Harmonizing Emissions Policy in Symmetric Countries: Improve the Environment, Improve Welfare?

Carol McAusland[1,2]

October 30, 2002

Comments welcome

Abstract: We examine how harmonizing emissions policy affects environmental quality and welfare when countries are symmetric, pollution is transboundary, and policy makers are politically motivated. We show that harmonization affects the preferences of governments through two channels: it effectively extends a government's jurisdiction and it amplifies the price effects of stringent environmental policy. Depending on the vested interests of a policy maker's constituents, these channels can work in opposite directions. We derive conditions under which the latter channel dominates such that symmetric countries will choose harmonized policy that is less stringent than what they would set when acting unilaterally; we find this can only occur when the decision makers' have constituents with below average vested interests in the polluting industry. We also derive conditions under which harmonization reduces local and global welfare; we find that welfare declines only when harmonization improves the environment.

JEL Classification: F18, D72

Keywords: trade, environment, harmonization, political economy

[1]Department of Economics, University of California, Santa Barbara, CA 93106. Phone: (805) 893-4823; fax: (805) 893-8830; email: mcauslan@econ.ucsb.edu.

[2]My gratitude to Joel Bruneau for helpful comments on a previous draft of this paper. The usual disclaimer applies.

1 Introduction

When countries exposed to negative transboundary externalities—for example global warming, acid rain, or ozone layer depletion—negotiate over their respective policies, there is a natural expectation that the negotiations will yield stricter policies for the negotiating countries than each would set if behaving unilaterally. In particular, we expect that similar countries would, to the benefit of all, agree to harmonize up.

We reconsider the effects of international policy harmonization in a model with politically motivated decision makers. Contrary to the expectations outlined above, we find that harmonization is not necessarily good for either the environment nor global welfare. In particular, we find that whenever the environmental externality is less than perfectly transboundary then cooperation may induce decision makers to harmonize down. And when they instead choose to harmonize upward, if the policymakers represent constituents with below average interests in the polluting industry, then this upward harmonization can reduce local and global welfare.

There has been a substantial amount of discussion, both within the economics profession and without, as to the usefulness of harmonizing environmental regulation internationally. Some economists have focused on conditions under which governments will pursue and adhere to multilateral environmental agreements in the first place; see, for example, Barrett (1997) and Carraro and Siniscalco (1998). Others have addressed the basic inefficiencies inherent in policy harmonization when the parties in question are dissimilar. For example, Bhagwati and Srinivasan (1996) point out that (globally) optimal levels of environmental protection will vary from region to region depending on the tastes and incomes of citizens, as well as on the assimilative capacities of regional ecosystems. Consequently, any policy that requires instrument levels be identical across countries is inefficient when those countries are asymmetric.

We focus on the effects of *de jure* harmonization[3], whereby equalization of regulations across countries is mandated by some international agreement. We examine the environmental and welfare consequences of this type of policy harmonization when the countries in question are symmetric and so the globally optimal instrument levels are indeed identical across countries. The model we use is of two identical endowment economies open to free trade with one another. Citizens within each country are endowed with immobile capacities to produce clean and dirty goods.[4] Production of dirty goods invariably generates welfare reducing emissions, although the rate at which emissions are created is decreasing in the fraction of dirty goods capacity that is allocated to abatement activities; this fraction is the policy parameter considered. Citizens have quasi-linear preferences for dirty and clean goods, and their utility is reduced both by local emissions and by emissions emitted abroad. The extent to which overseas emissions reduce the welfare of local citizens is treated as a parameter of the model. The stringency of the environmental policy in each country is set so as to maximize the objective function for a politically

[3] The term harmonization has been used elsewhere to describe one country altering its local standards so as to make them identical to those of another country, but without such equality being enforced by multilateral agreement; this would be best described as *de facto* harmonization and is not considered here.

[4] Some models of environmental regulation in the presence of internationally mobile capital also suggest—implicitly at least—that cooperation can be bad for the environment. See, for example, Markusen, Morey and Olewiler (1995), Wilson (1997) and McAusland (2002); each describes outcomes of interjurisdictional competition whereby governments set inefficiently strict local environmental regulation so as to either extract rents from overseas investors or to drive polluting firms abroad. In such cases cooperation would eliminate these strategic incentives and so induce downward harmonization. We do not allow for interjurisdictional capital mobility in the present paper and so NIMBY (Not In My BackYard) motives are not at play.

motivated decision maker. A convenient feature of the utility functions we posit for individual citizens is that the objective functions of the decision makers in a variety of institutional scenarios—majority rules, a political elite, and an incumbent policymaker influenced by political contributions—have the same structure as the utility functions of individuals except that they are evaluated at the (average) capacity endowments of the political agents' constituents. We then compare policy stringency levels preferred by identical political decision makers when policy is set unilaterally (non-cooperatively) and when it is harmonized across countries.

We find that harmonization need not be good for either the environment or global welfare. These results arise because harmonization affects policy preferences through two sometimes competing channels. The first channel is widely recognized: a harmonized standard gives a decision maker in one country control over the emissions created by its neighbor. If the neighbor's emissions harm the decision maker's country, then this extended control makes strict environmental policy more attractive when policy is harmonized than when it is set unilaterally.

The second channel also works through international flows, not of pollution but of emissions intensive goods, or more accurately through the prices of these goods. When countries are open to trade the prices for dirty goods depend on worldwide supply. When one country unilaterally makes its environmental policy more stringent, this raises compliance costs for local producers of dirty goods and leads to a curtailment of local supply; as a consequence the world price of the dirty good will rise somewhat, hurting consumers and partially compensating producers. However if environmental policy was instead made more stringent globally, the same increase in stringency leads to a larger curtailment in supply and so generates a larger price increase. Consequently, the price effects of a given tightening of policy are amplified when the tightening is carried out globally rather than just locally. This price amplification shifts some of the incidence of the policy tightening from local producers to local consumers of dirty goods.

When the decision makers represent constituents with above-average vested interests in the dirty industry, the two channels described above are complementary and so harmonization induces an unambiguous tightening of environmental policy.

However, when politicians instead represent constituents with below average vested interests then these two channels work in opposite directions: effectively extended jurisdictional control makes strict policy more attractive, but greater responsiveness of consumer prices to environmental regulation makes strict policy less attractive. We find that if constituents' vested interests in the dirty industry are sufficiently low, this latter concern dominates, making politicians prefer harmonized policy that is weaker than what each government would set when acting in concert with her country's trade partner.

We also examine how harmonization affects the joint welfare of citizens of the two countries. We find that harmonization may be bad for global welfare, but only if it induces stricter emissions policy. This possibility arises simply because a decision maker with constituents with below average interests in the polluting industry may well adopt a policy level that is already excessively strict even though imposed unilaterally. Tightening regulation even further in response to extended control over the transboundary component of pollution serves to push the level of policy stringency even further away from its global welfare maximizing level.

We derive conditions under which each of the two outcomes described above—that harmonization leads to a worsening of global environmental quality or a worsening of global welfare—occur. We show that the two outcomes discussed are mutually exclusive, and that the likelihood of either depends on the price elasticity of demand for dirty goods, the coefficient of transboundary transmission of environmental damage, and the capacity endowments of the policy makers' constituents.

This paper bridges the gap between two distinct literatures. There is first the literature concerning whether harmonization is a Pareto improvement relative to non-cooperative outcomes. Rauscher (1992) and Bhagwati and Srinivasan (1996), for example, stress that, as a general rule, policy harmonization across dissimilar countries is undesirable because it eliminates environmental comparative advantage. Others, however, have argued that in the presence of a variety of market failures harmonization may be desirable. For example Ulph (1997) and Kanbur, Keen and van Wijnbergen (1994) find that harmonization—at levels imposed by a supra-national authority—may be Pareto improving in the presence of strategic trade incentives or informational asymmetries if differences in damage costs across countries are not sufficiently large. In this literature it is implicitly assumed that if countries are perfectly symmetric, harmonization is at worst innocuous. We show this is not the case when harmonized policy levels are chosen by politically motivated governments, not social planners.

