Environmental Policies and Mergers' Externalities

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Abstract: A Cournot oligopolistic setting model of trade is characterized by local and foreign firms competing in the presence of pollution quota and tax. Local firms are foreign-owned (FDI) and repatriate their profits. First, we analyze the impact on welfare given by the merger of the local firms, as a response to external firms' competition and pollution abatement costs. Second, when merger is welfare decreasing, we study the best response of the government in order to compensate this negative externality. Finally, we compare the pollution quota and tax in order to determine their efficiency as a policy instrument.

Keywords: environmental policies, mergers, emission permits.

Resumen: En un modelo de comercio con competencia oligopolística de tipo Cournot, empresas domésticas y foráneas compiten en presencia de cuota e impuesto a la contaminación. Los dueños de las empresas domésticas son extranjeros (IED) que repatrian sus ganancias. Primero vamos a analizar el impacto de la fusión de empresas domésticas en el bienestar. Las fusiones son la respuesta a la competencia de empresas extranjeras y al costo de abatir la contaminación. Segundo, cuando la fusión reduzca el bienestar, estudiaremos la respuesta óptima del gobierno para compensar esta externalidad negativa. Finalmente, vamos a comparar la cuota y el impuesto a la contaminación para determinar su eficiencia como instrumento de política.

Palabras clave: políticas medioambientales, fusiones, permisos de contaminación.

JEL *Classification:* F2, H2, L1, N5

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Introduction

Greenhouse effect, acid rain, and the change in the temperature of the oceans are only a few adverse consequences derived from pollution. In this sense, pollution is blamed 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), hurricanes, twisters and floods have cost the US government a yearly average of 11,370 million dollars in the 1955-1999 period, at 1999 constant prices. Even in some years the cost reached >100 billion U.S. dollars. Moreover, the effect of pollution on people's health has reached alarming levels mainly in big cities, where respiratory diseases increased 200%, intestinal diseases 110%, auditory diseases 75% in the last 10 years, according to the Report of the World Health Organization (1997).

These devastating effects of pollution call for a coordinated effort to be made by governments worldwide. An example of this attempt is the unsuccessful Rio Conference in Brazil 1992 and the 2002 Johannesburg Summit. Intensive use of natural resources and polluting production processes are underscored as the main causes of pollution. If this is so, why are governments reluctant to apply pollution controls? Because they may be afraid of facing a decreasing international competitive advantage.

In this regard, there is an ongoing debate between the conventional wisdom that environmental regulations have large adverse effects on competitiveness, as considered by Pethig (1975), Siebert (1977), Yohe (1979), and McGuire (1982) among others, and the revisionist hypothesis in which environmental regulations stimulate innovation and improve competitiveness, as considered by Porter (1991).[1] Empirical evidence shows that there is no general causality between competitiveness and environmental regulations.[2] However, we will assume the former approach in which governments appear not to be willing to apply policies to reduce pollution because these policies may increase industrial costs and undermine the international competitiveness of domestic industries.

Additionally, in a globalized world the use of trade policies for strategic purposes has been increasingly ruled by the World Trade

[1] An exhaustive review of the literature on the relationship between environmental regulation and competitiveness can be found in SQW (2006).

[2] Jaffe *et al.* (1995) assemble and assess evidence on the linkage between environment regulation and competitiveness, with no conclusive results.

Organization (WTO). As a result, many countries employ environmental policies as strategic instruments in trade and investment. These regulations are seen as barriers to trade and at present this is extensively discussed in the free trade agreements.[3] Trade and investment liberalization are alleged to have created pollution havens, moving firms to developing countries with lax pollution restrictions. Countries can affect the flow of federal direct investment (FDI) and trade by setting the best pollution policy.[4]

In this context, developing economies face fierce competition in obtaining substantial benefits from trade and for attracting FDI. Employment, growth, and development are some benefits of trade and investment. Once subsidies and tariffs have been banned from trade agreements, strategic use of environmental policies appears crucial for these purposes. However, developing economies should take into account not only the benefit of lax pollution control, but also the damage of pollution on society. What is the best pollution policy for developing economies in a free trade context?

This question is our first motivation. We intend to explain, under very specific developing features, what the best environmental policies are for developing countries to follow in order to maximize their social welfare, taking trade and investment with other developing economies into account. Countries must consider the effect of policy restrictions on trade and FDI location.

In this respect, Kanbur *et al.* (1995) and Andonova (2003) study the incentives that firms possess to locate in a country with pollution control. They found that firms generally avoid locating in high-pollution-control countries, unless they receive an extra incentive. In Markusen *et al.* (1993) and (1995) and in Lahiri and Ono (1998), specific policy instruments are used to determine a foreign-investment level according to welfare needs. Lahiri and Ono (1998) especially analyze the properties of optimal tax and quantitative restrictions on pollution, and the firms' location decision. We will follow the latter paper more closely. However, none of the previously mentioned papers considers strategic environmental policies.

Kayalica and Lahiri (2001) and (2005) analyze a strategic trade-policy model in the presence of foreign direct investment. Domestic

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[3] An illustrative example comprise the tuna and avocado trade restrictions imposed by the U.S. government on Mexican producers.

[4] Jeppesen *et al*. (2002) provide an excellent survey on the relationship between pollution regulation and location decision of firms.

and foreign firms located in a host country compete for a third market. Different from this paper, we take into account not only the pollution quota, but the pollution tax as well. Additionally, the authors do not consider strategic policies in order to compete in trade between developing economies, but only for a third market. We consider the interface between reciprocal trade and strategic policies, which may enrich the model considerably.

As can be seen, although a vast body of literature exists on environmental regulations,[5] 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. The primary objective of this paper is to fill an important gap in the literature by considering strategic environmental policies in the presence of FDI and trade between developing economies in a reciprocal dumping framework.[6] We atempt 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.

On the other hand, the international dimensions of competition policies are receiving growing attention by national governments and international organizations alike. National competition authorities are increasingly examining the conduct of foreign producers. The Organization for Economic Co-operation and Development (OECD) and the WTO are paying increasing attention to crossborder-merger (or international-merger) competition issues. This raises the question of the manner in which countries are affected by, and how they should respond to, mergers.

Mergers and competition policies have been discussed intermittently in the literature on international trade under imperfect competition. Some authors, like Auquier and Caves (1979), point out that the optimal policy for a government is to encourage competition in the domestic market while allowing its firms to extract monopoly profits in foreign markets through an export cartel (or an export tax).

Following this line, Collie (1997) develops a significant paper on mergers and trade policy under oligopoly. He analyzes the effect of domestic and foreign mergers on the domestic country's optimal trade policy and on domestic and foreign welfare. Once the optimal trade pol-

[5] An extensive survey is presented by Cropper and Oates (1992).

