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Economic Research Institute Study Paper

ERI #2000-02

**INTRODUCTION AND OVERVIEW OF THE
ECONOMICS OF INTERNATIONAL
ENVIRONMENTAL AGREEMENTS**

by

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January 2000

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**INTRODUCTION AND OVERVIEW OF THE
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Amitrajeet A. Batabyal

ABSTRACT

I describe the theoretical and empirical contributions that rigorous economic analysis can make in improving our understanding of the causes of and the solutions to a variety of international environmental problems. I do this by analyzing and summarizing the intellectual contributions of fourteen papers about the design and the implementation of international environmental agreements (IEAs).

JEL Classification: Q20, F42

Key words: economic theory, game theory, international environmental agreement

INTRODUCTION AND OVERVIEW OF THE ECONOMICS OF INTERNATIONAL ENVIRONMENTAL AGREEMENTS¹

1. Preliminaries

The doctrine of utilitarianism tells us that the rational pursuit of self-interest by individual economic agents is likely to lead to the greatest good for the greatest number. Although this line of reasoning has exerted a powerful influence on a number of prominent Western thinkers, as Oran Young (1989, p. 1) has pointed out, it is important to recognize that this line of reasoning runs “counter to some of the most powerful findings produced by social scientists working in...international relations.” Indeed, in the world of international environmental affairs, it is now well known that the pursuit of self-interest, in the absence of efficacious institutions and rules is more likely than not “to produce collective outcomes that are socially undesirable...” (Young, 1989, p. 2).

Given this state of affairs, the general purpose of this book is to study a class of problems that typically arise in the world of international environmental affairs. In particular, the chapters in this book seek to document the theoretical and empirical contributions that rigorous economic analysis can make in improving our understanding of the causes of and the solutions to a variety of international environmental problems.²

¹I thank Qing Xu for competent research assistance, and Theo Panayotou and Tom Tietenberg for comments on a previous version of this paper. I acknowledge financial support from the Utah Agricultural Experiment Station, Utah State University, Logan, UT 84322-4810, by way of project UTA 024. The usual disclaimer applies.

²International environmental problems have attracted the attention of researchers in a number of fields other than economics. In particular, there is now a sizeable literature in political science on such problems. However, in this book, we shall be concerned almost exclusively with the economics of international environmental problems. For more on the relevant political science literature, the reader should consult Krasner (1983), Young (1989), Epstein and Gupta (1990), Benedick (1991), Peterson (1992), Rosenau and Czempiel (1992), Haas *et al.* (1993), Wettestad (1994), Bernauer (1995), and Victor *et al.* (1998).

There are at least three distinguishing features of international environmental problems. First, these problems have the property that the detrimental environmental effect on each affected country depends in large part on the *global* discharge of some hazardous material or materials. Examples of such problems include the effects of chloroflourocarbon (CFC) emissions on the earth's ozone layer and the effects of carbon dioxide (CO_2) and other greenhouse gas emissions on the world's climate.

Second, as the perspicacious work of Demsetz (1967) has made clear, one way to deal with global environmental problems is to require effective intervention by an apposite regulatory institution. Indeed, if one could design and empower an international institution to intervene for the good of all, then international environmental problems would be easy to redress. However, as Krasner (1983), Keohane *et al.* (1993), and Batabyal (1996, 1997, 1999) have noted, national sovereignty considerations have in general proved to be an effective stumbling block in the design of international institutions with teeth.

This leads to the third distinguishing feature of international environmental problems, i.e., the necessity of agreements in solving these vexing problems. As Keohane *et al.*, 1993, p. 4, emphasis added) have put it, "organized international responses to shared environmental problems will occur through *cooperation* among states, not through the imposition of government over them." This is also the position taken in this book. Recognizing the salience of international environmental agreements (IEAs) in solving global common property problems, the chapters in this book explore, from an economic standpoint, many of the issues that are germane in increasing our knowledge of the ways in which IEAs work, and the ways in which they can be made to work even better.