The second literature contains the growing body of research on the political economy of environmental policy in open economies. Hillman and Ursprung (1992) uses a political support model to examine how campaign contributions from environmental groups affect trade policy; McAusland (forthcoming) uses a median voter framework to compare pollution standards in autarky and a small open economy; Fredriksson (1997), Aidt (1998) and Schleich (1999) each use the Grossman-Helpman political contribution model to examine the impact of lobby groups on environmentally motivated production and trade taxes in small open economy settings. Schleich and Orden (2000) use this latter approach to compare production and trade taxes in large open economies when governments set policy unilaterally as opposed to cooperatively. They provide numerous arguments as to how cooperation—by eliminating incentives to manipulate policies for optimal-tariff and pollution shifting motives, and by internalizing the international effects of political support within individual countries—may have ambiguous environmental consequences. However, because their model generates multiple competing channels through which cooperation alters government incentives, they find that "no general conclusions can be drawn as to whether the cooperative equilibrium policies ... result in higher or lower environmental quality than the noncooperative policies...." (p. 690)

We take a different approach. We abstract from optimal tariff issues by considering only symmetric countries (who do not therefore engage in net trade in equilibrium even though trade is free and frictionless) so as to be able to focus on the simple effects cooperation has on how governments view the costs of pollution control. Similarly, we assume perfectly competitive output markets and immobile factors of production so that profit and pollution shifting motives are also absent. This approach permits us to derive specific conditions on environmental, taste, and political parameters under which cooperation leads to an unambiguous deterioration of environmental quality.

The remainder of this paper is structured as follows. Section 2 lays out the model and establishes the objective functions of the political decision makers in a variety of political economy scenarios. Section 3 characterizes equilibrium when environmental policy is set non-cooperatively while Section 4 examines policy stringency in the harmonized setting. Section 4 also derives conditions under which harmonization weakens environmental policy or reduces global welfare. Section 5 concludes.

2 Model

The simplest production and abatement structure is used. Each country is endowed with gross capacity to produce clean and dirty goods and technology for abating emissions arising from dirty good production. As in Stokey (1998), Antweiler, Copeland and Taylor (2001), and McAusland (2002, forthcoming), the larger the fraction of that capacity that is allocated to abatement activity rather than production of marketable output, the smaller that country's output of total emissions. In particular, if Home has an endowment of dirty good capacity X and allocates fraction θ of its capacity to abating emissions, then Home produces for consumption $[1-\theta]X$ units of the dirty good for consumption and generates $Z = z(\theta)X$ units of emissions, where z is a positive, strictly decreasing, strictly convex function defined over the interval $[0, 1]$ that satisfies the Inada-type conditions $-z'(0) = \infty$, $-z'(1) = 0$. As in Stokey (1998) and McAusland (2002, forthcoming), θ is also the policy parameter. Given $\frac{dZ}{d\theta} = z'(\theta)X < 0$ then higher values of θ correspond to more stringent environmental policy. Values for Foreign are indicated by asterisks. Note that each country is also endowed with an aggregate endowment of capacity to produce a numeraire clean good, Y, Y^* and with a fixed population size N, N^*. Because the focus of this paper will be on the role of special interests in determining the stringency of environmental policy in a number of settings, rather than on how cross country differences in aggregate endowments or populations affect policy, we assume throughout that $X = X^*$, $Y = Y^*$ and $N = N^*$.

The endowments to produce clean and dirty goods are assumed to be owned by citizens in each country. Index Home citizens by i and Foreign citizens by j. Then, for example, X_i, Y_i denotes the endowment portfolio of some citizen i in the Home country. We assume that a citizen's entire consumption must be financed out of earnings from her factor endowments, and that factor markets are perfectly competitive such that, if the retail price of a unit of dirty goods is P, then citizen i's income and budget for financing her own consumption is $I_i = P[1-\theta]X_i + Y_i$.

Citizens are assumed to have quasi-linear preferences over private goods and to suffer disutility from emissions both at Home and abroad. In specific, denote the utility of citizen i by

$$U_i = v(x_i) + y_i - [Z + \xi Z^*]$$

where $v(\cdot)$ is a positive, increasing, strictly concave function, x_i and y_i are individual consumptions of dirty and clean goods, and $\xi \in [0,1]$ is the coefficient of transboundary transmission of emissions. For example, if $\xi = 1$ then pollution is perfectly global: citizens of Home and Foreign suffer equally from emissions in each country; if $\xi = 0$ then pollution is perfectly local. In our analysis we focus largely on cases in between these two extremes, as we believe this accurately describes a number of prominent transboundary environmental problems.[5]

[5] Consider, for example, the activities responsible for the principle greenhouse gas carbon dioxide: the burning of coal, oil and natural gas. These same activities generate other pollutants with purely local effects: burning coal and gasoline creates ground level ozone, harmful to humans and plants; combusting

The market for sale of dirty goods is also assumed to be perfectly competitive. Consequently, citizen i chooses consumptions of dirty and clean goods to maximize U_i taking P, θ and θ^* as exogenous. This generates a demand curve for dirty goods $x_i(P)$ satisfying $P = v'(x_i(P))$ conditional on citizen i having adequate income to finance the desired level of expenditure; we assume that all i and j have clean capacity endowments sufficiently large for this condition to be met. Since goods may be freely traded across countries and so consumers in each face identical prices, then $x_i = x_j \ \forall i, j$; to conserve on notation we will drop the subscripts on this variable from here forward and let x denote individual consumption of dirty goods, where

$$v'(x) = P \, . \tag{1}$$

Substituting in expressions for Z and Z^* and employing the assumption of adequate income for all citizens gives an indirect utility function for citizen i that can be written as

$$W_i(\theta; \theta^*) = v(x) + P[1-\theta]X_i + Y_i - Px - [z(\theta)X + \xi z(\theta^*)X^*] \tag{2}$$

Now consider the preferences of a citizen with endowment portfolio X_i, Y_i over the emissions policy parameter θ, taking the emissions parameter in Foreign as exogenous; it solves the first order condition for an interior maximum

$$\frac{dW_i}{d\theta} = v'(x)\frac{dx}{dP}\frac{dP}{d\theta} - P\frac{dx}{dP}\frac{dP}{d\theta} + [1-\theta]X_i\frac{dP}{d\theta} - x\frac{dP}{d\theta} - PX_i - z'(\theta)X = 0 \, .$$

gasoline and oil generates carbon monoxide, low concentrations of which cause dizziness; and burning all three releases volatile organic compounds (VOCs), some of which are carcinogenic. Similarly, habitat conversion is the leading cause of species extinction worldwide, and creates global losses of associated intrinsic and pharmaceutical values. However habitat conversion also reduces flows of ecosystem services such as flood and erosion control, with purely local impacts. And finally, the long range problem of acidic deposition, which harms lakes, streams, forests and buildings, is caused by emissions of sulphur dioxide and nitrous oxides. Those same pollutants also contribute to smog, which has a more geographically limited range.

Given (1) the first two terms in the above cancel; collecting remaining terms and defining the variable

$$E_i \equiv [1-\theta]X_i - x \tag{3}$$

as i's net exports of dirty goods to the rest of the market gives

$$E_i \frac{dP}{d\theta} - PX_i - z'(\theta)X = 0\,. \tag{4}$$

Equation (4) implicitly defines citizen i's preferred level of stringency in emissions policy; denote this preferred policy level as θ_i. As in McAusland (forthcoming), Equation (4) can be interpreted as follows. The first term of (4)—$E_i \frac{dP}{d\theta}$—is the individual terms of trade incentive associated with environmental policy. If E_i is positive, then any increase in the retail price of dirty goods arising from stricter emissions policy (as measured by $\frac{dP}{d\theta}$) raises the value of i's net exports of dirty goods, inducing i to prefer a stricter policy, other things being equal. If instead i is a net importer of dirty goods from the rest of the economy—i.e. $E_i < 0$—then any increase in P makes these imports more expensive, providing i with a negative individual terms of trade incentive so that i prefers, other things equal, weaker emissions policy.