[6] See Brander and Krugman (1983) for a seminal paper on this issue.

icy has been set, the author studies not only loss and gain in welfare as a result of mergers, but also the optimal domestic response through the optimal trade policy.

Mergers in developing economies face institutional inefficiencies that may produce undesirable consequences on welfare. Lack of updated regulations and the need for foreign investment constitute the main reasons for the negative welfare impact on developing economies facing this firm strategy. The effects of mergers on the welfare of emerging economies are far from clear. Unclear welfare effects of mergers on the banking system in Mexico or on agroindustries in Central America will depend on institutional development and the government's ability to utilize available policy instruments.

At present, mergers appear to be a surviving strategy for many firms. Some of these mergers have very clear environmental implications. Developing economies consider this firm strategy crucial for employment and consumer surplus. However, environmental considerations should be taken into account because they are involved in a global economy in which pollution becomes a first-line issue in trade.

This is our second motivation, as we intend to analyze the effect of mergers on the welfare of developing economies. The emergence of mergers in developing economies appears to be rooted in the need to face international competition. Local firms are willing to merge with each other in order to obtain competitive advantage against foreign competition. This phenomenon in developing economies is practically unexplored by the majority of the economic literature.

In this paper, after setting optimal pollution policies within a reciprocal dumping framework and the features of developing economies, we analyze the effect of local mergers on one country's welfare in the presence of pollution policies and the responses of the government when mergers lead to a negative effect on welfare. To our knowledge, this is the first attempt in the literature that combines mergers and environmental externalities. We are interested in comparing these responses using two different pollution restrictions: pollution quota, and pollution tax.

The domestic country is characterized by unemployment, as in Brander and Spencer (1987), and reciprocal dumping framework, as in Brander and Krugman (1983). According to the former assumption, the present paper, in contrast to the bulk of the literature, assumes that firms' profits are taken out of the host country, so that waste due to transport costs will not affect welfare change, and the firm's variable input cost is considered as the income of the unemployed factors included in the welfare function. This assumption appears very convenient for a developing-country model.

We employ two-way trade in identical goods between two countries. In fact, a great portion of world trade today takes place in similar products. While some consumers in a country prefer goods' domestic brands, others may prefer the imported alternatives of these goods. This leads to intra-industry trade between countries.[7]

According to the National Asia Pacific Economic and Scientific Database (NAPES), intra-industry trade index, during the period of 1993-1995 more than 95% of world trade in products such as beverages and tobacco, chemicals, mineral fuels, etc., was subject to intra-industry trade. Therefore, one way to observe the strategic interaction between trade policies and environmental regulations and their effects on welfare is to construct a model in which similar commodities are traded.

Differently from Kayalica and Lahiri (2001, 2005), we determine not only pollution quota, but also pollution tax. Moreover, within a context of reciprocal dumping and not only in strategic export-oriented trade, we set optimal policies and consequences of mergers on welfare, as well as governmental responses to this strategic behavior of firms.

The model is spelled out in detail in the following section. Analysis of merger and pollution quota is performed in Section 2. In Section 3, we explore the effects of mergers in the presence of the pollution tax as a policy instrument. Finally, in Section 4 we present our conclusions.

I. The Model

We consider a partial-equilibrium model of an oligopolistic industry, in which there is an exogenous number of n identical foreign-owned firms (FDI) located in country A (the domestic country), and m, identical firms located in country B (the foreign country). Both types of firms produce a homogeneous and tradeable commodity. Each firm utilizes a Cournot perception: it takes the output of other firms as given, while maximizing its profits.

The output produced by the i firm in A and the j firm in B are X_i

[7] Broadly speaking, intra-industry trade can be classified into two categories: horizontal and vertical intra-industry trade, the former signifying exchange of similar goods that are differentiated by characteristics, while the latter consists of the exchange of similar goods of different quality.

and Y_j, respectively, where $X_i = X_i^A + X_i^B$ and $Y_j = Y_j^A + Y_j^B$, so that X_i^A is consumed in country A and X_i^B is exported to country B. Similarly, Y_j^B is for local consumption in B, and Y_j^A is exported to A.

Marginal costs for each firm in A and B are K_X and K_Y, respectively. These costs are taken as constant and are therefore equal to the average variable costs.[8] K_s ($s = X, Y$) is defined as follows:

$$K_s = C_s + T_s, \tag{1}$$

where C_s is the part of the unit cost determined by technological and factor-market conditions and is taken to be constant. For simplicity, we solely focus on the pollution arising in country A during production made by the n firms, so that $K_Y = C_Y$.[9] Because production of X implies pollution emission, T_X is the unit policy-induced cost of pollution abatement, which 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 are as follows:[10]

$$P_A = \mathscr{F}_A(D_A), \quad P_B = \mathscr{F}_B(D_B),$$

where

$$D_A = \Sigma_{i=1}^{n} X_i^A + \Sigma_{j=1}^{m} Y_j^A,$$
$$D_B = \Sigma_{i=1}^{n} X_i^B + \Sigma_{j=1}^{m} Y_j^B,$$

and P_r is the price in country r ($r = A, B$), $\mathscr{F}_r' < 0$ and $\mathscr{F}_r'' < 0$ for all D_r.

The profits of each firm located in A and B are given by

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[8] Implicitly, there is a numeraire good in the background, which is produced under competitive conditions. There is also a sole production factor in each country, whose price is determined in the competitive sector.

[9] When we consider pollution from foreign firms and the foreign government is playing a similar strategic environmental policy, our model suggests exactly the same result we obtained here. Furthermore, even when we assume a closed economy the same result holds. Therefore, for a more treatable analysis we only consider when domestic firms pollute. This is equivalent to saying that country B does not induce any policy pollution cost.

