RESEARCH SEMINAR IN INTERNATIONAL ECONOMICS

School of Public Policy
University of Michigan
Ann Arbor, Michigan 48109-1220

Discussion Paper No. 383

INTERNATIONAL EXTERNALITIES IN THE USE OF POLLUTION POLICIES

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November 11, 1995

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ABSTRACT

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The paper examines a simple partial equilibrium model of a polluting industry in a world economy. Optimal pollution taxes are derived and compared for the countries individually and collectively. Objective functions of governments are permitted to give different weights to producers than to other interests, in recognition of distributional, political economy, or other objectives. It is shown that if 1) pollution does not spill across national borders, and if 2) countries are too small to affect world prices with their pollution policies, then the pollution taxes that countries set independently cannot be improved upon by international cooperation. If these conditions are not satisfied, however, then independently set pollution policies will not be optimal. If pollution spills across borders, this will cause countries to set pollution taxes too low. In contrast, if countries are large enough to affect world prices, then exporting countries will set pollution taxes too high and importing countries will set them too low. However, if the two conditions are satisfied, then pursuit by governments of political-economy or other distributional objectives does not interfere with their achieving policies that cannot be improved upon -- in terms of these objectives -- by international cooperation.

Keywords: Policy Interdependence
Pollution Policy

JEL Subject Code: D62, F1, Q2

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I. Introduction

Environmental issues have begun in recent years to impinge more and more directly on the policies and institutions of international trade. Starting most notably with the "tuna-dolphin" case, in which a GATT panel disallowed a United States ban on imported tuna from countries that did not enforce dolphin-safe fishing, and continuing with the negotiation of an environmental side agreement between the United States and Mexico as an accompaniment to the North American Free Trade Agreement, members of the environmental movement have focused increasing attention on international trade. Some environmentalists have objected to the institutions and rules that have guided international trade policy for the last half century, arguing that these are insensitive to, or even directly contrary to, the needs of the environment. At the same time, other environmentalists have sought to include environmental considerations in international trade negotiations and institutions because they perceive that trade rules and trade sanctions provide one of the few acceptable means of enforcing international discipline, even on issues other than trade. Those of us who are members of the international trade community have often resisted these views and the pressures applied by

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*This paper was written originally as an appendix to Deardorff (1995), providing mathematical demonstration of results that were derived in that paper largely geometrically. In both papers I have benefitted from conversations with my colleague John Jackson, as well as from comments of participants in seminars at the Universities of Michigan and Florida, an international trade conference at the University of Western Ontario, the Spring 1995 Midwest International Economics Meetings in Iowa City, and the conference on Economic Analysis of International Law at George Mason University for which Deardorff (1995) was prepared. I am particularly indebted to Elias Dinopoulos for questioning one of my earlier results and motivating me to do the more systematic analysis of this paper. This research was supported in part by funds payable through Duquesne University Law School and the Law and Economics Center at George Mason University Law School, and in part by a grant from the Ford Foundation to the University of Michigan.

environmentalists because we feared that they would muddy the otherwise clear waters through which we evaluate trade and trade policy. But it is inevitable that countries must pursue objectives other than free trade, and in an interdependent world economy their pursuit of these objectives will in many cases have effects on other countries, often through the channel of international trade.

This paper examines one particular environmental policy, pollution policy, and asks under what circumstances international cooperation could improve on the policies that trading nations will employ acting independently. That is, if countries each set their pollution policies to levels that they regard as optimal given the policies that are being set in other countries, will they succeed collectively in achieving any sort of an optimum? If so, then there should be no need for countries to cooperate in setting their pollution policies. But if not, then there is at least the possibility that all countries could gain by coordinating their policies in some fashion.

I will address this issue in the context of a simple partial equilibrium model of production, consumption, and trade, in which production generates a negative externality that national governments seek to curb through production taxes. Governments will each have their own objective function, defined in terms of producer surplus, consumer surplus, the pollution externality, and the government budget. The objective may simply be to maximize the total of these four components, but I will allow also for the possibility that governments may place different weights on these components, for any of the variety of reasons that have been suggested in the literature on the political economy of trade policy.[1] I will derive the production taxes that will be nationally optimal by these criteria given the taxes of all other countries, and I will compare these to the policies that would be selected if national governments could cooperate.