What can economic *theory* tell us about the design of IEAs that will protect the world's fragile environmental resources? This is the general question that is addressed by the eight chronologically arranged chapters that comprise Part II of this book. The tools of microeconomic

and game theory are used effectively by the different chapters to analyze diverse issues such as (i) the effects that unilateral environmental actions have on the outcome of IEAs, (ii) the optimal number of countries that are needed to make an IEA viable, and (iii) the effect of limited liability on the design of IEAs. The six chronologically arranged chapters of Part III *apply* the economic theory of IEAs to practical situations to determine, *inter alia*, the extent to which this theory can inform actual policy decisions about international environmental problems. This part of the book focuses on topics such as (i) the determinants of environmental cooperation between Finland and the former Soviet Union, (ii) the voluntary provision of a public good in the German state of Saarland, and (iii) the role of collective action considerations in reducing sulfur and nitrogen oxide emissions in Europe.

2. Theory

Before one asks and attempts to answer interesting theoretical questions about the functioning of IEAs, one must first comprehend the nature of, as it were, the “beast.” This is the purpose of chapter 2. In this chapter, Scott Barrett provides the reader with a nice guided tour of the problem of global environmental protection. He points out that one reason for the lack of simple solutions to global international problems is the lack of a World Government that is empowered to intervene for the benefit of all citizens. Consequently, Barrett rightly suggests that IEAs provide the only reasonable way of solving global environmental problems. Combining the study of the putative gains from cooperation with a formal model of an IEA, Barrett points out that relative to the non-cooperative outcome, the benefits from cooperation are sometimes small. Consequently, even when it is needed, cooperation may *not* be forthcoming.

This saturnine conclusion leads to a number of questions. One such question relates to the efficacy of unilateral environmental actions. In particular, if the prospects of achieving global cooperation are limited, then what, if anything, can one say about instituting environmental policy unilaterally?³ This question is addressed lucidly by Michael Hoel in chapter 3. Hoel constructs a two-country game-theoretic model to study two instances of the institution of unilateral environmental policy. In the first instance, a positive and “unselfish” unilateral action is taken by one country in the absence of, or prior to, the establishment of an IEA. Hoel shows that in this instance, the pursuit of unilateral environmental policy has a salubrious effect on the environment. However, Hoel recognizes that an unselfish unilateral action may jeopardize subsequent negotiations on an IEA. This is the second instance that he studies. Here, Hoel shows that an unselfish unilateral action may compromise negotiations on an IEA and ultimately lead to *more* pollution emissions than would have occurred had both countries acted “selfishly” and not taken unilateral actions.

Because Hoel’s analysis is based largely on a two-country model, it is possible to question the generality of his results. For instance, one can ask what happens to his results when the analysis involves more than two countries. More generally, one can ask whether a *minimum number* of countries is necessary to successfully negotiate an IEA. This question is addressed ably by Jane Black, Maurice Levi, and David de Meza (BLM) in chapter 4. BLM focus on two salient aspects of the “minimum numbers” question. First, they demonstrate that if the goal is to effect a viable IEA, then it is better to include a “minimum agreement level or n-rule” rather than permit nations to take independent actions. This minimum agreement level refers to the minimum number of nations that are needed to participate in an IEA before action is taken by any one participant. Second, BLM point

³This question has been addressed in the “trade and the environment” literature as well. For more on this, see Batabyal (1993, 1994, 1998), and Xu and Batabyal (1999).

out that although signatories to an IEA may have their own country specific n-rules, signatories will often lose little by adopting the social welfare maximizing n-rule, instead of their own n-rule. This finding has the optimistic implication that countries may in fact be quite willing to put sovereignty questions aside and let an international institution set the participation level required to consummate an IEA.