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

$$\Pi_i^A = (P_A - K_X)X_i^A + (P_B - K_X - t)X_i^B, \tag{2}$$

$$\Pi_j^B = (P_B - C_Y)Y_j^B + (P_A - C_Y - t)Y_j^A. \tag{3}$$

Each firm decides what proportion of the commodity it produces is for domestic consumption and how much of the commodity is for export. Under Cournot-Nash assumptions, the first-order maximization conditions are the following: [11]

$$X_i^A\ \mathscr{F}_A' + \mathscr{F}_A = C_X + T_X, \tag{4}$$

$$X_i^B\ \mathscr{F}_B' + \mathscr{F}_B = C_X + t + T_X, \tag{5}$$

$$Y_j^A\ \mathscr{F}_A' + \mathscr{F}_A = C_Y + t, \tag{6}$$

$$Y_j^B\ \mathscr{F}_B' + \mathscr{F}_B = C_Y. \tag{7}$$

We have $2n$ first-order conditions for the benefit of n firms in country A, and $2m$ first-order conditions for the benefit of m firms in country B. Positive solutions to this system provide the equilibria under which two-way trade arises, provided second-order conditions are satisfied.[12]

However, as mentioned previously, we have identical n and m firms located in A and B, respectively. Cost structure among n firms and among m firms are symmetrical with respect to their own type. Therefore, we can assume that the output produced by each firm in A and B is the same with respect to their own type ($X_i^A = X^A$, $X_i^B = X^B$, $Y_j^A = Y^A$ and $Y_j^B = Y^B$) and the demand, for simplicity, can be written as follows:

$$D_A = nX^A + mY^A, \tag{8}$$

$$D_B = nX^B + mY^B, \tag{9}$$

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[11] These can be considered separately, given the assumption of constant marginal costs.

[12] Second-order conditions are

$$\Pi^A_{X_i^A X_i^A} = X_i^A \mathscr{F}''_A + 2\mathscr{F}'_A < 0, \quad \Pi^A_{X_i^B X_i^B} = X_i^B \mathscr{F}''_A + 2\mathscr{F}'_B < 0$$

$$\Pi^B_{Y_j^A Y_j^A} = Y_j^A \mathscr{F}''_A + 2\mathscr{F}'_A < 0, \quad \Pi^B_{Y_j^B Y_j^B} = Y_j^B \mathscr{F}''_B + 2\mathscr{F}'_B < 0$$

and

$$\Pi^A_{X_i^A X_i^A}\Pi^B_{Y_j^A Y_j^A} - \Pi^A_{X_i^A Y_j^A}\Pi^B_{Y_j^A X_i^A} > 0, \quad \Pi^A_{X_i^B X_i^B}\Pi^B_{Y_j^B Y_j^B} - \Pi^A_{X_i^B Y_j^B}\Pi^B_{Y_j^B X_i^B} > 0,$$

and the output of each firm can be expressed as

$$X = X^A + X^B,$$

$$Y = Y^A + Y^B.$$

To maintain the analysis at a tractable level, we shall henceforth assume linear and identical demand functions of the form

$$Pr = a - bDr, \tag{10}$$

where the parameters a and b are positive.

We shall close this section by deriving the closed-form solutions of the variables discussed previously, which are[13]

$$Y^A = \frac{(n+1)(a - C_Y - t) - n(a - C_X - T_X)}{b\alpha}, \tag{11}$$

$$X^A = \frac{(m+1)(a - C_X - T_X) - m(a - C_Y - t)}{b\alpha}, \tag{12}$$

$$X^B = \frac{(m+1)(a - C_X - t - T_X) - m(a - C_Y)}{b\alpha}, \tag{13}$$

$$Y^B = \frac{(n+1)(a - C_Y) - n(a - C_X - t - T_X)}{b\alpha}, \tag{14}$$

where $\alpha = m + n + 1$.

II. Optimal Quantity Restriction and Local Merger

Having set the basic framework, we shall now analyze the local-merger effect when a pollution-quota policy is set forth optimally by the domes-

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 also comprise the Routh- Hurwitz conditions for stability.

[13] It can be easily verified that, with linearity of demand second-order conditions are always satisfied.

tic country. It will be useful to review the welfare effect of horizontal mergers when the domestic country pursues an environmental regulation in the form of a pollution quota, the maximum allowance of pollution per unit of output.

In order to define the policy-induced cost, we will consider the original Lahiri and Ono (2000) cost structure, which was replicated by Kayalica and Lahiri (2001) and Kayalica and Lahiri (2005). From (1) we define

$$T_X = \gamma(\theta - z_A); \tag{15}$$

here the amount of pollution generated (prior to any abatement) by each firm in the domestic country is θX, where θ is the constant amount of pollution per unit of output produced. On the other hand, z_A is the maximum quantity of pollution per unit of output produced that firms in country A are allowed to emit into the atmosphere, such that $0 < z_A < \theta$.[14] We assume that abatement technology is such that it costs each firm a constant amount γ to abate one unit of pollution.[15] The parameter γ and θ together with the policy instrument utilized by the government, will determine the policy-induced part of the unit-cost K_X's.

The domestic horizontal merger is modeled after Salant *et al.* (1983) and Dixit (1984) as an exogenous reduction in the number of domestic firms.[16] We will analyze the effect of a change in number of firms n on the welfare of country A. Due to reciprocal dumping-model symmetry, analysis of country B with respect to m is similar and therefore omitted.

The welfare of the representative consumer in the host country, W_A, can be written as

$$W_A = nC_X X + CS_A - \psi z_A, \tag{16}$$

[14] Implicitly, θ is taken to be above the level that the World Health Organization (WHO) considers to be harmless. Likewise, in the case of θ, z_A is taken to be above the level that the WHO considers to be harmless.

[15] Of what does the cost of abatement consist? If pollution abatement is labor costs (labor used for abatement purposes), then it should appear in the welfare equation, and these costs should be part of the labor-income term. These may produce a very interesting change in the model. However, we —only on this occasion and for the sake of simplicity— assume that abatement does not use labor, but some other factors (such as raw materials), which are fully employed in the economy. Thus, abatement is a labor-free process; certain other factors (in a perfectly competitive factor market) are employed. Of course, the same assumption is considered in the following section.

[16] Although the number of domestic firms will obviously take an integer value, this will be treated as a continuous variable.

where the first term is the income of employed factors. We assume, as do Brander and Spencer (1987), that there is unemployment in the domestic country. Brander and Spencer (1987) define unemployment as an excess supply in the labor market, in which some workers who would like to work at the going wage are unemployed; yet wages do not fall to market-clearing level and this wage is assumed to be fixed. In particular, we consider that the variable costs of firms are bought in the host country, and that they are taken to be the income of the nationals of that country.[17]

According to Kayalica and Lahiri (2005), this is the income of the factors that remain unemployed in the absence of the production of the oligopolistic good. Moreover, as mentioned in footnote (17) the presence of a competitive sector producing a numeraire good in the background allows us to consider that the income maximization problem is equivalent to the dual problem of cost minimization. Additionally, as we mentioned previously, profits of FDI firms located in A do not remain in the host country; they are repatriated.[18]

The second term in (16) is the consumer surplus CS_A, and it is well-known that

$$dCS_A = bD_A dD_A. \tag{17}$$

In the third term in (16), Z_A is the total amount of pollution in country A, defined as $Z_A = nz_A X$, ψ is the marginal disutility of pollution.[19] We assume, as do Lahiri and Ono (2000) and Markusen *et al.* (1993, 1995), that the marginal disutility of pollution is constant.[20]

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[17] We assume implicitly that there is a competitive sector in the background that produces a numeraire good. This sector utilizes labor and a specific factor (for example, land) under constant returns to scale. The specific factor is supplied inelastically, and labor is freely mobile between the two sectors (within a country). The imperfectly competitive sector uses labor and a constant return to scale technology. The wage rate of labor (in terms of the competitive numeraire good) is given exogenously at a level higher than that of the market clearing. With these assumptions, total amount of labor utilized in the competitive sector, and the rental rate of land, would not depend on any of the policy parameters; thus, we are able to ignore the numeraire-good sector in our welfare analysis. Any policy inducing an employment change in the non-competitive sector would be the total change in employment in the economy.

