WP-2008-028

Environmental Standards as Strategic Outcomes:
A Simple Model

Rabindra N. Bhattacharya and Rupayan Pal

Indira Gandhi Institute of Development Research, Mumbai
December 2008
http://www.igidr.ac.in/pdf/publication/WP-2008-028.pdf

Environmental Standards as Strategic Outcomes: A Simple Model[1]

Rabindra N. Bhattacharya and Rupayan Pal

Indira Gandhi Institute of Development Research (IGIDR)
General Arun Kumar Vaidya Marg
Goregaon (E), Mumbai- 400065, INDIA
Email (corresponding author): rupayan@igidr.ac.in

Abstract

This paper examines the strategic nature of choice of environmental standards under different degrees of openness of countries. It also compares and contrasts equilibrium environmental standards and levels of pollution, local and global, with the world optimum levels. It shows that, in case of open economies, environmental standards can be strategic substitutes or complements. In equilibrium, countries set higher environmental standards in case of open economies compared to that in case of closed economies. It also shows that equilibrium standards in case of open economies are higher than the world optimum in certain situations. In contrast, countries set lower environmental standards, in equilibrium, than the world optimum in absence of international trade.

Key words: Environmental standards, strategic choice, openness, world optimum

JEL Code(s): Q58, Q56

[1]Rabindra N. Bhattacharya is with CSSSC, Kolkata, India and University of Calcutta, Department of Economics, India.

Environmental Standards as Strategic Outcomes: A Simple Model

Rabindra N. Bhattacharya and Rupayan Pal

1 Introduction

In the wake of trade liberalisation in the world economy and growing environmental consciousness, the issues of impacts of international trade and factor mobility on local and global environment are assuming increasing importance. Besides the effects of trade on environmental quality, there exists concerns that emanate from the use of a lax environment policy and/or standards as a means to attract investments in specific jurisdictions. These plant location decisions, in response to a weaker pollution standard, would have implications for the pattern of trade and resultant environmental outcomes. Moreover, countries may free ride on global pollution reduction, at least to some extent, by setting environmental standards strategically.

In the literature on these issues, environmental standard set by a country is treated as a part of an endogenous environmental policy having impacts on both the level and geographical distribution of pollution (e.g., Copeland and Taylor, 1994, 1995, 2003 and Chichilnisky, 1994). However, it is to be noted that the standard set in one country may influence standard setting actions in other countries. Existing literature ignores this strategic nature of choice of environmental standard. This paper aims at bridging this gap by formulating equilibrium standards in a strategic context.

Developing a simple model of two country world, this paper analyses strategic choice of environmental standards under different degrees of openness of countries. It also compares and contrasts equilibrium environmental

standards and levels of pollution, local and global, under strategic standard setting with that under cooperative standard setting, i.e., with the world optimum levels of standards and pollution.

There are two opposing strategic effects in case of open economies, (a) due to local pollution and (b) due to global pollution, of environmental standards. The first effect induces countries to set higher environmental standards in order to counteract the negative externality generated by the other country's environmental standard, whereas the second effect comes from the incentive to free ride on other country's efforts to combat global pollution. Therefore, if the strategic effect due to global pollution dominates (is dominated by) the strategic effect due to local pollution, environmental standards are strategic substitutes (complements). In contrary, in case of closed economies, environmental standards are always strategic substitutes, since only the incentive to free ride is in place. The strategic nature of environmental standards has implications to the equilibrium environmental standards and pollution levels.

This paper shows that, in case of open economies countries set higher environmental standards, which may result in lower levels of pollution, compared to that in case of closed economies. The underlying reason behind this result is, unlike in case of open economies, there is no negative externality of environmental standard of one country to the other in case of closed economies.

Comparing equilibrium standards under strategic setting with the world optimum, this paper shows that the world optimum level of environmental standards may lead to more damage to the environment in case of open economies in certain situations. It indicates that existence of supranational authorities that sets environmental standards for countries, or facilitates cooperative standard setting, may be harmful for the environment in case of

open economies. In contrast to this, in case of closed economies, cooperative standard setting always leads to higher environmental standards and levels of pollution than that under strategic choice of environmental standards.

The rest of the paper proceeds as follows. The next section describes the basic model considering partially open economies. Section 3 analyses the choice of environmental standards in case of closed economies. Fully open economies are considered in Section 4. Section 5 concludes.

