

THE ECONOMIC IMPACT OF ACIDIFICATION*

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ABSTRACT

The economic impact of acidification can be looked upon in two perspectives. The first is to focus on the economic losses caused by acid depositions. The second is to focus on the economic impact of policy responses to the acidification problem. Recent estimates of the economic losses caused by acid deposition are uncertain, but suggest that these losses can turn out to be significant. Due to international positive external effects of emission reductions in individual countries, coordination of emission control policies in Europe can lead to significant cost savings.

INTRODUCTION

The purpose of this paper is to review the economic aspects of acidification. To begin with I will try to identify the types of economic issues which seem to be relevant in this particular context, and to summarize the state of our knowledge about the economic impact of acidification. Then I will focus on the economic efficiency aspects of emission control policies. On the basis of some preliminary findings I will make two propositions. The first is that coordination of emission control policies in Europe can lead to significant cost reductions for the cooperating countries. The second is that efficient multicountry coordination of emission control policies calls for a system of cost-sharing between the countries.

THE STRUCTURE OF THE PROBLEM

The economic impact of acidification can be considered in at least two different perspectives. The first is to focus on the effects of acid depositions on the availability of scarce resources such as forestry, fishery and agricultural products, manpower, recreation opportunities and other aspects of environmental quality. The second is to focus on the economic aspects of policy responses to the acidification problem. That is, the costs

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and benefits of emission control policies. Moreover, the discussion on these matters can be confined to direct effects, or it can be extended to include various indirect, or general equilibrium, effects.

DIRECT EFFECTS OF ACID DEPOSITION

The direct effects of acid deposition on the availability of environmental and other scarce resources work through impacts on forest ecosystems, agricultural productivity, aquatic ecosystems, human health, historical monuments, materials and buildings. In order to make these effects comparable to each other, and to the costs of reducing emissions, they should be expressed in monetary units. Before that can be done, however, two problems have to be solved. The first is that the physical effects of acidification have to be identified and quantified. The second is that the quantified physical effects have to be expressed in monetary units.

The current state of knowledge is such that any monetary measure of the damage caused by acid deposition is highly uncertain. To some extent this is due to the difficulty of applying theoretically satisfactory measures of the cost of reduced availability of public goods such as environmental quality and historical monuments. The main source of uncertainty, however, is the uncertainty about the physical damage caused by acid deposition.

In spite of these difficulties several attempts to estimate the economic losses caused by acid deposition have been made. Just to mention one example, Crocker (ref. 1) estimated these losses to be 5.1 billion 1978 US\$ per annum for the eastern part of the United States. A significant share of the estimated losses, 2 billion US\$ was due to damage to materials. As I indicated before, this and similar estimates are very uncertain. Yet it is obvious that the economic losses due to acid deposition and thus the potential benefits of emission control, might turn out to be quite significant. Our problem today is that we do not know the probability of such an outcome.

INDIRECT EFFECTS OF ACID DEPOSITION

If acid deposition significantly reduces the availability of various scarce resources, that is most likely to have indirect effects on resource allocation and income distribution in several countries. In the economist's jargon there will be so-called general equilibrium effects. A case in point is the forest dieback which possibly is, at least to some extent, caused by acid deposition:

In the short run damage to the standing forest tend to create excessive cuttings and thus an increased timber supply. This will produce a downward pressure on timber prices, and thus terms-of-trade losses to countries who

are net exporters of timber. The terms-of-trade gains to countries who are net importers of timber is the other side of the coin.

In the long run the forest damages imply reduced productivity in forestry and thus smaller supply of timber. The result should be an upward pressure on timber prices, and terms-of-trade gains to countries who are net exporters of timber. This terms-of-trade gain may or may not compensate the loss caused by the reduced forestry productivity.

I believe it is important to be aware of potential general equilibrium effects of damages caused by acid deposition. At the current state of knowledge, however, it is not possible to make reasonable quantifications of these effects. Since research activities on topics of this sort are under way, the situation might be quite different in a few years time.

DIRECT AND INDIRECT EFFECTS OF POLICY RESPONSES TO ACIDIFICATION

The policy responses to acidification include the implementation of a number of measures such as fuel switching, fuel cleaning and flue gas desulphurization. There are three types of economic consequences of these policy responses. The first is the benefit in terms of reductions of the damage caused by acid deposition. For the reasons mentioned before the magnitude of this benefit is uncertain.

The second is the installation cost of the resources used for emission reduction purposes. Although there is some disagreement about the cost of reducing SO_x and NO_x emissions, the cost estimates are a lot less uncertain than the benefit estimates. This is in fact one of the key problems in the context of emission control policies.

In addition to the direct benefits and costs of emission control policies, there are indirect, or general equilibrium, effects. One example is that shifts in demand from high sulphur to low sulphur coal can have significant effects on relative coal prices as well as on the economic conditions in regions where incomes and employment are heavily dependent on coal mining.

There are a number of studies about the cost of emission control.¹⁾ Without going into detail it is clear that there are in general significant costs associated with major emission reductions. The relevant question, however, is not whether emission control costs are high or low, but whether the benefits are large enough to justify the costs. From an economic efficiency point of view additional emission reductions are justified as long as the marginal cost of emission control does not exceed the resulting marginal benefit.

