are positive, the valuation of the environmental damage has a stronger weight. Then *B* would choose the strict standard, since in this way the firm locates in the other country, polluting there.

In zone *III*, though *B* has the disadvantage of a higher fixed cost than *A*, its valuation of the environment is lower. In this zone, *A*'s dominant strategy is to choose the strict standard. Therefore, *B* will choose the lax one to get the firm to locate in its country, and thus obtain the wage incomes, although the environment is damaged. Given that $F \leq F_0$, the firm will locate in country *B*. As a result, although its fixed cost is higher, when *A*'s valuation of the environment is high enough ($g_A > g_2$) the firm locates in country *B*, generating positive wage incomes in this country, but at the cost of the highest environmental damage possible.

The literature on the choice of environmental policy, when the location of firms is endogenous, does not consider that there are positive wage incomes. To show the significance of this assumption, we shall compare the case in which there are positive wage incomes with the case in which there are no such incomes. The first case has been analyzed in the foregoing section. We shall consider the second case below.¹²

4. The choice of environmental standards when there are no wage incomes

In this section we assume that the wage is zero to focus on the case in which there are no wage incomes. We propose a three stage game. In the first stage, the two governments decide their environmental standard simultaneously and independently. In the second stage,

given the standard chosen by each government, the firm decides on its location and on a technology to comply with the environmental standard. Finally, in the third stage, the firm takes its production decision.

In the last stage the firm chooses the output level that maximizes its profit. When the firm locates in country k , in equilibrium, the firm's profit and the output sold in each country are given by (8), assuming that $w_k=0$.

In the second stage, the firm decides its location. As we saw in section 3, when the two governments choose the same standard or when A chooses the lax standard and B the strict one, the firm always locates in country A . The firm locates in country B only when $e_A=0$, $e_B=e$ and $F \leq F_I$; where F_I is the value of the fixed cost such that, given these standards, the firm obtains the same profit in the two countries; that is, $F_I = \frac{e(e+2a-2)}{4}$. When $F > F_I$ the firm locates in country A .

In the first stage each government chooses the standard that maximizes its social welfare. If the firm locates in country k , the social welfare function considered by the government of country i is given by (6) assuming that $w_k=0$. We assume that $g_i < \frac{1}{e^2} = \hat{g}$, $i=A, B$, to assure that social welfare is always positive. There are two countries and two standards; thus, the following cases arise.

The first case is that in which both governments choose the same standard: the strict one ($e_A=e_B=0$) or the lax one ($e_A=e_B=e$). In this case, the firm locates in country A , and the social welfare in countries A and B is given by:

$$W_{BA}^{00} = W_{AA}^{00} = \frac{(a-1)^2}{16}, \quad W_{AA}^{ee} = \frac{(a-1+e)^2(1-e^2g_A)}{16}, \quad W_{BA}^{ee} = \frac{(a-1+e)^2}{16}.$$

The second case is that in which A chooses the lax standard and B chooses the strict one ($e_A=e, e_B=0$). In this case the firm locates in country A , and the social welfare in countries A and B is $W_{AA}^{ee} = W_{AA}^{e0}$ and $W_{BA}^{ee} = W_{BA}^{e0}$.

The last case is that in which A chooses the strict standard and B the lax one ($e_A=0, e_B=e$). If $F > F_1$ the firm locates in country A and the social welfare in countries A and B is $W_{AA}^{0e} = W_{AA}^{00}$ and $W_{BA}^{0e} = W_{BA}^{00}$. If $F \leq F_1$ the firm locates in country B and the social welfare in

each country is: $W_{AB}^{0e} = W_{BA}^{ee}, W_{BB}^{0e} = \frac{(a-1+e)^2(1-e^2 g_B)}{16}$.

Next we solve the first stage of the game when $F > F_1$. In this case, the firm will locate in country A independently of the standards chosen by the two governments. Let $g_4 = \frac{2(a-1)+e}{e(a-1+e)^2}$ denote the level of g_A such that $W_{AA}^{eeB} = W_{AA}^{0eB}$ ($e_B=0, e$). Comparing the social welfare levels in each country in the above cases, we obtain the following result.

