CEE
Centro de Estudios Económicos
www.colmex.mx
El Colegio de México, A.C.

Serie documentos de trabajo

TRADE INCENTIVES AND THE STRENGTH OF ENVIRONMENTAL POLICIES UNDER IMPERFECT COMPETITION

Roberto Burguet and Jaime Sempere

DOCUMENTO DE TRABAJO

Núm. III – 1999

Trade incentives and the strength of environmental policies under imperfect competition

Roberto Burguet

Institute for Economic Analysis (CSIC)

Jaime Sempere

El Colegio de México

This version: March 1999

Abstract

Under imperfect competition and bilateral trade, (second best) efficient environmental policies may not equate marginal willingness to pay with social marginal cost. Then trade incentives may strengthen or weaken environmental policies even when tougher environmental policies imply higher unit cost for domestic firms.

J.E.L. Classification Numbers: D43,F13,H23.
Keywords: Environmental policy, bilateral trade, imperfect competition.

We gratefully ackonwledge comments by R. Caminal, S. Chattopadhyay, I. Ortuño, P. Regibeau, and the financial support of the Spanish Ministry of Education through the Programa de Cooperación Científica con Iberoamérica. Burguet also acknowledges support from the CICYT Grant PB96-0897. Sempere also acknowledges support from CONACyT.

1.-Introduction

We analyze the strategic distortions that trade incentives induce in environmental policies in the presence of bilateral trade and imperfect competition. For that, we compare the environmental policies that a global government would set with those expected from the decentralized decisions of governments of trading countries. In the first case, which we can consider as a situation where countries coordinate their environmental policies, first best efficiency is not guaranteed unless governments have enough instruments to attain possibly conflicting goals (inducing the correct choices of both technology and the level of output, for instance). That is, marginal willingness to pay for consumption goods may not equate their marginal social cost, which includes environmental damage.

We show that the origin of the possible distortions introduced by trade lies in the higher responsiveness of domestic output to the policy variables. Indeed, if policies are not coordinated, a change in one government's policy is not matched by a similar change in those of other governments. Therefore tougher (weaker) policies reduce (increase) domestic output by more than under policy coordination. Then, if marginal willingness to pay exceeds marginal social cost at the coordinated solution, trade incentives work in the direction of weaker environmental polices. However, if marginal willingness to pay is higher than marginal social cost, the opposite is true. We illustrate by providing examples of both cases for particular specifications of policy instruments that have been studied in the literature. We also give an example of first best instruments which (under symmetry) implies no trade incentives on environmental policies.

That strategic trade considerations could make environmental policies tougher is a result that has been obtained under several assumptions: with competition in prices (Barrett,1994); with enough firms in each country so that tougher environmental policies soften competition among domestic firms (Barrett,1994);[1] and when tougher standards force firms to undertake R&D to the point of actually reducing their unit costs (Ulph and Ulph ,1995; also, see Ulph, 1996, for a good survey of this literature).[2] Here we show that this result is possible even when tougher environmental policies imply higher unit costs for domestic firms and this increases the competitive pressure they face.

---

[1] Moreover, this result is general only because in Barrett's model firms sell in a third country, so that consumer surplus is not an argument in the welfare function.

[2] Without strategic considerations, Krutilla (1991) and Markusen (1975) show that environmental policies could be too strict in an open economy if the country is an exporter of a pollution intensive good.

2.- The model: Imperfect competition and bilateral trade

We consider a symmetric, Brander-Spencer (1984) model of bilateral trade. Two firms, each located in a different country, i=1,2, produce a homogeneous, tradable good. The demand for this good in each country is given by the inverse demand function $P(Q)$. [3]

Local production generates local environmental damage as a byproduct. [4] We assume that the level of this damage depends both on the level of local output q and an environmental instrument, c, the level of which is set by the government. Thus, $h(c,q)$ measures the externality (environmental damage) created by production. In the sequel we will consider different particular interpretations for the environmental instrument, but in all cases the extent of environmental regulation will translate into a constant increase in the marginal cost of the domestic firm. Also, we assume that $h()$ is convex, increasing in q, and decreasing in c.

Firms can freely export their output, and compete in quantities. To make the analysis simple, we assume that the firms' marginal cost of production, net of the cost of environmental regulation, c, is constant, and normalize this cost to zero.

This defines a two-stage game. In the first stage, the two governments simultaneously set their environmental variables with the goal of maximizing (domestic) surplus minus social (environmental) cost $h(c,q_i + q_i^*)$. In the second, firms set quantities. We denote by q_i and q_i^* respectively the quantities produced by firm i for sale in its domestic (i) and foreign (j) markets.

