

Economic Research Institute Study Paper

ERI #96-20

**AN AGENDA FOR THE DESIGN AND STUDY OF
INTERNATIONAL ENVIRONMENTAL AGREEMENTS**

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July 1996

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ABSTRACT

The combination of a general greening of international political debate, and the events of 1992 at the Rio Earth summit have led to great interest in the question of global environmental protection. While it is recognized that international environmental agreements (IEAs) are the means by which the earth's fragile environment is most likely to be protected, this recognition has been recent. Hence, there is very little formal research on the design and study of IEAs. As such, in this paper, I propose and describe a research agenda for the design and study of IEAs. Very generally, I propose that we frame the IEA design question as a problem in mechanism design. We will then be able to use, *inter alia*, the theory of common agency and the theory of hierarchies to generate interesting new theoretical and practical insights into the workings of IEAs.

JEL Classification: D73, D82, L50

Key words: international, environmental, agreement, design, game

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1. Introduction

A particular line of western social thought suggests that the rational pursuit of self interest by individual actors is likely to lead to the greatest good for the greatest number. While this line of thinking has had a powerful influence on western social thinking for quite some time, it is important to recognize that it runs “. . . counter to some of the most powerful findings produced by social scientists working in...international relations.” (Young 1989, p. 1). Indeed, in the area of international relations, the pursuit of self interest, in the absence of effective institutions and rules is more likely than not “. . . to produce collective outcomes that are socially undesirable . . .” (Young 1989, p. 2). Nowhere is this more apparent than in the area of international environmental relations. At various international forums,¹ developing and developed countries have repeatedly clashed over global environmental problems, in large part because of the manner in which these countries have construed the causes, nature, and solutions to such problems.

This suboptimal state of affairs and the fact that “. . . the cooperation required to solve collective action problems [of an environmental nature]...is elusive in the world of international relations . . .” (Young 1989, p. 3), suggests a research agenda regarding how one might hope to bring about international cooperation in an inherently noncooperative setting. There is not much dispute among scholars about the relevance of international cooperation. Indeed, as Maurice Strong (1990, p. 211) has argued, the “. . . need for international cooperation is inescapable.” Once such a need is recognized, three pertinent research questions arise.

¹See Rogers (1993) or Grubb et al. (1993).

First, given that institutions “. . . can be important factors in protecting the environment . . .” (Keohane, Haas, and Levy 1993, p. 7), what can economic theory tell us about the design of international environmental agreements (IEAs) which will protect the world’s fragile environmental resources?

Second, what is the impact of national sovereignty on the efficacy of IEAs? More specifically, how do difficulties associated with monitoring and enforcement, which stem from respecting the principle of state sovereignty, affect the above mentioned design question? To what extent is Krasner’s (1983a, p. 367) claim that sovereignty substantially weakens the position of international institutions and hence the attendant IEAs that such institutions may design, true?

Third, given developing country demands that “. . . the North . . . radically assist the South in choosing a different road to development than the one [the North has been] traveling on . . .” (Rogers 1993, p. 27), what is the impact of limited funds on the design of IEAs? Specifically, what are the properties of budget balanced IEAs which give rise to desirable levels of global pollution abatement?

Given these three research questions, the general purpose of this paper is: (1) to discuss these design, sovereignty, and funding questions; (2) to propose a theoretical research agenda for studying the various issues raised by these three questions; and (3) to show how specific aspects and objectives of such a research agenda might be accomplished. *Inter alia*, depletion of the earth’s ozone layer (Downing and Kates 1982; Parson 1993), destruction of tropical rainforest, and the attendant diminution in biodiversity (Gadgil 1995; Perrings 1995) remind us that a thorough understanding of the issues described by these three questions is vital to the optimal, and presumably less fractious, use and management of the earth’s environmental resources.

2. Three Key Research Questions Relating to IEAs

As discussed briefly at the end of the previous section, the three key research questions significantly affecting the study of IEAs concern: (1) the design of IEAs in a noncooperative international environment, (2) an analysis of the effects of national sovereignty on this design question, and (3) a study of the effects of limited funds, i.e., a study of the properties of budget balanced IEAs.