Proposition 3. *When $F > F_1$ and there are no wage incomes, in equilibrium, the firm locates in country A . When $g_A < g_4$ ($g_A \geq g_4$) government A chooses the lax (strict) standard. Government B is indifferent to the two standards.*

This proposition shows that, in this case, there is no strategic interaction between governments. As $F > F_1$ the firm locates in country A independently of the standards chosen by the two governments since it is too expensive to locate the firm in country B . When A 's valuation of the environment is low ($g_A < g_4$) it is a dominant strategy for A to choose the lax standard. The reason is that the greater consumer surplus offsets the greater environmental damage. If $g_A \geq g_4$ the result is reversed.

Next we solve the first stage of the game when $F \leq F_1$. It is easy to see that in this case $W_{BA}^{00} = W_{BB}^{0e}$ for $g_B = g_4$ and $W_{AB}^{0e} > W_{AA}^{ee}$. Comparing the social welfare levels in the different cases analyzed, we can identify the following four zones. Zone I' groups the values of g_A and g_B such that $g_A \leq g_4$ and $g_B \geq g_4$. Zone II' is formed by the values of g_i such that $g_i > g_4$, $i=A, B$. Zone III' groups the values of g_i such that $g_i > g_4$, $i=A, B$. Finally zone IV' is formed by the values of g_A and g_B such that $g_A \geq g_4$ and $g_B \leq g_4$. These four zones are shown in the figure 2, which illustrates the following result.

Proposition 4. When $F \leq F_1$ and there are no wage incomes, in equilibrium, in zone I' the firm locates in country A, $e_A = e$ and $e_B = 0$. In zone II' both governments choose $e_A = e_B = 0$ and the firm locates in country A. In zone III' there are two equilibria. In one of them $e_A = e$, $e_B = 0$ and the firm locates in country A; in the other $e_A = 0$, $e_B = e$ and the firm locates in country B. Finally, in zone IV' the firm locates in country B, $e_A = 0$ and $e_B = e$.

[INSERT FIGURE 2]

In zone I' , the firm always locates in country A, since its government chooses the lax standard. This standard generates a lower marginal production cost and a higher consumer surplus than the strict one. But, on the other hand, the lax standard causes greater environmental damage than the strict one. Given that in this zone A's valuation of the environment is low enough, A prefers the lax standard since the consumer surplus has a higher weight than the environmental damage in its social welfare function. However, as g_B is high enough, B prefers the strict standard to avoid the firm's locating in its country.

Therefore, in this zone, the government that has a greater valuation of the environment chooses the strict standard.

In zone II' , in equilibrium, both governments choose the strict standard to protect the environment since their valuation of environmental damage is high. In this zone, both governments want the firm to locate in the other country. But, as it is more expensive to locate the firm in country B , the firm will always locate in country A .

In zone III' there are two equilibria. In one of them $e_A=e$, $e_B=0$ and the firm locates in country A ; in the other $e_A=0$, $e_B=e$ and the firm locates in country B . To explain the results of this zone it must be noted that there are no wage incomes and thus each government has lower incentives to get the firm to locate in its country. Therefore, if one government chooses the lax standard, the other one will choose the strict standard since it assures that the firm locates and pollutes in the other country and the highest possible consumer surplus is obtained in both countries. If one government chooses the strict standard, the other one will choose the lax one. The reason is that as both governments have a low valuation of the environment, they would prefer to get the highest consumer surplus even though the environmental damage is the highest possible. Obviously each government prefers the firm to pollute in the other country.

In zone IV' , A has a high valuation of the environment and B has a low one. In this zone A 's dominant strategy is to choose the strict standard. Therefore, B will choose the lax standard to get the firm to locate in its country although it damages its environment. Given that $e_A=0$, $e_B=e$ and $F \leq F_1$ the firm will locate in country B .

5. Comparison of results

In this section we shall compare the case in which there are wage incomes with the case in which there are no such incomes when $F \leq F_o$ (see Figure 3). This is the most relevant case because, when social welfare is positive in both countries, there is strategic interaction between governments when they choose their environmental standards.

[INSERT FIGURE 3]

In figure 3 we can differentiate two main areas.¹³ The first one is made up of zones 1, 2, 3 and 4 while the second one is made up of zones 5, 6, and 7. We analyze the first area below.

In zone 1, the firm locates in both cases in country *A*, whose government chooses the lax standard. When there are wage incomes, *A*'s dominant strategy is to choose the lax standard to get such incomes, given that its valuation of the environment is low. When there are no wage incomes each government wants the firm to locate in the other country. *B* ensures this by choosing the strict standard. As a result, *A* chooses the lax standard.