BLM's n-rule can also be thought of as the minimum size of a *coalition* that is necessary to sustain an IEA. This coalition-theoretic view of IEAs has been adopted by a number of scholars and hence there is now a sizeable literature on coalition formation in the context of IEAs.⁴ In chapter 5, Carlo Carraro and Domenico Siniscalco present a coalition-theoretic account of IEAs in which the signatories to an agreement may choose to act either cooperatively or non-cooperatively. Recognizing the difficulty of obtaining universal participation in an IEA, Carraro and Siniscalco show that it is possible to design profitable and stable IEAs in which only a coalition or sub-group of countries participate. This finding raises a natural question: are there ways of increasing the number of signatories to an IEA? Carraro and Siniscalco point out that the size of the coalition can indeed be expanded by using self-financed welfare transfers and by requiring the coalition participants to display a minimal level of commitment. By explicitly focusing on the *stability* of IEAs, Carraro and Siniscalco rightly remind us that in the realm of international environmental affairs in which there is no potent "World Government," unstable IEAs are of little or no interest.

In chapter 6, Scott Barrett provides an alternate perspective on this stability issue. The reader will note that a country cannot be forced to join an IEA; moreover, once a country has joined an IEA, it can always choose to withdraw from the agreement. Consequently, a useful IEAs must accomplish

⁴For more on this literature, the reader should consult Bohm and Larsen (1993), Kverndokk (1993), Chander and Tulkens (1995, 1996), Welsch (1995), and Finus and Rundshagen (1998).

two things. First, it must appear attractive to potential signatories. Second, once a nation has agreed to join an IEA, this nation must want to carry out the terms of the agreement. Owing to these reasons, Barrett rightly observes that for an IEA to be utile, it must be *self-enforcing*. In the rest of this chapter, Barrett uses two alternate game-theoretic approaches to analyze the properties of self-enforcing IEAs. He concludes that a self-enforcing IEA which institutes rules for managing global common property resources will typically *not* be able to improve substantially upon the non-cooperative outcome. However, it is important to recognize that this potent and negative finding is based on an analysis of models in which there are *no* informational asymmetries of any kind, and all countries are *identical*. Recognizing the restrictiveness of these and other assumptions, Barrett wisely calls for additional research to determine the robustness of his findings.

This call for additional research is taken up by Emmanuel Petrakis and Anastasios Xepapadeas in chapter 7. Departing from the analytical approach adopted in chapter 6, these authors provide a stimulating, coalition-theoretic account of IEAs in a world in which countries are *heterogeneous* and informational *asymmetries* between countries are salient. This chapter contains two significant findings. First, consistent with the analysis presented in chapter 5, Petrakis and Xepapadeas show that if there exists a coalition of environmentally conscious countries that is committed to environmental protection, then this coalition can use self-financed transfers or side payments fruitfully to attract less environmentally conscious countries into their coalition. Second, it is shown that as long as global pollution can be measured accurately and costlessly, a mechanism can be constructed, which if incorporated into an IEA between environmentally conscious and less environmentally conscious countries, will lead to optimal pollution emissions by all the participating countries.

Asymmetries between countries comprise the subject matter of chapter 8 as well. In this chapter, Zhiqi Chen analyzes a well articulated discrete-time, infinite-horizon, model of an IEA in the context of the global warming problem. Chen explicitly address the effects that side payments⁵ between countries and population size have on the outcome of an IEA. Interestingly, he shows that although side payments are a part of the IEA that he analyzes, these side payments do *not* always reflect either the “polluter pays principle” or the “victim pays principle.” In particular, parts of these side payments arise because of the differential bargaining power of the two nations in his model. This leads Chen to note that care must be taken to ensure that the actual outcome of a given negotiation process is consistent with a principle such as the “polluter pays principle.” As far as population size is concerned, this chapter shows that a country with a small population will in general gain more from an IEA than will a country with a large population. This enables a small country to successfully take a less compromising stand in its negotiations about an IEA with a large country.

