North–South Environmental Debate: Strategic Price Distortions and Capital Flows

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Abstract

When governments set their environmental policies, they take into account the impact of these policies on international flows and prices. We consider a world of two regions; the North that is capital abundant, and the South that is not. Under perfect competition and free mobility of capital, the North has incentives to increase pollution levels beyond what is efficient, which has to do with strategic distortions in the price of capital exports. Softer environmental conditions at home induce scarcity in the international market which results in a higher return for the Northern capital exports. Under quite general conditions, the South also responds with dirtier policies.
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1 Introduction

In economics, there is an increasing interest in the relationship of environmental policies with other aspects of economic policy. Perhaps the most extensively studied aspect of this relationship has been that of trade policies and environmental policies. Thus, and led by practical concern in the wake of regional integration, we now understand not only the need for coordination between environmental policies when pollution is transboundary (see, for instance, Markusen, 1975, and Hoel, 1997), but also the way trade incentives affect the strategic setting of environmental policies when governments try to win a competitive edge for their firms (see, for instance, Kennedy, 1994, Barrett, 1994, Burguet and Sempere, 1998, and especially Ulph, 1996, for an excellent survey).

Also associated with trade, a branch of the literature has explored the issue of where we should expect dirtier activities to be located, in particular whether poorer (Southern) or richer (Northern) countries will house these activities. Here the common theme is comparative advantage in terms of productive factors (Copeland and Taylor 1995, 1997). [1]

There is, however, an issue that has been overlooked when considering the strategic implications of environmental policies, which is the possibility of using them to influence the relative prices of mobile factors. This is precisely our goal in this paper: to show that environmental policies, through their

[1] Also related to productive factors, Chichilnisky (1994) points to ill-defined property rights of environmental resources in the South as a reason for greater depletion of environmental resources in these countries.

effect on factor productivity, can influence the allocation of mobile factors, like capital. In this sense, even if international treaties eliminate all barriers to the flow of capital across borders, seemingly following a productive efficiency motive (Diamond and Mirrlees, 1971), the reluctance of governments to commit themselves to cleaner policies may have a strategic component associated with the manipulation of capital returns. In other words, environmental regulations have an impact not only on the return of investment at home; they also change the supply of funds worldwide, which may affect the return of national investment abroad. This may help explain the little willingness the North has shown to seriously cut down on emissions.

Thus, we present a model of perfect competition with two regions and environmental damage associated to production. The North is capital abundant in comparison with the South. Contrary to Copeland and Taylor, our focus is on the incentives to distort prices that this "market power" provides for the Northern government. By allowing higher emission levels, the North improves the productivity of capital at home, which in turn increases the world interest rate. This is the basic intuition, and directly implies that the North pollutes more than the South, other things equal. Whether the South itself reacts to this higher interest rate on its borrowing by reducing pollution or by allowing higher emissions depends on whether these emissions are strategic substitutes or complements. We show that under very general and plausible conditions the South will respond by increasing emissions in an attempt to minimize the loss of foreign capital.

Our work is complementary to that of Ludema and Wooton (1994). They have also shown how environmental policies can be an instrument in altering

relative prices in traded goods. It is also complementary to that of Markusen, Morey, and Olewiler (1995) who study the competition for attracting firms to the respective territory. One could think of their model as competition for quantities (employment, output), whereas our model focuses on the distortion of prices associated with "market power" in terms of national factors.

The rest of the paper is structured as follows. The next section presents the model. Section 3 then analyzes equilibrium policies set by governments and shows how capital price concerns distort these policies. Section 4 compares the policies set by Northern and Southern governments with globally efficient ones. Some concluding remarks close the paper.

2 The Model

Consider a world made up of two countries, North and South, respectively, n and s. In each of these countries there is a representative consumer. Time is divided in two periods: present (period 1) and future (period 2). There is only one good, which can be consumed or used as input (capital) in future production.