In zone 2, *A* chooses the lax standard when there are wage incomes, which ensures that the firm locates in its country and it obtains those incomes. When there are no wage incomes, each government wants the firm to locate in the other country, if this one chooses the lax standard (which assures that consumer surplus is the highest possible). As a result, one government will choose the lax standard and the other the strict one, and the firm will locate in the first country.

In zone 3, when there are no wage incomes, A (B) chooses the strict (lax) standard and the firm locates in country B . When there are wage incomes, A chooses the lax standard since the environmental damage generated by the firm is offset by the positive wage incomes; as a result, the firm locates in country A . When there are no wage incomes, A chooses the strict standard to avoid the firm's locating in its country. As B 's valuation of the environment is lower than A 's, B chooses the lax standard and the firm locates in its country.

In zone 4, the firm locates in country A but the standard chosen by A depends on whether there are wage incomes or not. When there are no wage incomes, both governments choose the strict standard. When there are wage incomes, A chooses the lax standard to get the firm to locate in its country because these incomes offset the environmental damage.

Next we analyze the second area. When there are no wage incomes and the government's valuation of the environment is higher than \hat{g} , the government does not permit the firm to locate in its country, since its social welfare would be negative. Only when the government's valuation of the environment is lower than \hat{g} could the firm locate in its country. Therefore, in zone 5 the firm locates in country A , in zone 7 the firm locates in country B and in zone 6 the firm is not allowed to locate in either country. In zones 5 and 7 the governments choose the standard on grounds of efficiency. Thus, as we have seen in section 4, if $g > g_4$ ($g \leq g_4$) the governments choose the strict (lax) standard.

When there are wage incomes, in zones 5, 6 and 7, the firm can locate in either country since the social welfare is positive in both. Therefore, in these zones the results may differ from those obtained when there are no wage incomes. When there are wage incomes and $g_A \leq g_I$, the firm locates in country A , whose government chooses the standard on grounds of efficiency. When there are wage incomes and $g_A > g_I$, there is strategic interaction between the governments; in this case, there are two possibilities: each government tries to get the firm

to locate in its country and each government tries to avoid it. Thus, the main difference with the case in which there are no wage incomes is that now there can be strategic interaction between the two governments, which can alter the standards chosen in equilibrium by the governments and the location of the firm.

6. Conclusions

The papers analyzing governments' choice of environmental policy when a firm's location is endogenous measure the social welfare of each country as the sum of consumer surplus, firms' profit, quality of the environment and tax incomes. However, they do not consider that firms' workers obtain positive wage incomes. In developed countries, labor is usually unionized, and thus there are positive wage incomes. Therefore, each government has incentives to choose a lax standard to get firms to locate in its country, since the welfare level in each country depends on such incomes.

These studies consider, generally, that the policy tools that governments use are environmental taxes. However, in practice, environmental standards are the policy tools used to control pollution. Therefore, we have considered a simple model in which governments choose environmental standards. We assume that workers are unionized, and thus there are positive wage incomes in the country in which the firm locates. We show that each government can strategically choose its environmental standard to get the firm to locate in its country even if it damages the environment. In this way, the country in which the firm locates obtains the wage incomes paid by the firm. In the absence of competition by governments, they could choose a stricter standard.

Notes

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1. Instead of considering unionized labor, we could assume that the polluting firm acquires inputs through a bilateral monopoly relation with a supplier; the supplier firm is owned by investors from the country in which the polluting firm locates. As Horn and Wolinski (1988) point out, some industrial inputs are acquired not in conventional markets, but rather through relations between suppliers and buyers. This would be the case when the product of the supplier is an intermediate good that the polluting firm uses.

2. Cairncross (1995, p. 59) argues that “regulations is by far the most common tool of environmental policy”.

3. It is well known that environmental regulation has an important effect in the location of new productive plants in the United States. Indeed, there is evidence that the 1970 Clean air Act and the 1977 Clean Water Act Amendments were designed, in part, to limit the ability of states to compete for businesses through lax enforcement of environmental standards (Portney, 1990). Jaffe *et al.* (1995) show that, although new environmental regulations in manufacturing industry in the United States will have a low effect on the firms’ relocation, their effect will be stronger in firms’ decisions as regards establishing new plants.

