

RECIPROCAL DUMPING AND ENVIRONMENTAL POLICES

Rafael S. Espinosa Ramírez*

RESUMEN

En un modelo de comercio con *dumping* recíproco se analizan los efectos sobre el bienestar de una reforma de política ambiental, en un contexto de desempleo y repatriación de beneficios. Las cuotas de contaminación, determinadas por el gobierno de cada país, restringen la producción local y reducen el daño social de la contaminación. Sin embargo, la cuota es una barrera comercial que inhibe el empleo y reduce el excedente de los consumidores. Teniendo presente tales aspectos, los países acuerdan una disminución uniforme de la cuota de contaminación, de manera infinitesimal y proporcionada. En ambos casos, el bienestar global se incrementará si la desutilidad marginal de la contaminación es mayor que el costo de reducirla. El efecto en cada país dependerá del tamaño del mercado y de los costos tecnológicos marginales. Bajo las mismas condiciones, cuando los países acuerdan armonizar sus cuotas de contaminación, el bienestar global se incrementará, pero el efecto sobre el bienestar de cada país será diferente.

Clasificación JEL: F2, H2

Palabras Clave: Ambiente, contaminación, permisos de emisión, Inversión Extranjera Directa

* Departamento de Economía, CUCEA-Universidad de Guadalajara, Periférico norte 799, Los Belenes 45100, Zapopan, Jalisco, México. Correo electrónico: <rafaelsa@cucea.udg.mx>. Miembro del Sistema Nacional de Investigadores (SNI II).

ABSTRACT

In a reciprocal dumping model of trade we analyse the effect of environmental policy reform on welfare in the presence of unemployment and repatriated profits. Pollution quota, used by the government in each country, restricts the local production and reduces the social harmful pollution. However, this quota is a barrier of trade which inhibits the employment and consumers surplus benefit. Bearing in mind this, both countries agree an infinitesimal and proportionate uniform reduction in pollution quota. In both cases global welfare will increase if marginal disutility of pollution is larger than the cost for abating pollution. The effect on each country will depend on the market size and marginal technological costs. Under the same conditions, when both countries agree harmonisation in pollution quotas the global welfare increase but the effect on the welfare of each country will be different.

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Keywords: Environment, pollution, emission permits, Foreign Direct Investment

1. INTRODUCTION

Greenhouse effect, acid rain, additive and change in the temperature of the oceans are only a few adverse consequences derived from pollution. In this sense, pollution is blame for the increase in the social and economic costs caused by natural disasters like hurricanes, twisters and floods. According to the Extreme Weather Sourcebook 2001 (National Center for Atmospheric Research, US) hurricanes, twisters and floods have cost to the US government a yearly average of 11 370 millions dollars in the 1955-1999 period at 1999 constant prices. Even in some years the cost reached more than 100 billion dollars. Moreover, the effect of pollution on health of people has reached alarming levels mainly in the big cities where the respiratory illness increased 200%, intestinal illness 110%,

additive illness 75% in the last ten years according to the 1997 Report of the World Health Organization.

These devastating effects of pollution in the world call for a coordinated effort made by the governments all over the world. An example of this attempt was the unsuccessful Rio Conference in Brazil 1992 and the recent 2002 Johannesburg Summit. The intensive use of natural resources and intensity production process is blamed to be the main cause of pollution. However the governments are not willing to apply policies to reduce pollution because these policies may increase the industrial costs and undermine the international competitiveness of domestic industries. In this sense, pollution control is a barrier to trade and, nowadays, it is extensively discussed in the free trade agreements.

Even though there is a vast literature on environmental regulations,¹ the existing literature has neglected the study of the effects of environmental regulations between developing economies. In these economies international competitiveness and employment become crucial variables in an environmental policy decision. This is our main motivation on this paper as we try to analyze the welfare effects of pollution regulation when trade takes place between two similar countries in the presence of foreign direct investment and unemployment.

Trade between similar products as the reciprocal export of coffee between Mexico and Costa Rica is an assumption we will consider on this paper. The natural explanation is that Costa Rica coffee is slightly different from Mexican coffee, so some consumers in each market prefer foreign coffee.

This two-way trade in similar (but not strictly identical) products is called intra-industry trade.² It has also been referred to as cross-hauling and has been discussed in the point-pricing literature of perfect competition. However, many attempts have been made at imperfect competitive framework and especially in a Cournot oligopolistic setting.³

¹ An extensive survey is given by Cropper and Oates (1992).

² Seminal papers on intra industry trade are Balassa (1966), Krugman (1979) and Lancaster (1980).

³ Some clear examples are Brander (1981), Brander and Krugman (1983).

Brander and Krugman (1983) prove that the rivalry of oligopolistic firms serves as an independent cause of international trade. Such rivalry naturally gives rise to ‘dumping’ of output in foreign markets. Such dumping can be ‘reciprocal’, that is, there may be a two-way trade in the same product.⁴ On the other hand, they also show that reciprocal dumping is rather striking in that there is pure waste in the form of unnecessary transport costs. Without free entry and low transport costs, welfare may improve as trade opens up and reciprocal dumping occurs. But it is also possible that welfare may decline with high transport costs.

