Political Economy of International Pollution

Marie L. Livingston and Harald von Witzke[1]

Abstract: International pollution poses special problems for economic analysis. National governments can, in principle, be successful in improving environmental quality when the sources of pollution are located within the government's jurisdiction. This is not possible, however, when pollution originates abroad. In essence, the rules that govern transboundary pollution represent an international public good. Any solution to the problem requires international coordination and explicit recognition of both political and economic aspects involved. This paper presents a public choice model that captures the incentive structures faced by resource users and the marginal political and economic benefits and costs of regulation. Hypotheses derived and discussed concern the relative political strength of producers and consumers, transactions costs faced by each group, structure of the input market, relative size of the polluting industries involved, level of economic development, and amount of the externality "exported" to or "imported" from other countries.

Introduction

Around the globe, the demand for environmental quality is growing. Air and water pollution that crosses international boundaries constitutes an increasing fraction of the problem. Transboundary pollution poses special problems for analysis. National governments can, in principle, be successful in improving environmental quality when the sources of pollution are located within the government's jurisdiction. This is not possible, however, when the domestic pollution originates abroad. The rules that govern the regulation of transboundary pollution represent an international institution and thus an international public good. No government can supply itself with such a good except in cooperation with other countries.

Transboundary pollution has gained some attention in the economic literature (D'Arge and Kneese, 1980; Baumol and Oates, 1986; and Kneese, Rolfe, and Harned, 1971). And, in recent years, models have been developed to accommodate problems that have both economic and political aspects (Bromley, 1982; Buchanan and Stubblebine, 1962; Mueller, 1981; and Olson, 1965). However, these models are rarely applied to international pollution. The objective of this paper is to model the political economy of international pollution using a public choice approach. First, a theoretical framework that captures the incentives of governments for regulation of pollution by domestic industries is developed. Then, specific hypotheses derived from the model and their policy implications are discussed.

A Public Choice Approach to International Pollution

The theoretical framework focuses on domestic pollution control policy decisions in the presence of trans-frontier movements of pollutants. The nomenclature of economics is adopted, and pollution is referred to as an externality. The model represents supply-side approaches to policy modelling in that it is based on the political economic calculus of the regulator as the supplier of environment policy.[2] A non-cooperative model based on Nash behaviour is presented below, using the following symbols:

W = policy maker's utility
V = political support
U_c = utility of consumers
π_b = profit of producers
π_c = income of consumers
b = externality (bad)
b_d = domestic externality consumed domestically
b_e = domestic externality exported to and consumed in third countries
b_m = externality from abroad; imported externality
b_t = total externality consumed domestically

In this paper, the amount of the externality from abroad considered is given by the regulator ($b_m=\bar{b}_m$). As will become evident, this assumption results in a Nash equilibrium from which the regulator cannot deviate unilaterally without being worse off. The domestically produced externality consumed abroad will be referred to as "exported" and the domestically consumed externality from abroad as "imported."

Assume a single regulator's strictly concave utility function that contains as arguments the political support from consumers and from a group of producers who also produce an externality in the form of pollution. The political support of the regulator from producers and consumers can be thought of as votes. Campaign contributions and other lobbying activities can be seen as generating votes from these two groups.

(1) $W = W(V_b, V_c)$

The regulator maximizes utility subject to the following two constraints which are assumed to be concave:

(2) $V_b = V_b[(\pi^*_b + \pi_b(b)]$

(3) $V_c = V_c[U_c[\pi_c(\pi_b), b_d, \bar{b}_m]]$

where:

(4) $b_d = \beta b$

(5) $0 \leq \beta \leq 1$

Equations (2) and (3) represent the political economic constraints that the regulator faces. According to Equation (2) the political support of producers is a function of their total profits, where π^*_b denotes the actual profits when the externality is internalized, π_b denotes the additional profits that result from the production of the externality, and π_b is a positive function of b. If the externality is denoted at the private optimum as $\bar{b}$, then total profits at the private optimum are the profits at the social optimum (where $b=s$) plus the additional profits that result if the output of the externality is not regulated and the industry produces at the private optimum.[3]

(6) $\bar{\pi}_b = \pi^*_b + \pi_b(\bar{b})$

In Equation (3), the regulator's political support from consumers is a positive function of consumer utility, where the utility is a positive function of consumer income and a negative function of the amount of the externality that is consumed domestically. Consumer income is related to producer income. How close this relationship is depends on the share of total inputs owned by consumers and used in the externality-producing industry. It also depends on the structure of the markets for production factors, as this determines how much the price and/or use of a production factor changes when profits change.