1) OECD (ref. 2) was the first major study on this topic.

At the current state of knowledge the exact implications of this decision rule, in terms of emission reductions in different countries, cannot easily be ascertained. Yet it is clear that economic efficiency is a very important aspect of emission control policies. What is less clear, however, is that emission control policies that are economically efficient in a European perspective are not likely to be implemented unless two specific problems are solved. In order to substantiate this statement I will briefly discuss the conditions for efficient emission control in a multicountry perspective.

ECONOMICALLY EFFICIENT EMISSION CONTROL IN A MULTICOUNTRY PERSPECTIVE

Let us, for the moment, simplify matters and assume that both benefits and costs of emission control measures can be accurately measured and expressed in monetary units. Furthermore, let us assume that emission control policies are designed on the basis of economic efficiency considerations only. Under these extremely simplified conditions each individual country would implement emission control measures to the point where the marginal cost of additional emission reductions, MC , is equal to the marginal benefit to the country of the resulting deposition reduction, MB_H . In other words the implemented measures would satisfy the condition

$$MC = MB_H \quad (1)$$

However, as is evident from the EMEP documentation of the atmospheric transportation patterns for sulphur dioxide emissions in Europe, emission reductions in one country will produce deposition reductions in several countries. In the economist's jargon there are international positive external effects of emission control measures in each individual country.

This means that the total marginal benefits of emission control can be subdivided into two parts. The first is MB_H , the benefits to the country which reduces its emissions. The second is MB_O , the benefits to all countries in which depositions are reduced as a result of the emission reductions in question. Thus, from the point of view of a coalition of countries, emissions should be reduced to a point where

$$MC = MB_H + MB_O \quad (2)$$

If all countries in the coalition actually adopt this rule the net benefits for the coalition is maximized. But this decision rule also implies that each individual country in the coalition should carry emission reductions to a point where the marginal cost of emission control exceeds the resulting

marginal benefit to itself, i.e. to a point where $MC > MB_H$. This observation points at a couple of problems in connection with international emission control policies. In the following I will denote these problems "the enforceability problem" and "the cost-sharing problem".

THE ENFORCABILITY PROBLEM

In general, agreements between countries cannot be enforced in the same way as agreements between firms or individuals. Let us therefore consider the incentives for individual countries to adhere to agreements on coordination of emission control policies. The numerical example in Table 1 illustrates the problem. There are two countries, 1 and 2, forming a coalition in order to coordinate emission control policies. Both countries have emission control options producing marginal benefits to the coalition in excess of their marginal costs. However, in all cases the marginal cost of emission control exceeds the marginal benefit to the country implementing the measures in question.

TABLE 1 CHOICE OF EMISSION CONTROL STRATEGY IN INDIVIDUAL COUNTRIES: PRISONERS' DILEMMA

Country 1

Cost of emission reduction	:	100
Benefit to country 1	:	75
Benefit to country 2	:	75

Country 2

Cost of emission reduction	:	100
Benefit to country 2	:	75
Benefit to country 1	:	75

Payoff matrix for strategies a (adhere) and b (break)

		2	
		Strategy	
		a	b
S t r a t e g y	a	(50,50)	(-25,75)
	b	(75,-25)	(0,0)

It is assumed that the agreement between the two countries cannot be legally enforced. In view of this both countries are faced with a choice between two strategies, a and b. The first, strategy a, is to adhere to the agreement, and the other, strategy b, is to, more or less secretly, break the agreement. Under these conditions each country is faced with a problem which is similar to the famous "Prisoner's dilemma": From the point of view of the coalition, the preferred outcome is that both countries adopt strategy a. The problem is, however, that both countries, acting in their own interest, tend to choose strategy b; for any choice of strategy by the other country each country can secure a larger payoff to itself by breaking the agreement. In other words b is a dominating strategy for both countries. Thus the inferior outcome (0, 0) is a possible result in spite of the fact that (50, 50) is a better outcome for both countries. This suggests that potential gains from coordinated action is not a sufficient condition for coordinated action to actually take place. Some kind of institutional arrangement for enforcement of agreements seems to be needed as well.

THE COST-SHARING PROBLEM

Another type of problem in connection with international coordination of emission control policies is illustrated in Table 2. Here it is assumed that international agreements can be enforced. Again coordinated action would be beneficial for the coalition of country 1 and country 2. However, unless there is a cost-sharing arrangement between the countries, country 2 would make a net loss by joining the coalition. Without coordination with country 2, country 1 prefers to refrain from implementing the emission control measures. Thus the outcome (0, 0) is possible in spite of the fact that the outcome (25, -10) could be shared in such a way that both countries would be better off.