The second term in (4) is the endowment incentive associated with environmental policy. Higher values of θ essentially conscript larger fractions of capacity away from production of non-market activities (and into production of environmental public goods) and so reduce the value of an individual's endowment. Other things equal the endowment incentive induces citizen i to prefer weaker environmental policy.

Finally, the third term in (4) is an abatement incentive. The larger the fraction of dirty capacity that is allocated to abatement of pollution, the smaller the emission coefficient associated with use of a unit of dirty capacity—$z(\theta)$—and, for given X, the lower the level of overall emissions. The abatement incentive is positive and, other things being equal, induces citizen i to prefer stricter regulation.

Regarding preferences over policy stringency in the Foreign country, by symmetry the indirect utility function of citizen j of Foreign is given by

$$W_j^*(\theta^*, \theta) = v(x) + P[1-\theta^*]X_j^* + Y_j^* - Px - [z(\theta^*)X^* + \xi z(\theta)X] \quad (5)$$

and the level of policy stringency she prefers by θ_j^*, the solution to

$$E_j^* \frac{dP^*}{d\theta^*} - P^* X_j^* - z'(\theta^*)X^* = 0 \quad (6)$$

where $E_j^* \equiv [1-\theta^*]X_j^* - x$.

Before proceeding to discuss how the preferences of individual citizens influence the emissions policy set by each country, note that a citizen's individual preference for policy stringency is decreasing in that individual's endowment of polluting capacity.

Before showing this let us first establish values for P and $\frac{dP}{d\theta}$. Clearing of the global dirty goods market implies $Nx + N^*x = [1-\theta]X + [1-\theta^*]X^*$. Rearranging terms and making use of symmetry in population and capacity endowments yields $x = \frac{[1-\theta+1-\theta^*]X}{2N}$. Substituting this into (1) gives

$$v'\left(\frac{[1-\theta+1-\theta^*]X}{2N}\right) = P\,. \quad (7)$$

Differentiating with respect to θ (for the scenario in which policy is set unilaterally) gives

$$\frac{dP}{d\theta} = \frac{P}{[1-\theta+1-\theta^*]\epsilon} \quad (8)$$

where $\epsilon \equiv -\frac{dx}{dP}\frac{P}{x}$ is the elasticity of demand for dirty goods. Similarly, $\frac{dP}{d\theta^*} = \frac{P}{[1-\theta+1-\theta^*]\epsilon}$ and so $\frac{dP}{d\theta^*} = \frac{dP}{d\theta}$, revealing that greater policy stringency in either country has an identical effect on consumer prices.[6] For simplicity, we assume throughout the remainder of the paper that the function $v(\cdot)$ is isoelastic in x with the following form: $v(x) = x^{\sigma}$ with $\sigma > 0$. Concavity of $v(\cdot)$ requires $\sigma < 1$, implying $\epsilon = \frac{1}{1-\sigma} > 1$ and so demand for dirty goods is elastic.

Equations (7) and (8) also show that the price of dirty goods P and the manner in which policy stringency affects that price are both invariant to the distribution of dirty capacity endowments.

We return now to the question of how an individual's dirty capacity endowment affects her preference for stringency in domestic environmental policy.

Differentiating (4), defining $W^i_{\theta\theta}$ as the second partial derivative of the indirect utility function W_i and invoking the envelope theorem gives

$$\frac{d\theta_i}{dX_i} = \frac{[1-\theta]\frac{dP}{d\theta} - P}{-W^i_{\theta\theta}}.$$

Combining this with (8) reveals

$$\frac{d\theta_i}{dX_i} = \frac{\left[\frac{\lambda}{\epsilon} - 1\right] P}{-W^i_{\theta\theta}} \tag{9}$$

where $\lambda = \frac{[1-\theta]X}{[1-\theta+1-\theta]X}$ is Home's share of the world market for dirty goods. Given that W_i is concave—global concavity of W_i in θ for all scenarios considered is verified in Appendix A—then $\frac{d\theta_i}{dX_i}$ is negative for all $\lambda \in [0,1]$.

This, combined with the concavity of the objective functions, implies that citizens have single peaked preferences over θ, and citizens' preferences can be ranked by the dirty capacity endowment of each citizen and so interpersonal comparisons can be made.

[6] As is shown below, more stringent environmental regulation impacts the price of dirty goods similarly when policy is harmonized: $\left.\frac{dP}{d\theta}\right|_{d\theta=d\theta^*} = \frac{P}{\epsilon[1-\theta]} > 0$.

Simply, holding constant the stringency of policy overseas, a citizen with a larger dirty capacity endowment wants a less stringent environmental standard than does a citizen with a smaller dirty capacity endowment: $X_i > X_k$ implies $\theta_i < \theta_k$. These are useful properties, since they permit individual preferences to be aggregated into objective functions for the representing political agents that are similar in structure to (2) and (5) in a number of institutional settings.

2.1 The Policy Makers

For the sake of expedience, we introduce policy "decision" makers—indexed by D and D^*—for each country. Below we show that the popular median voter and political contributions models of political economy, as well as a generic treatment of an uncontested political elite, each generate objective functions for each country's decision maker that are monotonic transformations of (2) and (5) when evaluated at some set of "represented" endowments (X_D, Y_D) or (X_D^*, Y_D^*); define by W_D and W_D as the functions (2) and (5) evaluated at these respective endowments, and define by θ_D and θ_D^* the respective maximizing arguments.

2.1.1 Majority Rules

If environmental policy is set via majority rules and there are an odd number of voters then since the W_i functions are single peaked in the policy parameter θ there exists a median voter whose policy preference will be the outcome of a majority rules referendum on the stringency of domestic environmental policy. Notably, the identity of this median voter is invariant to the policy choice of the country's trade partner. In the case of majority rules, X_D, Y_D then are merely the endowment's of the median voter, and the more concentrated is the ownership of dirty capacity in the hands of a few then the lower will be X_D and so by (9) the lower will be θ_D.

2.1.2 Political Elite

An uncontested minority elite with $M < N$ members that is constrained to set a single policy for all dirty production will choose θ so as to solve

$$\max_{\theta} \sum_{k=1}^{M} [v(x) + P[1-\theta]X_k + Y_k - Px - Z]$$

or its equivalent

$$\max_{\theta} M \left[v(x) + P[1-\theta]\frac{\sum_{k=1}^{M} X_k}{M} + \frac{\sum_{k=1}^{M} Y_k}{M} - Px - [z(\theta)X + z(\theta^*)X^*\xi] \right]$$

which is the same problem as for a single decision maker D maximizing (2) with endowments $X_D = \frac{\sum_{k=1}^{M} X_k}{M}$, $Y_D = \frac{\sum_{k=1}^{M} Y_k}{M}$. Interpreting this in light of (9), the larger is the average dirty capacity endowment of members of the elite $\frac{\sum_{k=1}^{M} X_k}{M}$ then the weaker is the environmental policy that will be preferred (holding θ^* constant).