Analyses of the first question will shed light on what Black, Levi, and de Meza (1993, p. 281) have referred to as “. . . the multi-faceted design . . . problem” Specific issues that deserve research attention include the impact of *ex ante* versus *ex post* contracting on pollution abatement levels, the nature of the monetary transfers required to generate participation by national governments under alternate assumptions about the objectives of such governments, and the number of participants that are necessary before a meaningful IEA can be designed.

The potentially deleterious effects of national sovereignty on this design question have been much discussed in recent times.² Indeed, Keohane, Haas, and Levy (1993, p. 6) have asked “How can international institutions, which necessarily respect the principle of state sovereignty, contribute to the solution of difficult global problems?” Research is needed to shed light on this and related sovereignty questions by formally modeling the effects of sovereignty.

The third main question that I wish to focus on concerns the problems arising from the limited availability of funds for global environmental protection. Of particular interest are issues pertaining to: (1) the demands of southern governments that northern governments “. . . radically

²For instance, see Krasner (1983b, pp. 16-18).

assist the South in choosing a different road to development . . .” (Rogers 1993, p. 27); and (2) the concern of northern governments that “. . . they [will be] left carrying the main [financial] burden . . .” (Guest 1990, p. 11) of global environmental protection.

The methods and techniques of game and mechanism design theory can be used to formally model the three questions discussed above. The application of such methods and techniques to study these issues is still in its infancy. As such, research which uses these methods will attain at least two objectives and thereby contribute substantially to our understanding of global environmental protection issues.

First, because of the inherently interdisciplinary nature of the underlying IEA design question, my research agenda explicitly recognizes the need for studying the role of sovereign national governments and their economic actions jointly. As such, the conduct of research along the lines suggested in this paper will contribute to the environmental economics literature and the nascent,³ largely narrative international relations and environmental politics⁴ literatures.

Second, the results of this research can be used to better understand the complex and fractious use and management issues relating to the world’s environment. Indeed, such comprehension must be the basis for providing policy guidance about how one might go about remedying and improving current global environmental use and management practices.

Clearly, these objectives are central to the question of international environmental protection. Given the increased concern about sustainable use of the world’s environment and

³See Keohane, Haas, and Levy (1993, p. 6) or Bernauer (1995, p. 352) for a more detailed corroboration of this claim.

⁴For more on this literature, see Rosenau and Czempiel (1992), Switzer (1994), and Wettstad (1994).

the international political battles over the opposite use of the environment, it is now more important than ever before to craft effective IEAs. Such action will, *inter alia*, enhance global welfare by ensuring that the joint gains from international cooperation are not left unrealized.

3. Previous Research and this Agenda⁵

I now briefly discuss the nascent formal literature on IEAs.⁶ There are two aspects of the underlying problem which deserve some comment at this stage. First, because nations are sovereign, an effectively crafted IEA must recognize (see Keohane, Haas, and Levy (1993)) that such nations may not live up to their contractual commitments in accordance with international law. Further, in the event of a contractual breach, nations typically cannot be held legally liable in the same way that domestic entities can. Second, for an IEA to function effectively, it must, in some way, address the monitoring and enforcement aspects of the problem. However, as Burke, Legatski, and Woodhead (1975) and others have noted, sovereignty limits and, on occasion, altogether precludes international institutions from undertaking effective monitoring and enforcement measures. As such, it is desirable that an IEA account for this “monitoring and enforcement” difficulty endogenously. Barrett (1992, 1994) has modeled IEAs as games between different countries. Although Barrett’s analyses are not in the design framework, Barrett makes the important point that, for IEAs to work at all, they must be self enforcing. However, the thrust of this point is considerably diminished by Barrett’s focus on identical countries, with no uncertainty. As a result, this line of inquiry is unable to address fundamental questions arising

⁵In the rest of this paper, I shall use the terms IEA and contract interchangeably.

⁶Also see footnotes 3 and 4.

from: (1) asymmetrically held information, and (2) the heterogeneity of the participating countries.