In Equation (4), the total externality produced is consumed in fixed proportions by domestic and foreign consumers. That is, $b = b_d + b_e$, where b_d is defined as in Equation (4) and, therefore, $b_e = (1-\beta)b$. If $\beta = 1$, the externality is only consumed domestically; in this case, the maximization problem is reduced to one of optimal regulation of domestic pollution. If $\beta = 0$, the externality is entirely exported to third countries.

The solution to this maximization problem is:

$$(7)\quad \left(\frac{\partial W}{\partial V_b}\right)\left(\frac{\partial V_b}{\partial \pi_b}\right)\left(\frac{\partial \pi_b}{\partial b}\right) + \left(\frac{\partial W}{\partial V_c}\right)\left(\frac{\partial V_c}{\partial U_c}\right)\left(\frac{\partial U_c}{\partial \pi_c}\right)\left(\frac{\partial \pi_c}{\partial \pi_b}\right)\left(\frac{\partial \pi_b}{\partial b}\right) = -\left(\frac{\partial W}{\partial V_c}\right)\left(\frac{\partial V_c}{\partial U_c}\right)\left(\frac{\partial U_c}{\partial b_d}\right)\beta$$

Equation (7) has an obvious political economic interpretation. It can also serve as a basis for the formulation of hypotheses about the political economic optimum amount of the externality. The two terms of the sum on the left hand side of Equation (7) represent the marginal political economic benefits of deviating from the social optimum. These benefits arise via increased political support from producers and/or consumers as their incomes grow with increasing b. The right-hand side of Equation (7) represents the marginal political economic costs of increasing the output of b, as consumer utility is negatively affected by an increase in the consumption of the externality. Hence, the optimal amount of b is chosen such that the marginal political economic benefit of an increase in b equals its marginal political economic cost.

The political economic optimum condition for the regulator's control variable b in Equation (7) can be illustrated graphically. Denote:

$$(8)\quad A = \left(\frac{\partial W}{\partial V_b}\right)\left(\frac{\partial V_b}{\partial \pi_b}\right)\left(\frac{\partial \pi_b}{\partial b}\right)$$

$$(9)\quad B = \left(\frac{\partial W}{\partial V_c}\right)\left(\frac{\partial V_c}{\partial U_c}\right)\left(\frac{\partial U_c}{\partial \pi_c}\right)\left(\frac{\partial \pi_c}{\partial \pi_b}\right)\left(\frac{\partial \pi_b}{\partial b}\right)$$

$$(10)\quad C = -\left(\frac{\partial W}{\partial V_c}\right)\left(\frac{\partial V_c}{\partial U_c}\right)\left(\frac{\partial U_c}{\partial b_d}\right)\beta$$

In Figure 1, the horizontal axis denotes the quantity of the externality and the vertical axis denotes the marginal political economic costs and benefits of deviating from the social welfare optimum(s).

In Equation (8), A is positive, as are all partial derivatives of A. The regulator's utility is positively affected by an increase in political support from producers, their political support grows with increasing profits, and producer profits are a positive function of b. Therefore, A is in the first quadrant.

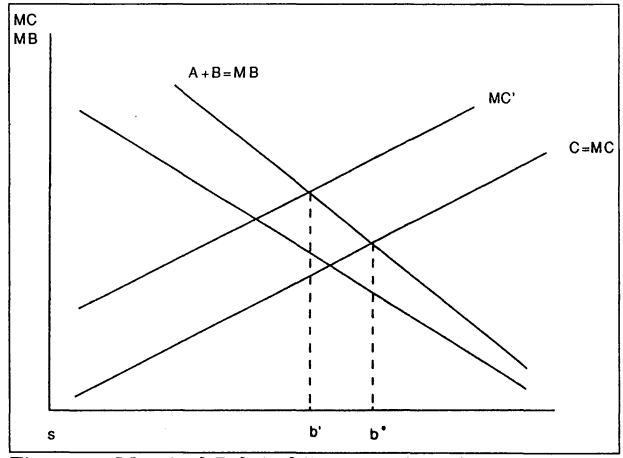

Figure 1—Marginal Political Economic Benefits and Costs of Government Regulation of a Negative Externality

Convexity of the constraint in Equation (2) implies that the private optimum in production is finite, that is, the marginal profit of an additional amount of the externality must be declining with increasing b, and A (in Figure 1) has a negative slope.