Chen’s analysis depends on his assumptions that (i) the world consists of only *two* countries and that (ii) governments have *complete* information about the state of the world’s climate and the economy. These assumptions are eschewed by Amitrajeet Batabyal in his chapter 9 analysis of the design of IEAs. Batabyal studies the problem faced by an *imperfectly* informed supra-national governmental authority (SNGA) with limited monetary resources that wishes to design an IEA for $N \in \mathbb{N}$ developing countries (DCs). Using a hierarchical principal-agent model, Batabyal investigates the properties of the optimal limited liability IEA that can be implemented by the SNGA when polluting firms and national governments in the individual DCs collude to the detriment of the SNGA. His

⁵This question has been discussed by a number of scholars. For additional details, see chapters 2, 9, and 11 in this book and Maler (1990).

analysis shows that obtaining voluntary participation by the firms and the governments and preventing *ex post* breach of the IEA by these two players is costly for the SNGA. Moreover, Batabyal's analysis tells us that because a SNGA can successfully design collusion-proof IEAs, IEAs are *not* inherently doomed due to a basic monitoring and enforcement problem stemming from national sovereignty. However, the success of IEAs *is* fundamentally contingent on the funds available for environmental protection.

Chapters 2 through 9 of this book provide us with diverse theoretical perspectives on the economics of IEAs. Collectively, these chapters illustrate the many useful theoretical insights that can be gained by engaging in rigorous microeconomic and game-theoretic analyses of IEAs. A logical question now is this: How can this theoretical knowledge be used to increase our understanding of the practical aspects of IEAs? It is to this application issue that we now turn.

3. Applications

In chapter 10, Roger Congleton constructs models of democratic and authoritarian environmental policy making to explore the effect that political institutions have on the willingness of governments to control pollution. Congleton notes that although data and other limitations preclude one from testing whether democratic regimes—relative to authoritarian ones—are more likely to adopt strict environmental regulations, this hypothesis can be tested using data on IEAs. As such, using national area as a proxy for natural resources, Congleton analyzes a data set consisting of 118 countries. Congleton's helpful analysis shows that a nation's environmental policy decisions *are* determined primarily by its political institutions, and that as compared to authoritarian nations, liberal democracies are considerably *more* likely to participate in IEAs.⁶ These two findings lead

⁶This finding is corroborated by the results contained in chapter 14 and in Olson (1993).

Congleton to conclude that IEAs will attract more signatories as the number of democratic regimes in the world increases.

This issue of international participation in an IEA is examined from the perspectives of efficiency and equity by Johan Eyckmans, Stef Proost, and Erik Schokkaert (EPS) in chapter 11. EPS divide the world into twelve homogeneous blocks of countries and then examine the CO_2 emissions reduction strategies employed by each of these twelve players (blocks). In the benchmark non-cooperative game in which players behave in Cournot fashion, there is almost no reduction of CO_2 emissions. This pessimistic conclusion changes in the first-best and in the second-best solutions of an international carbon emissions game. In particular, while there is virtually no worldwide pollution abatement in the benchmark game, there is almost 17% pollution abatement in the first-best game. The extent of pollution abatement in the second-best game depends on the magnitude of a parameter called the degree of inequality aversion. Interestingly, EPS show that in the context of their modeling framework, there is no game outcome in which the net payoffs of *all* the nations is positive. From this, EPS conclude that an analysis of realistic IEAs will need to pay attention to side payments and incorporate participation constraints⁷ explicitly into the analysis.

Why are side payments so important? This question is addressed by Olli Tahvonen, Veijo Kaitala, and Matti Pohjola (TKP) in their chapter 12 analysis of an acid rain game between Finland and the former Soviet Union. TKP focus on the terms of a 1987 IEA between Finland and the Soviet Union that called for a 50% reduction in sulfur emissions throughout Finland and in adjacent regions of the Soviet Union. TKP calculate the cost-effective and the non-cooperative sulfur abatement policies for these two countries and they show that the 1987 IEA is *not* cost-effective. Moreover,

⁷Participation constraints and their salience have been studied in chapter 9 by Amitrajeet Batabyal.

they demonstrate that the abatement costs implied by the agreement are *higher* than those in the non-cooperative equilibrium. Interestingly, TKP show that although there are significant potential gains from cooperation between these two countries, this cooperation is unlikely to arise because in general, cost-effective sulfur IEAs are likely to benefit Finland but *not* the Soviet Union. This raises the thorny issue of side payments once again. As noted by TKP, the implementation of cost-effective sulfur IEAs is likely to require side payments from Finland to the Soviet Union. However, from a political standpoint, it may not be possible to make such payments. Consequently, other ways of implementing cost-effective IEAs will have to be considered.