Consumers

Consumer i $(i = n, s)$ cares about consumption in both period 1, C_1^i and period 2, C_2^i. Each consumer has initial resources W^i that she can consume in the first period, or save. The return of these savings will add to the second period consumption. We will assume that the North is richer than the South in terms of the initial resources so $W^n > W^s$. Let S^i denote savings by consumer $i = n, s$. Consumers also (inelastically) provide labor

in the second period. The wage revenue will also add to the second period consumption. We will assume that consumers are price takers, so that they take both wages and interest rate as given. In particular, when deciding how much to save, they do not take into account how these savings may affect their wages in period 2.

Thus, we let the consumers' preferences be represented by the utility function $u^i(C_1^i, C_2^i, E^i)$, where E^i is an index of environmental quality, which consumers take as given. We assume:

(A.1) $u^i(C_1^i, C_2^i, E^i)$ is twice differentiable, quasiconcave, increasing in present and future consumption, and in E^i. Moreover, u^i is separable in consumption and environmental quality. We will normalize E^i so that u^i is linear in E^i. That is, $u^i_{q3} = 0$ for $q = 1, 2, 3$. Then, let

$$u^i(C_1^i, C_2^i, E^i) = U^i(C_1^i, C_2^i) + E^i$$

This last simplifying assumption means, in particular, that savings are independent of the environmental quality, for a fixed interest rate. Obviously this assumption will make income effects, such as those discussed in Copeland and Taylor (1997), disappear. This will allow us to concentrate on the effects of capital market distortions. Then, the consumers' budget constraints when taking their consumption and savings decisions are

$$C_1^i + S^i \leq W^i,$$

$$C_2^i \leq S^i(1 + r) + w^i l^i + \pi^i,$$

where π^i represents the profits of firm i, which we assume is owned by local consumers. Utility maximization under these constraints and price taking

behavior results, as usual, in the equality of the intertemporal rate of substitution and the gross return of savings,

$$\frac{U_1^i}{U_2^i} = 1 + r. \tag{1}$$

This defines each country's savings function $S^i(r)$. Let $S^T(r) = S^n(r) + S^s(r)$ be the total savings function.

Production

There is a single firm in each country that produces the consumption good for the second period using capital and labor. Firms borrow their capital from consumers' savings. We assume no barriers to capital mobility across borders, and also price taking by firms in the capital market. Denote by k_i^j the amount lent by consumer i to the firm in country j (for $i, j = n, s$). Then $S^i = k_i^j + k_i^i$. Let f^i represent the technology available to firm i. Then, firm i's output is given by $f^i(l^i, k^i, E^i)$, where l^i and $k^i = k_i^i + k_j^i$ are, respectively, the labor and capital used in production by firm (country) i for $i = n, s$. Production generates local pollution as a by–product. Thus, we measure environmental quality by an index E^i. The higher this environmental quality, the lower the output that can be obtained by using the productive inputs, capital and labor.[2]

We make the following functional assumptions:

[2]Notice that we model pollution (or its complement environmental quality) as an argument of the production function as in Copeland and Taylor (1994, 1995, 1997) or Hoel (1997). However in these models pollution was a variable which was freely chosen by the firms. In this model, instead, it will be set by the governments and regarded as a parameter by the firms.

(A.2) The production function is twice differentiable, concave, and also satisfies that $f_3^i < 0$, and $f_{j3}^i \leq 0$.

Here f_j^i denotes the derivative of the production function with respect to the jth argument, and f_{jk}^i is the cross derivative of f^i with respect to the kth and jth arguments. Apart from the traditional decreasing returns, the idea behind the sign of the derivatives in (A.2) is that for each additional unit of labor and/or capital that is used in production, a part of it must be used to keep the environmental quality constant, and the better this environmental quality, the larger this part is.

Assumption (A.2) seems to agree with existing empirical evidence about the impact of environmental regulation on factor productivity. These studies show that plants with stricter regulations tend to have lower productivity levels and slower productivity growth.[3]

Given price taking behavior by all agents and free mobility across borders, there will be a single interest rate in the world capital market, r, which, when measured in terms of the consumption commodity, will be determined by equal productivity of capital; that is, equilibrium capital demand in each country $k^i(r, E^i)$ is given by

$$(1 + r) = f_2^n(l^n, k^n, E^n) = f_2^s(l^s, k^s, E^s). \tag{2}$$

[3]See Gollop and Roberts, (1983), Gray, (1987), Barbera and McConnell, (1986), and Gray and Shadbegian, (1995), among others. For instance, Gray and Shadbegian's (1995) calculations using plant-level productivity data for three industries show that a plant with 1 dollar higher abatement costs tends to have the equivalent of 1.74 dollars lower productivity in paper, 1.35 lower in oil, and 3.28 lower in steel.