2.1.3 Lobby Groups

Finally, consider the case in which lobby groups influence the stringency of policy set by an incumbent local government. Using the political contributions approach of Grossman and Helpman (1994), lobby groups make policy contingent contributions similar to a menu auction as in Bernheim and Whinston (1986). The incumbent then sets policy so as to maximize some linear combination of political contributions and the aggregate welfare of citizens. For example, defining $C_k(\theta)$ as the policy contingent contribution to the incumbent from lobby group k, then when the incumbent chooses policy level θ, she receives welfare

$$W_I = \gamma \sum_k^K C_k(\theta) + \sum_i^N W_i(\theta; \theta^*)$$

where γ is a parameter, K is the total number of lobby groups, and W_i are the welfare functions of individual citizens as defined by (2). In this framework, each lobby group chooses its contribution schedule so as to maximize the welfare of its members subject to a participation constraint for the incumbent, and taking the contribution schedules of competing lobby groups and overseas policy stringency as exogenous. If every citizen is a member of a lobby group then the contributions offset one another and the incumbent chooses policy so as to maximize $\sum_i^N W_i$. A more interesting case is where only a subset of citizens are represented by a lobby group; given the construction of our model with only two industries, we focus on the case in which only one industry—either the dirty goods or the clean goods industry—is organized. With only one lobby group present, that group's contribution schedule would be set so as to induce the policy vector

$$\theta \in \arg\max_\theta \sum_l^L [v(x) + P[1-\theta]X_l + Y_l - Px - [z(\theta)X + z(\theta^*)X^*\xi]] - C$$

subject to the constraint $\gamma C + \sum_i^N W_i(\theta; \theta^*) \geq \max_{\tilde{\theta}} \sum_i^N W_i(\tilde{\theta}, \theta^*)$; L is the number of members in the lobby group. Since the lobby group would not contribute more than the minimum required, the constraint can be treated as binding. This gives an expression for the lobby group's contributions C that can be substituted into the objective function above; collecting terms give the equivalent policy vector

$$\theta \in \arg\max_\theta \frac{\gamma L + N}{\gamma} \left[v(x) + P[1-\theta] \frac{\gamma \sum^L X_l + X}{\gamma L + N} + \frac{\gamma \sum^L Y_l + Y}{\gamma L + N} - Px - [z(\theta)X + z(\theta^*)X^*\xi] \right] - \beta \tag{10}$$

where $\beta \equiv \max_{\tilde{\theta}} \sum_i^N W_i(\tilde{\theta}; \theta^*)$ is a constant. Assuming, as is the practice in these models, that membership in the lobby group is exogenous then the objective function in (10) will be maximized by the same policy as would maximize (2) for a decision maker with endowments $X_D = \frac{\gamma \sum_l^L X_l + X}{\gamma L + N}$, $Y_D = \frac{\gamma \sum_l^L Y_l + Y}{\gamma L + N}$. Given (9) the stringency level induced by political contributions is increasing in the aggregate dirty capacity endowments of the lobby group's members. A larger weight γ placed by the incumbent on the relative importance of lobby group contributions has an ambiguous effect on policy stringency:

$$\frac{d\theta_D}{d\gamma} = \frac{d\theta_D}{dX_D}\frac{dX_D}{d\gamma} = \left[\frac{\frac{\lambda}{\epsilon} - 1}{-W_{\theta\theta}^D}\right] \frac{P\left[N \sum^L X_l - XL\right]}{(\gamma L + N)^2}.$$

For example, if the lobby group has as members all local owners of dirty capacity then $\sum^L X_l = X$; so long as $L < N$ then $\frac{d\theta_D}{d\gamma} > 0$. Conversely, if the mean dirty capacity endowment of lobby group members is below the Home average—i.e. $\frac{\sum^L X_l}{L} < \frac{X}{N}$, as would likely be the case if the lobby group instead represented the clean goods industry—then a heavier weight placed by the incumbent on contributions would generate a preference for weaker emissions policy.

As indicated earlier, in each of these models of political economy the policy preferences of the political actor are mimicked by the preferences of a single decision maker with the objective function defined in (2) and with some dirty and clean capacity endowments X_D and Y_D. In the sections to follow we refer to X_D and Y_D interchangeably as the endowments "of" and the endowments "represented by" the political decision maker, with the understanding that the former description is more appropriate in the case of majority rules and the latter as arguably more appropriate in the Political Elite and Political Contributions settings.

3 Non-Cooperative Policy

We are now ready to characterize an equilibrium for the model when policy is set unilaterally by the policy makers D, D^* in each country. We assume that in the non-cooperative setting each policy maker takes the level of policy stringency in the neighbor country as exogenous (and so we concentrate on Nash equilibria).

To begin, substitute expressions for $\frac{dP}{d\theta}$ and $\frac{dP}{d\theta^*}$ into (4) and (6) and cancel like terms to get

$$\left[\lambda X_D - \frac{X}{2N}\right]\frac{P}{\epsilon} - PX_D - z'(\theta)X = 0 \tag{11}$$

$$\left[[1-\lambda]X_D^* - \frac{X}{2N}\right]\frac{P}{\epsilon} - PX_D^* - z'(\theta^*)X = 0\,; \tag{12}$$

(11) and (12) respectively define the best response functions $\theta_D(\theta^*)$ and $\theta_D^*(\theta)$ for each decision maker, and jointly characterize the Nash equilibrium policy levels θ_D^N, θ_D^{*N} when policies are set unilaterally. Notably, the best response functions are not necessarily monotonic: for X_D sufficiently low there exist overseas policy levels that are strategic complements to domestic policy stringency.[7] The best response functions for a variety of decision maker types in each country are depicted in Figure 1. In the interest of brevity we avoid analysis of cases with asymmetric decision makers, restricting attention instead to cases in which $X_D = X_D^*$: this simplifies the analytics without eliminating the important role played by vested interests in policy formation.

[7] For example, differentiate (11) and rearrange terms to get

$$\frac{d\theta_D(\theta^*)}{d\theta^*} = \frac{\frac{dP}{d\theta^*}\left[X_D\left[1-\frac{\lambda[\epsilon+1]}{\epsilon}\right]+\frac{\lambda}{\epsilon}\frac{X}{2N}\right]}{-W_{\theta\theta}^D}\,. \tag{13}$$

Since $\epsilon > 1$ then $\frac{d\theta_D(\theta^*)}{d\theta^*}$ is negative whenever $\lambda \leq \frac{1}{2}$ (i.e. whenever $\theta > \theta^*$). Thus whenever overseas policy is (weakly) stricter than local policy it is a strategic substitute for local stringency. However if $X_D < \frac{X}{2N}$ then at sufficiently high values of θ^* (i.e. λ high) then $\frac{d\theta_D(\theta^*)}{d\theta^*}$ is negative and overseas policy stringency is a strategic complement to domestic stringency.

In the symmetric decision makers case, the following is straightforward to prove.

Proposition 1 *When $X_D = X_D^*$ the non-cooperative (Nash) equilibrium policy levels θ_D^N, θ_D^{*N}*

1. *are symmetric, i.e. $\theta_D^N = \theta_D^{*N}$,*
2. *are unique,*
3. *are interior, i.e. $\theta_D^N = \theta_D^{*N} \in (0, 1)$, and*
4. *are decreasing in the symmetric dirty*[8] *capacity endowments of the decision makers, i.e. $\frac{d\theta_D^N}{dX_D} = \frac{d\theta_D^{*N}}{d\theta^*} < 0$ for $dX_D = dX_D^*$.*

Proof: see Appendix B

The first three parts of Proposition 1 merely confirm that the non-cooperative equilibrium with symmetric decision makers is itself symmetric and is well-behaved. The fourth part confirms that the usual relationship between the endowments represented by the political agents and policy stringency are as one would expect from most stories of political economy: the more vested in the polluting industry are the interests of the decision makers' constituents then the weaker will be the policies set in the non-cooperative equilibrium. Because the non-cooperative equilibrium policy levels are symmetric, in order to conserve notation we will refer only to θ_D^N in the discussion to follow, recognizing that all statements are equally applicable to the equilibrium value for Foreign, θ_D^{*N}.

Next we compare the stringency levels that would be set by the decision makers if policy were harmonized instead.

[8] Given the quasi-linear nature of preferences over private consumption goods, an increase in a citizen's endowment of clean goods has no effect on her preferred policy level. McAusland (forthcoming) analyzes the case in which demands for both clean and dirty goods have positive income elasticity and so changes in a citizen's endowment of any type of capacity affects her preference for stringency in emissions policy.