In Equation (9), B represents the marginal political economic benefits to the regulator that result from an increase in b via the consumer income effect. The sum of A and B represents the total marginal political benefits (MB) of an increase in the externality. All

partial derivatives of B are non-negative. The only partial derivative that in reality may be zero is the change in consumer incomes as a consequence of a change in producer incomes. This would be the case when the price of consumer-owned inputs or their quantity is not affected by the change in producer profits, either because of a lack of consumer market power on input markets or because all inputs of producers are owned by non-consumers (e.g., foreigners). As long as none of the partial derivatives is negative, B is in the first quadrant.

The slope of B is negative for the same reason that A's slope is negative. Hence, the total marginal political economic benefit of deviating from the social optimum ($A+B$) declines with increasing b.

C represents the marginal political economic costs (MC) of a growing deviation from the social optimum via the loss in political support from domestic consumers that is the consequence of the increasing disutility of consuming b_d. The first two derivatives are positive, while $\partial U_c/\partial b_d$ is negative. As the expression on the right-hand side of Equation (10) is negative, C must be in the first quadrant. The slope of C is determined by β; it is positive as long as $\beta > 0$.

All other things being equal, the slopes of the curves are given by $\partial\pi_b/\partial b$ and β, respectively. The position of the curves in space is determined by the other components that determine the political economic costs and benefits of government regulation of the externality; i.e., these partial derivatives act as shifters of one or more of the curves in Figure 1. According to Equation (7) the political economic equilibrium is determined by the intersection of MB ($=A+B$) and MC ($=C$). In Figure 1, this is the case at b^o.

The model discussed here has several implications for the amounts of the externality produced domestically.

Political weights ($\partial W/\partial V_b$; $\partial W/\partial V_c$). The marginal political weight of consumers does not determine, *a priori*, how much of the externality b will be produced at the political economic optimum. This is the case because consumer utility declines with increasing b. However, consumers may also benefit from the production of b via $\pi_c(\pi_b)$; i.e., $\partial W/\partial V_c$ affects both MB and MC. For instance, a growing marginal political weight of consumers would not only shift MC to the left but would also shift B and thus MB ($=A+B$) to the right. Whether this results in an increase or decline of the optimal b depends on the magnitude of these shifts, which are also affected by the other components of B and C.

The effect of the marginal political weight of producers is unambiguous: the larger the weight, the larger will be the optimum b.

This can be illustrated by rewriting Equation (7), as follows:

$$(7a)\quad \left(\frac{\partial W}{\partial V_b}\right)\left(\frac{\partial V_b}{\partial \pi_b}\right)\left(\frac{\partial \pi_b}{\partial b}\right) = -\left(\frac{\partial W}{\partial V_c}\right)\left(\frac{\partial V_c}{\partial U_c}\right)\left[\left(\frac{\partial U_c}{\partial \pi_c}\right)\left(\frac{\partial \pi_c}{\partial \pi_b}\right)\left(\frac{\partial \pi_b}{\partial b}\right) + \left(\frac{\partial U_c}{\partial b_d}\right)\beta\right]$$

In Equation (7a), the left-hand side depicts the marginal political economic benefits of deviating from the social optimum via growing support from producers, whereas the right-hand side contains the net cost of doing so via changing political support from consumers. As the first three partial derivatives in parentheses are larger than or equal to zero while $\partial U_c/db_d < 0$ and $0 \leq \beta \leq 1$, the sum in brackets can be positive or negative and thus can be the net political support from consumers; i.e., whether the net support from consumers is positive or negative is determined by the expression in brackets on the right-hand side of Equation (7a), where the marginal political weight attached to consumers acts as a multiplier (as does $\partial V_c/\partial U_c$). Of course, a regulator who is indifferent with regard to the origin of the votes will attach the same weights to producers and consumers.

Political influence of producers ($\partial V_b/\partial \pi_b$). All other things being equal, the more sensitive the political support from producers to changes in profits ($\partial V_b/\partial \pi_b$), the farther A (and thus MB) will be to the right in Figure 1 and the more b will exceed the social optimum. According to a central hypothesis of public choice theory, any group can be expected to react in a more pronounced way with political support and thus will be more influential the more efficiently it can organize its lobbying efforts. Typically, relatively small groups, groups with fairly homogenous interests, groups that can supply their members with selective benefits, or

those which have low costs of organizing a lobby for other reasons (e.g., because they are regionally concentrated) are more successful on political economic markets (see Olson, 1965).

Political influence of consumers ($\partial V_c / \partial \pi_c$). Arguments similar to those for political weights and political influence of consumers hold for the determinants of the marginal change in political support from consumers when their utility changes. Group characteristics determine the sensitivity of political support to changes in consumer utility. However, the direction of impact on the optimum b cannot be determined *a priori*; $\partial V_c / \partial U_c$ acts as a multiplier, and the direction of its impact depends on whether the expression in brackets on the right-hand side of Equation (7a) is positive or negative.

