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Appendix

A NOTE ON TRANSFRONTIER EXTERNALITIES, TRANSACTIONS COSTS, AND LONG-RUN INTERNATIONAL ADJUSTMENT IN FIRMS AND FACTORS OF PRODUCTION

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Transactions costs (or information, negotiation, and policing costs) may affect negotiations in a multitude of ways depending on their source. These include: uncertainty and information gaps (or costs); known or unknown contracting or negotiation costs; costs associated with organizing and sustaining negotiation between countries including dissemination of information; and enforcement costs for existing contracts or treaties. Of these different types of transactions costs we shall concentrate briefly on two types—those associated with confronting an uncertain prospect of a future perturbation (externality) and those costs associated with negotiation once the externality has occurred. What we wish to establish is that differences in risk aversion between emitters and receptors will cause adjustments in the allocation of resources and negotiated level of externality depending on whether the "third party" principle or "victim pays" principle prevails.

There appear to be four cases regarding transactions costs for trans-

NOTE: A model not too dissimilar to the one applied here emphasizing intracountry location is developed by W. J. Baumol in "On Taxation and the Control of Externalities," *American Economic Review* (June 1972). This is an abbreviated and transformed section of a paper by the same authors entitled, "Coase Proposition, Wealth Effects, and Long-Run Equilibrium," Working Paper No. 19, *Program in Environmental Economics,* University of California, Riverside (April 1972).

frontier externalities: (a) where transactions costs are always or nearly zero between emitter and receptor countries; (b) where transactions costs are positive and significant both before and after emergence of an externality; (c) where transactions costs are positive before the externality appears but zero thereafter; and (d) where transactions costs are zero before the externality appears but positive and perceptively significant thereafter. Case (a) can easily be disposed of as one which rules out the existence of externalities that are not a priori resolved by market negotiations. The Coase proposition is a special case of (c). Case (d) appears to be unreasonable. Finally, case (b) is the important one taxonomically for analyzing "real world" problems. An important subset of cases under case (b) arises where transactions costs are different for the two parties either independent of or dependent upon the prevailing rule for liability, i.e., either the "third party," "polluter pays," or "victim pays" principle are operative or not.

A semirealistic case is one where, under complete liability, the receptor country incurs negotiation costs and, under complete nonliability, the emitter country must pay such costs.[1] Thus, we simply assume those who potentially gain are assumed to initiate negotiation and underwrite the cost of negotiation. Let Ψ_{TP}^*, Ψ_{VP}^*, Ψ_{TP}, and Ψ_{VP} denote the level of externality-generating activity, for the cases of zero transactions costs and *TP*, zero transactions costs and *VP*, positive transactions costs with *TP*, and positive transactions costs with *VP* rules, respectively. Given the assumption that the contract curve is upward sloping, and not too dissimilar marginal utilities of income or marginal disutilities of payments for negotiation exist between countries, then it can be asserted $\Psi_{TP}^* \leqq \Psi_{TP}$ and $\Psi_{VP}^* \leqq \Psi_{VP}$. That is, positive negotiation costs, regardless of *VP* or *TP* rules, will impede negotiation so that the optimal level of externality-generating activity *with* zero negotiation costs is not achieved. Given the assumptions above, then $\Psi_{TP}^* \leqq \Psi_{VP}^*$. This implies $\Psi_{TP}^* \leqq \Psi_{VP}^* \leqq \Psi_{VP}$, but does not imply $\Psi_{TP} \leqq \Psi_{VP}$. Thus, costly negotiation where one country incurs these costs may lead to a case where the TP rule results in a higher level of externality-generating activity than the VP rule. This outcome can be induced by differences in marginal utility of income between the emitter and receptor countries as well as a large number of other assumptions on initial endowments or preference maps. The important point here is that it cannot be a priori determined that complete liability or the "third party" principle will reduce external diseconomies by a greater amount

1. However, that component of information and negotiation attributable to court proceedings may be awarded to the receptor after settlement.

than no such principle when negotiation costs are introduced and must be paid by the country initiating negotiation. If negotiation costs are different for the two countries, the outcome is even less clear. It has often been contended that emitters must have lower negotiation or organization costs than receptors since receptor countries are generally more in number while the emitter is usually viewed as a single (source) country. With this type of differential in negotiation costs, there is still no clear-cut statement that can be made on the inequality between Ψ_{VP} and Ψ_{TP}. It depends again on who incurs the costs of organization and negotiation. Under the TP rule, the receptor country must undertake negotiation costs since there is no incentive for the emitter to do so. However, under the VP rule, there is an incentive for both to undertake negotiation and incur such costs. If the receptor must pay negotiation costs under either legal rule, then without further assumptions the inequality between Ψ_{VP} and Ψ_{TP} cannot be determined. If the receptor country pays negotiation costs with the TP rule but the emitter country pays these costs under the VP rule, then it can be expected that $\Psi_{VP} \leqq \Psi_{TP}$, provided the emitter has lower negotiation costs. What is important from the above statements is that the "third party" principle (TP) or lack of it with negotiation costs for allocative efficiency requires an additional rule specifying who incurs these costs. Without such a rule, negotiation may be completely stopped and thereby yield inefficiencies.