Labor, on the other hand, cannot be traded internationally and is supplied inelastically. Thus, any change in labor demand in each country will only result in changes in the domestic wage rate.

Private agents' equilibrium

Equations (1) and (2) plus the capital market equilibrium equation

$$S^T(r) = k^n(r, E^n) + k^s(r, E^s), \tag{3}$$

define the savings, capital, and interest rate for given levels of environmental quality. Consumers of both countries will determine the total amount of savings S^n and S^s. Equilibrium conditions in capital markets will determine the allocation of these savings to capital across countries, k^s and k^n, as a function of E^n and E^s, given l^n and l^s.

3 Environmental Policies

The last type of agent that we consider is the government. We assume that governments set their domestic environmental index E^i. This is the only policy instrument for the governments. This will be equivalent to having governments set environmental instruments (for instance, environmental taxes, emissions standards, etc) so that the desired level of environmental quality is attained. Also, we assume that the South is small in the world capital market, so that the government of the South takes the interest rate r as given.

3.1 Non-Strategic Policies

Let us first analyze what the savings, consumption, and environmental decisions would be in the absence of strategic country interaction. For that, we consider the "autarky" case, that is, the case in which each country is isolated from the other (no capital flows). In that case, the government would choose the level E so as to maximize u, taking the decisions implied by equation (1) as given. From the government point of view, $C_1 = W - S(r)$ and $C_2 = f(l, S(r), E)$. Then, the first order condition that defines optimal environmental quality E is

$$-U_1 S' \frac{dr}{dE} + U_2[f_2 S' \frac{dr}{dE} + f_3] + 1 = 0$$

which substituting equation (1), and since in equilibrium $f_2 = (1 + r)$, can be written as

$$U_2 f_3 + 1 = 0 \tag{4}$$

This equation, together with equation (1), would then define the savings level S and environmental quality E (and then consumption too) under autarky. In particular, the level of E would balance the positive effect that a less stringent environmental policy would have on the second period consumption through increased output ($U_2 f_3$) with the direct utility impact of a worse environment. The savings level S would simply equate the marginal rate of substitution between consumption today and consumption tomorrow with the relative cost, the productivity of capital. As we will see below, this "autarky solution" coincides with the one that would prevail under price (in-

terest rate) taking behavior by the governments, except that the interest rate would then be common to both countries. The goal of the next subsection is to analyze the incentives introduced by the fact that the Northern government can affect the world interest rate by using its environmental policies.

3.2 Strategic Equilibrium Policies

We now turn to the posibility of capital imports and exports and their influence on the governments' policies. Notice that the consumption in the second period by each consumer is now equal to the level of output in their country net of interest payments across borders. Thus,

$$C_2^i = f^i(l^i, k^i, E^i) + (1+r)(k_j^i - k_i^j)$$

In equilibrium, only one country will be exporting capital. In general[4], the North will be a net exporter, with $k_n^s = S^n - k^n$, and $k_s^n = 0$. Then, the objective function of the s's government is

$$u^s(C_1^s, C_2^s, E^s) = U^s[W^s - S^s, f^s(l^s, k^s, E^s) - (1+r)(S^n - k^n)] + E^s, \quad (5)$$

where we are taking into account the interest payments for the import of capital $(S^n - k^n)$ from n. Likewise, the objective function of n's government is

$$u^n(C_1^n, C_2^n, E^n) = U^n[W^n - S^n, f^n(l^n, k^n, E^n) + (1+r)(S^n - k^n)] + E^n. \quad (6)$$

[4]This requires "relative" capital abundance; for instance, and for similar technologies, larger per capita savings in the North.