[18] This feature is very customary in many developing economies. Absence of domestic investment in some industries is due to different reasons, for example the opening of markets to more efficient foreign competitors, or simply the existence of large sunk costs. Much agroindustry in Central America (see Tamara, 2001) or the automobile industry in Mexico are examples.

[19] Because we are considering a small economy, we will ignore cross-border pollution. For an analysis of cross-border pollution, see, for example, Copeland (1996).

[20] Other authors, such as Asako (1979), consider that marginal disutility is an increasing function of output. However, we will see that this assumption will not change our results, as the concavity condition of the welfare function holds.

This completes model specification and we turn to its analysis. From the total differentiation of demands, reaction functions and welfare function (4)–(7), (8), (9), and (16), we have

$$dWA = \left[\left(nC_X - \psi n z_A \right) 2\gamma \left(\frac{m+1}{ab} \right) + \frac{n\gamma D_A}{\alpha} - nX\psi \right] dz_A$$
$$+ \left[\left(C_X - z_A \psi \right) \frac{(m+1)X}{\alpha} + D_A b \frac{X^A}{\alpha} \right] dn, \qquad (18)$$

In the case of pollution restrictions where n and C_X are constant, the effect on X will determine the direction of the effect on employment and pollution; for example, an increase in z_A will reduce the cost of producing in country A and give n firms a competitive edge over country B firms. There will be an increase in X and a consequent increase in employment and pollution. Regarding the effect on the consumer, an increase in the pollution quota decreases marginal costs, and therefore prices in both countries.

From (18), we found contradictory effects of setting pollution restriction. Government intervention is rooted in this ambiguity. The government is willing to intervene politically, to establish strict pollution control in general and a pollution quota in this particular case, to reduce the negative effect of pollution on people's health.

However, pollution restrictions reduce the domestic-firms' competitive advantage of in the face of foreign firms. This disadvantage may lead to a production reduction, and consequently to a reduction of the income of unemployed factors. In this case, the government may be interested in promoting domestic production in order to promote domestic employment, because there is a failure in the labor market that can be compensated with a pollution-control reduction.

In addition to the latter argument, pollution restriction may lead to the production of monopolistic distortions in this model. Pollution restriction increases firms' costs, and therefore the price of the homogeneous good. In Barnett (1980), subsidizing output is an answer to deal with monopoly distortions. Even when we are unable to set a subsidy in the case of pollution quota, the Barnett result is an incentive for government intervention to reduce impact on the consumer by reducing pollution control.

Therefore, there are three reasons for governmental intervention:

the health of the populace; domestic employment, and monopoly distortions. The former argues for tighter pollution control, while the latter two call for weaker pollution regulation; government intervention should balance all three. In the case of pollution tax in the next section, we will see that the government should consider not only these previously mentioned three reasons, but also the income they obtain from taxing pollution: tight restriction implies additional income for the government.

On the other hand, we can see in the second term of the right side of equation (18) that a reduction in n will reduce the number of firms polluting the local country and the income of employed factors. This reduction in n will reduce the total amount of goods consumed and will increase their price. It should be noted that a fall in n has two effects: first, there is a reduction in the number of firms producing locally. Second, this reduction would increase the market share and the output of each firm. In the end, net effect is a fall in total output, as the fall in number of firms is greater than the increased output of each firm.

From the coefficient of dz_A in (18), taking dn as given, we obtain the Nash optimal z_A as:[21]

$$z_A^N = \frac{C_X}{\psi} + \frac{bD_A}{2\psi(m+1)} - \frac{\alpha b X}{2\gamma(m+1)}. \tag{19}$$

From (19), we can see that when γ is sufficiently smaller than ψ imposing pollution control no costs but only benefits. Therefore, the optimal policy is to impose the severest pollution restriction, that is, $z_A^N = 0$. On the other hand, when γ is sufficiently larger than ψ, the quota would be positive.

Intuitively, a high marginal abatement cost implies that pollution control exerts a significant negative impact on production and price.

[21] For welfare functions to be concave in z_A, from (18) we must have

$$\alpha b \frac{d^2 W_A}{dz_A^2} = n\gamma[n\gamma - 4\alpha(m+1)\psi] < 0.$$

Clearly, the abovementioned conditions are satisfied if and only if

$$\psi > \frac{n}{4\alpha(m+1)}\gamma.$$

This condition does not affect our results in any fashion, in that it is always possible to obtain feasible results by holding this condition.

Reduction in output reduces employment, while a price increase reduces consumer surplus. Therefore, when the marginal abatement cost is sufficiently high, the government may be forced to allow a positive amount of pollution. However, when the marginal cost for abating pollution is sufficiently small, the harmful effect of pollution outweighs the benefit obtained by employment and consumer surplus. The government dictates the severest pollution policy because it reduces optimal output, and consequently the level of pollution.

On evaluating optimal policy (19) in the coefficient of dn in (18), we have

$$\frac{dW_A}{dn} = \frac{bX^2\psi}{2\gamma} + \frac{bD_A}{2\alpha}\left(X^A - X^B\right) \tag{20}$$

where it follows from (12) and (13) that $X^A > X^B$, and therefore (20) is positive.[22]

Mergers of local firms will reduce welfare in the domestic country. A reduction in n will produce monopolistic distortions, reducing consumer surplus and employment by a greater proportion than the reduction in pollution. Formally we can say,

Proposition 1. *In a reciprocal dumping model of trade, when a local government pursues a quota pollution restriction mergers in local firms will reduce welfare in the local country.*

Intuitively, a reduction in the number of firms will produce monopolistic distortions, so that price increases will reduce the consumer surplus. Even when each firm produces additional output, the net effect on total output is negative due to the decreased number of firms. With mergers, consumer surplus decreases because the amount of output available for consumption increases the output price.

In the employment effect, a reduction in number of firms will reduce employment, because fewer firms hire fewer factors. Also, payment to the employed factors is lower due to reduction in total output. Both effects consumer surplus and employment are welfare-decreasing.