Thus far, we have not introduced uncertainty explicitly into the discussion even though the characterization of a world with externalities hints at analyzing externalities as unexpected, or at least, uncertain events. If externalities can be identified as uncertain events where a probability distribution is identified for each type of externality and there are methods to reduce the probability of occurrence to zero or some reasonable level, e.g., construct and operate a tertiary treatment plant on the Rhine, then the externality problem can be analyzed, at least partially, with tools from probabilistic microeconomics. We shall not do that here but suggest some obvious results. First, if the emitter country is more risk averse than the receptor, then its government may require purchase of control dvices under the TP but the receptor may not with its absence.

So far, we have viewed transactions costs as the dominant factor in externality negotiations. Next, we turn to a semiclassical long-run case of competition between firms, in an international context. In so doing, a particular set of transactions costs are preserved, namely, that firms are price takers, but output adjustments shift international prices. Firms are assumed to move internationally in search of the highest profits with no hindrance by governments or entry costs and observing no other signals

than current profits. Thus, a "perfect capital" market internationally is implied. We also make the simplifying assumption that each country has a distinct comparative advantage in producing one type of commodity and that is *all* it produces. In addition, to avoid balance of payments and other complications, we presume that each country is in a partial equilibrium world where demand price for their product is prespecified at any level of output. Finally, no third party is presumed to enter and arbitrage externalities such that potential gains from trade are exhausted. The question to be resolved is whether or not negotiations between producing countries' firms exploiting the gains from trade made available by an externality in production will result in an efficient solution not just in the short run but in the long run among countries. Since profitability among countries determines entry (presumed to be costless), and since the adoption of either the TP or VP principles will affect relative profitability in emitter and receptor countries, it is clear that the international location of industry will be affected by which principle is adopted.

We will consider a two-country partial equilibrium model with a diffuse externality such that the output of industry in country 2 adversely affects the production of every firm in country 1 in a like manner. An example might be the release of air pollutants by industry of one country into an airshed with instantaneous horizontal mixing which also contains a second country's industry. The questions would then be to determine how large the industries should be in each country from the viewpoint of international efficiency. Where there are n_1 identical firms each producing output y_1 in country 1 and n_2 identical firms each producing output y_2 in country 2, we can write inverse demand functions (price P_i as a function of country output $n_i y_i$) for country 1 as $P_1(n_1y_1)$ with $P_1'(n_1y_1) < 0$ and for country 2 as $P_2(n_2y_2)$ with $P_2'(n_2y_2) < 0$, where the prime denotes a first derivative. The total production cost for each firm in country 1 is given as $C_1(y_1) + D_1(n_2y_2)$ where $C_1(y_1)$ is the direct cost of production for each firm in country 1 and $D_1(n_2y_2)$ is the damage incurred by each firm in country 1 as the result of the emissions of country 2. Note that we are presuming damages are separable of other production costs in the receptor country. However, our results concerning the optimality of various policy measures are generally not dependent on this assumption. Total cost for each firm in country 2 is $C_2(y_2)$. We assume C_1', C_2', C_1'', $C_2'' > 0$ and D_1', $D_1'' > 0$ in the relevant regions of production.

The conditions for a global optimum for both countries taken together is obtained by maximizing net benefits (NB) which can be defined as the difference between willingness to pay for the output of both countries and

the total cost of production in both countries. Thus, the international optimum in a partial equilibrium framework is a maximum of:

$$NB = \int_0^{n_1 y_1} P_1(s_1)\, ds_1 + \int_0^{n_2 y_2} P_2(s_2)\, ds_2 \qquad (1)$$
$$- \{n_1[C_1(y_1) + D_1(n_2 y_2)] + n_2 C_2(y_2)\} \qquad y_1, y_2, n_1, n_2 \geqq 0$$

where s_1 and s_2 are dummy variables of integration in the demand functions for the output of each country. Assuming an interior solution, the first order conditions are:

$$\partial NB/\partial y_1 = n_1(P_1 - C_1') = 0, \qquad (1.1)$$
$$\partial NB/\partial y_2 = n_2(P_2 - C_2' - n_1 D_1') = 0, \qquad (1.2)$$
$$\partial NB/\partial n_1 = P_1 y_1 - (C_1 + D_1) = 0 = \pi_1^*, \text{ and} \qquad (1.3)$$
$$\partial NB/\partial n = P_2 y_2 - (C_2 + n_1 D_1' y_2) = 0 = \pi_2^*. \qquad (1.4)$$