4. An alternative interpretation of the utility function of workers would be in terms of the union being utilitarian with risk neutral members and no alternative income (see Oswald, 1985)

5. For example, Golombek and Raknerud (1997) point out that in Norway firms are regulated by annual emission quantities and/or by maximum concentration (emission quantities per unit of volume). Similarly, the European Parliament has approved a law that compels cars manufacturers to pay the cost of recycling cars at the end of their useful lives (*El País*, 4-2-2000). This means that firms have a pollution abatement cost per unit of output. This cost includes any R&D expenses associated with the use of a less contaminating technology, as well as the direct cost of emission reduction (see Carraro and Siniscalco, 1992).

6. If environmental damage were global, each government would compete strongly to get the firm to locate in its country since each country is polluted independently of the location of the firm.

7. This type of damage function is commonly used in literature and assumes that the environmental damage is a convex function of the total pollution level. See, for example, Falk and Mendelsohn (1993), van der Ploeg and Zeeuw (1992) and Ulph (1994b). This damage is exogenous for consumers; they do not take into account the effect of their consumption decisions on the environment.

8. We consider that a third country is the owner of the firm; thus, the firm's profit does not enter into the social function of countries A and B . It can be shown that the results of the paper do not change if we assume that government A owns a percentage $\alpha \in [0, 1]$ of the firm and the other country owns the rest, $1 - \alpha$. The reason is that each government always owns the same percentage of the firm's profit independently of the location of the firm.

9. As there is a fixed cost and there are neither transport costs nor import or export tariffs, the firm will only establish one plant. If transport costs or import or export tariffs exist the firm could decide to set up a plant in each country (see Markusen *et al.*, 1995).

10. We assume that the profit of the firm, when it is located in the country B , is not negative:

$$F \leq \frac{9(a+e-1)^2}{64}. \text{ It is easy to see that } F_o \text{ is lower than this.}$$

11. We consider, to eliminate irrelevant cases, that the size of the single market is high enough, that is, $a > 1 + 5.8e$; this assures that $g_2 > g_1$.

12. If A is a developed country and B is an underdeveloped one, the firm will locate in country B unless the fixed cost in this country is high enough in relation to the cost in the other country. The advantage that an underdeveloped country usually offers firms is that its environmental policy is lax, since an underdeveloped country has a low valuation of the environment, and that workers are not unionized and, therefore, wages are very low.

13. The assumption that $a > 1 + 5.8e$ assures that $g_4 < \hat{g} < g_3 < \bar{g}$ and that $g_4 < g_1 < \hat{g} < g_2 < \bar{g}$.

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Illustration of proposition 2

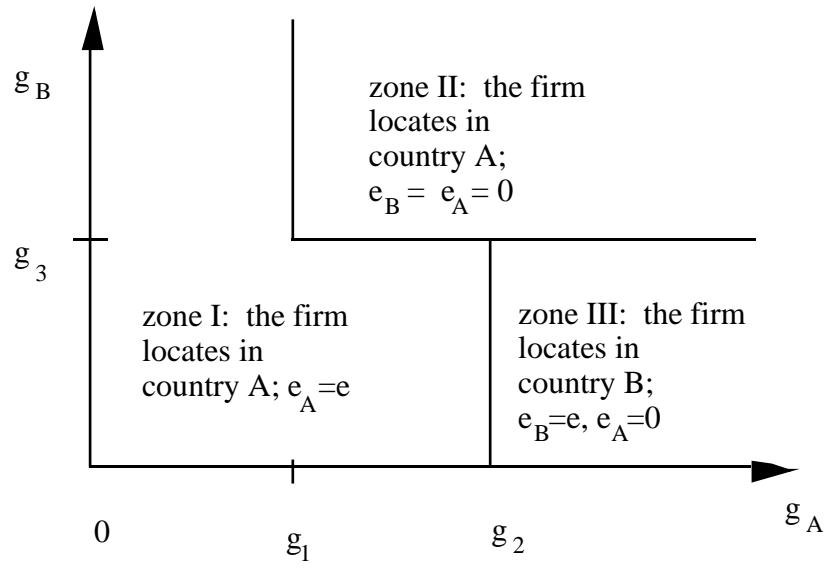


Figure 1.