4 International Policy Harmonization

In this section we consider *de jure* harmonization, whereby the level of policy stringency is mandated to be identical across the two countries. Using this definition, then when policy is harmonized net world supply of dirty goods is $[1-\theta][X+X^*]$ and so $x = \frac{[1-\theta]X}{N}$. Substituting this into (1) yields $P = v'\left(\frac{[1-\theta]X}{N}\right)$ and so $\frac{dP}{d\theta} = \frac{P}{\epsilon[1-\theta]}$ in the harmonized setting. Substituting these values into (2) and recognizing that θ and θ^* are constrained to be equal, we can write the welfare functions of the decision makers as the same function[9]

$$W_D^H = W_D^{*H} = v\left(\frac{[1-\theta]X}{N}\right) + P[1-\theta]X_D + Y_D - P\frac{[1-\theta]X}{N} - [1+\xi]z(\theta)X$$

given the symmetry of capacity endowments at the country and decision maker levels. Maximizing W_D^H and W_D^{*H} with respect to policy stringency gives the associated first order condition

$$\frac{dW_D^H}{d\theta^H} = \frac{dW_D^{*H}}{d\theta^{*H}} = \left[\frac{X_D}{X} - \frac{1}{N}\right]\frac{PX}{\epsilon} - PX_D - z'(\theta^H)X[1+\xi] = 0 \qquad (14)$$

that defines $\theta_D^H = \theta_D^{*H}$, D's and D^*'s preferred level of policy stringency when policy is harmonized.[10]

Since the two countries have symmetric endowments and populations, and we have restricted attention to cases in which $X_D = X_D^*$, then the Home and Foreign decision

[9] In what follows we not only treat $X_D = X_D^*$ but $Y_D = Y_D^*$ as well. This latter assumption is unnecessary for any of the analysis that follows, however it allows us to write W_D^H and W_D^{*H} as functions with identical arguments.

[10] Appendix A shows that W_D^H (and W_D^{*H}) is strictly concave in θ^H. It is also the case that θ_D^H is decreasing in X_D^H: differentiating (14), rearranging terms and invoking the envelope theorem gives $\frac{d\theta_D^H}{dX_D} = -\frac{P[1-\epsilon-1]}{\frac{d^2W_D^H}{d\theta^2}} > 0$; by symmetry θ_D^{*H} is decreasing in X_D^{*H}. As when policy was set unilaterally, these conditions imply that individual citizens have single peaked preferences over θ^H and can be ranked in their preferences according to their dirty capacity endowments. Since these capacity endowments are exogenous, then the pattern of domestic support for a given political actor is the same as in the non-cooperative setting and so the identities of the decision makers in each country are unchanged by the move to harmonization.

makers prefer an identical level of policy stringency in the harmonized case. This means that the symmetric decision makers will unanimously agree that the value θ_D^H that solves (14) is the best level of policy stringency in the harmonized case. Without providing specifics concerning the negotiation process, we assert that this policy level will be the harmonized policy level. Again to conserve notation, from here on we will discuss the harmonized policy level prefered by each country's decision maker by referring to θ_D^H only.

4.1 When harmonization harms the environment

A generic argument in favor of harmonization in the presence of a bilateral transboundary externality between symmetric countries is that harmonization will induce policy makers to act as if they were internalizing the costs that their exports of pollution impose on their neighbor; the corresponding expectation is that the respective policy makers will prefer more stringent environmental regulation when policy is harmonized than when set unilaterally. However, we find that harmonization leads to a tightening of environmental policy only under certain conditions.

Proposition 2 *When countries have symmetric endowments, populations and decision makers—i.e. $X = X^*$, $N = N^*$, $X_D = X_D^*$—then harmonization strengthens environmental policy if and only if*

$$X_D > \frac{X}{N}\frac{1-\xi}{2\epsilon\xi + 1 - \xi}\,. \tag{15}$$

Proof: Evaluate $\frac{dW_D^H}{d\theta^H}$ in the harmonized setting but at the decentralized, open economy value θ_D^N:

$$\left.\frac{dW_D^H}{d\theta^H}\right|_{\theta=\theta_D^N} = \frac{PX}{2\epsilon}\left[\frac{X_D}{X}[2\epsilon\xi + 1 - \xi] - \frac{1}{N}[1-\xi]\right].$$

Rearranging terms gives

$$\left.\frac{dW_D^H}{d\theta^H}\right|_{\theta=\theta_D^N} = \frac{P[2\epsilon\xi + 1 - \xi]}{2\epsilon}\left[X_D - \frac{X}{N}\frac{1-\xi}{2\epsilon\xi + 1 - \xi}\right].$$

Since W_D^H is globally concave in θ then positive (negative) $\left.\frac{dW_D^H}{d\theta^H}\right|_{\theta=\theta_D^N}$ implies $D's$ preferred level of policy stringency in the harmonized setting is stricter (weaker) than in the non-cooperative setting.

Proposition 2 implies that when, for example, $\xi = 1$ or $X_D > \frac{X}{N}$, then $\theta_D^H > \theta_D^N$. That is, whenever pollution is perfectly transboundary or the policy makers have above average vested interests in the polluting industry, harmonization induces them to choose stricter policy.

However when $\xi < 1$ and the policy makers instead have sufficiently below average interests in the polluting industry, harmonization instead induces them to *weaken* their environmental policies. Indeed, if pollution were exclusively local, i.e. $\xi = 0$, then harmonization would weaken environmental policy any time the decision makers had below average vested interests in the polluting industry.

Two simple mechanisms underlie these results. First, as expected harmonization makes a decision maker want stricter policy, ceteris paribus, because the harmonization extends the jurisdiction over which policy is binding and so effectively gives the policy maker in one country control over emissions emanating from abroad.

The second mechanism works via prices. When policy is harmonized across countries then a choice of a stricter emission standard raises the compliance costs of producers worldwide, leading to a worldwide contraction in supply. Consequently, the effect on prices of the same increase in policy stringency is amplified by harmonization. This intuition is confirmed by comparison of $\frac{dP}{d\theta} = \frac{P}{\epsilon[1-\theta]}$ in the harmonized case with $\frac{dP}{d\theta} = \frac{P}{\epsilon[1-\theta+1-\theta^*]}$ in the non-cooperative case. This amplification has the effect of shifting the incidence of environmental regulation from the producers to the consumers of dirty goods, with consequences for how different levels of policy stringency are viewed by different vested interests. It reduces opposition to stringent environmental regulation by producers of dirty goods because they will be better compensated for their abatement activities by a global reduction in supply and hence global price increase; harmonization similarly limits the extent to which domestic consumers want excessively strict policy because it reduces their ability to insulate themselves from the costs of domestic emissions abatement by buying dirty goods on international market at low prices.

When the policy makers represent constituents with above-average vested interests in the polluting industry, then the effect of amplified prices works in the same direction on policy preference as does concern over the transboundary externality, and so harmonization induces an unambiguous tightening of environmental policy. However when decision makers represent below-average vested interests in the polluting industry, these two mechanisms work in opposite directions. Interpreting Proposition 2, price concerns are likely to dominate concerns over transboundary pollution the smaller is the coefficient of transboundary transmission ξ, the less elastic is the demand for goods, and the smaller are the vested interests of the decision makers' constituents; when this occurs the decision makers will agree to harmonize their policies downward instead of up.

To understand intuitively why this outcome is possible, recall that the countries in question are linked in two ways: via a transboundary externality and via goods prices. When policy is made more stringent, Home, for example, gains not only because its own emissions fall but also because it is exposed to less pollution from abroad. If there is some purely local component of pollution, though, as when $\xi < 1$, then Home does not receive the full benefit of Foreign's emission reductions. It does however experience the full effect on prices of Foreign's contraction in supply of dirty goods via international markets. The larger are the implicit imports (E_D) of the decision makers' constituents, then the more deleterious is this price response, and the more likely that concerns over price will dominate concern over transboundary transmission of pollution, and so in turn the more likely that the decision makers will agree on weaker environmental policy when coordinating instead of acting unilaterally.