On the other hand, less total output signifies less pollution, this consequently benefiting the health of the people. This is a welfare-increasing effect. According to (20), the fall in payment to employed fac-

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[22] One characteristic of the present model is that each firm possesses a smaller share of the foreign market than of its domestic market (see Brander, 1981, p. 7). We have $X^A > X^B = t(2m + 1)/b\alpha$.

tors and in consumer surplus dominates over the positive effect produced by a reduction in the amount of pollution produced by domestic firms. The welfare of the domestic country will be reduced.[23]

Prior to following the analysis, it is important to note that this result holds unequivocally when each firm produces a larger amount of output for the local market than for the foreign market ($X^A > X^B$). This difference renders the second term on the right side of equation (20) always positive. This result occurs under the consideration of equal market size in both countries. How will the result change when we have a different market size in the two countries?

One way to analyze this problem is by defining different parameters for the linear demand function in each country. According to Martin (1983, p. 15), the market size, which is explicitly defined as $S = (a - C)/b$ (in terms of our parameters), could be measured from the value of a. Thus, we can define different values of parameter a in each linear demand. From (10), the demand may be set as $P_r = a_r - bD_r$, where $r = A, B$ (as previously), and $a_A \neq a_B$.[24]

In this sense, we can rewrite equations (12) and (13) as

$$X^A = \frac{(m+1)\left(a_A - C_X - T_X\right) - m\left(a_B - C_Y - t\right)}{b\alpha}$$

$$X^B = \frac{(m+1)\left(a_B - C_X - t - T_X\right) - m\left(a_A - C_Y\right)}{b\alpha}$$

If we set the difference between these two latter expressions as in (20), $X^A - X^B$, we find

$$X^A - X^B = \frac{\left(a_A - a_B\right)(2m+1) + t(2m+1)}{b\alpha}.$$

At this point, it is naive to say that the result in proposition 1 holds in the case where there exists either equal market size in both countries, or a domestic market larger than the foreign market ($a_A \geq a_B$). This result follows the same intuition mentioned previously.

However, the ambiguity of (20) appears when the market in country B is sufficiently larger than the market in country A ($a_A < a_B$), and when

[23] With full employment, the latter proposition holds, as (20) does not change. Reduction in harmful pollution is smaller than reduction in consumer surplus, and the effect on local welfare will be negative.

[24] We may also change the value of b in order to have b_A and b_B; nonetheless, we may always find values of a_A and a_B, which would set a difference in the market size. This consideration will aid us in maintaining the analysis at a tractable level.

transport cost, t, is sufficiently small. In this case, amount of output produced for export may be larger than output produced for local consumption ($X^A < X^B$).

When the foreign market is sufficiently larger than the domestic market and amount of output produced for export is larger than output produced for local consumption, mergers in local firms may improve the welfare of the country where they are located. However, from (20) the result is not clear-cut, because it also depends on other variables such as marginal disutility, transport cost, and marginal abatement cost. We are certainly unable to say much concerning the problem; only speculations can be made at this point.

If we solely speculate and assume that the foreign market is sufficiently larger than the domestic market ($a_B >> a_A$) to obtain a much larger market for exported goods rather than for domestic goods ($X^A << X^B$), we may consequently assume that the second term in the right side of equation (20) may be larger than the first term. If this is so, mergers of domestic firms may produce an increase in welfare. Why would that be?[25]

As we mentioned previously, a reduction in the number of domestic firms reduces both consumer surplus (afforded by a rise in price) and income of employed factors. Additionally, reduction in n firms will increase the benefit of people's health due to a reduction in pollution emission. The comparative statistic does not change, but when (20) is negative we can speculate that the magnitude of the effects are different in this case.

A large foreign market means additional production for export and relatively limited production of local goods. With such a small local production, consumer surplus and payment to employed factors producing local goods are small. In this regard, the merging of local firms would have a small impact on welfare. On the other hand, the amount of pollution is large, as the amount of output produced for export is also large. A merger will wield an important impact on pollution reduction. The benefit of reducing pollution is greater than the loss afforded by the reduction in consumer surplus and in the income of employed factors. Therefore, any reduction in polluting firms will benefit welfare.

Independently of which market is larger than the other, both results hold only if there is harmful pollution. Otherwise, a merger will simply reduce the competitive edge of local firms by reducing employment and producing certain monopolistic distortions. When we consider pollution,

[25] Even when we can get some numerical figures about this possible scenery, it is not worthy to set a proposition as there are many possibles parameters combinations involved in the result.

a benefit from merger should exist. However, this benefit depends not only on pollution, but also on the impact of pollution on health.

No impact on health is equivalent to stating that there is no pollution at all. Considering the existence of pollution, we should assume that the marginal disutility is greater than zero; otherwise ($\psi = 0$). A simple inspection of (18) will reveal that merger will simply harm welfare by reducing employment and consumer surplus.[26]

Finally, to end this section we follow the analysis made by Collie (1997). When a local merger reduces local welfare, the government attempts to correct this negative externality by employing policy instruments. In this case, when the government pursues an optimal pollution policy in what way should the local country respond to a local merger?

In order to resolve this question, we obtain the comparative statistic of a reduction in the number of local firms on the optimal pollution quota. Differentiating the optimal quota (19) with respect to n, we found

$$\frac{dz_A^N}{dn} = \frac{bX^A}{2\psi(m+1)\alpha} \tag{21}$$

This expression is evidently positive, and a local merger will promote a reduction in the pollution quota allowed. Thus, we may state formally:

Proposition 2. *The optimal response of the domestic country to a local merger is to decrease its pollution quota.*

This result appears odd, according to a very accurate comment by an anonymous referee. Previously, we had mentioned that a merger reduces welfare because consumer surplus and employment fall in a greater proportion than the reduction in pollution. Now, from (21), the optimal response of government to that merger is to decrease its pollution quota.

However, a tighter pollution policy implies a reduction in consumer surplus and the income of employed factors, the same harmful effect produced by the merger. Why does the government pursue such a policy response? Moreover, why not permit a larger pollution quota in order to increase consumer surplus and employment?

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[26] The existence of a second-best pollution policy is critical to these assumptions.

Once the government has set the optimal pollution policy, evaluating not only the impact on employment and consumer surplus but also the damage of pollution on the populace, local firms react and merge in order to achieve better profits by obtaining monopolistic advantages. The government may increase the pollution quota to stimulate domestic production and employment and to reduce consumer prices. Nevertheless, the government does not proceed in this way. Why? Because of pollution: no pollution means no governmental response.