2 The Model: Partially Open Economies

Suppose that there are two countries, A and B, in the world. Both countries are partially open in the sense that free trade of commodities between countries is allowed, but relocations of production units from one country to another is prohibited by regulation. Both countries aim to minimize loss due to environmental pollution, which is generated due to production activities, by imposing environmental standards. We consider pollutants like CO_2 which cause both local as well as global pollution. Now, in the free trade environment, higher environmental standard in one country likely to weaken its position in international trade, which will induce higher production activity in the other country. As a result, higher environmental standard in country j likely to increase local pollution in country i; $i, j = A, B$, $i \neq j$. In other words, increase in the level of environmental standard in one country reduces local pollution in that country, but increases local pollution in the other country. Therefore, we can write the level of local pollution in country i as follows.

$$L_i = L^0(1 - s_i + \beta s_j) \tag{1}$$

In (1), L^0 is the level of local pollution in country i in absence of any environmental standard. s_i $(0 \leq s_i \leq 1)$ denotes environmental standards imposed in country i. $s_i = 0$ and $s_i = 1$ corresponds to two extreme situations, (a) where there is no environmental standard and (b) the maximum level of environmental standard is in place, respectively. β $(0 < \beta < 1)$ is the marginal effect of country j's standard on country i's local pollution.

Now, production activities not only generate local environmental pollution, that also contribute to global environmental pollution. The global environmental pollution can be expressed as

$$G = G^0(2 - s_A - s_B), \tag{2}$$

where G^0 is the level of global pollution in absence of environmental standards.

The cost of imposing environmental standard of country i $(i, j = A, B$ and $i \neq j)$ is given by

$$C_i = cs_i + ws_i - \rho s_j, \tag{3}$$

where c is the marginal implementation (administrative) cost, w is the marginal economic loss due to higher standard in own country, and ρ is the marginal economic gain due to higher standard in the other country $(0 < c,\ 0 < \rho < w)$.

The loss function of country i due to environmental pollution, inclusive of the cost of imposing environmental standard, is

$$\begin{aligned} D_i &= L_i^2 + \delta G^2 + C_i \\ &= l(1 - s_i + \beta s_j)^2 + \delta g(2 - s_i - s_j)^2 + cs_i + ws_i - \rho s_j, \end{aligned} \tag{4}$$

where δ (≥ 0) is the weight given to global pollution, $l = L^{0^2}$, $g = G^{0^2}$; $i, j = A, B$, and $i \neq j$. For the sake of simplicity, we consider that countries

have symmetric loss functions. That is, we consider that β, c, w, ρ, and δ are invariant across countries. We assume that $2l\beta < w + c < 2l + 4\delta g$ and $2l\beta(1-\beta) < w + c - \rho < 2l(1-\beta) + 8\delta g$, which ensures the equilibrium environmental standards lie in the unit interval.[1]

We begin with the scenario where country A and B decide levels of environmental standards, s_A and s_B, independently and simultaneously. Both countries, A and B, want to minimize their respective loss functions by choosing environmental standards appropriately. So, the problem of country i can be written as,

$$Min_{s_i}\ D_i = l(1 - s_i + \beta s_j)^2 + \delta g(2 - s_i - s_j)^2 + cs_i + ws_i - \rho s_j. \qquad (5)$$

There are two opposing strategic effects: strategic effect due to local pollution ($\frac{\partial^2 L_i^2}{\partial s_j \partial s_i} = -2\beta l < 0$), and strategic effect due to global pollution ($\frac{\partial^2(\delta G^2)}{\partial s_j \partial s_i} = 2\delta g > 0$). It is easy to see that $\frac{\partial^2 D_i}{\partial s_j \partial s_i} = \frac{\partial}{\partial s_j}(\frac{\partial D_i}{\partial s_i}) = 2(\delta g - \beta l)$. If $\beta < \frac{\delta g}{l}$, i.e., if the strategic effect due to global pollution dominates the strategic effect due to local pollution, marginal reduction in loss due an increase in s_i decreases with an increase in s_j. In other words, if $\beta < \frac{\delta g}{l}$, environmental standards, s_A, s_B, are strategic substitutes. Alternatively, if $\beta > \frac{\delta g}{l}$, environmental standards, s_A, s_B, are strategic complements. That is, if the marginal effect of one country's standard on the local pollution in the other country, i.e., the negative externality generated to other country, is less (greater) than a critical level, environmental standards are strategic substitutes (complements). In other words, if the strategic effect due to global pollution dominates the strategic effect due to local pollution, s_A and s_B are strategic substitute; otherwise, s_A and s_B are strategic complements.