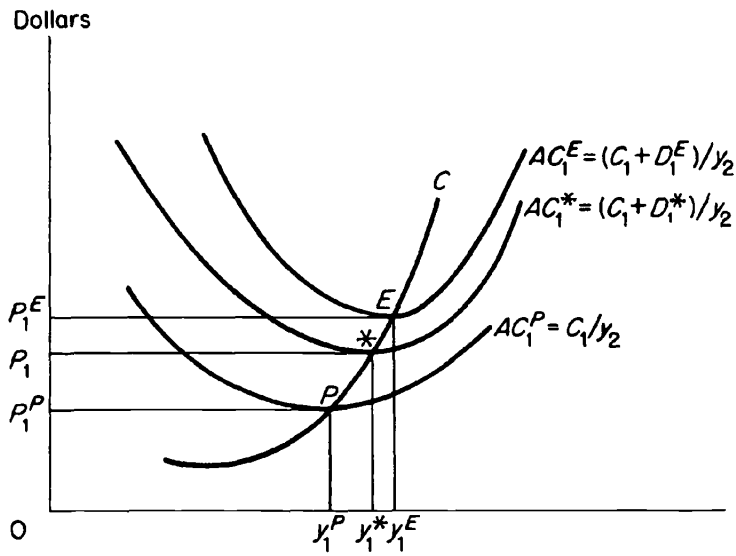
The interpretation of (1.1) and (1.2) is quite straightforward and implies, where $n_1, n_2 \neq 0$, that for each firm in country 1 price should be equal to marginal cost (C_1'), and that for each firm in country 2 price should be equal to marginal cost (C_2') plus marginal damages to country 1 ($n_1 D_1'$). These are the usual short-run conditions with a unidirectional external diseconomy between countries. The conditions for a long-run optimum, (1.3) and (1.4), are more interesting since they should correspond to the definition of zero profits for firms in countries 1 and 2 respectively (assuming firms enter or leave countries until profits are zero). Equation (1.3) implies that $\pi_1^* = 0$ is the optimum level of profits where the receptor country bears the full cost of the externality D_1 at the optimum. This result suggests that compensation for damages will distort long-run equilibrium in the receptor country. Equation (1.4) implies that $\pi_2^* = 0$ is the optimum level of profits where the emitter country must bear an additional cost of $n_1 D_1'$ per unit of output y_2 produced. This can be interpreted as an optimum long-run Pigovian tax equal to marginal damages on the output of the firms in the emitter country.[2] We note then, that the optimal policy after taxation by an "international tribunal" or agency is to do nothing with respect to the receptor country, allowing it to bear the cost of the externality after the optimal tax on output has been applied to firms in country 2. This will assure the optimum number of firms in each country.

2. A similar result is obtained by Baumol in his *American Economic Review* article. Baumol, "On Taxation."

The relationship between the optimal Pigovian tax case (denoted *), the unadjusted externality case (denoted E), and the TP principle case (denoted P) can be best demonstrated with the aid of figures 1 (a firm in country 1) and 2 (a firm in country 2). In figure 1, the optimal long-run

Figure 1

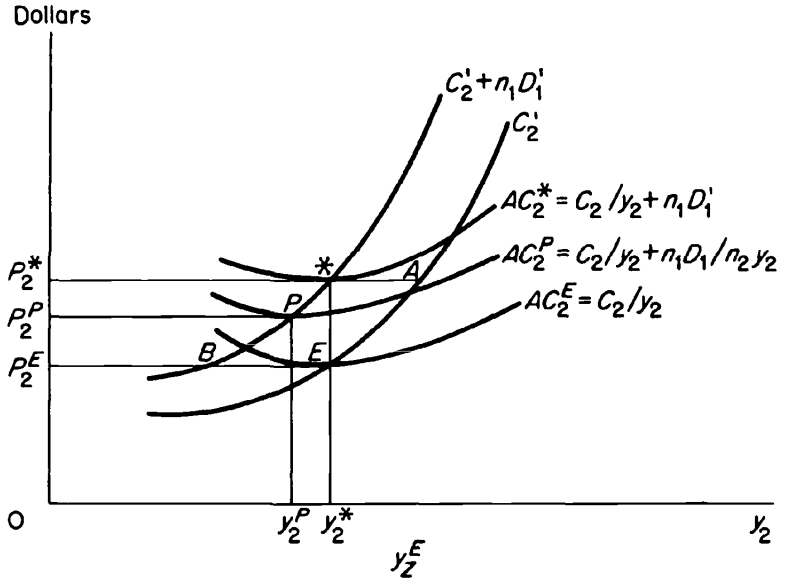
Costs and Output Adjustments of One Firm in Receptor Country



equilibrium point for receptor firms is * at the lowest point of the average total cost curve *including* optimal damages suffered (AC_1*). This point is defined by the intersection of the marginal cost curve (C_1') with the adjusted average total cost curve (AC_1*). As damages (D_1) increase with increasing output of country 2, the average total cost curve of firms in country 1 including damages shifts upward. We presume that where the optimum tax is applied to firms in country 2 and free entry exists for both countries, there will be a convergence to D_1*, the optimal long-run level of damages, and optimal price P_1* and quantity y_1* will result from the long-run equilibrium point (*). Note that this optimum is a basis of comparison since gains from trade are possible between the two countries