Also, the South takes r as given, whereas the North considers the effect of E^n on r. Note that increases in the environmental quality in the North will have a negative effect on the interest rate. Indeed, differentiating in equation (3) we have

$$\frac{dr}{dE^n} = \frac{\partial k^n/\partial E^n}{S^{T\prime} - \partial(k^s + k^n)/\partial r},$$

where we omit arguments of the functions for simplicity, and $S^{T\prime}$ is the derivative of the total savings with respect to r according to equation (1). Now, if we substitute for $\partial k^n/\partial E^n$ and $\partial(k^s + k^n)/\partial r$ (from equation (2)), we obtain

$$\frac{dr}{dE^n} = f^n_{23} G \frac{1}{1 - S^{T\prime} f^n_{22} G} < 0,$$

where

$$G = \frac{f^s_{22}}{f^s_{22} + f^n_{22}}.$$

The sign comes from the fact that $G > 0$, $S^{T\prime} > 0$, and $f^i_{22}, f^n_{23} < 0$. The effect of E^s on r would have a similar expression, substituting the superscript n for s and vice versa. However, the South is a price taker, which means that the denominator is very large. This is the case if $S^{T\prime}$ is very large with respect to f^n_{23}. That is, if the South is indeed small in the world capital market. To summarize the above discussion, we have:

PROPOSITION 1: *If a country (the North) is large in the capital market, an improvement in its environmental quality will lead to a fall in the interest rate.*

The interpretation of this effect is simple. As country i increases its environmental quality, the productivity of capital at home decreases by f^i_{23}.

However, this creates an imbalance in the productivity of capital in both countries which will generate a flow of capital to the other country until the marginal productivities are equalized again, which in turn reduces the original impact. The measure of this capital flow has a direct component: recovering the balance would take a flow which is proportional to the relative responsiveness of the marginal productivity of capital in the foreign country to changes in the capital, which is measured by G. It also has an indirect component related to the response of savings (total capital supply) to the change in productivity conditions; a flow away from the country would increase the productivity of capital, thus increasing the total capital supply S^T. Then, the total capital flow away from the country (measured in terms of capital units) that would restore the balance in productivity is just $G/(1-S^{T\prime}f^s_{22}G)$. This tends to reduce the original impact of E on the productivity of capital (for a small country, in fact the original impact is completly eliminated).

This effect is the origin of the strategic behavior of the Northern government when setting its environmental policies. Indeed, if we take interest payments and (1) and (2) into account, the first order conditions for optimal environmental indexes, that is, for maximization of (5) and (6), the latter for exogenous r, are respectively,

$$U^s_2 f^s_3 + 1 = 0 \tag{7}$$

and

$$U^n_2 \left[f^n_3 + \frac{dr}{dE^n}(S^n - k^n) \right] + 1 = 0 \tag{8}$$

Compare these equations with equation (4) above. The difference in (8) is the second term in the parenthesis: the incentives of the government to manipulate the interest rate so as to influence the revenues associated with capital exports. At least if the governments' objective functions are concave in the corresponding instruments, E^i, that implies that the Northern country has incentives to set lower environment standards (quality) so as to improve the returns on its capital exports.

The first order conditions above have an intuitive interpretation. When increasing the level of environmental quality in its country, government i considers the positive, direct impact on utility, as measured by $U_3^i = 1$, and the decrease in local output that the higher level of environmental quality produces, as measured by $U_2^i f_3^i$. These are the non-strategic incentives. However, on top of this, the Northern government has an incentive to manipulate the marginal productivity of capital, that is, interest rate. Indeed, the government of country n, which is a net exporter of capital, will have an additional incentive to lower environmental quality, which improves the global productivity of capital, $\frac{dr}{dE^n} < 0$, and therefore the price foreign borrowers pay for the Northern capital. These strategic incentives are represented by the second term on the left hand side of (8).