Income level ($\partial U_c / \partial b_d$; $\partial U_c / \partial \pi_c$). The direct effect of consumer incomes on the politically optimal output of the externality is unambiguous. The higher the income, the larger the marginal disutility of consuming the externality ($\partial U_c / \partial b$) and the smaller the marginal utility of income ($\partial U_c / \partial \pi_c$) generated by an additional unit of the externality. In Figure 1, the higher the income level, the further to the left will be both MC and MB and thus the lower will be the optimal b, all other things being equal. Hence, one can expect the regulation of a negative externality to become tighter when incomes rise.

Structure of input market ($\partial \pi_c / \partial \pi_b$). The marginal change in consumer incomes as a consequence of a profit change in the industry that produces the externality and thus the position of B is affected by the structure of the input market and the amount of production factors of the industry that is owned by consumers. The latter is, of course, also influenced by the size of the industry in terms of employment.

The structure of the input market directly affects the incidence of consumer incomes and the profit of producers and thus $\partial \pi_c / \partial \pi_b$. Curve B will be further to the left and the optimum b will be lower the less factor prices and/or total factor inputs increase with growing profits. For instance, if producer capital is predominantly owned by foreigners and/or its share in total employment is small, a change in profits will only marginally affect domestic consumers. Therefore, such industries will face relatively tight environmental regulation, all other things being equal.

Sensitivity of producer incomes to environmental regulation ($\partial \pi_b / \partial b$). The more sensitive producer profits are to changes in b, the more inelastic will be both A and B in Figure 1. With increasing sensitivity of producer profits, environmental regulation will be less affected by a shift of MC to the left. Hence, one can expect that those industries that are crucially dependent on a process that results in the externality will face looser environmental regulation than those that can more easily substitute such a production process, *ceteris paribus*.

Domestic consumption and export of the externality (β). In Equation (10), β represents the share of the total output of the externality that is consumed domestically. If β is zero (i.e., if the externality is consumed entirely by foreigners), the marginal political economic costs of environmental regulation are zero unless either altruism or some form of strategic behaviour with regard to mutually exported externalities is introduced. With increasing β, less of the externality is exported and more is consumed domestically, and MC in Figure 1 is further to the left, *ceteris paribus*. Consequently, the optimum will be at a lower b. For $\beta = 1$, the externality is entirely consumed domestically. If, in addition to this, there is no import of the externality from abroad, the problem is reduced to one of the political economic optimal environmental regulation in a closed country with no trans-frontier movements of the externality.

Import of the externality (b_m). When domestic consumers are affected by an exogenously given externality from abroad that cannot be avoided, MC in Figure 1 shifts to MC′, where the difference between MC′ and MC results from the loss in political support by consumers who also consume the imported externality. As a consequence, the political economic optimum would shift to the left (b'); i.e., the optimal domestic output of the externality is lower in the presence of a given externality from abroad. From Figure 1, it is also clear that any reduction in the externality from abroad increases the domestic political economic optimum output of b.

Summary and Conclusion

The model developed in this paper suggests several reasons for the existence of policies that allow the private sector to deviate from the social optimum if there are externalities in production. The foregoing analysis suggests that, *ceteris paribus*, one would expect greater regulation of transboundary pollution in jurisdictions that are net importers of pollution and in higher-income countries.

The incentives for producers are clear. Pressure for regulation from producers decreases when ownership of factor inputs is largely domestic, when profits are sensitive to regulation, and as the political influence of producers grows. The impact of transboundary pollution on consumers is uncertain, in terms of its impact on regulation. Even if consumer political influence is equal to that of producers, regulatory pressure from this group still hinges on which predominates: the direct disutility of pollution or the indirect utility of additional income via factor ownership.

Any agreement on international pollution policy consists of a set of rules that specifies the signatories' rights and obligations. Such an agreement represents a global public good. Public goods are frequently difficult to supply efficiently because of free riding. The free-rider problem can be solved in principle, however, through a system of conditional commitments to contribute to the production of a public good (Sugden, 1984). The key for international agreements on transboundary pollution is that they must be perceived as fair (Baumol, 1982) and provide the assurance that everybody plays by the rules (Sen, 1967). This assurance is crucial for the production of any public good (Runge, 1984). The model presented here provides a basis for predicting which countries are likely to pursue and abide by international pollution agreements in specific cases.