The answer is concerned with the speed of change in output and pollution. Reduction in output and consequently in employment and consumer surplus afforded by a local merger is greater than the increase in output conferred by an increase in the allowed pollution quota. On the other hand, the reduction in harmful pollution provided by a merger is smaller than the increase in pollution afforded by an increase in the pollution quota. Additionally, with a merger the effect of regulation on consumer surplus becomes less important.

In other words, the government is willing to increase policy restrictions for two reasons: first, the government is unable to compensate completely for the reduction in consumer surplus and employment brought about by local merger utilizing a relaxed pollution quota. Second, the harmful effect of pollution on health will be greater than the benefit in consumer surplus and employment brought about by a relaxed pollution policy. The government will be unable to compensate the loss in consumer surplus and employment without producing a larger disutilty caused by pollution. Thus, the optimal response is to reduce the pollution quota.

III. Optimal Pollution Tax and Local Merger

Having analyzed the effect of a merger on local welfare in the presence of a pollution quota, we now commence analyzing the effect of a merger when the domestic government pursues an environmental pollution tax. In this section, we intend to clarify which instrument is most frequently appropriated for controlling pollution in the presence of mergers. According to Cropper and Oates (1992, pp. 681-2) under perfect knowledge, the environmental authority can achieve the same objective with either a pigouvian tax or a quantitative restriction on pollution.

However, in the Cropper and Oates (1992) result, firms are allowed to make competitive bids for emission permits. As Lahiri and Ono (2000) stated, although the concept of marketable emission permits is neat for operational difficulties it is scarcely ever used in reality. Therefore, it would be profitable to compare a pollution tax with a quantitative pollution restriction, when the quantitative restriction is not marketable or imposed by authorities as a mandate. This is the added value of this section.

We will closely follow the analysis made by Lahiri and Ono (2000),[27] and shall concentrate on the case of uniform tax policy on pollution.

The pollution tax includes two associated costs to n firms: (i) the tax paid, and (ii) the cost of pollution abatement. Denoting by q_A the post-abatement pollution level per unit of output (which is an endogenous variable chosen by the firms), the unit cost of each firm located in A is rendered by[28]

$$K_X = C_X + \gamma(\theta - q_A) + tq_A \tag{22}$$

where C_X is as previously mentioned, $\gamma(\theta - q_A)$ is the unit abatement cost, and tq_A, the unit tax paid.

With this cost structure, n firms decide on q_A and X_A. From (22), a straightforward definition of the optimal behavior on pollution emission as:[29]

$$q_A = \begin{cases} 0 \text{ if } t \geq \gamma \\ \theta \text{ if } t < \gamma \end{cases} \tag{23}$$

When tax rate is equal to or larger than private marginal abatement cost, n firms do not abate pollution at all, because the tax is a cheaper option than financing anti-pollution strategies. On the other hand, when the tax rate is smaller than the marginal cost of abatement, n firms emit only a harmless pollution level, in that a high tax is significant.

Substituting (23) for (22) we have

[27] Similar to Lahiri and Ono (2000, footnote 15), we note two distortions in our model, viz., product-market imperfection and pollution externalities. The government should introduce two instruments, a Pigouvian tax on pollution and a Marshalian production subsidy to achieve the first best. However, as Cropper and Oates (1992, p.864) note, environmental regulators are unlikely to subside the outputs of monopolists. Then, we consider an optimal second-best tax on pollution, as in Barnett (1980) and Lee (1975).

[28] Again, it is just in our interest to analyze the effect of domestic mergers in the host country. So, the unit cost of every firm located in country B is, as before, C_Y.

[29] This result depends on the assumption of linearity in the abatement function.

$$K_X = \begin{cases} C_X + \gamma\theta \text{ if } t \geq \gamma \\ C_X + t\theta \text{ if } t < \gamma \end{cases}, \tag{24}$$

and from (23) we obtain the total amount of pollution Q_A as

$$Q_A = \begin{cases} 0 \quad \text{ if } t \geq \gamma \\ nX\theta \text{ if } t < \gamma \end{cases}, \tag{25}$$

From (25), when $t \geq \gamma$ the pollution amount is zero, independent of the tax rate (t). When $t < \gamma$, all n firms pay the pollution tax because none of the firms abate any pollution.

To this point, we have defined cost structure and amount of pollution. Taking these latter expressions into account, the domestic country's welfare is rendered by

$$W_A = nC_X X + CS_A - \psi Q_A + tq_A nX, \tag{26}$$

where the first, second, and third terms comprise income of employed factors, consumer surplus, and pollution disutility, respectively, as described previously. The last term is, namely, the tax revenue.

If we perform a total differentiation of (26) with respect to n and t, we get

$$dW_A = \left[(\psi - t)\left(\frac{q_A^2 2n(m+1)}{b\alpha} \right) - \frac{nD_A q_A}{\alpha} + q_A nX - \frac{2n(m+1)q_A C_X}{b\alpha} \right] dt$$
$$+ \left[(C_X - q_A\psi + tq_A)\frac{(m+1)X}{\alpha} + D_A b\frac{X^A}{\alpha} \right] dn, \tag{27}$$

where the concavity of welfare function holds

$$\frac{d^2 W_A}{dt^2} = \frac{nq_A^2}{b\alpha^2}\left(1 - 4\alpha(m+1)\right) < 0. \tag{28}$$

In the comparative static approach, an increase in the pollution tax will increase the production cost of the firm in A, and provide these firms with a competitive disadvantage with respect to those in country B. There is a reduction in optimal output of n firms, which reduces income of employed factors, consumer surplus, and pollution disutility.

On the other hand, an increase in n signifies an increase in number of polluting firms, income of employed factors, consumer surplus, and tax revenue.

We are now able to define the optimal tax from (27) as

$$t = \frac{b_X \alpha}{2q_A(m+1)} - \frac{bD_A}{2q_A(m+1)} - \frac{C_X}{q_A} + \psi. \tag{29}$$

This expression is rather ambiguous and depends on, among other parameters, marginal disutility for pollution, ψ, marginal production cost, C_X, and amount of output produced by n and m domestic and foreign firms, respectively.

The optimal tax will be as great as the impact of pollution is on people's health and tax revenue, despite reduction in employment and consumer surplus. A smaller tax will be levied if impact on health and tax revenue is rather limited.

On the other hand, we have the problem of discontinuity in the welfare function with respect to the tax (t). The welfare function is not necessarily continuous in t, and possible discontinuity occurs when $t = \gamma$. From (24) and (25) in the case in which $t \geq \gamma$, the amount of pollution is zero and the welfare function does not depend on the tax.