Given our assumptions on costs, firms consider the two markets separately. The first order conditions for their profit maximization in market (country) i are

$$P'(q_i+q_j^*)\, q_i + P(q_i+q_j^*) - c_i = 0,$$

$$P'(q_i+q_j^*)\, q_j^* \quad P(q_i+q_j^*) - c_j = 0. \qquad (2)$$

Equations (1) and (2) implicitly define the equilibrium $q_i(c_i,c_j)$ and $q_j^*(c_i,c_j)$, for i=1,2.

Now we can analyze the first stage of the game, that is, the governments' competition on environmental policies. Let $Q_i = q_i+q_j^*$ denote the supply in country i. Also, let R_i represent the revenue of firm i in its domestic market and R_i^* represent its exports revenue and denote by $C = (c_1, c_2)$. Then, we can write the government's objective function as

---

[3] As usual, we will implicitly assume that this demand function is not too convex, so that the solution to the system (1), (2) below is unique (see for instance Tirole, 1988).

[4] The same features would be obtained under spillovers in pollution, as far as there is still a component of local pollution.

$$W_i(C) = CS(Q_i) + R_i[q_i, q_j^*] + R_i^*[q_j, q_i^*] - h(c, q_i + q_i^*) \quad (3)$$

where q_i and q_i^* for $i =$,2, are defined by the equilibrium equations (1) and (2), and

$$CS(Q_i) = \int_0^{Q_i} [P(x) - P(Q_i)]dx$$

is the consumer surplus in country i. The first order condition for this problem is

$$\frac{\partial W_i(C)}{\partial c_i} = 0 \quad (4)$$

The set of equations (1) through (4) (for $i = 1,2$) defines (interior) equilibrium in this game.

3. Trade incentives and the environment

We now turn to the analysis of how the decentralized solution characterized above compares to the environmental policy that a global government would set. That is, we investigate the incentives to manipulate the environmental policies associated with trade concerns.

Since we have assumed constant returns to scale in production and convex environmental damages, the coordinated solution would imply symmetric policies and therefore symmetric outputs. Thus the problem for the planner would be[5]

$$\underset{c}{Max} \int_0^{Q(c)} P(X)dx - h(c, Q(c)).$$

where $Q(c)$ represents the production of two symmetric, competing firms, each one having unit costs equal to c. The first order condition for this problem is

$$\left[P(Q) - \frac{\partial h}{\partial Q}\right]\frac{dQ}{dc}$$

Notice, in particular, that the solution to the problem above needs not imply that the price is equal to the marginal social cost of production, $\frac{\partial h}{\partial Q}$. More generally, (5) does not necessarily imply that $\frac{\partial h}{\partial Q} = P$; consequently it does not imply $\frac{\partial h}{\partial c} = 0$.

[5] We are restricting the instrument available to the governments to their environmental instruments (for instance, we don't consider tariffs). Whether governments have sufficient instruments plays an important role, as will be seen later.

Now we return to the decentralized case. Using equations (1) and (2), equation (4) above becomes:[6]

$$\frac{\partial W_i(C)}{\partial c_i} = \left[P(Q_i) - \frac{\partial h}{\partial Q}\right]\frac{\partial(q_i + q_i^*)}{\partial c_i} - \frac{\partial h}{\partial c} = 0. \tag{6}$$

Equations (5) and (6) differ in that we have $\frac{dQ}{dc}$ in (5) whereas in (6) we have $\frac{\partial(q_i + q_i^*)}{\partial c_i}$ The former is the output response of two competing firms to increases in their respective marginal costs. The latter is the output response of two firms faced with an increase in their marginal costs when each is competing with another firm whose costs do not change. Then, in general (when evaluated at the same output levels) $\frac{dQ}{dc}$ will be smaller in absolute terms than $\frac{\partial(q_i + q_i^*)}{\partial c_i}$ That is, the origin of the distortion introduced by trade considerations is the larger reaction of domestic output to (unilateral) changes in c as compared to coordinated (bilateral) ones.