The present study, in contrast to the bulk of the literature, remarks the developing economy features and assumes that the firms’ profits are taken out the host country so that the waste due to transport costs will not affect welfare change. We also assume that firms located within a country have the same marginal costs, but different from those of the other country. However, as in Brander and Spencer (1987), we assume that there is unemployment in the host country. The variable input cost of the firm is taken to be the income of the unemployed factors.

We also assume that, as a result of production, there is environmental degradation. We shall use a reciprocal dumping model with pollution quota restriction to determine the effect of multilateral policy reforms on the welfare of each country. Although there is no cross border pollution, each country has to take into account the effect of the policy reform on employment, consumer surplus and pollution disutility on local welfare.

The model is spelt out in detail in the following section. In section 3 we derivate optimal policies in a non-cooperative equilibrium and their properties. Section 4 describes the effects of policy reforms (uniform reduction and harmonisation) on the welfare of each country and on global welfare. Finally, some concluding remarks are made in section 5.

⁴ Normally, the phenomenon of dumping in international trade can be explained by the standard theory of monopolistic price discrimination. A good survey is provided by Caves and Jones (1977).

2. THE MODEL

Assume that there are two countries, country A and country B , producing a homogeneous good. We consider a partial equilibrium model of an oligopolistic industry in which there are exogenous n identical firms in A , and m identical firms in B . Each firm has a Cournot perception: each firm takes the output of other firms as given while maximising its products.

The homogeneous output produced by firms located in A and B are X and Y respectively, where $X = X^A + X^B$ and $Y = Y^A + Y^B$ such that X^A is consumed in country A and X^B is exported to country B . Similarly, Y^B is for local consumption in B and Y^A is exported to A .

The marginal costs of firms in A and B are K^X and K^Y , respectively. These costs are taken to be constant, and therefore equal the average variable costs.⁵ A part of K_j ($j=X, Y$) is given by technology and factor market conditions, and another part is policy induced, and this will be spelt out later on. There is transport cost t incurred in exporting goods from one country to the other which is borne by the producers.

We have segmented markets with homogeneous goods, and the inverse demand functions are⁶

$$P_A = \mathcal{F}_A(D_A), \quad (1)$$

$$P_B = \mathcal{F}_B(D_B), \quad (2)$$

where

⁵ Implicitly, there is a numeraire good in the background which is produced under competitive conditions. There is also just one factor of production in each country whose price is determined in the competitive sector.

⁶ We assume that the utility functions, in each country, can be approximated by $U_A = u(X^A, Y^A) + \mathcal{M}_A$ and $U_B = u(X^B, Y^B) + \mathcal{M}_B$ where X and Y are the goods under consideration and \mathcal{M}_A and \mathcal{M}_B are the expenditure on the numeraire goods. The use of this approximation removes a number of theoretical difficulties, including income effects.

$$D_A = nX^A + mY^A, \quad (3)$$

$$D_B = nX^B + mY^B, \quad (4)$$

and P_i is the price in country i ($i = A, B$), and $\mathcal{F}'_i < 0$ for all D_i .

The profits of the firms located in A and B are given by

$$\Pi^A = (P_A - K_X)X^A + (P_B - K_X - t)X^B, \quad (5)$$

$$\Pi^B = (P_B - K_Y)Y^B + (P_A - K_Y - t)Y^A, \quad (6)$$

respectively where K_j is defined as follow,

$$K_j = C_j + T_j, \quad (7)$$

where C_j is the part of the unit cost that is determined by technological and factor market conditions (it will be called simply marginal cost), and is taken to be constant. As the production of X and Y implies emission of pollution, T_j is the unit policy-induced cost of pollution abatement. This policy-induced cost is defined as⁷

$$T_j = \gamma(\theta - z_i), \quad (8)$$

where θ is the amount of pollution per-unit of output produced so that θX and θY are the total amount of pollution produced per firm (before any abatement) located in country A and B respectively,⁸ z_i is the maximum quantity of

⁷ For simplicity θ and γ are the same in both countries.

⁸ Implicitly, this unit pollution parameter is taken to be over and above the level which the World Health Organisation (WHO) considers to be harmless. On the other hand, $n\theta X$ and $m\theta Y$ are the countries' total pollution produced by A and B respectively before any abatement.

pollution per unit of output produced that the firms in country j are allowed to emit into the atmosphere.⁹ We assume that the abatement technology is such that it costs each firm a constant amount γ to abate one unit of pollution. The parameter γ and θ together with the policy instrument used by the government will determine the policy induced part of the unit cost K_j 's.

Each firm decides what proportion of the commodity it produces is for domestic consumption and how much for export. Under Cournot-Nash assumptions the first-order maximisation conditions are:¹⁰

$$X^A \mathcal{F}'_A + \mathcal{F}_A = C_X + T_X, \quad (9)$$

$$X^B \mathcal{F}'_B + \mathcal{F}_B = C_X + t + T_X, \quad (10)$$

$$Y^A \mathcal{F}'_A + \mathcal{F}_A = C_Y + t + T_Y, \quad (11)$$

$$Y^B \mathcal{F}'_B + \mathcal{F}_B = C_Y - T_Y. \quad (12)$$

Positive solutions to this system give the equilibria where two-way trade arises, provided the second order conditions are satisfied.¹¹

⁹ Like in the case of θ , these instruments are taken to be over and above the level which the WHO considers to be harmless.