4.2 When harmonization lowers welfare

One may expect that harmonization downward, occuring because there is a political failure that remains uncorrected, signals a loss of welfare for the general populace; in fact the opposite is true. Instead we find that if $\theta_D^H < \theta_D^N$ then harmonization unambiguously raises welfare relative to the non-cooperative case. This is not to say that harmonization is always good for global welfare. We will also derive sufficient conditions for harmonization to lower the joint welfare of citizens in the two countries, and show that joint welfare can only be reduced if there is harmonization up.

Denote by $W_G \equiv \sum_{i=1}^{N} W_i + \sum_{j=1}^{N^*} W_j^*$ the sum of welfare of all citizens of both countries. Denote the level of policy stringency that maximizes W_G by θ_G. It solves the associated first order condition for an interior maximum

$$\frac{dW_G}{d\theta} = -2PX - 2z'(\theta)XN[1+\xi] = 0, \tag{16}$$

or, rearranging and substituting in for P using (1), θ_G solves

$$\frac{v'\left(\frac{[1-\theta_G]X}{N}\right)}{N[1+\xi]} = -z'(\theta_G)\,. \tag{17}$$

Notably, W_G is globally concave (see Appendix A), and so any move toward θ_G improves joint welfare W_G and any moves solely away from it reduce W_G. Moreover, because gross endowments, population and emission abatement technologies are identical across countries, and because W_G is strictly concave in the policy stringency in either country, then W_G is maximized by setting a uniform policy for the two countries. Consequently, θ^G is the globally optimal policy regardless of whether harmonization is mandated or not.

There is a simple relationship between θ^G, θ_D^H, and the endowments represented by the decision makers:

Lemma 1 $\theta_D^H \gtreqless \theta^G$ iff $X_D \lesseqgtr \frac{X}{N}$.

Proof: Any X_D can be written as $X_D = \frac{X}{N}\beta$ where β is some non-negative number not greater than N. Making this substitution in (14) gives $\frac{dW_D^H}{d\theta} = [\beta - 1]\frac{PX}{N}\left[\frac{1}{\epsilon} - 1\right] - \frac{PX}{N} - z'(\theta)X[1+\xi]$. Evaluating $\frac{dW_D^H}{d\theta}$ at θ^G using (17) gives $\left.\frac{dW_D^H}{d\theta}\right|_{\theta=\theta^G} = [\beta - 1]\frac{PX}{N}\left[\frac{1}{\epsilon} - 1\right]$ which is negative (positive) whenever β greater (less) than unity. Since W^H is globally concave in θ then $X_D > \frac{X}{N} \Rightarrow \theta_D^H < \theta^G$, $X_D < \frac{X}{N} \Rightarrow \theta_D^H > \theta^G$, and only when $X_D = \frac{X}{N}$ is $\theta_D^H = \theta^G$.

Lemma 1 states that the decision maker sets the globally optimal policy level in the harmonized setting if and only if she has an average interest in the polluting industry. If she instead has below (above) average vested interest in that industry she sets harmonized policy too strictly (weakly) from the perspective of global welfare. In the discussion below we will refer to an individual with an average endowment of dirty capacity X/N, and so one who sets policy correctly in the harmonized setting, as a representative agent. The partition of endowment space created by the representative agent's endowment is useful in assessing sufficient conditions under which harmonizing policy raises or lowers global welfare.

Proposition 3 *When countries and decision makers are identical, global welfare is higher when policy is harmonized than when set non-cooperatively if either*

1. *the symmetric decision makers have vested interests in the polluting industry that are average or above average, i.e.,* $X_D \geq \frac{X}{N}$*, or*
2. *the symmetric decision makers have vested interests in the polluting industry that are well below average, i.e.,* $X_D < \frac{X}{N}\frac{1-\xi}{2\epsilon\xi+1-\xi}$.

Proof: If $X_D \leq \frac{X}{N}$ then by Proposition 2 $\theta_D^N < \theta_D^H$ and by Lemma 1 $\theta_D^H < \theta^G$. Similarly, if $X_D < \frac{X}{N}\frac{1-\xi}{2\epsilon\xi+1-\xi}$ then by Proposition 2 $\theta_D^N > \theta_D^H$ and by Lemma 1 $\theta_D^H > \theta^G$. In either case the policy level is closer to the globally optimal policy level in the harmonized setting than in the non-cooperative setting. Since W_G is globally concave in θ then any such moves solely toward the globally optimal policy level θ^G raise global welfare.

Combining Propositions 2 and 3 gives the following corollary:

Corollary 1 *Harmonization lowers global welfare only if it induces tighter environmental policy than in the non-cooperative setting.*

Proposition 3 gives separate sufficient conditions for harmonization to raise global welfare. If the decision makers have at or above average interests in the polluting industry, then both channels through which harmonization affects policy preferences make stricter environmental policy more attractive. And since these types of decision makers *always* set policy that is inefficiently weak—they always favor industry at the expense of consumers and the environment by setting $\theta < \theta^G$—if harmonization induces them to set stricter policy it therefore raises welfare.

If, instead, the decision makers have vested interests in the polluting industry that are well below average—in specific $X_D < \frac{X}{N}\frac{1-\xi}{2\epsilon\xi+1-\xi}$—then the amplified price effect of harmonization dominates the extended control effect and the decision makers want harmonized policy that is weaker than in the non-cooperative setting. But these are decision makers who always set policy stricter than would a representative agent who would "get it right" by choosing θ^G in the harmonized setting. Thus the weakening of policy induced by H when $X_D < \frac{X}{N}\frac{1-\xi}{2\epsilon\xi+1-\xi}$, while bad for the environment, raises welfare overall because it brings policy closer to the globally optimal level. As discussed earlier, this happens because harmonization shifts some of the burden of environmental protection away from producers and toward consumers of dirty goods. It does so by magnifying the link between goods prices and the costs of abatement—via curtailed supply in this model—and so harmonization reduces the extent to which vested interests want to distort environmental policy. In some ways harmonization can thus be viewed as a mechanism for reducing the bias generated by the political failure, and when this partial correction compliments the extended control effect of harmonization, or is at least strong enough to dominate it, then harmonization unambiguously raises welfare.

However, as the next proposition shows, there are definable cases in which harmonization instead reduces global welfare.

Proposition 4 *When countries and decision makers are identical, harmonization lowers global welfare if* $X_D \in \left(\frac{X}{N}\frac{1-\xi}{2\epsilon\xi+1-\xi}, \frac{X}{N}\frac{2\epsilon-1-\xi}{[2\epsilon-1][1+\xi]}\right]$.

Proof: Evaluate $\frac{dW_G}{d\theta}$ at $\theta = \theta_D^N$ and rearrange terms to get

$$\left.\frac{dW_G}{d\theta}\right|_{\theta=\theta_D^N} = \frac{PN}{2\epsilon}[2\epsilon-1][1+\xi]\left[X_D - \frac{X}{N}\frac{2\epsilon-1-\xi}{[1+\xi][2\epsilon-1]}\right],$$

revealing that whenever $X_D \leq \frac{X}{N}\frac{2\epsilon-1-\xi}{[1+\xi][2\epsilon-1]}$ then $\theta_D^N \geq \theta^G$: the decision makers' set policy too strictly in the *non*-cooperative setting. If in addition $X_D = X_D^* > \frac{X}{N}\frac{1-\xi}{2\epsilon\xi+1-\xi}$ then by Proposition 2 $\theta_D^N < \theta_D^H$, and so by the global concavity of W_G in θ, harmonization reduces global welfare. The interval $\left(\frac{X}{N}\frac{1-\xi}{2\epsilon\xi+1-\xi}, \frac{X}{N}\frac{2\epsilon-1-\xi}{[2\epsilon-1][1+\xi]}\right]$ is non-empty if $\epsilon > \frac{3}{2} - \frac{\xi}{2}$ when $\xi > 0$.