To analyze the direction of this distortion, we compute $\frac{\partial W_i(C}{\partial c_i}$ evaluated at the coordinated solution. If this derivative is negative, the governments would react to policy competition by decreasing the levels of environmental protection. Thus, in equilibrium we would expect less environmental protection than the coordinated one. But the opposite would be true if the derivative is positive. Evaluating equation (6) at this (symmetric) level of c, that we denote by C^*, and substituting for $\frac{\partial h}{\partial c}$ using equation (5), we have that

$$\frac{\partial W_i(C^*)}{\partial c_i} = \left[\quad \frac{\partial h}{\partial Q}\right]\left[\frac{\partial(q_i + q_i^*) - dQ}{\partial c_i}\right], \tag{7}$$

and since, as argued above, $\left[\frac{\partial(q_i + q_i^*)}{\partial c_i} - \frac{dQ}{dc}\right] < 0$, (7) is negative whenever $\left[P(Q) - \frac{\partial h}{\partial Q}\right] > 0$ at the coordinated solution, that is, using equation (5) again, whenever $\frac{\partial h}{\partial c} < 0$ at that solution.

---

[6] We should add to this the terms $P'(Q_j)\, q_i^* \frac{\partial Q_j}{\partial c_i} - P'(Q_i)\, q_j^* \frac{\partial Q_i}{\partial c_i}$. The first term represents the increase in the cost of imports for country i induced by an increase in c_i. The second term represents the corresponding decrease of exports revenues. In any symmetric situation with no tariffs, these two terms are equal, since firms are then symmetric in both markets.

This result is easy to explain: Increasing consumption in the country is desirable if the marginal willingness to pay is higher than the social marginal cost. Now, since the output response is higher under policy competition, reducing c in this situation increases the consumption in the country by more than under coordination. Therefore, under policy competition that positive effect of a reduction in c more than outweighs the negative direct impact on social cost. However, the opposite is true if the marginal willingness to pay (under coordination) is lower than the marginal social cost.

What has been said above with respect to the equilibrium values of the environmental instrument also extends to the environmental damage. Indeed, if governments respond to trade by increasing the value of c, then firms will also cut their output, since their marginal costs raise, and both changes lead to a cut in environmental costs $h(c,q)$. The opposite occurs if governments respond by lowering the value of c.

The question is now whether (7) has a definite sign. That is, whether marginal willingness to pay is always higher or always lower than marginal social cost at the coordinated solution. We now consider several particular forms of $h(c,q)$, and then several particular cases of environmental instruments, that have been used in the literature. With them we will show that the answer to the above question is in the negative. That is, trade incentives may work in the direction of tougher or weaker environmental policies.

(i) <u>Taxes on output</u>: The only instrument for the government is a tax on output. Then $h(c,q) = H(q)$. This is the model studied by Hung (1994). Notice that $\frac{\partial h}{\partial c} = 0$ and therefore the coordinated solution is actually first best. Moreover, this first best solution coincides with the decentralized solution and then, in this symmetric world, trade incentives do not alter environmental policies. [7]

(ii) <u>Tax on emission and technology choice</u>: The government can tax emissions directly, but firms can choose among several constant marginal cost technologies with different degrees of pollution. A particular case is the model analyzed by Kennedy (1994). Governments set tax rates τ on emissions which are given by the function $Z(\theta,q) = q/\theta$, where θ represents the technology chosen by the firm after observing the government's choice of τ. Technology θ also results in input unit costs θ for the firm. Hence, cheaper technology results in higher pollution.

---

[7] Hung (1994) mistakenly concludes that trade incentives work against environmental protection. He also obtains his result by comparing the expression for the optimal tax on emissions under coordination and under strategic interaction. The expression for the strategic solution includes (apparently) the same terms as the coordinated solution plus a new term, which is negative, and this explains his conclusion. The mistake comes from the fact that those terms (including derivatives of emissions and output with respect to tax) are only apparently the same. In reality they are different because they refer to different changes in tax: unilateral change versus bilateral changes.

For each desired level of output q, a firm chooses technology θ so as to minimize cost, that is, to minimize

$$\theta q + \tau Z(\theta,q) = \theta q + \tau (q/\theta).$$

Then the firm chooses $\theta = \tau^{1/2}$, for any level of production. Thus, the cost for the firm is linear in θ, $2\theta q$, and choosing τ is equivalent to choosing θ. On the other hand, emissions cause damage given by the increasing and convex function $e(Z)$. With all this, and letting $c = 2\theta$, Kennedy's model is recovered by setting $h(c,q) = (c/2)\, q + e(2q/c)$.