Figure 2

Costs and Output Adjustments of One Firm in Emitter Country



so long as a Pigovian tax is not charged and receipts randomly distributed.

The optimum equilibrium point in figure 2 for firms in country 2 is also denoted *. This can be defined by the intersection of the average total cost curve including the tax (AC_2^*) with marginal social cost ($C_2' + n_1 D_1'$). Note that this point corresponds to the zero profit condition for firms in country 2 where AC_2^E is the unadjusted average cost and the area $P_2^E E^* P_2^*$ is the optimal long-run tax collected from each firm in the emitter country. This implies that if through some mechanism not involving a tax or levy the two countries reach the optimum points * in figures 1 and 2, positive profits equal to the area $P_2^E E^* P_2^*$ times n_2^* will be obtained. Since positive profits will induce more firms to enter country 2, the optimum point * cannot be a stable equilibrium under free entry. Thus, the Pigovian tax, if achieved through international management agencies, serves to remove these destabilizing profits.

The uncompensated externality case results in a long-run equilibrium

at point E in figure 2 for firms in country 1. Here, since damages received (D_1^E) will be greater than optimal (D_1^*), the average cost curve (AC_1^E) will lie above AC_1^*. Since the externality is separable, the marginal cost function (C_1') does not shift, so entry or exit occurs until profits are zero resulting in a long-run price of P_1^E and output per firm of y_1^E. This implies, where the demand function for country 1 as a whole is downward sloping ($p_1' < 0$), that total industry output and number of firms will be less than optimal in the unadjusted externality case for receptors, since externality price and output for each firm are both greater than optimal price and output per firm, respectively. This occurs because at the higher (nonoptimal) price, demand for the country's product is less. In figure 2 the long-run externality equilibrium point for firms in the emitter country occurs where average cost (AC_2^E) equals marginal cost (C_2') resulting in a price (P_2^E) lower than the optimum price (P_2^*). However, firm size is still optimal since output (y_2^E) in this case is identical to the case under taxation (y_2^*). The intuitive explanation of this result which is not dependent on separability is simply that, in spite of the externality, international product is still maximized by producing each unit of y_2 as cheaply as possible. This implies that in the unadjusted externality case, there will be too much total output from the emitter country and too many firms, because the demand curve for the country is assumed to be downward sloping ($P_2' < 0$) even though each firm perceives demand as infinitely elastic. Thus, in the unadjusted externality case, there is an *underallocation* of resources to the receptor country and *overallocation* of resources to the emitter country compared with the international optimum.

In the complete liability or TP case discussed here we assume that firms in country 1 are compensated for damages and that potential entrants into the industry of county 1 are aware that they too will be compensated. Firms in country 2 are responsible for damages done to country 1 and we assume, since the externality is diffuse and the firms are taken as identical, that each must bear the cost of compensation equally. With liability, profits for firms in country 1 and 2 can then be written as:

$$\pi_1 = P_1 y_1 - C_1(y_1) - D_1(n_2 y_2) + [D_1(n_2 y_2)] \tag{2}$$

and

$$\pi_2 = P_2 y_2 - C_2(y_2) - [n_1 D_1(n_2 y_2)/n_2],$$

where the terms in brackets are compensation or liability payments by firms in each country respectively. The first order conditions for maximum profits in each firm, assuming an interior solution, are:

$$\partial\pi_1/\partial y_1 = P_1 - C_1' = 0 \tag{2.1}$$

and

$$\partial\pi_2/\partial y_2 = P_2 - C_2' - n_1 D_1' = 0, \tag{2.2}$$

which imply that the conditions for short-run optimality are satisfied. However, if it is assumed that firms enter until profits are zero, compensation to country 1 results in a long-run equilibrium (position P in figure 1), the lowest point on the average cost curve without damages (AC_1^P) for firms in the receptor country. Again, the marginal cost function (C_1') does not shift since damages are separable and the resulting price (P_1^P) and output for each firm (y_1^P) under the TP principle is less than optimum. Thus, both *total* output of country 1 and the number of firms will be too large for the receptor country in the TP principle case since demand for the country's output will be greater at the lower price.