¹⁰ They can be considered separately given the assumption of constant marginal costs.

¹¹ Second order conditions are

$$\begin{aligned} \Pi_{X^A X^A}^A &= X^A \mathcal{F}''_A + 2\mathcal{F}'_A < 0, & \Pi_{X^B X^B}^A &= X^B \mathcal{F}''_A + 2\mathcal{F}'_B < 0 \\ \Pi_{Y^A Y^A}^B &= Y^A \mathcal{F}''_A + 2\mathcal{F}'_A < 0, & \Pi_{Y^B Y^B}^B &= Y^B \mathcal{F}''_B + 2\mathcal{F}'_B < 0 \end{aligned}$$

and

$$\Pi_{X^A X^A}^A \Pi_{Y^A Y^A}^B - \Pi_{X^A Y^A}^A \Pi_{Y^A X^A}^B > 0, \quad \Pi_{X^B X^B}^A \Pi_{Y^B Y^B}^B - \Pi_{X^B Y^B}^A \Pi_{Y^B X^B}^B > 0.$$

which in turn implies that reaction functions cross only once and they do so such that the equilibrium is stable (See Nikaido, 1968, ch.7). These conditions are also the Routh Hurwitz conditions for stability.

We assume, as do Brander and Spencer (1987), that there is unemployment in both countries. In particular the variable costs of the firms, are bought in the host country and are taken to be income of the nationals of the host country i .¹² The profits of the firm located in A and B do not remain in the host country as these firms are foreign owned. Therefore the welfare of the representative consumer in the host country, W_i , can be written as,

$$W_A = nC_X X + \mathcal{CS}_A - \psi_A Z_A, \quad (13)$$

$$W_B = mC_Y Y + \mathcal{CS}_B - \psi_B Z_B, \quad (14)$$

where \mathcal{CS}_i is the consumer surplus. It is well known that

$$d\mathcal{CS}_A = -D_A \mathcal{F}'_A dD_A, \quad (15)$$

$$d\mathcal{CS}_B = -D_B \mathcal{F}'_B dD_B. \quad (16)$$

Z_i is the total amount of harmful pollution in country i defined as $Z_A = nz_A X$ and $Z_B = mz_B Y$ for country A and B respectively.¹³ Finally, ψ_i is the marginal disutility of pollution which we assume, as do Lahiri and Ono (1998a) and Markusen, *et al.* (1993, 1995), that the marginal disutility of pollution is constant.¹⁴

¹² Implicitly, we assume that there is a competitive sector in the background. This sector uses labour and a specific factor (say land) under constant returns to scale. The imperfectly competitive sector uses labour and a constant returns to scale technology. The wage rate of labour (in terms of the numeraire competitive good) is exogenously given at a level higher than the market clearing one. With these assumptions, the total amount of labour used in the competitive sector and the rental rate of land would not depend on any of the policy parameters. Any policy induced change in employment in the non competitive sector would be the total change in employment in the economy.

¹³ As we are considering a small economy, we ignore cross border pollution. For an analysis of cross border pollution see, for example, Copeland (1996).

¹⁴ Other authors, like Asako (1979), consider that marginal disutility is an increasing function of the output. However, this alternative assumption will not contradict our results and a constant marginal disutility is a more convenient assumption.

This completes the model specification and we turn to its analysis. From the total differentiation of demands and reaction functions (3), (4), (9)-(12) we get

$$dX^A = -\frac{\gamma(1+m\Delta_3)}{\mathcal{F}'_A\alpha_1}dz_A + \frac{m\gamma\Delta_1}{\mathcal{F}'_A\alpha_1}dz_B, \quad (17)$$

$$dX^B = -\frac{\gamma(1+m\Delta_4)}{\mathcal{F}'_B\alpha_2}dz_A + \frac{m\gamma\Delta_2}{\mathcal{F}'_B\alpha_2}dz_B, \quad (18)$$

$$dY^A = -\frac{\gamma(1+n\Delta_1)}{\mathcal{F}'_A\alpha_1}dz_B + \frac{n\gamma\Delta_3}{\mathcal{F}'_A\alpha_1}dz_A, \quad (19)$$

$$dY^B = -\frac{\gamma(1+n\Delta_2)}{\mathcal{F}'_B\alpha_2}dz_B + \frac{n\gamma\Delta_4}{\mathcal{F}'_B\alpha_2}dz_A, \quad (20)$$

Where

$$\begin{aligned} \mathcal{F}'_A\Delta_1 &= X^A\mathcal{F}''_A + \mathcal{F}'_A, & \mathcal{F}'_B\Delta_2 &= X^B\mathcal{F}''_B + \mathcal{F}'_B, \\ \mathcal{F}'_A\Delta_3 &= Y^A\mathcal{F}''_A + \mathcal{F}'_A, & \mathcal{F}'_B\Delta_4 &= Y^B\mathcal{F}''_B + \mathcal{F}'_B, \end{aligned}$$

And

$$\alpha_1 = 1 + n\Delta_1 + m\Delta_3, \quad \alpha_2 = 1 + n\Delta_2 + m\Delta_4,$$

such that $\Delta_r > 0$ ($r = 1, 2, 3, 4$), $\alpha_1 > 0$, and $\alpha_2 > 0$.¹⁵

¹⁵ In the literature Δ_r is generally to be assumed positive. This assumption corresponds to the 'normal' case in Seade (1980) and to strategic substitutes in Bulow, Geanakoplos and Klemperer (1985) and Dixit (1986).