The question now is how this strategic distortion in the Northern environmental quality influences the Southern level E^s, as compared to a non-strategic solution in the North. Indeed, even if the Southern government cannot influence the interest rate in the world market, it can certainly influence the inflow of capital from abroad by manipulating the domestic productivity conditions with the environmental variable. To answer this question,

we totally differentiate the first order condition for optimal E^s with respect to both r and E^s to obtain

$$\frac{dE^s}{dr} = -\frac{f_3^s[-U_{21}^s\ S^{s'} + U_{22}^s(\frac{d(1+r)S^s}{dr} - k^s)] + U_2^s\frac{df_3^s}{dr}}{U_{22}^s(f_3^s)^2 + U_2^s\frac{df_3^s}{dE^s}}. \tag{9}$$

Notice that for u^s to be quasiconcave, both U_{22}^s and U_{21}^s must be negative. That is, both an increase in consumption in the first period and in the second reduce the marginal utility of the consumption in the second period. Equation (9) describes the effect induced on E^s by a change in r. This effect can be seen as the change that would balance the product $U_2^s f_3^s$ back to its level of -1. The original change in r implies an increase in savings by the consumer in the South, which reduces consumption in the first period and then increases the marginal utility of consumption in the second period. On the other hand, these higher savings and interest rate imply higher revenue in the second period, but also lower profits for the firm, due to higher interest payments, which means lower revenue. If the country is small in initial resources (high capital imports), we expect this second effect to be larger unless the responsiveness of savings to interest rates is extremely high[5]. Then, the induced lower second period consumption increases the marginal utility of this consumption too. Finally, as the interest rate grows and capital in the South decreases, the (negative) effect of the environmental index is reduced. That is, f_3^s becomes larger:

$$\frac{df_3^s}{dr} = \frac{f_{32}^s}{f_{22}^s}.$$

[5]If we analyze discrete changes in the interest rate, as would actually follow from strategic incentives by the North, this responsiveness is bounded by initial resources and can then never be too high.

These effects are the ones that appear in the numerator of equation (9). Except for this latter one, we expect these effects to be negative (since f_3^s is negative). Thus, unless the productivity of capital is very responsive to the environmental variable and very unresponsive to the level of capital itself, the effect of r on $U_2^s f_3^s$ should be negative. How should E^s change in order to compensate for this? First, a change in E^s reduces output in the second period, and then increases the marginal productivity of consumption in that period. However, the effect of E^s on f_3^s is less clear. The direct effect of E^s, f_{33}^s, could be (at least partially) compensated for by the reduction in capital that lower productivity induces:

$$\frac{df_3^s}{dE^s} = f_{33}^s - \frac{(f_{32}^s)^2}{f_{22}^s}.$$

These effects are the ones that appear in the denominator. Again, unless the productivity of capital is very responsive to the environmental variable in the South and not very responsive to changes in the level of this capital, the denominator is negative. Then, the environmental index has to be reduced in order to compensate for the higher interest rate, i.e., $\frac{dE^s}{(1+r)} < 0$. That is, the South will also reduce the environmental standards as a response to the lower standards set by the North. That is, their policies are strategic complements. The total effect is a global decrease in environmental quality, as the next proposition states.

PROPOSITION 2: *For moderate values of f_{22}^s and f_{23}^s, the strategic distortion that capital exports causes in the Northern environmental policies makes both the North and the South dirtier.*

The South responds to the lower environmental quality in the North by also decreasing environmental quality so as to compensate for the capital flight from the South. We should consider it unlikely that a higher interest rate should induce a very high increase in savings in the South, so high as to increase the consumption in the second period in this capital importing country. Then the only possible exceptions to Proposition 2 would require high responsiveness of the productivity of capital to the environmental variable and/or low responsiveness to the level of capital so that one of the following two cases, but not the other, would occur:

1) The increase in interest rate causes a steep decline in the level of capital in the South ($\frac{1}{f^s_{22}}$), which reduces the negative effect of the environmental quality on output drastically (f^s_{23}).

2) Tougher environmental regulations reduce the level of domestic capital drastically ($-\frac{f^s_{23}}{f^s_{22}}$), so the marginal effect of these regulations on output (f^s_3) is lower for tougher regulations.

In these cases, environmental policies could be strategic substitutes and then the South would set more stringent regulations on the environment as a response to the lenient policies of the North. However, in general we expect the policies to be strategic complements and the South to respond with dirtier policies too.