My results will show that optimizing governments acting independently will achieve an outcome that cannot be improved upon by cooperation if the following two conditions are satisfied:

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[1]See Deardorff (1995) for more discussion of why governments might choose to weight different constituencies differently. A recent political-economic motivation for this assumption may be found in Grossman and Helpman (1994)

1) All pollution externalities are local and do not spill over to directly affect welfare in other countries.

2) All countries are too small to affect world prices.

I do *not* require any restriction on the weights that national governments apply to their various constituencies. In particular, if some (not necessarily all) governments give extra weight to, say, the welfare of their producers than to consumers, such as they might do in response to political motivations, then it will still be true under conditions (1) and (2) that countries cannot improve upon the decentralized policy outcome in terms of these same objective functions. That is, as long as we grant countries the right to set their own domestic objectives, whatever those may be, then small countries dealing with local pollution can be left to their own devices in setting their policies.

II. The Analysis

Consider the following model of the world market for a good supplied and demanded by countries, i:

$$\sum_i S_i(p - t_i) = \sum_i D_i(p) \tag{1}$$

where $D_i(\cdot)$ is country i's demand, a function of the world price, p, and $S_i(\cdot)$ is country i's supply, a function of country i's price to suppliers, $r_i = p - t_i$, which is the world price net of production tax, t_i. Differentiating and solving for the change in price in terms of changes in taxes,

$$dp = \sum_i \theta_i dt_i \tag{2}$$

where

$$\theta_i = \frac{S_i'}{\sum_j (S_j' - D_j')} \tag{3}$$

are positive fractions that sum to $\theta = \sum_i \theta_i < 1$ since $S_i' > 0$ and $D_i' < 0$ for normally sloped supplies and demands.

Welfare of country i is given by the sum of weighted producer surplus, consumer surplus, tax revenue, and a pollution cost E_{ij} borne by county j per unit of output in country i:

$$W_i = (\lambda_i + 1)\int_0^{p-t_i} S_i(\rho)d\rho + \int_p^{\infty} D_i(\rho)d\rho + t_i S_i(p-t_i) - \sum_j E_{ji} S_j(p-t_j) \tag{4}$$

If $\lambda_i = 0$, the country gives equal weight to all sources of welfare. If $\lambda_i > 0$, it gives greater weight to producers in this industry than to other groups. Equation (4) does not allow for varying weights on other components of welfare, although these could be added easily. Most interesting might be to attach a lower weight on pollution for countries that do not acknowledge it as a problem, but since E_{ij} already is defined as the externality as viewed by country i, that possibility can be handled by making E_{ij} small or zero.

Differentiating (4), one obtains the following expression for the change in welfare in country i:

$$\begin{aligned} dW_i &= (\lambda_i + 1)S_i(p-t_i)(dp - dt_i) - D_i(p)dp \\ &\quad + S_i(p-t_i)dt_i + t_i S_i'(dp - dt_i) - \sum_j E_{ji} S_j'(dp - dt_j) \\ &= \lambda_i S_i dr_i + (S_i - D_i)dp + t_i S_i' dr_i - \sum_j E_{ji} S_j' dr_j \end{aligned} \tag{5}$$

where changes in producer prices, $dr_i = dp - dt_i$, have been substituted to simplify, replacing dt_i. The same substitution in (2) yields

$$dp = \sum_i \theta_i (dp - dr_i) = \theta dp - \sum_i \theta_i dr_i \tag{6}$$

from which

$$dp = -\sum_i \frac{\theta_i}{1-\theta} dr_i = -\sum_i \alpha_i dr_i \tag{7}$$

where

$$\alpha_i = \frac{\theta_i}{1-\sum_j \theta_j} = \frac{\dfrac{S_i'}{\sum_k (S_k'-D_k')}}{1 - \sum_j \dfrac{S_j'}{\sum_k (S_k'-D_k')}} = \frac{S_i'}{-\sum_k D_k'} \tag{8}$$

Note that under normal circumstances these slopes of supply and demand curves will be nonzero and finite, and α_i will therefore be approximately zero for small countries. Substituting (7) into (5) we find how each country's welfare depends on all supply prices:

$$dW_i = \lambda_i S_i dr_i - (S_i-D_i)\sum_j \alpha_j dr_j + t_i S_i' dr_i - \sum_j E_{ji} S_j' dr_j \tag{9}$$