A relaxation of pollution restriction ($dz_i > 0$), reduces costs of production and therefore raises outputs and demands. From (13) and (14) and taking (15)-(20), we obtain

$$dW_A = \left[(nC_X - \psi_A n z_A) \gamma \left(-\frac{m\Delta_3 + 1}{\alpha_1 \mathcal{F}'_A} - \frac{m\Delta_4 + 1}{\alpha_2 \mathcal{F}'_B} \right) + \frac{n\gamma D_A}{\alpha_1} - nX\psi_A \right] dz_A + \left[(nC_X - \psi_A n z_A) m\gamma \left(\frac{\Delta_1}{\alpha_1 \mathcal{F}'_A} + \frac{\Delta_2}{\alpha_2 \mathcal{F}'_B} \right) + \frac{m\gamma D_A}{\alpha_1} \right] dz_B, \quad (21)$$

$$dW_B = \left[(mC_Y - \psi_B m z_B) \gamma \left(-\frac{n\Delta_1 + 1}{\alpha_1 \mathcal{F}'_A} - \frac{n\Delta_2 + 1}{\alpha_2 \mathcal{F}'_B} \right) + \frac{m\gamma D_B}{\alpha_2} - mY\psi_B \right] dz_B + \left[(mC_Y - \psi_B m z_B) n\gamma \left(\frac{\Delta_3}{\alpha_1 \mathcal{F}'_A} + \frac{\Delta_4}{\alpha_2 \mathcal{F}'_B} \right) + \frac{n\gamma D_B}{\alpha_2} \right] dz_A. \quad (22)$$

The equations (21) and (22) form the backbone for the following analysis.

3. OPTIMAL POLICIES

In order to keep the analysis at a tractable level, we shall henceforth make two assumptions. First, we assume that the marginal disutility of pollution in both countries are the same so that $\psi_A = \psi_B = \psi$.¹⁶ Second, we assume linear and identical demand functions in both countries of the form

$$P_i = a - bD_i, \quad (23)$$

such that $\mathcal{F}'_r = \mathcal{F}'$, $\mathcal{F}''_r = 0$, $\Delta_r = 1$ and $\alpha_1 = \alpha_2 = \alpha$ and where the parameters a and b are positive.

¹⁶ The damage for pollution is the same in both countries. Apart from some particular exceptions the damage on any human being is generally identical.

The closed form solutions for the following variables are obtained as¹⁷

$$\Pi_A = b(X^A)^2 + b(X^B)^2, \quad (24)$$

$$\Pi_B = b(Y^B)^2 + b(Y^A)^2, \quad (25)$$

$$Y^A = \frac{(n+1)(a - C_Y - t - T_Y) - n(a - C_X - T_X)}{b(m+n+1)}, \quad (26)$$

$$X^A = \frac{(m+1)(a - C_X - T_X) - m(a - C_Y - t - T_Y)}{b(m+n+1)}, \quad (27)$$

$$X^B = \frac{(m+1)(a - C_X - t - T_X) - m(a - C_Y - T_Y)}{b(m+n+1)}, \quad (28)$$

$$Y^B = \frac{(n+1)(a - C_Y - T_Y) - n(a - C_X - t - T_X)}{b(m+n+1)}. \quad (29)$$

Taking into account the assumptions made before, for the welfare functions to be concave in z_A and z_B , we must have

$$\begin{aligned} \alpha b \frac{d^2 W_A}{dz_X^2} &= n\gamma [n\gamma - 4\alpha(m+1)\psi] < 0, \\ \alpha b \frac{d^2 W_B}{dz_Y^2} &= m\gamma [m\gamma - 4\alpha(n+1)\psi] < 0. \end{aligned}$$

Clearly the above conditions are satisfied if and only if

¹⁷ It can be easily verified that, with linearity of demand, the second order condition are always satisfied.

$$\begin{aligned}\psi &> \frac{n}{4\alpha(m+1)}\gamma, \\ \psi &> \frac{m}{4\alpha(n+1)}\gamma.\end{aligned}$$

For simplicity we assume as in Brander and Krugman (1983), that $m = n = 1$. With this, the second order condition is $\psi > \gamma/24$, and using the assumption made above, we obtain the Nash optimal values of z_A and z_B as:

$$z_A^N = \frac{1}{10\gamma\psi(\gamma - 9\psi)} \left[(30a - 42C_X - 15t + 12C_Y - 30\gamma\theta)\psi^2 - (10a + 40C_X + 10C_Y - 5t - 10\gamma\theta)\psi\gamma + 2(C_X - C_Y)\gamma^2 \right], \quad (30)$$

$$z_B^N = \frac{1}{10\gamma\psi(\gamma - 9\psi)} \left[(30a - 42C_Y - 15t + 12C_X - 30\gamma\theta)\psi^2 - (10a + 40C_Y + 10C_X - 5t - 10\gamma\theta)\psi\gamma + 2(C_Y - C_X)\gamma^2 \right]. \quad (31)$$

From (30) and (31) we get

$$z_A^N - z_B^N = \frac{2\gamma + 3\psi}{5\psi\gamma} (C_X - C_Y). \quad (32)$$

The more inefficient country will allow a greater amount of pollution per-unit of output. Formally we have:

Proposition 1: At the non-cooperative equilibrium, the optimal quantity restriction of the inefficient country will be greater than that of the efficient country.