In chapter 13, Werner Pommerehne, Lars Feld, and Albert Hart (PFH) study the question of international cooperation from a public goods perspective. The issue here is the construction of a waste incinerator in Grosblierstroff (in France) that would have adverse impacts on the residents of Kleinblittersdorf (in Germany). On the basis of direct negotiations, it was determined that Kleinblittersdorf would buy the land in question from Grosblierstroff and then look for an investor who would be willing to operate a less pollution-intensive incinerator. Bringing this plan to fruition required a certain amount of money. PFH analyze the factors that determined the provision of this public good, i.e., the construction of an “environmentally more benign” incinerator. On the basis of an econometric study of a random sample of 400 households in Kleinblittersdorf, PFH note that non-economic factors play a crucial role in the voluntary provision of public goods. This leads them to conclude that it is important to remember that as compared to economic factors, *non-economic* factors are often a more important determinant of a citizen’s voluntary contribution to a particular public good.

Chapter 14 continues the investigation of the voluntary provision of public goods begun in the previous chapter. In this chapter, James Murdoch and Todd Sandler provide a thought provoking

account of cutbacks in CFC emissions that, for the most part, predated the institution of the Montreal Protocol on Substances that Deplete the Ozone Layer. Their econometric analysis validates a key empirical prediction of the theory of the voluntary provision of public goods. That is, these authors demonstrate that when tastes are controlled and three outlier nations are excluded from the sample, a statistically significant *linear* relationship emerges between CFC emission cutbacks and national income. On the basis of this demonstration, Murdoch and Sandler claim that the Montreal Protocol was initially instituted because it codified reductions in CFC emissions that polluting nations were *voluntarily* prepared to undertake. This leads these authors to conclude that (i) the Montreal Protocol may *not* be a good model for other IEAs, (ii) that foreign aid is likely to quicken the adherence to mandated diminutions in CFC emissions, and (iii) that the promotion of democracy is likely to increase the number of nations that will take steps to effectively deal with global pollution problems.

How general are the conclusions of chapter 14? Do they apply to pollutants such as sulfur and nitrogen oxides? This and other questions are analyzed by James Murdoch, Todd Sandler, and Keith Sargent (MSS) in chapter 15. From their theoretical framework, MSS derive an econometric model of the demand for emission reductions which adjusts for the spatial dispersion of the pollutant in question. This model enables them to explain why European nations have been able to meet or exceed mandated reductions in sulfur emissions, but not mandated reductions in nitrogen oxide emissions. MSS point out that sulfur emissions are easier to control than nitrogen oxide emissions because, *inter alia*, a greater proportion of sulfur emissions falls within a country's jurisdiction and within an IEA's jurisdiction. Moreover, consistent with the conclusions of chapters 10 and 14, these authors point out that because increases in income and political freedoms increase emission reductions, foreign aid and the promotion of democracy can result in a cleaner environment for all nations. Perhaps the most significant conclusion to emerge from this chapter is that collective action

problems that seem superficially similar, can in fact be quite *dissimilar*. Consequently, one should be careful in lumping collective action problems together, even if they involve the same participants.

4. Conclusions

The different chapters in this book effectively describe the theoretical and empirical contributions that rigorous economic analysis can make in improving our understanding of the causes of and the solutions to a variety of international environmental problems. These chapters also provide us with a “state of the art” perspective on what is currently known about the theoretical and the empirical properties of IEAs. The task for researchers now is to use the findings contained in this book to better design and implement actual IEAs. With talk of rising disparity between the developed world and the developing world and the increasingly contentious nature of international discussions about the use of environmental resources, IEAs take on particular salience. This is in no small measure due to the fact that the design and the implementation of IEAs will do more to engender and maintain international security than will most unilateral or non-cooperative policy measures.

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