[1]For many parametric configurations, these restrictions are satisfied.

Proposition 1: *If an increase in environmental standard in one country generates negative externality to other country less than a critical level, i.e., if* $\beta < \frac{\delta g}{l}$*, environmental standards (*s_A *and* s_B*) are strategic substitutes. Alternatively, if such negative externality is beyond that critical level, i.e., if* $\beta > \frac{\delta g}{l}$*, environmental standards (*s_A *and* s_B*) are strategic complements.*

Proposition 1 indicates that, given the initial level of local and global pollution (L^0 and G^0) and countries' perceptions about harmfulness of global pollution (δ), strategic nature (substitutes or complements) of environmental standards depend on the intensity of international trade, since the degree of negative externality of environmental standard to other country depends on the intensity of international trade. If there is no trade between countries, i.e, if countries are completely closed, $\beta < \frac{\delta g}{l}$ always holds true, since $\beta = 0$ in case of closed economies; hence, environmental standards are strategic substitutes in case of closed economies.

Now, the F.O.Cs of two countries' minimization problems yield reaction functions

$$s_A = \frac{2l + 4\delta g - c - w}{2(l + \delta g)} - s_B \frac{\delta g - \beta l}{l + \delta g}, \tag{6}$$

and

$$s_B = \frac{2l + 4\delta g - c - w}{2(l + \delta g)} - s_A \frac{\delta g - \beta l}{l + \delta g} \tag{7}$$

of country A and B, respectively. Clearly, if $\beta < \frac{\delta g}{l}$, i.e., if s_A and s_B are strategic substitutes, reactions functions (6) and (7) will be negatively sloped in the $s_A - s_B$ plane. Alternatively, if s_A and s_B are strategic complements, reaction functions will be upward slopping. Note that the reaction functions rotate outwardly with increase in β: $[\frac{\partial}{\partial \beta}(\frac{\partial s_B}{\partial s_A})]_{CountryA} < 0$

and $[\frac{\partial}{\partial\beta}(\frac{\partial s_B}{\partial s_A})]_{CountryB} > 0$. That is, given country j's environmental standard, country i sets higher environmental standard, if β is higher, i.e., if the marginal increase of local pollution in one country due to an increase in standard in the other country is higher. Also, if β is higher, change in country i's environmental standard due to a change in country j's environmental standard will be lower (higher) when s_i and s_j are strategic substitutes (complements). Solving (6) and (7), we get the Cournot-Nash equilibrium levels of environmental standards as given in Lemma 1.

Lemma 1: *In case of partially open economies, when countries choose environmental standards independently and simultaneously, the Cournot-Nash equilibrium levels of environmental standards are as following.* $s_A^* = s_B^* = \frac{2l+4\delta g-c-w}{2l(1-\beta)+4\delta g} = s^*$.

Clearly, the equilibrium environmental standards increase with an increase in negative externality of environmental standard in one country to the other country, $\frac{\partial s^*}{\partial\beta} > 0$. The reason is, higher is the negative externality (i.e, higher is the β), countries' incentives to counteract by raising environmental standard is higher. It implies that, countries set higher environmental standards when s_A and s_B are strategic complements compared to that in case of strategic substitutability of standards. This is consistent with the implications of industrial organization theories. Note that, in the present scenario, positive externality of environmental standard in country j to country i, in terms of economic gain to country i (ρs_j), does not affect equilibrium environmental standards; only negative externalities matter. The reason is, while choosing environmental standards independently and simultaneously, countries fail to internalize economic gains due to environmental standard imposed in other country. Since countries are symmetric with respect to the loss function, countries set the same level of environmental standards in

equilibrium. It implies that, in equilibrium, environmental standards does not have any effect on terms of trade.

We now characterise the optimum environmental standards from the world 's perspective. The loss of the world is the sum of the losses of the countries. Therefore, we can write the problem as follows.

$$Min_{s_A,s_B}\ D_W = D_A + D_B = l[(1 - s_A + \beta s_B)^2 + (1 - s_B + \beta s_A)^2] + 2\delta(2 - s_A - s_B)^2 + s_A(c + w - \rho) + s_B(c + w - \rho) \tag{8}$$

Note that, in our context, the problem (8) can also be interpreted as the problem of the countries together, if they set environmental standards cooperatively.[2] Solving this problem we get the equilibrium outcome as given in Lemma 2.