Suppose now that all countries use taxes, t_i, to manipulate these supply prices in order to maximize W_i. Then holding $dr_j=0$, $j \neq i$, we have

$$0 = \left.\frac{dW_i}{dr_i}\right|_{dr_j=0,\ j\neq i} = \lambda_i S_i + \hat{t}_i S_i' - (S_i-D_i)\alpha_i - E_{ii} S_i' \tag{10}$$

at the level of the tax $\hat{t}_i$, that optimizes for country i alone given taxes (or supply prices)[2] elsewhere. Thus, solving (10) for $\hat{t}_i$,

$$\hat{t}_i = E_{ii} - \lambda_i \frac{S_i}{S_i'} + \alpha_i \frac{S_i-D_i}{S_i'} \tag{11}$$

[2]Strictly speaking, taxes and supply prices are equivalent for this purpose only if the country is small. What is being identified here is really a Nash equilibrium in supply prices, not taxes, but the two will be the same if countries perceive that they have no affect on the world price. A large country, in contrast, will set its own policy somewhat differently if it believes that other countries will hold their own taxes fixed when it, say, raises its own, *versus* if it believes that they will raise their own taxes in order to stabilize their supply prices. None of the conclusions offered below depend on this distinction, however.

In contrast, world welfare, $\bar{W}=\sum_i W_i$, is maximized[3] when

$$\begin{aligned} 0 \;=\; d\bar{W} \;&=\; \sum_i dW_i \\ &=\; \sum_i \lambda_i S_i dr_i \;-\; \sum_i (S_i - D_i)\sum_j \alpha_j dr_j \;+\; \sum_i t_i S_i' dr_i \;-\; \sum_i \sum_j E_{ji} S_j' dr_j \\ &=\; \sum_i \lambda_i S_i dr_i \;-\; \sum_j \alpha_j dr_j \sum_i (S_i - D_i) \;+\; \sum_i t_i S_i' dr_i \;-\; \sum_j S_j' dr_j \sum_i E_{ji} \end{aligned} \tag{12}$$

Note that $\sum_i (S_i - D_i)=0$ at equilibrium, and let $\bar{E}_j=\sum_i E_{ji}$ be the total external pollution cost of country j's production. We can then isolate the effect of a single country's supply price on world welfare and set it to zero at the world optimum:

$$0 \;=\; \left.\frac{d\bar{W}}{dr_i}\right|_{dr_j=0,\; j\neq i} \;=\; \lambda_i S_i \;+\; \bar{t}_i S_i' \;-\; \bar{E}_i S_i' \tag{13}$$

Solving, this yields the globally optimal tax, $\bar{t}_i$, as

$$\bar{t}_i \;=\; \bar{E}_i \;-\; \lambda_i \frac{S_i}{S_i'} \tag{14}$$

The following conclusions can now be read immediately from (11) and (14):

Proposition 1 (No Policy Externalities): If pollution is strictly local ($E_{ii}=\bar{E}_i$) and if countries are too small to affect world prices ($\alpha_i \approx 0$), then governments will independently set globally optimal pollution

[3]This formulation of world welfare, as just the sum of the national welfares, would be a valid guide to international cooperation only if side payments were possible among countries. However, for my purpose that is not essential. If maximal $\bar{W}$ can be reached without cooperation, then there is no scope for Pareto improvement even with cooperation.

taxes. These will be equal to the local externality if producers get no extra weight in welfare (λ_i=0), but smaller than that if λ_i>0.[4]

Proposition 2 (Pollution Spillovers): If there are pollution spillovers ($\bar{E}_i > E_{ii}$) and countries are too small to affect world prices ($\alpha_i \approx 0$), then pollution taxes will be set too low ($\hat{t}_i < \bar{t}_i$).

Proposition 3 (Terms of Trade Effects): If countries trade and are large enough to affect world prices ($S_i \neq D_i$, $\alpha_i > 0$), and if there are no pollution spillovers ($E_{ii} = \bar{E}_i$), then pollution taxes will be set too high in exporting countries ($S_i > D_i$) and too low in importing countries ($S_i < D_i$).[5]

The general case of both pollution spillovers and terms of trade effects is a mixture of Propositions 2 and 3 and will offer an unambiguous conclusion only in importing countries, where pollution taxes will be set too low.