Illustration of proposition 4

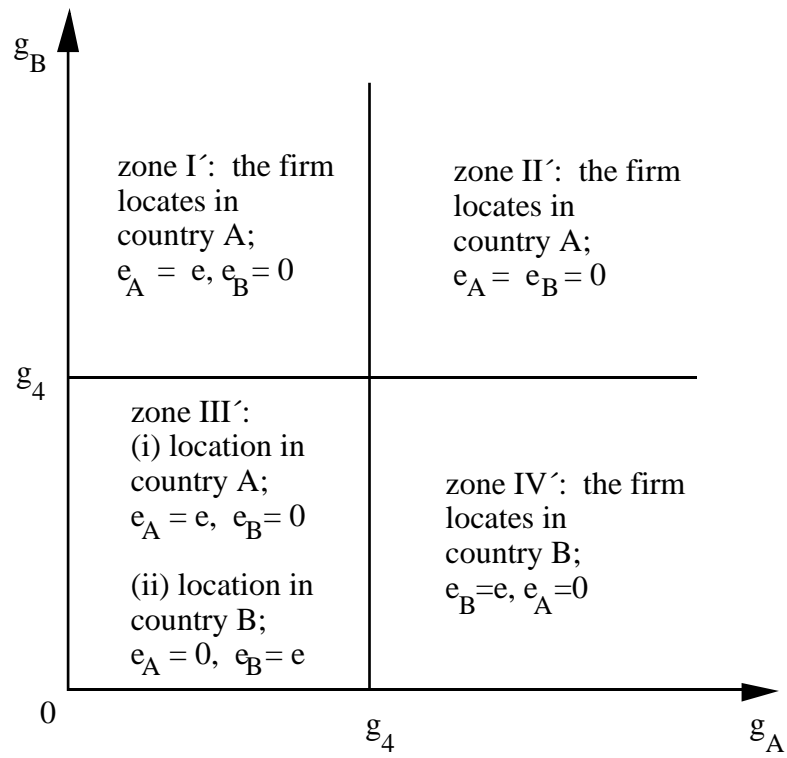


Figure 2.

Comparison of the results when $F \leq F_o$

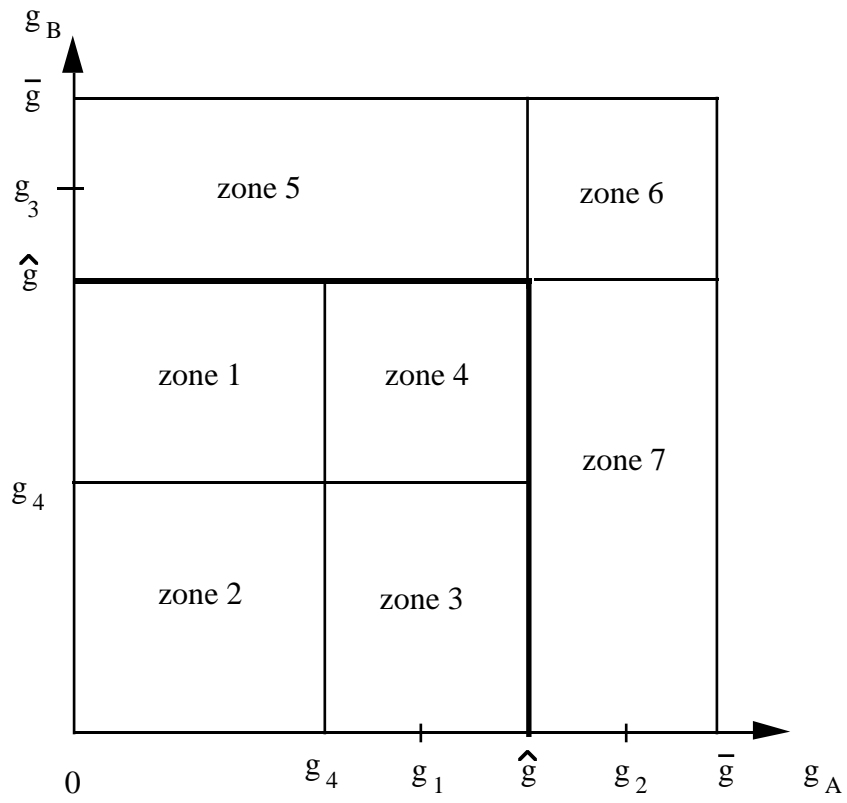


Figure 3.