Lemma 2: *The world optimum level of environmental standards are,* $s_A^w = s_B^w = \frac{2l(1-\beta)+8\delta g-c-w+\rho}{2l(1-\beta)^2+8\delta g} = s^w$. *These are also the equilibrium environmental standards, if countries decide environmental standards cooperatively.*

Clearly, if $c + w - \rho < [l(1 - \beta) + \frac{4\delta g(1-2\beta)}{1-\beta}]$, $\frac{\partial s^w}{\partial \beta} > 0$. Therefore, we can say that, the world optimum level of environmental standards, i.e., the cooperative level of environmental standards, increase with an increase in β, if the cost of imposing environmental standard is low. Now, the cost of imposing standard in country i is negatively related to marginal economic gain (ρ) due to environmental standard in country j. So, the world optimum level of environmental standard increases with an increase in β, if ρ is high, $\rho > \hat{\rho} = c + w - l(1 - \beta) - \frac{4\delta g(1-2\beta)}{1-\beta}$. In other words, if countries decides environmental standards cooperatively, equilibrium level of standard increases

[2]Such situation is similar to that of collusion among firms.

due to an increase in β, if $\rho > \hat{\rho}$. This result is in contrast to that in case of independent and simultaneous choice of environmental standards by the countries.

Comparing Lemma 1 and Lemma 2 we get, $s^w < s^*$, if

$\rho < \bar{\rho} = \frac{[2l+4\delta g-c-w][2l(1-\beta)^2+8\delta g]}{2l(1-\beta)+4\delta g} - [2l(1-\beta)+8\delta g-c-w]$. Alternatively, if $\rho > \bar{\rho}$, $s^w > s^*$. That is, in equilibrium, the world optimum level of environmental standards are lower (higher) compared to that chosen by countries independently and simultaneously, if the positive externality (marginal economic gain) of one country due to an increase in environmental standard of the other country is lower (higher) than a critical level. It indicates that, if $\rho < \bar{\rho}$, at the world optimum level of standards both local pollution in countries and global pollution will be higher compared to that at the equilibrium standards set by countries independently and simultaneously. [3] In other words, if $\rho < \bar{\rho}$, cooperative standard setting leads to higher pollution, both local and global, than in case of strategic standard setting by countries.

Proposition 2: *When economies are partially open, in equilibrium, the world optimum level of environmental standards are lower (higher) than that under strategic (i.e., non-cooperative) standard setting by countries, if marginal economic gain (ρ) of one country due to an increase in environmental standard in the other country is less (greater) than a critical level ($\bar{\rho}$). Moreover, if $\rho < \bar{\rho}$, levels of local and global pollution are also higher at the world optimum level of standards.*

From the above proposition, we can say that, in case of partially open economies, coordination among countries to set environmental standards may cause more damage to the environment compared to the situation where no

[3] $\rho < \bar{\rho} \Rightarrow s^w < s^* \Rightarrow G(s^w, s^w) < G(s^*, s^*)$, from (2); and $L_i(s^w, s^w) < L_i(s^*, s^*)$, $i = A, B$, from (1), since $0 < \beta < 1$.

such coordination is possible. It also indicates that existence of supranational authorities, which can set standards for countries or facilitates cooperation among countries to set standards jointly, may be detrimental for the environment in certain situations.

3 Closed Economies

We now consider a scenario in which both countries, A and B, are closed. Since both are closed economies, no trade is possible between countries. Therefore, there is no positive or negative externalities of environmental standards of one country to the other country, except its effect on global pollution. So, we have $\beta = 0$ and $\rho = 0$ in (1) and (3) respectively.

Clearly, in case of closed economies, environmental standards, s_A and s_B, are strategic substitutes. When countries decide environmental standards independently and simultaneously, the Cournot-Nash equilibrium levels of environmental standards are as given in Lemma 3.

Lemma 3: *In case of closed economies, when countries decide environmental standards independently and simultaneously, the Cournot-Nash equilibrium environmental standards are as follows,* $s_A^{*c} = s_B^{*c} = \frac{2l+4\delta g-c-w}{2l+4\delta g} = s^{*c}$.

Comparing Lemma 1 and Lemma 3, we get $s^{*c} < s^*$. That is, in case of closed economies countries set lower environmental standards compared to that in case of partially open economies. Since there is no negative externality of environmental standard of one country to the other in case of closed economies, a country's local pollution solely depends on its own standard. That is, the strategic effect due to local pollution is non-existent in case of closed economies. As a result, equilibrium level of environmental standard is lower in case of closed economies compared to that in case of partially open

economies.