Hoel (1991, 1992) has addressed the implications of, in turn, unilateral emissions reduction by countries, and uniform emissions reduction by all countries. Hoel (1991, p. 69) shows that, *inter alia*, unilateral actions “. . . may . . . reduce global welfare . . .” by increasing the total emissions of pollutants. Hoel (1992) argues against the institution of uniform emissions reduction policies in IEAs, showing that other policies yield higher levels of social welfare.

Shogren, Baik, and Crocker (1992, hereafter SBC), Black, Levi, and de Meza (1993, hereafter BLD), Carraro and Siniscalco (1993, hereafter CS), and Sandler and Sargent (1995, hereafter SS) have all addressed the question of the minimal number of nations needed to sustain an IEA. In a multiplayer strategic setting, SBC show that countries will sometimes join IEAs because the expected gains from such action outweigh the gains from not joining. However, beyond a critical threshold value, some countries will prefer to free ride and not join such an IEA, whereas the IEA members will want nonparticipants to join. BLD have explored this notion of a threshold value, which they call “the optimal ratification level.” BLD show that this level is reasonably robust to variations in contractual circumstances; more significantly, BLD argue that the prospects for effecting an IEA are not necessarily diminished by there being a large number of countries. CS have provided a game theoretic analysis of the design of IEAs. They argue that partial cooperation can be used to design stable IEAs between subgroups of nations. However, CS show that if the number of participants to an IEA is to be increased, transfers and a minimum level of commitment by the various nations will be required. SS show that the attainment of international coordination by a

“minimal-sized group” is fundamentally dependent on “. . . how individual pollution activities add to the total pollutants experienced . . . [by nations]” (p. 152).

While these papers have certainly advanced our understanding of some aspects of the IEA design problem, many other important questions remain unanswered. What kinds of pollution abatement patterns can one expect to observe in environments in which an imperfectly informed supra-national governmental authority (SNGA) contracts with governments and polluting firms in individual countries? What kinds of monetary transfers will be necessary to get sovereign nations to voluntarily participate in IEAs? What is the effect of *ex ante* versus *ex post* contracting on the nature of pollution abatement levels? How does the SNGA’s inability to monitor pollution abatement in the individual countries affect the IEA design question? What are the effects of pollution ceiling constraints on the design of IEAs? Finally, how does the limited availability of funds affect the SNGA’s IEA design task?

These unanswered questions form the core of this paper’s research agenda. I now discuss specific research methods and procedures which provide a framework within which the above described questions can be analyzed.

4. Proposed Research Methods and Procedures

The theory of games and the theory of incentives, as presented in Kreps (1990) or Fudenberg and Tirole (1991), have both advanced to a point where it is now possible to comprehensively model, analyze, and understand the issues that I have discussed in the previous two sections of this paper. Very generally, I propose that the IEA design question be studied as a problem in mechanism design. More specifically, I propose that the basic design question be

modeled and analyzed as two different kinds of principal/agent games. In the first proposed scenario, researchers can draw on the theory of common agency and focus attention on the interaction between *two* categories of players, i.e., a SNGA and national governments. In the second scenario, researchers can build on the theory of hierarchies and focus attention on the interaction between *three* categories of players, i.e., a SNGA, national governments and polluting firms in the different countries.

4a. The Common Agency Scenario

The theory of common agency⁷ is concerned with situations in which a single agent takes actions which affect the welfare of several principals. The preferences of the principals for the various possible actions typically conflict, and the agent has private information about some aspect of his actions. The key question concerns the kinds of contracts that the principals can design so as to induce desirable actions from the common agent.

The simplest adaptation of this basic construct to the IEA design question involves the analysis of a model in which a developing country government and a developed country government (the two principals) interact with a SNGA (the common agent) responsible for undertaking actions to protect the global environment.⁸ The two governments contribute funds with which the SNGA undertakes its actions, and the SNGA has private information about the level of environmental quality that it would like to see arise.