The intuition behind Proposition 4 is as follows. When acting unilaterally, even though the policy maker in each country is choosing policy to maximize the utility of only a subset of local interests, this political myopia may nonetheless over-compensate for each decision maker's failure to consider the transboundary consequences of local emissions and generate non-cooperative policy that is even stricter than θ^G. Simply, policy set non-cooperatively need not be unduly lax. And if harmonization makes these decision makers want even stricter policy, this moves the economies even further away from the social optimum than they were in the non-cooperative setting, to the detriment of global welfare.

We note that there also exist endowments—in particular $X_D \in \left(\frac{X}{N}\frac{2\epsilon-1-\xi}{[2\epsilon-1][1+\xi]}, \frac{X}{N}\right)$—that do not fit into any of the categories described in Propositions 3 and 4. For such endowments the non-cooperative policy is below the global optimum but the harmonized policy level above: harmonized policy overshoots. Without imposing specific forms on the functions $v(\cdot)$ and $z(\cdot)$ we cannot compare W_G in the harmonized and non-cooperative settings for these remaining endowments, and so cannot divide up this remaining interval into endowments for which the decision makers' responses to harmonization raise or lower global welfare. Instead we simply note that there exist additional endowments not described in one of the propositions above under which harmonization aids the environment but may help or hurt global welfare.

We end this section by summarizing results so far. When the stringency of environmental policy is determined by political agents with identical constituent bases, and the countries themselves are symmetric and experience a symmetric bilateral transboundary externality, policy harmonization does not necessarily generate either environmental or welfare improvements. We have compared policy outcomes in two settings—a non-cooperative setting in which respective policy makers take the stringency levels abroad as given, and a cooperative setting in which policy is harmonized across countries—and found that harmonization has two sometimes counteracting effects on the levels of stringency preferred by the political agents: ceteris paribus, effective control over overseas emissions makes everyone want stricter policy; ceteris paribus, price amplification makes policy makers want stricter or laxer policy depending on the vested interests of their constituents. When these two channels of influence work in opposite directions, which dominates is shown to depend on the size of the transboundary externality, the responsiveness of goods prices to curtailment in net supply, and the extent to which the vested interests represented are below average.

In the analysis above we have concentrated on outcomes when $X_D < X/N$, as these are the cases in our simple symmetric model in which harmonization generates perverse outcomes. Indeed, when decision makers have constituents with above average vested interests in the dirty industry, we find harmonization is unambiguously good for both the environment and aggregate welfare. We caution the reader from concluding that harmonization is therefore a panacea when the interests of dirty industry are over-represented in the objective function of decision makers. Consider, for example, the case where countries are asymmetric only in their gross endowments (i.e. $X \neq X^*$). Then even if both countries had decision makers representing dirty vested interests (i.e. $X_D > X/N$, $X_D^* > X^*/N^*$) in the smaller (importing) country the decision makers' constituents may well be net importers of the dirty good, and so given (4) again prefer weaker policy when harmonizing than when acting unilaterally.

4.3 Over-compliance

A natural question that should always accompany any discussion of policy harmonization is whether subscribing parties have an incentive to cheat on their commitments. And, given that global welfare may well be reduced by harmonization in the case under scrutiny, whether political representatives would ever agree to harmonize in the first place.

In the model presented, the decision makers would always be willing to agree to harmonize policy under the assumption that the other country abides by the policy; this follows from a simple revealed preference argument, since the symmetric nature of the countries considered yields only symmetric non-cooperative equilibria.

The first question—whether the decision makers would always like to abide by the agreement reached—is also straightforward, and as one would expect the general answer is no. If, for example, decision makers D and D^* agreed to harmonize their levels of policy stringency at θ_D^H, it is easy to show that each would prefer to domestically institute a different level of stringency. Evaluating the derivative $\frac{dW_D}{d\theta}$ at $\theta = \theta^* = \theta_D^H$ and treating θ^* as fixed gives

$$\left.\frac{dW_D}{d\theta}\right|_{\theta^*=\theta=\theta_D^H,\ d\theta^*=0} \gtreqless 0 \quad \text{iff} \quad X_D \lesseqgtr \frac{X}{N}\frac{1-\xi}{2\epsilon\xi+1-\xi}\,. \tag{18}$$

That is, in the absence of penalties, a decision maker would like to cheat on the agreement so long as she had preferences that didn't generate $\theta_D^H = \theta_D^N$. This is a rather obvious point: if you could set the policy of your neighbor simultaneously you would like the opportunity to do so, but if you could then adjust your own policy afterward you would like that even better. However the inequality in (18) reveals that if $X_D < \frac{X}{N}\frac{1-\xi}{2\epsilon\xi+1-\xi}$ then D would like to deviate from the harmonized solution by setting *stricter* policy domestically than the internationally agreed upon level. This means that some welfare enhancing multilateral environmental agreements will not be maintainable (given the definition of an appropriate solution to a repeated game) unless penalties for upward defection are also explicit.

5 Conclusions

We have used a purposely simple model of production to investigate the effects of policy harmonization between symmetric countries when environmental regulations are determined by politically motivated decision makers. Using this framework, we have compared levels of policy stringency preferred by decision makers in two countries when acting cooperatively and non-cooperatively. This comparison reveals that cooperation will lead to stricter environmental policy when the decision maker in each country has constituents with above average interests in the polluting industry.

If, however, the decision makers represent constituents who are largely the consumers of polluting goods, then harmonization need not lead to greater stringency in environmental regulation even when there exists a negative transboundary externality. This latter possibility arises whenever the transboundary externality is less than perfect, i.e. if there is some purely local component of pollution. In this case strict harmonized regulation benefits a decision maker's constituents by reducing the amount of pollution that actually spills over from abroad, but to a smaller extent than if the externality were perfectly transboundary. This is in contrast to the way that global prices are affected by strict harmonized policy. When the countries in question are open to free trade then there is full transmission of the price effects of stringent policy, price effects that are detrimental to constituents who are predominately the consumers of polluting goods. When the decision makers' constituents have sufficiently below average interests in the polluting industry then this concern over price effects dominates concern regarding transboundary pollution and cooperation will lead to harmonization downwards instead of up.

We also explore the effects of harmonization on the aggregate welfare of citizens in the two countries. Given the political motivations assumed to drive the decision makers in the two countries, not surprisingly we find that harmonization can lower aggregate welfare. However we find that harmonization that leads to *weaker* environmental policy can only improve welfare, simply because harmonization can only weaken policy if the policy makers were already setting policy excessively high to begin with. It is only when harmonization instead leads to a tightening of environmental policy that welfare may be reduced.

And finally we examine whether the decision makers in question have an incentive to cheat on their commitments to harmonize environmental policy: they do. But not always to enact local policies that are weaker than the internationally agreed upon levels. In the same scenarios under which cooperation would lead to a harmonized policy level that is weaker than what would be set when decision makers act unilaterally, decision makers would like to cheat by setting local standards that *exceed* the international standard. Consequently multilateral environmental agreements may require penalties for excessively green behavior just as they would for excessively polluting behavior if welfare improving agreements are to be maintained.

References

Aidt, Toke. 1998. "Political Internationalization of Economic Externalities and Environmental Policy," *Journal of Public Economics* 69: 1-16.

Antweiler, Werner, Brian Copeland and Scott Taylor. 2001. "Is Free Trade Good for the Environment?" *American Economic Review,* 91: 877-908.

Barrett, Scott. 1997. "Towards a theory of international environmental cooperation," in Carlo Carraro and Domenico Siniscalco, eds., *New directions in the economic theory of the environment.* Cambridge, UK: Cambridge University Press.

Bernheim, B. Douglas and Michael D. Whinston. 1986. "Menu Auctions, Resource Allocation, and Economic Influence," *Quarterly Journal of Economics,* 101(1): 1-31.