Now, analysing environmental standard setting from the world's perspective we get the following.

Lemma 4: *In case of closed economies, if the world optimum level of environmental standards are as follows,* $s_A^{wc} = s_B^{wc} = \frac{2l+8\delta g-c-w}{2l+8\delta g} = s^{wc}$.

Comparing Lemma 2 and Lemma 4 we get $s^{wc} < s^w$, if in case of partially open economies the marginal economic gain (ρ) of country i due to environmental standard in country j is greater than a critical level ($\hat{\rho} = c+w-l(1-\beta)-\frac{4\delta g(1-2\beta)}{1-\beta}$). Otherwise, if $\rho < \hat{\rho}$, $s^{wc} > s^w$. That is, the world optimum level of standards in case of closed economies are lower (higher) compared to that for partially open economies, if, in case of partially open economies, the extent of positive externality, in terms of economic gain, to the other country is high (low).

Now, comparing Lemma 3 and Lemma 4 yields the following proposition.

Proposition 3: *In case of closed economies, the world optimum level of environmental standards are higher than the simultaneous and independent choice of individual countries:* $s^{wc} > s^{*c}$.

Clearly, it indicates that, if countries set environmental standards cooperatively, in case of closed economies both local and global pollution are lower compared to the situation where environmental standards are chosen by countries independently and simultaneously. Note that, in case of closed economies, environmental standards are strategic substitutes ($\frac{\partial^2 D_i}{\partial s_j \partial s_i} = 2\delta g > 0$). In other words, there is no strategic effect due to local pollution; only strategic effect due to global pollution is in place. Therefore, countries tend to set lower standards in case of non-cooperative setting compared to the world optimum level. Therefore, in case of closed economies, cooperative standard setting, or existence of supranational authority that decides envi-

ronmental standards for countries or facilitates cooperative standard setting, leads to lower pollution, both local and global. In contrast to this, as we have seen in Section 2, in case of partially open economies cooperative standard setting or the existence of supranational authority may lead to higher pollution. Therefore, the impact of cooperative standard setting or the impact of the existence of supranational authority on the environment, compared to that of the strategic choice of standards, crucially depends on (a) trade policies of countries and (b) marginal economic gain of one country due to environmental standard in the other country.

4 Fully Open Economies

We now attempt to analyse a scenario in which economies are fully open. In other words, free trade between countries as well as relocation of production units from one country to the other is allowed. In this scenario, higher environmental standard in country i not only adversely affects its comparative advantage in trade, it may also induce firms to relocate production units from country i to country j. For the shake of simplicity we assume that, if $s_j > s_i$ ($i, j = A, B$, $i \neq j$), some production units are relocated from country j to country i. Therefore, the marginal effect of country j's environmental standard on country i's local pollution is higher in case of fully open economies compared to that in case of partially open economies. We can rewrite the level of local pollution in country i, in case of fully open economies, as follows.

$$L_i = L^0(1 - s_i + \tilde{\beta} s_j), \tilde{\beta} > \beta \tag{1a}$$

The expression for global pollution remains same as that in case of partially open economies, given by (2). Now, the cost of imposing environmental

standard of country i, in case of open economies, is as follows.

$$\begin{aligned} C_i &= cs_i + ws_i - \rho s_j - \phi(s_j - s_i) \\ &= cs_i + (w+\phi)s_i - (\rho+\phi)s_j, \end{aligned} \tag{3a}$$

$i, j = A, B$, $i \neq j$, $0 < \phi < w$, where ϕ is the marginal economic gain (loss) of country i due to relocation of production units from country j (i) to country i (j), if $s_j > (<) s_i$. The objective functions of countries and the world-damage function are similar to (5) and (8) except β, w and ρ are now replaced by $\tilde{\beta}$, $w + \phi$, and $\rho + \phi$ respectively.

Since $\tilde{\beta} > \beta$, strategic effect due to local pollution is higher in case of fully open economies compared to that in case of partially open economies. It may induce countries to set higher standards. However, on the other hand, some production units may relocate to the other country due to lower standard there, which induces countries to set lower standard. The net effect depends on the relative strength of these two effects and on the strategic effect due to global pollution. When countries set environmental standards independently and simultaneously, the Cournot-Nash equilibrium standards are as follows.