Turning to figure 2, firms in country 2 will reach an equilibrium point (P) in the long run under the TP principle which is the lowest point of the average total cost curve including each firm's share of damages to be paid (AC_2^P). Note that because total damages increase at an increasing rate, marginal damages ($n_1 D_1'$) are greater than average damages ($n_1 D_1 / n_2 y_2$), so AC_2^P lies below AC_2^* and therefore the intersection of the marginal social cost function ($C_2' + n_1 D_1$) and AC_2^P must be below and to the left of the optimum point (*). This is the point of zero profits including liability for damages for the emitter country. Both price (P_2^P) and output (y_2^P) are too low for each firm in country 2. However, total country output will be too high and there will be too many firms in the emitter country under a TP principle since, given the lower price, aggregate demand for the country's output will be too high. Thus, there results a long-run *overallocation* of resources to *both* country 1 and 2. Taxes or other controls are necessary to prevent a misallocation of resources in long-run international production even if there are well-defined rights with a TP principle on the externality.

A TP principle solution *could* be adjusted to the optimum equilibrium point by taxing receptors an amount equal to the damage payments they receive and taxing emitters an amount equal to the difference between average damages and marginal damages, a procedure inefficient as regards international information and enforcement costs to make this bargaining solution appear unattractive.

The complete nonliability case or victim-must-pay principle can best be explained in two steps. First, we will demonstrate that a negotiated solution under a nonliability rule cannot sustain the optimum points (*)

assuming that the number of firms in each country is constrained to be less than or equal to the optimum ($n_1 \leqq n_1^*$, $n_2 \leqq n_2^*$). As will be seen later, this assumption prevents a free rider problem from upsetting the potential equilibrium point (*) in figures 1 and 2. Assume that firms in both countries are initially at *. Next, observe that * for firm 1 in figure 1 is a point of zero profits. However, in figure 2 it is clear that firms in country 2 could earn profits greater than those obtained under * by moving to point A. Thus, for * to be achieved by negotiation for firms in country 2, firms in country 1 must offer to pay a bribe at least equal to the difference between profits at * and profits at A to existing firms in country 2. Clearly, firms in country 1 are making zero profits at * in figure 1 and cannot pay any bribe. Thus, the optimum points * in figures 1 and 2 are not feasible under a "victim pays" rule even ignoring the destabilizing effects of entry on coalitions since firms in country 2 must be made at least as well off at market price P_2^* as they would be by not adjusting for the externality. Thus, firms in country 2 would be unwilling to remain at *. It is conceivable, with the number of firms fixed by controlling entry through some licensing or national ownership process, to achieve a short-run optimum with a solution somewhere along the marginal social cost function ($C_2' + n_1 D_1'$) in figure 2. However, the number of firms in country 1 must be fixed ($n_1 \leqq n_1^*$) such that profits sufficient to cover bribes to firms in country 2 can be obtained. Clearly, without some taxation policy, even by controlling entry, the long-run optimum solution is not attainable under the VP principle since the receptor country cannot afford to bribe emitters.

If free entry is allowed, potential entrants always have a valid threat of entry in the nonliability case if market prices are above P_2^E in country 2 or above the lowest point of the current average cost plus average damages in country 1. It is clearly impossible to bribe potential firms to stay out of a country as long as they could earn positive profits by entering; because of free information regarding current profitability, an indefinitely large number of potential firms would eventually threaten to enter. In figure 2, entry would result in an eventual price of P_2^E for firms in country 2 with a short-run optimum position at point B, implying negative profits for emitter firms. However, this point cannot be stable because firms in country 1 must earn sufficient profits to compensate firms in country 2 for their losses. But free entry into country 1 will tend to force profits in that country to zero by a free rider process where receptors will enter (given a level of emissions reduced by negotiations between existing firms), join the coalition, but find profits eventually reduced to the point where firms in country 2 can no longer be bribed to reduce

output. Potential entrants cannot realize that entry must lower prices, thereby destabilizing existing solutions; nor does the country's government establish entry constraints by assumption. This sketch of events implies that under a VP rule with free entry, negotiated solutions are unstable. One can again imagine a sufficiently complicated set of regulations and/or taxes to allow an optimal solution to be obtained under a VP rule.

Although we have excluded explicit negotiation costs from this analysis, it is difficult to imagine any set of circumstances, in which firms are competitive (free entry is of course a necessary condition for the existence of competitive firms), an externality exists between countries, and long-run optimality is achieved without taxation or other forms of internationally established entry restrictions. It is possible that governments could act in concert to simulate a "Pigovian" solution provided agreement could be achieved on the "third party" principle. In this case, an efficient allocation of global resources could be achieved by the receptor government collecting damage payments from the emitter government and using them for purposes other than compensating the firms or citizens adversely affected.