Bhagwati, Jagdish and T.N. Srinivasan. 1996. "Trade and the Environment: Does Environmental Diversity Detract from the Case for Free Trade?" in Jagdish Bhagwati and Robert E. Hudec, eds., *Fair Trade and Harmonization: Prerequisites for Free Trade?*, Volume 1. Cambridge, MA: MIT Press.

Carraro, Carlo and Domenico Siniscalco. 1998. "International Environmental Agreements: Incentives and Political Economy," *European Economic Review* 42: 561-72

Fredriksson, Per. 1997. "The Political Economy of Pollution Taxes in a Small Open Economy," *Journal of Environmental Economics and Management* 33: 44-58.

Grossman, Gene and Elhanen Helpman. 1994. "Protection for Sale," *American Economic Review* 84(4):833-850.

Hillman, Ayre L. and Heinrich W. Ursprung. 1992. "The influence of environmental concerns on the political determination of trade policy," in Kym Anderson and Richard Blackhurst, eds., *The Greening of World Trade Issues.* London: Harvester Wheatsheaf.

Kanbur, Ravi, Michael Keen and Sweder van Wijnbergen. 1994. "Industrial Competitiveness, Environmental Regulation and Direct Foreign Investment," in Ian Goldin and Alan Winters, eds., *The Economics of Sustainable Development.* Cambridge, UK: Cambridge University Press.

Markusen, James R., Edward R. Morey, and Nancy Olewiler. 1995. "Competition in regional environmental policies when plant locations are endogenous," *Journal of Public Economics* 56: 55-77.

McAusland, Carol. 2002. "Cross-Hauling of Polluting Factors," *Journal of Environmental Economics* 44: 448-470.

McAusland, Carol. *forthcoming.* "Voting for Pollution Policy: The Importance of Income Inequality and Openness to Trade," *Journal of International Economics.*

Rauscher, Michael. 1992. "International economic integration and the environment: the case of Europe," in Kym Anderson and Richard Blackhurst, eds., *The Greening of World*

Trade Issues. London: Harvester Wheatsheaf.

Schleich, Joachim. 1999. "Environmental Quality with Endogenous Domestic and Trade Policies," *European Journal of Political Economy* 15: 53-71.

Schleich, Joachim and David Orden. 2000. "Environmental Quality and Industry Protection with Noncooperative Versus Cooperative Domestic Trade Policies," *Review of International Economics* 8: 681-697.

Stokey, Nancy. 1998. "Are There Limits to Growth?" *International Economic Review* 39: 1-31.

Wilson, John D. 1997. "Capital Mobility and Environmental Standards: Is There a Theoretical Basis for a Race to the Bottom?" in Jagdish Bhagwati and Robert E. Hudec, eds., *Fair Trade and Harmonization: Prerequisites for Free Trade?*, Volume 1. Cambridge, MA: MIT Press.

Ulph, Alistair. 1997. "International environmental regulation when national governments act strategically," in John G. Braden and Stef Proost, eds., *The Economic Theory of Environmental Policy in a Federal System.* Cheltenham, UK: Edward Elgar, pp. 66-96.

Appendix A: Global concavity of objective functions

When countries set their policy non-cooperatively then $\frac{dW_i}{d\theta} = E_i \frac{dP}{d\theta} - PX_i - z'(\theta)X$. Substituting in expressions for E_i and $\frac{dP}{d\theta}$ from (3) and (8) and collecting terms gives $\frac{dW_i}{d\theta} = -P\left[X_i\left[1-\lambda/\epsilon\right]+\frac{X}{2N\epsilon}\right] - z'(\theta)X$. Differentiating gives $\frac{d^2W_i}{d\theta^2} = -\left[X_i\left[1-\lambda/\epsilon\right]+\frac{X}{2N\epsilon}\right]\frac{P\lambda}{[1-\theta]\epsilon} - \frac{PX_i}{\epsilon}\left[\frac{1-\lambda}{1-\theta+1-\theta^*}\right] - z''(\theta)X < 0$.

When the same policy is used in both countries (i.e. in the harmonized case) then $\frac{dW_i}{d\theta} = -P\left[X_i\left[1-1/\epsilon\right]+\frac{X}{N\epsilon}\right] - z'(\theta)X[1+\xi]$; differentiating gives $\frac{d^2W_i}{d\theta^2} = -\left[X_i\left[1-1/\epsilon\right]+\frac{X}{N\epsilon}\right]\frac{P}{[1-\theta]\epsilon} - z''(\theta)X[1+\xi] < 0$.

And finally, when policy is chosen so as to maximize the sum of welfare of citizens in both countries, then $\frac{dW_G}{d\theta} = -PX - XN[1+\xi]z'(\theta)$; differentiating gives $\frac{d^2W_G}{d\theta^2} = -\frac{PX}{[1-\theta]\epsilon} - XN[1+\xi]z''(\theta) < 0$.

Appendix B: Proof of Proposition 1

Part 1: If $\theta_D^N, \theta_D^{*N}$ are the Nash equilibrium values then they jointly satisfy (11) and (12) and so $\left[\lambda X_D - \frac{X}{2N}\right]\frac{P}{\epsilon} - PX_D - z'(\theta_D^N)X = 0 = \left[[1-\lambda]X_D^* - \frac{X}{2N}\right]\frac{P}{\epsilon} - PX_D^* - z'(\theta_D^{*N})X$. Canceling like terms and rearranging gives the equivalent condition $[z'(\theta_D^{*N}) - z'(\theta_D^N)]X = [1-2\lambda]X_D\frac{P}{\epsilon}$. Without loss of generality, suppose $\theta_D^N > \theta_D^{*N}$. Then $\lambda < \frac{1}{2}$ and the right hand side of this expression is positive. However $\theta_D^N > \theta_D^{*N}$ implies the left hand side of this expression is negative since z is a convex function. This contradicts the supposition that $\theta_D^N > \theta_D^{*N}$. By symmetric reasoning θ_D^N cannot be less than θ_D^{*N} and so the equilibrium policies are symmetric when the decision makers have symmetric endowments.

Part 2: Define by θ^N the symmetric Nash equilibrium policy level in each country. By part 1, when $X_D = X_D^*$ then the equilibrium values solves (11) and (12) evaluated at $\lambda = 1 - \lambda = \frac{1}{2}$, implying θ^N solves

$$\left[X_D - \frac{X}{N}\right]\frac{P}{2\epsilon} - PX_D - z'(\theta^N)X = 0 \tag{19}$$

where $P = v'\left(\frac{[1-\theta^N]X}{N}\right)$. Since $\frac{d}{d\theta}\left[\left[X_D - \frac{X}{N}\right]\frac{P}{2\epsilon} - PX_D - z'(\theta)X\right] = \left[X_D[2\epsilon - 1] + \frac{X}{N}\right]\frac{X}{N}\frac{v''}{2\epsilon} - z''(\theta)X < 0$ then the left hand term in (19) is monotonic decreasing in policy stringency, and so (19) is satisfied only at a single value of θ_D^N and the equilibrium is unique.

Part 3: This follows from the Inada-type conditions imposed in section 2. For example, $\left.\frac{dW_D}{d\theta}\right|_{\theta=1} = -\frac{XP}{2N\epsilon} - PX_D < 0$ whenever $\theta^* \in [0,1]$; similarly $\left.\frac{dW_D}{d\theta}\right|_{\theta=0} = \left[\frac{X_D}{2-\theta^*} - \frac{X}{2N}\right]\frac{P}{\epsilon} - PX_D + \infty > 0$ whenever $\theta^* \in [0,1]$.

Part 4: Differentiating (19) with respect to the decision makers' symmetric endowments and rearranging gives $\left.\frac{d\theta^N}{dX_D}\right|_{dX_D = dX_D^*} = \frac{P\left[1-\frac{1}{2\epsilon}\right]}{[X_D[2\epsilon-1]+\frac{X}{N}]\frac{X}{N}\frac{v''}{2\epsilon} - z''(\theta)X} < 0$.