4 Globally-efficient Policies

One could also question what the strategic incentives imply with respect to optimally set policies. These would be different from autarkic ones, since

the countries are asymmetric in initial endowments, and then even a central authority would induce capital exports. To answer this question, assume that one central authority can set the environmental quality for both countries so as to maximize some social welfare function with weights α and $(1-\alpha)$ for the Northern and Southern consumer respectively. Thus, the central authority sets E^n and E^s so as to maximize

$$(1-\alpha)\ u^s(C_1^s, C_2^s, E^s) + \alpha\ u^n(C_1^n, C_2^n, E^n)$$

where consumption is given by consumers' utility maximization, and savings are assigned through the capital market as before. Then, the first order conditions of this problem with respect to the environmental quality levels, provided we mantain the assumption of a small South whose policies do not affect the interest rate ($\frac{dr}{dE^s} = 0$), are:

$$(1-\alpha)\ [U_2^s f_3^s + 1] = 0$$

and

$$\alpha\ [U_2^n f_3^n + 1] + \frac{dr}{dE^n}(S^n - k^n)\,[\alpha U_2^n - (1-\alpha)U_2^s] = 0$$

Notice that the difference between these first order conditions and the ones solved by decentralized governments is the additional term in the condition for E^n:

$$-\frac{dr}{dE^n}(S^n - k^n)\frac{1-\alpha}{\alpha}U_2^s > 0$$

This term represents the effect of changes in the interest rate due to Northern environmental quality on second period consumption in the South. That

is, when the North manipulates the interest rate, it does not take into account the negative effect that this manipulation has on the second period consumption in the South. Then, evaluated at the decentralized solution, the derivative of the central authority's objective function is positive with respect to E^n. Again, under concavity (which locally should hold for the above conditions to describe the central authority's optimum), this implies a tendency of the North to set an environmental quality which is too low when compared to (virtually) any social optima. Then, under the same conditions of Proposition 2, we have

PROPOSITION 3: *The decentralized strategic equilibrium environmental quality levels are too low with respect to globally efficient ones.*

Therefore, whether we compare them with non strategic conditions or with efficient ones, the strategic incentives for the North to manipulate capital returns result in a dirtier global environment.

5 Concluding remarks

We have presented a very stylized model of perfect competition with two regions, a North that is capital abundant, and a South, that is not. Our results predict strategic incentives for the North to decrease the environmental quality below the efficient level. The incentive has to do with strategic distortions in the price of capital exports. This is done through inducing scarcity of this capital via softer environmental conditions at home.

If the South consists of small countries with respect to the effect their policies can have on world interest rates, their environmental decisions would

those corresponding to a non-strategic situation given the decisions of the North. However, under quite plausible conditions, they would respond to the lower environmental quality levels in the North, and the subsequent interest rates, by decreasing environmental quality.

There are some simple extensions that can be accomodated in our model with no difficulty. The first is the case where there is unemployment. If there is unemployment, and goverments are concerned about it, there is an incentive to increase labor productivity by relaxing environmental regulations. In our model, this would change the first order conditions for optimal policies by including an additional term representing this incentive. This would imply higher levels of pollution in countries with unemployment.

The second simple extension is transboundary pollution. This could be trivially accomodated in our additive damage function. Then the strategic levels of environmental variables would not change, but the globally-efficient ones would be even higher. That is, the traditional externality would simply add to the price distortion effects. Of course there is a second order effect: when the North increases the interest rate, it considers the response of the South, which will in general reduce environmental quality, therefore increasing pollution in the North too. This second order effect would be more important in similar cases to those analyzed by Ludema and Wooton (1994), where the Southern country is the main polluter and the North gets (values) most of the environmental damage.

The third extension is to include income effects such as those discussed in Copeland and Taylor (1997). These would obviously go in the opposite direction to our strategic effects, since one expects that richer countries value

environmental quality more highly.

In general, this paper has illustrated a simple result: environmental policies could be used as an instrument to distort factor prices when other ways (source-based capital taxation, for instance) have been ruled out. Globally, the result is simply dirtier production.

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