COMMENT

Larry E. Westphal, Northwestern University

D'Arge's paper contains a provocative argument that is unfortunately obscured by his attempt to cover too much ground in a single paper. This discussion will concentrate on that argument both because of its importance and because much of d'Arge's subsequent analysis stems from it. In reading the paper, one is immediately led to ask what distinguishes transnational environmental externalities from those environmental externalities whose effects are confined within a single nation (hereafter called national environmental externalities). One might argue that there is no *analytical* difference, so that the distinction is unwarranted. But d'Arge's contention is that there is a basic *political* difference that has substantive implications.

His argument rests on two observations. First, national sovereignty makes it impossible to force a nation to pay environmental damages. Second, nations are likely to find it politically expedient to avoid the explicit entitlement or regulation of common property resources, as each nation's perceived ownership in the absence of explicit rules exceeds the share that it could "reasonably" expect under a system of rules. In short, each

nation (or at least a sufficient number of nations to block any common agreement) expects that it will be better off without explicit entitlement or regulation, and there is no means to force either upon unwilling nations. Following from these observations is the conclusion that transnational environmental externalities will be dealt with through bilateral negotiations coupled with side payments between receptor and emitter nations. This is in contrast to their resolution through the action of supranational agencies having regulatory control over particular resources or through explicit multinational agreements on the entitlement of or regulating the use of common property resources such as the oceans. D'Arge also draws from these observations the implication that negotiations will follow the "victim must pay" principle under which the receptor nation either (a) does what is possible within its borders to resolve the effects of the externality without the cooperation of or compensation from the emitter, or (b) "bribes" the emitter to take appropriate remedial action.

The original contribution of the paper is this argument: it is an argument that bears scrutiny. d'Arge's implicit view of the resolution of national environmental externalities seems naive and may lead him to overstate the distinction between expected modes of resolving environmental externalities at the national and multinational levels. In the first instance, the observations made regarding national sovereignty and perceived versus "actual" common property rights apply as well to individuals. Without government coercion, individuals (at least the strongest) cannot be forced to pay damages and may be unwilling to establish rules concerning common property rights. And, to varying degrees, governments are dependent upon the will of constituent interest groups and so do not constitute agents that are somehow completely independent of these. Why is it, then, that individuals within a nation find it in their collective interest to subscribe to a system of rules enforced by government coercion, whereas nations do not or will not find it in their interest to come under an analogous set of enforceable rules?

Early in the paper, it appears to be suggested that the answer rests upon the greater severity of distributional gain and loss problems, measurement problems, questions of responsibility assignment, uncertainty, etc. in the case of transnational externalities. But this answer is not acceptable; for each of the observations made on these pages applies equally well to national externalities. Reading between the lines of d'Arge's paper, I suspect that ultimately the answer lies in two peculiar attributes implicitly ascribed to transnational externalities: they are limited in number and they are predominantly unidirectional (i.e., with a single emitter causing damages to a single receptor without the receptor

of one form of pollution being the emitter of another form and vice versa). If this is true, we may then imply reluctance on the part of nations to enter into multinational arrangements parallel to those found at the national level by the following argument. It seems reasonable to argue that "sovereign" entities, be they individuals within a nation or nations within the world, decide whether or not to enter into a collective and enforceable agreement regarding externalities on the basis of the expected gains and losses from entering into the collective agreement. Where the probability of being adversely affected by the external effects of others' actions is large enough (and the costs high enough), an individual party will find it in his interest to subscribe to a set of rules even though this limits his own action or imposes costs. Where that probability is small, it is less likely that the individual parties will agree to a common set of rules. It further seems reasonable to argue that an individual party's assesssment of the probability of being adversely affected by externalities depends upon the number of externalities perceived. If they are few, then the expected gain from entering into an agreement will be small. Thus, if the number of significant transnational externalities is limited, it follows that enforceable agreements among nations will not be in the interests of any but those on the receiving end of particular externalities. In particular, such agreements will not be perceived to be in the self-interest of "today's" emitter nations who will assign a very low probability to being receptors at some future point in time.[1] Finally, the unidirectional nature of the externalities implies that no additional gain results from increasing the number of parties to any agreement.

If the above argument is essentially right, then whether d'Arge's expectation of resolution through bilateral negotiations based on the "victim must pay" principle is correct or not is an empirical issue. Are transnational externalities limited in number and predominantly unidirectional? One source of examples with which I am familiar suggests that neither characterization is correct.[2] The paper's almost exclusive concern with the bilateral negotiation of unidirectional externalities therefore appears too restrictive, and it may be misleading.

1. A corollary to the foregoing argument is that agreements are more likely to be mutually acceptable the broader their scope, i.e., the larger the number of externalities (existing and potential) dealt with in the agreement. For example, nations that might block agreements on water pollution within a particular body of water or along a specific water course may find it in their self-interest to subscribe to agreements covering all water and air pollution.