TABLE 2 CHOICE OF EMISSION CONTROL STRATEGY IN INDIVIDUAL COUNTRIES: UNEQUAL DISTRIBUTION OF POTENTIAL GAINS

<u>Country 1</u>		
Cost of emission reduction	:	100
Benefit to country 1	:	95
Benefit to country 2	:	15

<u>Country 2</u>	
Cost of emission reduction :	100
Benefit to country 2 :	75
Benefit to country 1 :	30

Payoff matrix for strategies a (adhere) and b (break)

		2	
		Strategy	
		a	b
S t r a t e g y	a	(25,-10)	(-5,15)
	b	(30,-25)	(0,0)

These simple examples suggest that efficient international coordination of emission control policies requires an institutional framework within which international agreements can be enforced and cost-sharing arrangements designed and implemented. However, the practical importance of this issue to a very large extent depends on the magnitude of the gains from coordinated action. Before turning to that issue, however, the problem of defining operational goals for international coordination of emission control policies has to be discussed.

OPERATIONAL GOALS FOR EMISSION CONTROL POLICIES

So far I have discussed potential coordination gains in terms of net benefits. As I have already indicated, however, the benefit estimates are inherently uncertain. Ongoing research will probably reduce or eliminate some of the uncertainties. But it seems to be reasonable to assume that practical emission control policies cannot, or at least will not, be based on monetary measures of the net benefits of emission control measures in the near future.

This does not mean that there is no room for economic efficiency considerations when emission control policies are designed and implemented. It only means that we have to focus on emission control costs and cost-effectiveness considerations. We can then distinguish two types of cost-effectiveness problems.

The first emerges once a target emission reduction has been determined for an individual country. The problem then is to identify the set of emission control measures that makes it possible to attain the target emission level at the lowest possible cost. A closely related problem is to design an institutional framework and a set of environmental policy measures which are conducive for cost-effectiveness in national emission control policies. It would take me too far to go into details in this issue. Yet it is worth mentioning that various attempts in the U.S. to allow trade in so called emission permits have led to considerable cost savings. (See ref. 3).

The second type of cost-effectiveness problem emerges if a group of countries agree on a set of deposition standards, or target deposition reductions, for each country. These deposition standards would then reflect current knowledge about the physical damage caused by acid deposition, as well as estimates of the economic losses which these physical damages represent. The deposition standards could also differ across countries.

The problem then is to identify the set of emission reductions in the individual countries which would minimize the overall cost to attain the agreed upon deposition standards. Thus, the emission reductions in individual countries would be determined through agreements between the countries on the basis of cost-effectiveness considerations. For a group of countries such agreements can lead to cost savings. The question then is how big these cost savings might be.

THE MAGNITUDE OF POTENTIAL COST SAVING

In order to estimate the potential cost savings we are concerned with, one needs to know the relation between emission reductions and (minimum) emission control costs in individual countries. Although our current knowledge about the costs of emission control is less uncertain than our knowledge about the benefits of emission control, it is still insufficient to allow us to carry out the desired calculations with a reasonable degree of precision. However, in order to get a very rough first estimate of the magnitude of possible gains from international coordination of emission control policies, I have carried out some simple calculations.

The point of departure is the EMEP, so called source-receptor matrix (see ref. 4) which gives estimates on how emission reductions in individual countries lead to deposition reductions in the home country as well as in other countries. In order to simplify matters as much as possible it is assumed

that the marginal cost of emission reduction in 27 European countries is constant, and equal across all countries, up to a maximum reduction level corresponding to 30 % of initial emissions in each country. Beyond that level, emission reductions are assumed to become infinitely costly. Moreover, it is assumed that there is an agreed upon deposition reduction target for each country. For each individual country this target deposition reduction is set equal to the deposition reduction attained by reducing domestic emissions by 30%, while all other countries maintain their initial emission levels.

From the point of view of an individual country two extreme cases can be identified under these conditions. In the first the target deposition reduction for the country in question is attained by independent action. In the second the country joins a grand coalition with all other 26 countries. This would be a coalition in which emission control policies are coordinated in such a way that the total cost of simultaneously attaining the deposition targets in all countries are minimized, and cost savings are shared in such a way that each country in the coalition gets the same proportional cost reduction.

Under the assumed conditions it turns out that the cost saving which can be attained through coordinated action is more than 40 % of the cost of attaining the target deposition reduction by independent action. Moreover, this also holds under alternative assumptions about emission control costs in the different countries. Of course these results should be regarded as very preliminary. Yet it seems quite reasonable to conclude that potential gains from coordinated action are likely to be quite significant. Recent studies in the United States (ref. 5) support this conclusion.

CONCLUDING REMARKS

The economics of acidification is beset with uncertainties. Yet economic analysis and rough calculations seem to lead to a couple of quite strong policy conclusions. The first is that there is a case for aiming at cost-effectiveness in national as well as international emission control policies. In general this is simply because the more efficient resources are used for emission control purposes, the more emission reduction can be attained for a given amount of resources. Moreover, rough calculations as well as recent studies suggest that these gains can indeed be significant.

The other conclusion is that an institutional framework which is conducive for international cooperation is needed. More precisely, cost-effective coordination of emission control policies has to be based on a set of enforceable agreements, including a formula for sharing the costs of emission control. A first step in this direction would be to change the focus in emission control policies from emission reductions to deposition reductions, and to initiate a major research program on the costs of emission control in the European countries.

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