⁷See Baron (1985), Bernheim and Whinston (1985, 1986), Gal-Or (1991), and Fudenberg and Tirole (1991, pp. 301-3).

⁸This SNGA could be the Commission on Sustainable Development (CSD), which was created in Agenda 21 at the Rio Earth Summit or the World Bank in its role as an administrator of the Global Environmental Facility (GEF).

In this kind of setting, researchers will be able to answer many of the questions discussed in sections 2 and 3 of this paper. For instance, what level of global environmental quality arises, in turn, in a cooperative and in a noncooperative equilibrium? It is clear that monitoring and enforcement problems stemming from national sovereignty are not germane in an equilibrium in which the two governments cooperate. How are the equilibria of the cooperative and the noncooperative games affected by capping the funds contributed by the two governments? Finally, in this common agency setting, one can also explore the effects on the equilibrium of one government, possibly the developed country government, acting as a Stackelberg leader in its interactions with the second government and the SNGA.

4b. The Hierarchy Scenario

The very recent literature on the economics of hierarchies⁹ has extended the basic two-tier principal/agent construct to three tiers in which the second tier is occupied by an intermediary of some sort. The simplest such extension involves the analysis of a vertical structure consisting of a single fork, i.e., a single principal, a single intermediary, and a single agent. More involved extensions involve the analysis of a vertical structure with “many” forks. The “many” refers to many principals, many intermediaries, many agents, or a combination of these three possibilities. In the typical case, this tripartite interaction is assumed to be characterized by the existence of private information at the level of intermediaries and/or agents.

To see how this hierarchy scenario can be used to model the design of IEAs, consider the following conceptual framework. The world is represented by a n forked, three-tiered hierarchy.

⁹See Tirole (1986), Demski and Sappington (1987), Kofman and Lawarree (1993), and Batabyal (1995).

Occupying the first tier is the relevant SNGA (principal).¹⁰ The second and third tiers of the hierarchy consist of national governments (intermediaries) and representative polluting firms (agents). The n forks represent the n countries which are a party to the IEA. Firms in the individual countries know the pollution abatement technology available to them (private information), national governments may or may not acquire this private information, but the SNGA is never privy to this information. Hence, the problem is characterized by asymmetrically held information. Finally, the random variables representing the private information possessed by firms in each of the n countries can be modeled as being uncorrelated or correlated across countries.

This framework can be used to answer a number of important questions about the design of IEAs. First, the above framework can be embedded in a static or a dynamic game of incomplete information. Once this has been done, one can determine the equilibrium pattern of pollution abatement across countries. Further, one can account for the sovereignty issue by disallowing the possibility of monitoring and enforcement and then analyzing IEAs which have been designed to preclude collusion between governments and firms in the individual countries. Finally, the impact of limited funds on the properties of the underlying game equilibrium can be studied by explicitly incorporating budget balance constraints, either in a weak *ex ante* sense, or in a strong *ex post* sense.

Further, this conceptual framework can be extended to permit the inclusion of additional nuances such as relative performance evaluation by the SNGA. In an IEA involving relative

¹⁰Also see footnote 8.

performance evaluation, similar¹¹ countries are held to similar contractual requirements and the requirements for one country—in a similar category of say two countries—are contingent on the requirements for the second country. In this way, the three issues discussed in sections 2 and 3 of this paper can be effectively analyzed.

5. Conclusions

I believe that the research agenda described in this paper will enable us to obtain a deep and thorough understanding of the many and varied intricacies of IEAs designed to protect the global environment. Further, because a key aim of this paper is to delineate a policy-oriented research agenda, I expect that the conduct of this kind of research will generate significant and implementable policy guidelines.

Finally, it should not go unsaid that with talk of rising disparity between the developed world and the developing world and the increasingly fractious nature of international discussions regarding the use of environmental resources, the IEA design question discussed in this paper takes on particular significance. This is in no small measure due to the fact that the implementation of such mechanisms will do more to engender and maintain international security than will most unilateral or strategic policy measures.

¹¹Similarity can be measured in many different ways. One possibility is to consider per capita GNP.

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