The above result can be explained intuitively as follows. In the absence of any policy instrument, the amount of output produced by the inefficient firm is

less than that produced by the efficient firm. Therefore disutility from pollution is smaller in the high cost country than in the low cost country. Moreover any increase in the pollution quota in a country will augment the same firm's output. This increase in output will increase the consumer surplus and employment. From this point of view, the government has incentives to increase the level of allowed pollution. Therefore, given that the inefficient country creates a lower level of pollution than the efficient country, the inefficient country is always willing to allow a greater pollution level than the efficient one.

The optimal values of z_A^N and z_B^N have been not fully characterised yet. Apart from the marginal costs C_X and C_Y , other parameters affecting the values of z_A^N and z_B^N are the marginal disutility level ψ and the marginal cost of abatement γ . When γ is very small, imposing pollution control has no costs but only benefits. Therefore the optimal policy in both countries is to impose the severest pollution restrictions, i.e. z_A^N and z_B^N . On the other hand, when γ is large both policy instruments are positive. Formally we can write the following proposition¹⁸

Proposition 2: At the non-cooperative equilibrium, the optimal restrictions are given by

$$\begin{aligned} z_A^N = z_B^N = 0 & \quad \text{if } \psi \gg \gamma, \\ z_A^N > 0, z_B^N > 0 & \quad \text{if } \psi \ll \gamma. \end{aligned}$$

This proposition can be explained intuitively as follows. A high marginal cost of abatement means that pollution control has significant negative impact on

¹⁸ For instance, taking $\gamma = 6\psi$ we can write $z_A = \frac{1}{12\psi}(2a + 8C_Y + 14C_X - t - 12\theta\psi)$ and $z_B = \frac{1}{12\psi}(2a + 8C_X + 14C_Y - t - 12\theta\psi)$.

In this case $X^B = \frac{1}{3b}(2a + 8C_X + 2C_Y - 2.5t - 12\theta\psi)$

and $Y^A = \frac{1}{3b}(2a + 8C_Y + 2C_X - 2.5t - 12\theta\psi)$. Because X^B and Y^A must be positive, therefore by inspection of these expressions $z_A^N > 0$ and $z_B^N > 0$. Implicitly the Nash pollution

quotas can be written as $z_A^N = b/\psi\gamma 4[(\gamma - 3\psi)X^A + Y^A\gamma - 3X^B\psi + C_X]$

and $z_B^N = b/\psi\gamma 4[(\gamma - 3\psi)Y^B + X^B\gamma - 3Y^A\psi + C_Y]$.

production and price. A reduction in output reduces employment and an increase in price reduces consumers surplus. Therefore, when the marginal cost of abatement is high ($\psi \ll \gamma$), the government is forced to allow positive amount of pollution. However, when the marginal disutility is sufficiently bigger than the marginal cost for abating pollution, the harmful effect of pollution outweighs the benefit obtained by the employment and consumer surplus. The government sets the severest pollution policy as it reduces the optimal output and consequently the pollution level.

A third result emerges taking proposition 1 and 2 together. The existence of positive policy instrument in one country and zero in the other is possible if there is no difference between γ and ψ and there is a big difference in the marginal costs.¹⁹ Formally we can say

Proposition 3: At the non-cooperative equilibrium, we have $z_A^N = 0$ and $z_B^N > 0$ if $C_X \ll C_Y$ and $\psi = \gamma$.

Intuitively, the explanation is a combination of both previous explanations. The difference between ψ and γ is not longer decisive. When there is a sufficient difference in marginal costs, the more inefficient country (which produces higher employment) will be lax in the restrictions on pollution it imposes whilst the efficient firm will apply the severest restrictions. With a high marginal cost in the inefficient country, the output is small and the governments have incentives to increase the employment reducing the industrial cost through a positive quota. In the efficient country, the output and consequently the pollution will be large, so the pollution disutility will be greater than the employment and consumers surplus, and the government will apply the severest pollution quota.

¹⁹ In this case $z_A = -\frac{1}{4\gamma}(a - 4C_X - 0.5t - \gamma\theta)$, $z_B = -\frac{1}{4\gamma}(a - 4C_Y - 0.5t - \gamma\theta)$ and, $Y^A = X^B = \frac{1}{4b}(a - 2.5t - \gamma\theta)$. With feasible variables it is clear to see that if $C_X \rightarrow 0$, $z_A < 0$. If C_X is sufficiently large $z_A > 0$. For example $a = 10$, $C_X = 4$, $C_Y = 1$, $t = 1$, $\theta = 0.3$, $\gamma = 15$, $\psi = 15$ $z_A = 0.18$ and $z_B = -0.016$.

4. POLICY REFORMS

Having analysed the properties of the optimal quantity restrictions on pollution, we now analyse the effect of a multilateral uniform reduction and harmonisation of the level of pollution quota on welfare.