Notes

[1]University of Northern Colorado and University of Minnesota, respectively.

[2]Notice that political economic models typically result in optima different from social welfare optima.

[3]As we have formulated the model such that the externality may partially or in total affect foreign countries, the term social optimum refers to a global social optimum.

References

Baumol, W.J., "Applied Fairness Theory and Rationing Policy," *American Economic Review*, Vol. 72, 1982, pp. 639–651.

Baumol, W.J., and Oates, W.E., *The Theory of Environmental Policy*, Cambridge University Press, Cambridge, UK, 1986.

Bromley, D.W., "Land and Water Problems: An Institutional Perspective," *American Journal of Agricultural Economics*, Vol. 64, 1982, pp. 834–844.

Buchanan, J.M., and Stubblebine, W.C., "Externality," *Economica*, Vol. 29, 1962, pp. 371–384.

D'Arge, R.C., and Kneese, A.V., "State Liability for International Environmental Degradation: An Economic Perspective," *Natural Resources Journal*, Vol. 20, 1980, pp. 427–450.

Kneese, A.V., Rolfe, S.E., and Harned, J.W. (Eds.), *Managing the Environment: International Economic Cooperation for Pollution Control*, Praeger, New York, N.Y., USA, 1971.

Mueller, D.C., *Public Choice*, Cambridge University Press, Cambridge, UK, 1981.

Olson, M., *The Logic of Collective Action*, Harvard University Press, Cambridge, Mass., USA, 1965.

Runge, C.F., "Institutions and the Free Rider: The Assurance Problem in Collective Action," *Journal of Politics*, Vol. 46, 1984, pp. 154–181.

Sen, A.K., "Isolation, Assurance, and the Social Rate of Discount," *Quarterly Journal of Economics*, Vol. 81, 1967, pp. 112–124.
Sugden, R., "Reciprocity: The Supply of Public Goods through Voluntary Contributions," *Economic Journal*, Vol. 94, 1984, pp. 772–787.

Discussion Opening—*László Kárpáti* (Agricultural University of Debrecen)

The paper discusses a very important problem: how to incorporate the effect of transboundary pollution in a neoclassical econometric model that determines the economic versus social optima for a given country. The importance of the topic cannot be underestimated. Transboundary pollution is an even more delicate issue than intracountry environmental control since the whole topic is embedded in the general set of relationships among independent countries. The paper concentrates mainly on questions relating to a hypothetical country. The other main problem of how to formulate an effective international agreement is not discussed, however, in any detail.

The topic suggested by the title of the paper is the political economic aspects of allocation of pollution among different countries. In this sense, the export/import ratio of pollution for a given country plays the most important role since this is the figure that represents one politically independent country in the material interchange with another politically independent country.

The ratio between the exported and imported "bad" externalities plays an important role in determining how the domestic regulations should be modified. This ratio is especially important in the case of European countries where the level of environmental contamination is high and, in addition, the size and geography of the countries make "pollution exports" unavoidable. Larger countries, like the USA or Canada, have two advantages over the smaller ones; they have a smaller "pollution transaction" ratio (because of their geography) and greater political economic bargaining power, which has an important role in the model in any case.

Three main topics can be suggested for discussion in connection with the paper. First, it is worthwhile considering the implications of different "pollution transaction" ratios on domestic pollution control policy in the case of countries of different sizes, based on the assumptions of the Livingston-Witzke model. The relative importance of total/traded ratio should also be taken into account. Secondly, the foundations of an effective bilateral pollution control agreement are worthy of review: balancing the interests of the two countries, reallocation of public goods, and simultaneous levelling of polluting sources. This question cannot be separated from the political economic (and sometimes, the military) power of the countries in question.

Applying the Livingston-Witzke model macro-regionally, a third question can be generated: whether the model can be applied as a simultaneous model system for a set of different countries on a multilateral base.

The theory of international negotiations, for example Raiffa's work at Harvard University, deals with the exploration of mutually advantageous elements for the participating countries. A theoretical model system that assists a group of independent countries find a mutually acceptable solution among themselves and partially suggests a domestically advantageous environment controlling policy would certainly be welcomed. In this, case domestic and international regulations may be connected, and the best tool for testing a new environmental treaty would be one in which the individual interests of the single countries and the common public goods ("total externalities") are better harmonized. Technically, it can be solved in other ways: large-scale multi-period linear programming, input-output analysis, and a simultaneous model system with a bargaining simulation framework.

The ideas in the paper support and demand a substantial rethinking in this area of science.

[Other discussion of this paper and the authors' reply appear on page 143.]