2. See Baumol, William J., *Environmental Protection, International Spillovers and Trade,* Wiksell Lectures 1971 (Stockholm: Almquist & Wiksell, 1971).

To conclude these more general comments, I do not agree with d'Arge's expectation that bilateral negotiation will be the common mode of resolution.[3] Nor does he appear to agree with it completely, for he seems to feel that the probability of acceptance of the "third party" principle is sufficiently great to warrant its detailed analysis. If there can be common agreement on the third party principle as the basis for bilateral negotiation, then why is agreement on, for example, the formation of supranational agencies impossible? This is not to suggest that supranational agencies are the answer to the problem; however it does appear that continuing and simultaneous negotiations involving a number of nations is a more efficacious way of dealing with the problem than is case-by-case bilateral negotiation. As regards the empirical basis for d'Arge's conclusion, two further observations come to mind. First, it is only recently that transnational externalities have become a matter of great concern. As more thought and effort are directed toward this problem one can expect the perceptions of its dimensions to increase along with the number of perceived cases of transnational externalities. Second, some of the most glaring instances of transnational externalities involve more than two parties, at least as receptors (e.g. pollution of the Rhine in Europe).

Why should we be concerned with the mechanisms through which transnational externalities are likely to be resolved? Here I think that d'Arge has a valid and extremely important point: the efficiency with which resources are allocated depends upon the negotiating mechanisms through which transnational externalities are resolved. Equally important, the distribution of gains and losses depends critically on the negotiating rules. If resolution is to be expected through bilateral negotiation, then d'Arge is more than justified in investigating the allocative and distributional consequences of alternative bilateral negotiating schemes, as he does throughout the paper. On the other hand, if bilateral negotiation has as its consequence continued misallocation, then it is important to scrutinize the empirical basis for expecting bilateral negotiation and to seek multilateral alternatives. It may be expected that bilateral negotiation, which implies that each nation *separately* strives for efficient allocation within a set of negotiating rules, will be less efficient globally than arrangements under which system-wide efficiency is sought.[4] D'Arge demonstrates that, under a plausible set of assumptions including interna-

3. In fact there are already some instances of multilateral agreements. See Baumol, *Environmental Protection*.

4. See Baumol, *Environmental Protection*, p. 42, for an additional example to that cited from d'Arge's paper.

tional capital mobility, none of the forms of bilateral negotiation contemplated lead to an efficient allocation of resources.[5]

I now turn to a number of specific comments. With the exception of those parts of the paper which use a game theory approach, the remainder of d'Arge's paper is largely an application of models developed in relation to national externalities to the problem of transnational externalities. The conclusions reached, for the most part, parallel similar conclusions regarding national externalities. One shortcoming of the paper is the complete neglect of trade policy, which in isolated cases may yield a feasible first best solution. To give but one example: assume that country A in producing commodity X transmits an external diseconomy to country B, and assume further that country B is the sole consumer of commodity X, all of which it obtains through trade with country A. If country A cannot be forced to take action resolving the external diseconomy, then country B could levy a tariff on imports of X and thereby achieve a Pareto efficient allocation of resources with respect to its own consumption and production. (In this case the global allocation is also Pareto efficient; see Baumol, *Environmental Protection,* section 13.) The matter becomes more complicated in an "n" country world, but "defensive" trade policy may still yield an improved allocation of resources from the receptor's point of view.

In the second section of the paper, in which the measurement of wealth effects is discussed, it is alleged that removal of the externality or compensation may make the receptor worse off due to a change in world market prices. This is a much more complex issue than is recognized in the discussion, which is based on the assumption, employed throughout, that individual nations are price takers in international trade. If this assumption is removed and, for example, the possibility for an "optimum" tariff is introduced, then it seems unlikely that the receptor can be made worse off through the resolution of an externality. The only case in which such a possibility might be realized arises where the receptor's actions have no effect on world prices, all of the effect coming from the emitter's actions.

The third section of the paper deals with consumption externalities and concludes that bilateral adjustment schemes lead to a Pareto efficient allocation so long as all factors of production are not internationally mobile. This is a consequence of the derived result that transnational externalities will generally not cause a shift from convexity to concavity of

5. D'Arge does not analyze the "polluter pays principle" which might, if suitably implemented, lead to an efficient outcome.

the domestic production transformation frontiers. But this last result is surely a trivial one. It still remains true that the "international" transformation frontier may be concave, implying a globally inefficient allocation. Thus there is still cause for concern. D'Arge's point is simply that, so long as the receptor acts as an externality taker (i.e., perceives the level of the externality as fixed and optimizes subject to that fixed level), the receptor's national transformation frontier will remain convex if it were convex in the absence of the externality. The point being made in criticism is that only in exceptional cases will the level of the externality be completely independent of the receptor's actions.