4.1 INFINITESIMAL AND PROPORTIONATE UNIFORM REDUCTION

We shall analyse a uniform and a proportionate uniform reduction in the pollution quota when the initial levels are the Nash optimal ones. In the first case, we consider the effect of small uniform reduction

$$dz_A = dz_B = -\epsilon_1 < 0, \quad (33)$$

where $\epsilon_1 > 0$ is a small number.

Since we start from the Nash solution, (30) and (31), the effect of this reform on W_A , W_B and global welfare ($W_A + W_B$) are given by the international externality ($\partial W_A / \partial z_B$, $\partial W_B / \partial z_A$). That is,

$$dW_A = -\frac{1}{2}(\gamma - \psi) \left[D_A - \frac{2}{5b}(C_X - C_Y) \right] \epsilon_1, \quad (34)$$

$$dW_B = -\frac{1}{2}(\gamma - \psi) \left[D_A + \frac{2}{5b}(C_X - C_Y) \right] \epsilon_1, \quad (35)$$

$$d(W_A + W_B) = -(\gamma - \psi) D_A \epsilon_1, \quad (36)$$

where

$$D_A = X^A + Y^A = \frac{2}{(9\psi - \gamma)b} [(2a - C_X - C_Y - t - 2\theta\gamma)\psi + \gamma(C_X + C_Y)]. \quad (37)$$

If the marginal pollution disutility is greater than the marginal cost for abating pollution, a uniform reduction of the quotas will increase global welfare. If $\psi < \gamma$ we obtain the opposite result. As for the effect on individual countries, assuming $C_X \simeq C_Y$, the effect of policy reform on each country's welfare and global welfare is the same. Formally we can say

Proposition 4: Starting from the Nash solution, an infinitesimal uniform reduction in the pollution quota will produce the following results:

- (a) global welfare will increase if and only if $\psi > \gamma$
- (b) if $\psi > \gamma$ and $C_X = C_Y$, then both countries and so global welfare will benefit,
- (c) if $\psi < \gamma$ and $C_X = C_Y$, then both countries and so global welfare will be harmed.

The intuition behind this is quite straightforward since both countries have the same marginal disutility and marginal cost for abating pollution, when the former is bigger than the latter, any uniform reduction will benefit both countries. Outputs in both countries will be reduced, and the positive effect given by the reduction in pollution is greater than the negative effect given by the reduction in employment and consumer surplus. On the other hand, when the disutility is smaller than the unit cost for abating pollution, the positive effect from the reduction in pollution will be smaller than the loss from the employment and consumer surplus reduction.

One important case is given by $\psi \simeq \gamma$. In this case, it is clear from (34)-(36) that this type of reform will leave the welfare levels unchangeable. The positive effect given by the reduction in pollution is equal to the negative effect given by the reduction in employment and consumers surplus.

For the rest of the analysis on this paper we assume $\psi > \gamma$ and, without loss of generality, that $C_X > C_Y$. In this case, from (34)-(36), the welfare in the efficient country and global welfare will increase. What is not clear is the effect of this policy on welfare of inefficient country *A*. The value of the term inside the square brackets in (37) is not clearly defined and it can be written as

$$D_A - \frac{2}{5b}(C_X - C_Y) = \frac{2}{5b(9\psi - \gamma)} [\psi(10a + 4C_Y - 14C_X - 5t - 10\theta\gamma) + \gamma(4C_Y + 6C_X)]. \quad (38)$$

With a large value of a , (38) will be positive and an infinitesimal pollution quota reduction will also benefit the inefficient country. Formally we can say

Proposition 5: Starting from the Nash solution, an infinitesimal uniform reduction in pollution quota will benefit both countries if the demand for goods is sufficiently large.

Intuitively, in both countries, the positive effect of a reduction in pollution is greater than the negative effect produced by a reduction in the employment and consumers surplus. When demand is large, the two countries non-cooperatively compete for a bigger cake. In this case, negative international externalities associated with policies are higher. Therefore, a coordinated policy reform benefits both countries.

Until now we have been considering an infinitesimal uniform policy reduction. However following the tradition of the competitive literature, it might seem more natural to consider uniform proportionate contractions. A proportionate uniform reduction is a change in the policy taking into account the proportion of the initial policy in each country. The proportionate uniform reduction is given by

$$dz_A = -\epsilon_2 z_A^N, \quad (39)$$

$$dz_B = -\epsilon_2 z_B^N, \quad (40)$$

where $\epsilon_2 > 0$ is a small number, and z_A^N and z_B^N are the known pollution quota levels.

Starting from the Nash solution, the effect of this reform on the welfare of A and B , and consequently on global welfare is found to be

$$dW_A = -\frac{\epsilon_2}{2}(\gamma - \psi) \left[D_A - \frac{2}{5b}(C_X - C_Y) \right] z_B^N, \quad (41)$$

$$dW_B = -\frac{\epsilon_2}{2}(\gamma - \psi) \left[D_A + \frac{2}{5b}(C_X - C_Y) \right] z_A^N, \quad (42)$$

$$d(W_A + W_B) = -\frac{\epsilon_2}{2} \left[D_A(z_A^N + z_B^N) + \frac{4\gamma + 6\psi}{25\psi\gamma b}(C_X - C_Y)^2 \right] (\gamma - \psi) \quad (43)$$

Because the term inside the square bracket in (43) is positive, we can say

Proposition 6: Starting from the Nash solution, a proportionate uniform reduction in pollution quota will increase the global welfare if $\psi > \gamma$.