Kennedy has shown that for this particular specification, trade incentives always work against environmental standards. That is, (7) is negative. However, consider the following, alternative specification of policy on inputs:

(iii) Input standard: There is a continuum $\theta \in [0,b]$ of possible, perfectly substitutable, inputs from which to produce commodity q at constant returns to scale, where θ is also the (fixed, exogenously given) price of the input. The higher θ, the lower the level of emissions of any given output q, which is given by $(b-\theta)q$. Finally, the environmental damage of emissions increases more than proportionally with its level, and is given by $A[(b-\theta)q]^2$. Both b and A are positive constants. The instrument for governments is the setting of a standard on inputs, taken here as the setting of the maximal admissible polluting (i.e., cheapest) input c, which the firm will actually choose to use. Then, the social cost of production (input costs plus emissions costs) are $h(c,q) = cq + A[(b-c)q]^2$.

Assume the demand function is $P = 1 - Q$, and let $A = 10$. If $b = .8$, then the solution to (7), that is, the coordinated solution, is $c = .621$, which results in $Q = .26$. and then $\left[P(Q) - \frac{\partial h}{\partial Q}\right] = -.05$. As predicted, the decentralized solution implies tougher environmental policies, $c = .6265$ and lower output, $Q = 248$, and emissions. However, for $b = .2$ the solution to (7) is $c = .1$, with production $Q = .6$ (and then $\left[P(Q) - \frac{\partial h}{\partial Q}\right] = .18$), and the decentralized policies would be weaker: $c = .0895$ with higher output, $Q = .606$, and emissions.

4.-Concluding remarks

In this paper we have analyzed the effects of trade on environmental policies in a world of bilateral trade and market power by firms. Governments equate costs and benefits of environmental policies, taking into account strategic considerations. Under free trade and symmetry, we have shown that the strategic distortions linked to trade are represented by the higher responsiveness of production to changes in the environmental policy as compared to what we would have under environmental policy coordination. The sign of this distortion on environmental policies depends on the interplay between the use of the environmental policies as an instrument to make firms internalize the environmental costs of production, and its direct use as an instrument to regulate the total social cost of production. As a consequence of this latter use, total output under policy coordination could be higher than the level at which the marginal willingness to pay equals the marginal social cost of production. If this is the case, policy competition would induce a tougher environmental policy. Otherwise, policies softer than efficient would result. We have presented examples of both types.

References

Barrett S. (1994) "Strategic Environmental Policy and International Trade", *Journal of Public Economics*, 54 pp. 325-38.

Brander, J. And B. Spencer (1984) “Tariff Protection and Imperfect Competition,” in H. Kierzkowski ed. *Monopolistic Competition in International Trade*, Oxford University Press.

Hung N.M. (1994) "Taxing Pollution in an International Duopoly Context". *Economics Letters* 44, pp. 339-343.

Kennedy P. (1994) "Equilibrium Pollution Taxes in Open Economies with Imperfect Competition", *Journal of Environmental Economics and Management* 27, pp. 49-63.

Krutilla J. (1991) "Environmental Regulation in an Open Economy" *Journal of Environmental Economics and Management* 20, pp. 127-42.

Markusen J. (1975) "International Externalities and Optimal Tax Structures" *Journal of International Economics* 5, 15-29.

Tirole J. 1988) *The Theory of Industrial Organization* MIT Press.

Ulph A. and D. Ulph (1995) "Trade, Strategic Innovation and Strategic Environmental Policy. A General Analysis" Economics Energy Environment, Fundazione Eni Enrico Mattei.

Ulph A. (1996) "Strategic Environmental Policy, International Trade and the Single European market" in Branden, J., Folmer, H. and T. Ulen eds. *Environmental policy with Political and Economic Integration: The European Union and the United States,* Edward Elgar Publishing Limited, UK, pp. 235-56.

SERIE DOCUMENTOS DE TRABAJO DEL CEE

El Centro de Estudios Económicos de El Colegio de México, ha creado la *Serie Documentos de Trabajo* con el propósito de difundir investigaciones que contribuyan a la discusión de importantes problemas teóricos y empíricos, aun en su versión preliminar. Con esta publicación se busca estimular el análisis de las ideas ahí expuestas, así como la comunicación con sus autores. El contenido de los trabajos es responsabilidad exclusiva de estos últimos.