However, when $t < \gamma$, all firms pay the pollution tax; consequently there is an effect on welfare. W_A will depend on t, and we are able to write

$$\frac{dW_A}{dt}\bigg|_{t<\gamma} = (\psi - t)\left(\frac{\theta^2 2n(m+1)}{b\alpha}\right) - \frac{nD_A\theta}{\alpha} + \theta nX - \frac{2n(m+1)\theta C_X}{b\alpha}. \tag{30}$$

In this case as presented in the latter expression, welfare depends on t. The $t \geq \gamma$ case appears rather irrelevant, as welfare does not depend on t. However, we intend to know the value of t and closely following the Lahiri and Ono (2000) analysis, we will determine the slope of the welfare function with respect to the tax when we are near the discontinuity point. This analysis will allow us to identify the level of optimal tax, considering (according to equation (28)) that the welfare function is concave in t.

When t approximates and approaches γ from the right and from the left, unit cost of n firms K_X given in (24), and therefore, the consumer surplus (CS_A) and income of employed factors (nC_XX) converge at the same respective values, regardless of the direction of the convergence. Therefore, from (25) and (26) we obtain

$$\lim_{t\downarrow\gamma} W_A(t) - \lim_{t\uparrow\gamma} W_A(t) = (\psi - \gamma)nX\theta \gtrless 0 \Leftrightarrow \psi \gtrless \gamma \tag{31}$$

From this latter expression, we can appreciate that there may exist a positive number ξ, such that $\psi - \gamma \geq \xi$ and as in Lahiri and Ono (2000) the optimal tax is set at any level higher than the unit abatement cost γ, reducing pollution emission to a harmless level. If $\psi - \gamma < \xi$, the optimal tax rate is strictly lower than γ, resulting in no abatement of pollution.

When ψ is larger than γ, the beneficial effect of pollution control dominates all other effects, causing the tax rate to be set at such a level that it eliminates any pollution. The positive impact of pollution control (by means of a high tax) on people's health outweighs damage to local production, and consequently to the income of employed factors. This is a similar conclusion to the case of the pollution quota, as observed previously.

However, when ψ is samller than γ, the optimal tax rate is set at a lower level and the optimizing firms therefore decide to pay the tax and not abate any pollution. The abatement cost is greater than pollution's impact on health and tax revenue. This case is different from the quota case, in which firms lack the freedom to choose the abatement level. Therefore, tax and quota cases are not necessarily equivalent in this case.

Evaluating optimal policy (29) in the coefficient of dn in (27), we have

$$\frac{dW_A}{dn} = \frac{bX^2}{2\gamma} + \frac{bD_A}{2\alpha}\left(X^A - X^B\right); \tag{32}$$

from (12) and (13), it is clear that $X^A > X^B$: thus (32) is positive. Mergers in local firms will reduce welfare in the domestic country. A reduction in n will produce monopolistic distortions that reduce consumer surplus, employment, and tax revenue in a greater proportion than the reduction in pollution. Formally, we can state:

Proposition 3. *In a reciprocal dumping model of trade, when government pursues a pollution-tax restriction, mergers in local firms will reduce welfare in the local country.*

Intuitively, a reduction in the number of firms will produce monopolistic distortions through a price increase that will reduce consumer surplus. Furthermore, a reduction in number of firms will reduce employment and tax revenue, because fewer firms hire fewer factors and provide a lesser income to be taxed. These three effects dominate over the positive effect produced by a pollution-amount reduction in domestic firms. Hence, welfare in the domestic country will be reduced.

As in the pollution-quota case, this result depends on the assumption of equal market size. When the foreign market is significantly larger than the domestic market, we may have a larger market for exported goods than for locally consumed goods. As in the quota case, with a foreign market sufficiently larger than the local market the benefit of pollution reduction may be greater than the loss from the reduction in consumer surplus, tax revenue, and income of unemployed factors. Existence of pollution is crucial in this tax policy case as well.

Again, to obtain the best response to this negative effect of mergers on domestic welfare we should differentiate (29) with respect to n to obtain

$$\frac{dt}{dn} = \frac{b\left(\alpha X + X^{A}\right)}{2q_{A}(m+1)\alpha} < 0. \tag{33}$$

This expression is evidently negative and a local merger will produce an increase in the optimal pollution tax. Formally, we can state:

Proposition 4. *The optimal response of the domestic country to a local merger is to increase its pollution tax.*

Intuitively, a pollution-tax increase will increase tax revenue and cost for local firms, reducing their production and their competitive advantage over foreign firms; employment and consumer surplus will be reduced. On the other hand, the increase in local firms' costs will reduce harmful pollution. Therefore, the best response from local government would be to increase the pollution tax in order to compensate for the reduction in consumer surplus and employment and to benefit from pollution reduction and tax revenue.

Again, as in the previous section the result appears odd, as tighter pollution restriction exacerbates loss in consumer surplus and employment previously afforded by the merger of local firms. As in the pollution-quota case, the explanation is quite similar: the government is willing to increase pollution restriction because otherwise, it is unable to compensate for the loss (after merger) in consumer surplus and employment with a relaxed pollution restriction. Because the government is unable to compensate for this loss, a tighter policy will benefit the health of the populace and, differently from the quota case, will increase government tax revenue. Increase in tax revenue and in people's health will be greater than loss in consumer surplus and employment, which will increase welfare.

It appears that monopolistic distortions comprise the dominant effect of merger on local welfare in both cases. When the domestic government pursues either of the two policy instruments, the effect of a merger on local welfare and the response to this merger from local government appear equivalent. Reduction in consumer surplus is the principal origin of this negative effect, and pollution is the main reason why the local government strengthens pollution policy in both cases.

Although the merger effect on welfare and policy response appears equivalent in both cases, it is true solely in the case in which marginal disutility is sufficiently small. When marginal disutility is sufficiently large, the negative effect of a merger on local welfare would not be responded to by the government. The intuition behind this phenomenon is different in each case.

With a large ψ, the harmless pollution level is set in both cases. In the first case, there is no pollution quota ($z_A = 0$), and the negative effect of a merger will not be responded to by the government. With $z_A = 0$, the government has no instrument available to compensate for the reduction in welfare produced by the merger.

In the case of a pollution tax, a large ψ implies a great impact of pollution on people's health. The government possesses incentives to set a significantly high pollution tax, increasing the cost of local firms. In this respect, firms have incentives to reduce pollution to a harmless level and no change in t will affect the firms' cost.

Conclusion

Despite the well-known negative effect of pollution on human health, coordinated efforts made by governments worldwide have been rather limited. The pessimism and inflexibility expressed by all 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, but only under specific conditions.

We modeled, in a Cournot oligopolistic setting of reciprocal dumping, the effect of mergers (in the presence of pollution restrictions) on welfare, the best response from government when a merger produces a negative externality. In this same context, we analyzed the efficiency of two policy restrictions: pollution quota, and pollution tax.