Because the expression in the square brackets in (41) and (42) are similar to (34) and (35), the problem of proportionate uniform reduction in pollution quotas is similar to the problem of infinitesimal uniform reduction in pollution quotas. The effect on global welfare of an infinitesimal uniform pollution quota reduction and a proportionate uniform pollution quota reduction are equivalent. Moreover, the previous analysis and the intuition made before on the particular welfare of each country hold in this case.

4.2 HARMONISATION

Having analysed the effect of a reduction in the level of allowed pollution on both countries and global welfare, we shall now analyse the harmonisation of the pollution quotas between the countries.²⁰

²⁰ Most of the work made on harmonisation correspond to tax harmonisation. Keen (1987 and 1989) presents welfare analysis of commodity tax harmonisation.

On the issue of harmonisation we shall take the Nash equilibrium as our starting point. According to Keen (1987) programmes of harmonization typically connote both a convergence of participating countries towards a common policy structure and the further presumption that the convergence point will be some kind of weighted average of those from which they begin. We will use this principle in the context of pollution quota harmonisation. Consider the multinational reform

$$dz_A = \epsilon_3(H - z_A^N), \quad (44)$$

$$dz_B = \epsilon_3(H - z_B^N), \quad (45)$$

where ϵ_3 is a small positive scalar and H is the harmonised target of allowed pollution toward which (30) and (31) require both to converge. The reform (44) and (45) can be thought of as describing harmonisation towards an average of pre-existing quota structure.

According to Keen and Lahiri (1993) with the same preferences in both countries, H is the arithmetic mean of those pollution levels. So H can be written as

$$H = \frac{z_A + z_B}{2},$$

Therefore

$$dz_A = \frac{\epsilon_4}{2}(z_B^N - z_A^N), \quad (46)$$

$$dz_B = \frac{\epsilon_4}{2}(z_A^N - z_B^N). \quad (47)$$

The effect of this reform on W_A , W_B and global welfare is found to be

$$\mathcal{B}dW_A = \frac{\epsilon_3}{2}(\gamma - \psi) \left[D_A - \frac{2}{5b}(C_X - C_Y) \right] (C_X - C_Y), \quad (48)$$

$$\mathcal{B}dW_B = -\frac{\epsilon_3}{2}(\gamma - \psi) \left[D_A + \frac{2}{5b}(C_X - C_Y) \right] (C_X - C_Y), \quad (49)$$

$$\mathcal{B}d(W_A + W_B) = -\frac{4\epsilon_3}{10b}(\gamma - \psi)(C_X - C_Y)^2, \quad (50)$$

Where

$$\mathcal{B} = \frac{5\psi\gamma}{2\gamma + 3\psi} > 0.$$

Again, focusing in the case in which $\psi > \gamma$, global welfare will increase. Remarkable the effect of a uniform pollution reduction (infinitesimal and proportionate) and harmonisation on global welfare are equivalent. Formally we can say

Proposition 7: Independent of the multilateral policy reform applied and starting from the Nash solution, the global welfare will increase if the marginal disutility of pollution is larger than the cost for abating pollution.

However, the intuition behind this result is different and depends on the effect of this policy on the welfare of each particular country. Uniform pollution quota reduction and harmonisation are equivalent policies as regards the effect on global welfare, but different as regards the effect on individual welfare. As seen in the previous subsection, taking the assumption $C_X > C_Y$, the welfare effect of harmonisation on the efficient country is positive and on the inefficient country is ambiguous because the term inside the square bracket in (48) is not clearly defined.

Under the conditions set in the proposition 5 the welfare in the inefficient country decrease and, with appropriate international compensation, both policies are pareto improving. This result is consistent with Keen (1987) in which harmonisation of commodity tax is strictly welfare improving in the sense of generating a strict potential pareto improvement. Different to uniform reduction, in which both countries benefit, in this case the welfare of the inefficient country goes down.

However, a more interesting result takes place in the case in which the difference between marginal costs is sufficiently large. With a sufficiently large difference between marginal costs (37) will be negative and therefore (48) will be positive.²¹ Harmonisation will increase the welfare in both countries. Formally we can say

Proposition 8: Starting from the Nash solution, when the marginal disutility of pollution is larger than de cost for abating pollution, harmonisation will produce the following results:

- (a) if $a \gg 0$ the welfare in the efficient country and global welfare will increase and the welfare in the inefficient country will decrease,
- (b) if $C_X \gg C_Y$ both individual welfares will increase.

With harmonisation the higher pollution quota will decrease and the lower pollution quota will increase. Moreover, we have shown before that the inefficient country will allow greater pollution at the Nash equilibrium. Therefore, the output of the inefficient country goes down and the output of the efficient country goes up. Harmonisation will increase (decrease) employment, and disutility for pollution in the efficient (inefficient) country.²²

²¹ For instance, if $a = 10$, $b = 1$, $C_X = 7.9$, $C_Y = 2$, $t = 0.5$, $\theta = 0.5$, $\psi = 10$, $\gamma = 9$, $z_A^N = 0.67$, $z_B^N = 0.04$, $X^A = 1.3$, $X^B = 0.8$, $Y^A = 1.04$, and $Y^B = 1.54$, $BdW_A = 0.059$ and $BdW_B = 13.8$.