Los siguientes documentos de trabajo pueden solicitarse a: The following working papers are still available upon request from:

Rocío Contreras, Centro de Documentación, Centro de Estudios Económicos, El Colegio de México A.C., Camino al Ajusco 20, 01000 México, D.F., México. crocio@colmex.mx

1994

I Székely, Miguel. *Cambios en la pobreza y la desigualdad en México durante el proceso de ajuste y estabilización.*

II Calderón, Angel. *Fiscal policy, private savings and current account deficits in Mexico.*

III Sobarzo, Horacio. *Interactions between trade and tax reform in Mexico: Some general equilibrium results.*

IV Urzúa, Carlos. *An appraisal of recent tax reforms in Mexico.* (Corrected and enlarged version of DT. núm. X-1993)

V Sáez, Raúl and Carlos Urzúa. *Privatization and fiscal reform in Eastern Europe: Some lessons from Latin America.*

VI Feliz, Raúl. *Terms of trade and labour supply: A revision of the Laursen-Metzler effect.*

VII Feliz, Raúl and John Welch. *Cointegration and tests of a classical model of inflation in Argentina, Bolivia, Brazil, Mexico, and Peru.*

VIII Sempere, Jaime. *Condiciones para obtener ganancias potenciales de liberalización de comercio.*

IX Sempere, Jaime y Horacio Sobarzo. *La descentralización fiscal en México: Algunas propuestas.*

X Sempere, Jaime. *Are potential gains from economic integration possible with migration?*

XI Gollás, Manuel. *México 1994. Una economía sin inflación, sin igualdad y sin crecimiento.*

1995

I Schettino, Macario. *Crecimiento económico y distribución del ingreso.*

II Schettino, Macario. *A function for the Lorenz curve.*

III Székely, Miguel. *Economic Liberalization, Poverty and Income Distribution in Mexico.*

IV Taylor, Edward y Antonio Yúnez. *Impactos de las reformas económicas en el agro mexicano: Un enfoque de equilibrio general aplicado a una población campesina.*

V Schettino, Macario. *Intuition and Institutions: The Bounded Society.*

VI Bladt, Mogens. *Applied Time Series Analysis.*

VII Yúnez Naude, Antonio y Fernando Barceinas. *Modernización y el mantenimiento de la biodiversidad genética en el cultivo de maíz en México.*

VIII Urzúa, Carlos M. *On the Correct Use of Omnibus Tests for Normality.*

IX Castañeda, Alejandro. *Market Structure and Innovation with Multiproject Firms. The Role of the Timing of Innovation.*

X Urzúa, Carlos M. *Omnibus Tests for Multivariate Normality of Observations and Residuals.*

1996

Castañeda, Alejandro. *Poder de mercado en el sector manufacturero mexicano. Estimación con variables instrumentales.*

Benetti, Carlo, Alejandro Nadal Egea y Carlos Salas Páez. *The Law of Supply and Demand in the Proof of Existence of General Competitive Equilibrium.*

III Jaime Sempere y Horacio Sobarzo. *Elementos económicos de una propuesta de reforma en materia de federalismo fiscal en México.*

IV Sempere, Jaime y Horacio Sobarzo. *Federalismo fiscal en México.*

V Sékely, Miguel. *Explaining changes in poverty: some methodology and its application to Mexico.*

VI Becerril G., Javier, G. Dyer, J. E. Taylor y Antonio Yúnez Naude. *Elaboración de matrices de contabilidad social para poblaciones agropecuarias: el caso de El Chante, Jalisco*

VII Burguet, Roberto and Jaime Sempere. *Environmental protection under bilateral trade and imperfect competition; free trade versus strategic tariffs.*

1997

Casco, Andrés y José Romero. *Propuesta de gasto público para el campo.*

II Hammond, Peter and Jaime Sempere. *On the contrast between policies toward trade and migration.*

Romero, José. *Mexican agriculture: Distribution and efficiency effects of eliminating price distortions.*

1998

Sobarzo, Horacio. *Applied General Equilibrium Models: The Mexican Experience of NAFTA.*

II Burguet, Roberto. *Auction Theory. A guided tour.*

III Romero, José. *El holocausto y su secuela: la Revolución Mexicana de 1910.*

IV Calderón-Madrid, Angel. *In and out of the formal and informal labour markets in Mexico: Transition analysis using durantion models.*

V Calderón Madrid, Angel. *Explicaciones de la caída del ahorro privado en México desde tres perspectivas.*

VI Burguet, Roberto and Jaime Sempere. *North-South Environmental Debate: Strategic Price Distortions and Capital Flows.*

VII Castañeda, Alejandro. *Measuring the degree of collusive conduct in the mexican manufacturing sector.*

VIII Gollás, Manuel. *El tamaño del gobierno y el crecimiento.*

1999

Gollás, Manuel. *Las eficiencias pública y privada.*

Gollás, Manuel. *La movilidad del ahorro y la inversión en México.*

III Burguet, Roberto and Jaime Sempere. *Trade incentives and the strength of environmental policies under imperfect competition.*