Considering the existence of unemployment and in the presence of a pollution quota, a local merger will reduce local welfare. Monopolistic distortions and reduction in employment are greater than the benefit in pollution reduction. To compensate for this negative effect of mergers on welfare, the government in the local country reduces the pollution restriction, thus reducing the competitive advantage of local over foreign firms. This effect will provide the market with cheaper products. On the other hand, a local merger in the presence of a pollution tax will reduce welfare as well. In this case, the government will increase the pollution tax in order to expand consumer surplus despite the increase in pollution.

Even when these two effects and the action taken by the government are similar in both instrument cases, this is only true with a small marginal disutility for pollution. When the marginal disutility is large, there is no response from local government, and the intuition behind each case is different.

References

Andonova, L. B. (2003), "Openness and the environment in Central and Eastern Europe: can trade and foreign investment stimulate better environmental management in enterprises?", *Journal of Environment and Development*, 12(2), 177-204.

Asako, K. (1979), "Environmental pollution in an open economy", *Economic Record*, 55(151), 359-367.

Auquier, A. and R. Caves (1979), "Monopolistic export industries, trade taxes and optimal competition policy", *Economic Journal*, 89(355), 559-581.

Barnett, A. (1980), "The pigouvian tax rule under monopoly", *American Economic Review*, 70(5), 1037-1041.

Brander, J. (1981), "Intra-industry trade in identical commodities", *Journal of International Economics*, 11(1), 1-14.

Brander, J. A. and P. Krugman (1983), "A 'reciprocal dumping' model of international trade", *Journal of International Economics*, 15(3,4), 313-321.

Brander, J. A. and B. J. Spencer (1987), "Foreign direct investment with unemployment and endogenous taxes and tariffs", *Journal of International Economics*, 22(3,4), 257-279.

Collie, D. R. (1997), "Mergers and trade policy under oligopoly", *Workshop on International Trade and Industrial Organization, December 1997,* Centre for Economic Policy Research, Barcelona, Spain.

Copeland, B. R. (1996), "Pollution content tariffs, environmental rent shifting, and the control of cross-border pollution", *Journal of International Economics,* 40(3,4), 459-476.

Cropper, M. L. and W. E. Oates (1992), "Environmental Economics: A Survey", *Journal of Economic Literature,* 30(1), 675-740.

Dixit, A. K. (1984), "International Trade Policy for Oligopolistic Industries", *Economic Journal,* 94 (Supplement), 1-16.

Extreme Weather Sourcebook (2001), "Economic and other societal impacts related to hurricans, floods, tornadoes, lightning and other U.S. weather phenomena". The National Center for Atmospheric Research (NCAR), National Oceanic and Atmospheric Administration (NOAA), U.S. Weather Research Program (USWRP), National Science Foundation (NSF), and the American Meteorological Society (AMS). Available at http://sciencepolicy.colorado.edu/sourcebook/index.html

Jaffe, A. B.; S. R. Peterson and R. N. Stanvis (1995), "Environmental regulation and the competitiveness of U.S. manufacturing: what does the evidence tell us?", *Journal of Economic Literature,* 33(1), 132-163.

Jeppesen, T.; J. A. List and H. Folmer (2002), "Environmental regulations and new plan location decisions: evidence from a meta-analysis", *Journal of Regional Science,* 42(1), 19-49.

Kanbur, R.; M. Keen and S. Van Wijnbergen (1995), "Industrial competitiveness, environmental regulation and direct foreign investment", in I. Golding and L. A. Winters (eds.), *The Economics of Sustainable Development,* Cambridge, UK, Cambridge University Press.

Kayalica, O. and S. Lahiri (2001), *Strategic environmental policies in the presence of foreign direct investment,* Working Paper 55, Fondazione Eni Enrico Mattei, Italy.

Kayalica, O. and S. Lahiri (2005), "Strategic environmental policies in the presence of foreign direct investment", *Environmental and Resource Economics,* 30(1), 1-21.

Lahiri, S. and Y. Ono (1998), "Tax competition in the presence of cross-hauling", *Weltwirtschaftliches Archiv,* 134, 263-279.

——— (2000), *Protecting environment in the presence of foreign direct investment: tax versus quantity restriction,* Discussion Paper 506, Department of Economics, University of Essex, England.

Lee, D. (1975), "Efficiency of pollution taxation and market structure", *Journal of Environmental Economics and Management,* 2(1), 69-72.

McGuire, M. C. (1982), "Regulation, factor rewards, and international trade", *Journal of Public Economics*, 17(3), 335-354.

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(1), 69-86.

——— (1995), "Competition in regional environmental policies when plant locations are endogenous", *Journal of Public Economics,* 56(1), 55-57.

Martin, S. (1983), *Advanced industrial economics,* Cambridge, Mas., Basil Blackwell.

NAPES, Comprehensive database of long-term economic indicators for the Asia-Pacific region covering bilateral trade, economic and industrial research and development and patents. International Economic Databank at ANU and the Victorian University of Technology. Available at http://napes.anu.edu.au

Nikaido, H. (1968), *Convex structures and economic theory,* New York, Academic Press.

Pethig, R. (1976), "Pollution, welfare, and environmental policy in the theory of comparative advantage", *Journal of Environmental Economics and Management,* 2(3), 160-169.

Porter, M. E. (1991), "America's green strategy", *Scientific American,* April, 168.

Salant, S. W.; S. Switzer and R. J. Reynolds (1983), "Losses due to merger: the effects of exogenous change in industry structure on Cournot-Nash equilibrium", *Quarterly Journal of Economics,* 98(2), 185-200.

Siebert, H. (1977), "Environmental quality and the gains from trade", *Kyklos,* 30(4), 657-673.

SQW, Ltd. (2006), "Exploring the relationship between environmental regulation and competitiveness: a literature review". Department for Environment, Food and Rural Affairs, UK Government Research Report. Available at http://www.sqw.co.uk/pdfs/epes0506-11-litreview.pdf

Tamara, J. (2001), "Algunas reflexiones sobre las implicaciones de la liberalización de los intercambios comerciales a partir del 'conflicto de la banana' I y II parte", *DHIAL* 21. Disponible en http://www.iigov.org/dhial.

World Health Organization (1997), "The World Health Report 1997-conquering, suffering, enriching humanity", World Health Organization. United Nations. Available at http://www.who.int/whr/1997/en/index.html.

Yohe, G. W. (1979), "The backward incidence of pollution control - some comparative static in general equilibrium", *Journal of Environmental Economics and Management,* 6(3), 187-198.