²² With harmonisation in both pollution quotas the consumers surplus effect is cancel out.

In the efficient country, the positive effect of an increase in employment is bigger than the negative effect of an increase in pollution. On the other hand, when the demand for good is large, international externalities due to policies is here. Since the efficient country allows more pollution with harmonisation, the externality effect goes up in the inefficient country, reducing its welfare. When the difference between the marginal costs is sufficiently large, the welfare of the inefficient country will increase. In this case, the negative effect of a stricter pollution quota in the inefficient country will be relatively low.

5. CONCLUSIONS

In spite of the well known negative effect of pollution on the health of people, coordinate efforts made by governments all over the world have been rather limited. The pessimism and inflexibility expressed by all the members of the Rio Conference in Brazil is rooted in possible losses in consumption and production. Even coordinated actions against environmental degradation could be successful just under specific conditions.

We modeled, in a Cournot oligopolistic setting of reciprocal dumping, the effect of policy reforms on the welfare of each country and global welfare. Even when there is no cross border pollution, in the reciprocal dumping model there is interdependence between the pollution quotas through the optimal output produced by each country. Any arbitrary change in the pollution quota in the local country will change its output and change the output in the foreign country. This changes in output will affect employment, consumers surplus and pollution disutility in both countries.

In previous studies generally analysis is focused on unequal countries (see Kanbur *et al.*, 1995; Pethig, 1976; and Merrifield, 1988). Moreover, they do not allow for unemployment. In contrast, in this paper trade takes place in similar countries and in similar output with unemployment and repatriated profits. In this case the optimal pollution quotas will depend on the difference between marginal cost in each country.

Generally, when the marginal disutility of pollution is sufficiently larger than the private cost of abatement, the government will apply the severest quota restriction. It is a common result in the literature. However, we show that the difference between marginal costs will determine who is applying stricter quota. The inefficient country will apply laxer quota since the disutility of pollution in a high cost country is smaller than in a low cost country. In this case the employment effect takes a predominant place in this model. The government will take into account not only the amount of output produced, but the benefit in employment that the quota can produce.

Multilateral policy reform is important in the presence of international externality caused by pollution. In order to reduce environmental degradation, governments are encouraged to reduce simultaneously the pollution level. However this reduction affects not only the output but also employment and consumer surplus in both countries. The trade off in which each government has to weigh up among employment, consumer surplus, and environmental degradation, is determined by the marginal cost of abatement, pollution disutility, size of the demand for goods and the difference between marginal costs.

According to Kanbur *et al.* (1995) the literature makes a distinction between those models in which pollution damage strikes the country that causes the pollution to begin with, and those in which pollution damage strikes people in other countries. In the reciprocal dumping model we have, there is pollution damage in the country that produces pollution and an impact on the welfare of the people in the other country through the output produced and traded. According to Asako (1979) this characteristic is given by the presence of international trade in the model.

The strategic issues that environmental regulation raises in an international setting are similar to those brought up by fiscal competition that have long been studied in the public finance literature. However the distinctive concerns that arise in the environmental context have received little attention in the formal literature. In this paper we contribute to the theory of environmental regulations using not tax but pollution quota in a reciprocal dumping model with unemployment and foreign owned profits.

A uniform reduction will reduce the output of both countries; will reduce disutility of pollution, employment and consumers surplus. As long as the reduction in pollution is larger (smaller) than the fall in employment and consumer surplus, the world welfare will increase (reduce). In the case in which the marginal disutility is greater than the cost for abating pollution, the global welfare will always increase and the benefit of the countries will depend on the demand of the traded good. As long as the demand for the good is large, both countries will benefit of a reduction in pollution quota, otherwise this policy is pareto improving with appropriate international compensation.

Different to the current literature on tax competition, we have two remarkable results: first, we have an equivalent effect produced by infinitesimal or proportionate pollution quota reduction on welfare in both countries. Second, the size of the demand becomes crucial to determine the benefit of the inefficient country.

On the other hand, we found that as long as the marginal disutility is larger than the cost for abating pollution, harmonisation will increase the global welfare. When trade takes place between two similar countries harmonisation and uniform reduction are equivalent with respect to the effect on global welfare. This unique result guarantees that at least, with appropriate international compensation, harmonisation and uniform reduction will be pareto improving.

According to Kanbur *et al.* (1995) when countries are of unequal size, harmonisation of environmental standards will always leave the small country worse off, irrespective of the level at which standards are harmonised. As a consequence, no harmonisation strategy is likely to be agreed upon without some sort of international compensation mechanism. However in the case of similar countries we found that this conclusion will depend on the size of demand and the level of efficiency of the firms.

In our model harmonisation will reduce the output of the inefficient country and increase the output of the efficient, such that the effect on the welfare of the efficient country and on global welfare will be positive. However, in the case of the inefficient country, harmonisation will reduce the welfare in the inefficient country if the demand for goods is large. On the other hand, the welfare of the inefficient country will increase if the difference between marginal costs is sufficiently large.

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