The game theory discussion, though far from rigorous, is suggestive and is the most interesting and significant part of the paper. The discussion is ambiguous at many points, however. To cite but one example, the concluding sentence under point 5 appears to confuse two issues with regard to negotiation. The first issue is whether any action at all toward the resolution of an externality will be taken on the part of the emitter. Clearly, under the "third party" principle, such action will be forced upon the emitter by the receptor unless transactions costs are both prohibitive and levied upon the receptor. In this sense, negotiation will take place because of the incentives to the receptor to force negotiation (i.e. resolution) on the emitter; clearly the emitter is better off not opening up negotiations through a third party. The second issue concerns whether the resulting resource allocation is efficient. With respect to this issue, it is not clear that the emitter is better off not negotiating. To take a simple example, let us assume that the costs of pollution abatement in the emitter country are 100 while they are 80 in the receptor country. Under the "third party" principle, the emitter must pay for the corrective action, but he may either undertake the action himself or pay the receptor to do so. In the example, assuming there were no uncertainty, the emitter clearly has an incentive to negotiate with the receptor to pay the latter to take the corrective action. The same incentives exist under the "victim must pay" rule if the costs in the receptor country are 100 while they are 80 in the emitter country. Thus the asymmetry is only with respect to the first issue, and not with respect to the second.

D'Arge's argument that pollution may be greater *than desirable* under the "third party" rule with transactions costs being paid by the receptor (point 5) is unconvincing, particularly insofar as it rests on the observation that the receptor might perceive that it would be better off without negotiation. For this to be the case, the expected negotiation costs would have to exceed the known costs of the externality (if these are not completely known, they are presumably better known than the negotiating

costs). Unless the uncertainty regarding negotiation costs borders on complete and at least partially avoidable ignorance, it would seem that where expected negotiation costs exceed resolution benefits, the global optimum is no resolution. My point here is that one should not define efficiency on the basis of complete and certain knowledge when in fact there is uncertainty; we need an efficiency criterion that explicitly introduces uncertainty.[6]

One wonders how the results derived from the two country partial equilibrium model would hold up under a more realistic set of assumptions. Rather unrealistic assumptions have been chosen to reduce the discussion to the level where a model applicable in the single country case can be applied. (To illustrate with but one assumption, the unit price of nonmobile factors such as labor is assumed constant, as each firm's production cost function depends only upon its own level of output.) In this argument, as in several others, d'Arge would at least make a stronger case for his conclusion by using a model whose assumptions are compatible with international trade theory rather than merely adapting a model used for the analysis of national externalities.

Finally, insufficient attention is paid to several aspects of transnational externalities that will significantly impact on the negotiating process. First, where there is more than a single receptor, certain forms of negotiation will be subject to the "free rider" problem. This is clearly the case under the "victim must pay" rule if one assumes that the efficient solution is to bribe the emitter to take corrective action, for there is then a problem in assessing payments by the individual receptors. Second, negotiations are likely to be multileveled with various interest groups within each nation being involved as well as the national governments. In many cases the pressure for resolution will come from segments of the receptor's population and their stake in the outcome will require them to participate, at least through discussions with their government; likewise, costs, if imposed, in the emitter nation are likely to fall unequally upon segments of its population. Third, to the extent that the externality also adversely affects groups within the emitter nation, it is not merely a matter of negotiation between two nations with distinctly identifiable interests. Fourth, the "victim must pay" principle may lead to individual

6. It is also unclear why d'Arge insists on assuming that transactions costs must be paid by the receptor under a "third party" rule. If agreement on a "third party" rule is possible, then so too is agreement on the emitter's paying transactions costs. The emitter's lack of incentive to pay these costs appears irrelevant once the principle is adopted, for they can be forced upon him.

nations profiting from threats of directed diseconomies; on this ground alone it is likely that international agreement on an unmodified "victim must pay" negotiating process would not be achieved. Lastly, it may be that in some cases the most effective strategy open to the receptor will be an offensive one, perhaps in areas not directly related to the externality. If the diseconomy is sufficiently great and the receptor is an important export market for the emitter, then in the last resort the receptor may threaten to close his market to the emitter unless the externality is resolved. Or, where a common resource is involved, the "injured party" may threaten to jump on the band wagon of injudicious depletion or he may actually join in to get what he can before the resource is exhausted.

In conclusion, d'Arge's paper leaves open a number of interesting and relevant questions. The paper's virtue is that it asks the questions and poses the issues in a fruitful manner that should clarify the needed research in this heretofore little studied area. D'Arge's search for an efficient mechanism for negotiating the resolution of externalities is valuable and needs to be carried forward, particularly with respect to multilateral negotiation and nonunidirectional externalities, which appear to be far more relevant than bilateral negotiation and unidirectional externalities, respectively.