Lemma 5: *In case of fully open economies, if countries set environmental standards independently and simultaneously, the Cournot-Nash equilibrium standards are,* $s_A^{*f} = s_B^{*f} = \frac{2l+4\delta g-c-w-\phi}{2l(1-\tilde{\beta})+4\delta g} = s^{*f}$.

Clearly, $\tilde{\beta}$ and ϕ has opposing effects on s^{*f}. Therefore, whether countries set higher standard in case of fully open economies, compared to that in case of partially open economies, depends on the relative strength of these two opposing effects: increase in local pollution due to relocation and increase in economic gain due to relocation.

The world optimum level of environmental standards, which are same as

the equilibrium standards set by countries cooperatively, are as follows.

Lemma 6: *In case of fully open economies, the world optimum level of environmental standards are,* $s_A^{wf} = s_B^{wf} = \frac{2l(1-\tilde{\beta})+8\delta g-c-w+\rho}{2l(1-\tilde{\beta})^2+8\delta g} = s^{wf}$.

Note that, in contrast to the situation where countries decide environmental standards independently and simultaneously (i.e., non-cooperatively), the world optimum level of environmental standards do not depend on the economic cost (or gain) of countries due to relocation. However, unlike in case where countries decide standards non-cooperatively, the world optimum level of standards crucially depends on the parameter ρ, which is marginal economic gain due to increase in comparative advantage in international trade of commodities triggered by an increase in environmental standard in the other country. Comparing Lemma 5 and Lemma 6 yields the following proposition.

Proposition 4: *In case of fully open economies, the world optimum level of environmental standards are lower (higher) compared to the equilibrium levels when countries set environmental standards strategically, if marginal economic gain due to increase in comparative advantage in international trade of commodities triggered by an increase in environmental standard in the other country is lower (higher) than a critical level* $\tilde{\rho}$*, where* $\tilde{\rho} = \frac{[2l+4\delta g-c-w-\phi][2l(1-\tilde{\beta})^2+8\delta g]}{2l(1-\tilde{\beta})+4\delta g} - [2l(1-\tilde{\beta}) + 8\delta g - c - w]$.

From Proposition 2 and Proposition 4, we can say that the impacts of strategic choice of environmental standards, compared to that under cooperative standard setting, are very similar in cases of partially open and fully open economies. Since the impact of $\tilde{\beta}$ on $\tilde{\rho}$ is ambiguous, possible relocation of plants from one country to the other due to differential environmental standards in case of fully open economies need not necessarily increase the possibility of global optimum standards to be less than the non-cooperative

equilibrium standards compared to that in case of partially open economies.

5 Conclusion

This paper examines the strategic nature of choice of environmental standards under different degrees of openness of countries and compares equilibrium outcomes with the world optimum. It shows that, if countries are open to trade, strategic choice of environmental standards leads to higher levels of standards and lower pollution compared to that in case of closed economies. It also shows that whether cooperative choice of environmental standards, which gives rise to world optimum, leads to higher environmental standards or not, compared to the situation where countries decide environmental standards non-cooperatively, crucially depends on (a) the degree of trade openness and (b) the marginal economic gain of one country due to increase in environmental standard in other country. In case of partially open economies, if the second factor is weak, simultaneous and independent choice, i.e., strategic choice, of environmental standards by countries leads to higher environmental standards than the world optimum. In contrast, the world optimum level of environmental standards are always higher than that under strategic choice, in case of closed economies.

Our results indicate that existence of supranational authorities that set environmental standards for the countries from the world welfare perspective or facilitates cooperation among countries to set environmental standards cooperatively, need not necessarily lead to lower levels of pollution compared to that under strategic choice.

In this paper, for simplicity, we have considered symmetric loss functions of countries. However, it is easy to observe that as long as countries are not

too asymmetric with respect to their loss functions, qualitative results of this paper will remain valid. Nonetheless, it might be interesting to examine the implications of different aspects of asymmetry between countries explicitly. It might also be interesting to extend the present analysis by considering repeated move of countries.

References

Chichilnisky, G. (1994). North-south trade and the global environment. *American Economic Review*, 84(4):851–74.

Copeland, B. R. and Taylor, M. S. (1994). North-south trade and the environment. *Quarterly Journal of Economics*, 109(3):755–87.

Copeland, B. R. and Taylor, M. S. (1995). Trade and transboundary pollution. *American Economic Review*, 85(4):716–37.

Copeland, B. R. and Taylor, M. S. (2003). *Trade and the Environment: Theory and Evidence*. Princeton University Press, Princeton and Oxford.