Note what is perhaps surprising in Proposition 1. In a world of many small countries without pollution spillovers, countries can be left to their own devices even if they disagree on their definitions of country welfare or if they pursue objectives that we might deplore. Thus one or more (even all) countries can attach very high weights to producer interests, for political economy reasons perhaps, and it will still be the

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[4]A special case of local pollution is no pollution at all, in which case this proposition merely deals with the optimal production subsidy, which will be positive if producers get extra weight in the welfare function.

[5]Note that this holds even with extra weight on producer welfare, in which case "too high" and "too low" are in comparison to the world-optimal policies for favoring producers. If there is no pollution and producers get extra weight, then this will translate to production subsidies that are too small in exporting countries and too large in importing countries. The analysis here has not included trade policies, but it is suggestive of a recent result of Bagwell and Staiger (1995), who argue that international cooperation in trade policy (ie., the GATT or WTO) is motivated not by political economy reasons but by terms of trade effects. The analogue here is that production subsidies that are purely for political economy purposes do not require international cooperation unless countries are large enough to influence world prices.

case that none can do better without others doing worse even with cooperation, all in terms of their own objective functions.

Suppose for example that all governments do in fact accord high weights to producers in this polluting industry. Then even though none may be large enough to affect world prices by restricting supply, it is certainly true that they could do so collectively. And it might seem that they would wish to do so, since they could simultaneously reduce pollution and benefit their favored producers by raising pollution taxes and thus raising the world price.[6] But this does not take into account the adverse effect of such a price increase on consumers. It turns out that once all governments of small countries independently balance their own producer, consumer and other interests in setting their policies, no further benefit can be gained collectively.

This analysis has directed attention to two conditions under which countries do not gain from international cooperation. There is a third condition that should be mentioned as well, although it is difficult to model formally and thus has not been mentioned up to now. I have assumed that governments are unconstrained in their pursuit of their objective function, or equivalently that any constraints they do face are unaltered by international cooperation or institutions. Likewise I have assumed that each government really can pursue whatever objective function it or the country collectively believes to be appropriate. But many would argue that political realities either impose constraints on government policy, or that they redirect it toward objectives that most agree are not desirable. In such cases it may be possible for international agreements or institutions either to change the constraints that governments face or to themselves constrain governments from pursuing inferior goals. In such cases, a third clear role for international cooperation becomes apparent: facilitating the pursuit of goals that countries on their own somehow cannot or do not attain. This is one of the purposes that has been suggested for the GATT and now the World Trade Organization (WTO), the existence of which provides a counterweight that helps governments to resist

[6]Indeed, that is precisely what I thought would be optimal in an early draft of Deardorff (1994).

domestic political forces that they view as contrary to the national interest.[7] Likewise in dealing with pollution, governments might agree on the costs of pollution but be unable politically to implement optimal policies because of producer interests that are present but are not viewed as legitimate. Here too an international agreement might be helpful, even for small countries dealing with local pollution. These are considerations that I have implicitly omitted from the formal analysis here by assuming that governments can and do maximize the national welfare function, *W*.

III. Conclusion

This analysis has pointed to two conditions under which it may be desirable to bring environmental issues into a world forum to be addressed. The first is obvious: if pollution crosses national borders, then we cannot expect national governments, acting independently in their own interests, to achieve a desirable outcome. Instead, all will have an incentive to under-tax pollution, the classic problem of a public good. The second is perhaps less obvious, and arises in a context of trade. If countries are large enough to influence world prices with their pollution taxes, then exporting countries have an incentive to over-tax pollution, while importing countries under-tax, both seeking to turn the terms of trade in their own favor. Thus, in a trading world pollution policies have trade effects, and these too may call for some form of international cooperation or coordination. Of course, to say that independent policies are suboptimal is not to imply that any particular international institution, such as the WTO, would necessarily do any better. But it does suggest that forms of international cooperation that link trade and the environment should at least be considered.

If anything is surprising in these results, it is that they do not depend on governments pursuing any particular conception of economic welfare. Thus governments may consider income distribution in setting

[7]See Jackson (1989) for a comprehensive discussion of the role of the GATT in the world trading system.

their policies, or they may respond to political interests that favor some groups or individuals over others, and it is still the case that small countries dealing with local pollution can be left alone.

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