



**Development and Global Finance:
The Case for an International Bank
for Environmental Settlements**

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The approach suggested here was proposed by the author during discussions with members of (a) the Intergovernmental Negotiating Committee (INC) of the United Nations Framework Convention on Climate Change (FCCC), (b) the United States Council of Economic Advisors, (c) the Global Environment Facility, and (d) the Organisation for Economic Cooperation and Development. An earlier version of this paper was presented as a keynote address to the Third Annual World Bank Conference on Effective Financing of Environmentally Sustainable Development in October 1995. The author thanks the participants of UNDP meetings in March and June 1996 for their comments as well as Dr. Jorge Werthein of UNESCO.

Foreword

There is growing consensus that development cannot simply be equated with economic growth. Development—if it is to be sustainable and people-centred—must seek to reconcile economic, social and environmental concerns. Yet, while the concept of sustainable human development (SHD) is increasingly being recognized, policy-makers are often at a loss when it comes to “doing” SHD. Practical and pragmatic policy options for implementing the SHD paradigm are still lacking.

The Office of Development Studies (ODS) has therefore selected as one of its major areas of study the issue of reconciling economic, social and environmental concerns of development. The focus of ODS's contribution in this area is on innovative policy measures—making SHD work.

The present paper by Graciela Chichilnisky forms part of this ODS research focus. The author resumes and carries forward the debate on permits for the emission of greenhouse gases. Chichilnisky points out that borrowing and lending emission rights might be preferred to trading or selling them. Selling one's right, for example, to emit carbon dioxide, the main greenhouse gas, could be tantamount to selling one's ability to use coal and petrol in the future—thereby also relinquishing eventually one's right for further industrialization.

The most innovative feature of the paper, however, concerns Chichilnisky's newly discovered links between efficiency and distribution of prop-

erty rights in emissions permits leading to a proposal for an international bank for environmental settlements (IBES).

The proposed IBES would act as a clearing house for the global environmental market, matching parties in environmental trade, mediating borrowing and lending and ensuring the integrity of market transactions and their settlement. The IBES will provide the necessary institutional framework for the lending and borrowing of emissions rights.

The IBES could use as collateral the world's environmental resources—its forests, bodies of water and its atmosphere—thereby helping to realize the value of environmental assets without destroying them. It would balance the positions of large and small traders by offering a neutral trading base for all and an anonymous process where several small sellers could meet large buyers. The IBES could borrow short from developed countries and lend long to developing countries—fulfilling the function of a financial intermediary.

Like the other ODS Discussion Papers, the present paper invites development thinkers and practitioners as well as financial experts to respond to the findings of the study. A selection of the responses will be published at a later date.

Other papers in the series on reconciling economic, social and environmental concerns are listed on the inside back cover of this paper. They include in particular the studies by Sudhir Anand and Amartya K. Sen, by Lance Taylor and Ute Pieper, by Sudhir Anand and Lincoln Chen and by Isabelle Grunberg.

Inge Kaul
Director
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I.

Introduction

The Bretton Woods Institutions are creatures of the postwar reconstruction. Since World War II, a newly introduced system of national accounts has supported the activities of the World Bank, the International Monetary Fund (IMF) and the GATT, institutions that have led the world economy into an unprecedented period of industrialization, material expansion and global commerce.

During this period economic progress has come to mean doing more with more. But as the century turns, industrial society's voracious use of the earth's resources has reached its logical limits. For the first time in history, human activity has reached levels at which it can alter the atmosphere of the planet and change irreversibly the complex web of species that constitutes life on earth. Humans have the ability to destroy in a few years the massive infrastructure that supports the survival of the human species on the planet, the global habitat to which humans have adapted optimally throughout the ages. Industrial society's runaway and uneven use of the planet's resources is now under close scrutiny.

This paper proposes a new global institution with sensitivities where the World Bank, the IMF and the World Trade Organization (WTO) fall short: an International Bank for Environmental Settlements (IBES) to help redress environmental imbalances of the past fifty years.¹

The aim is to develop innovative financial institutions and instruments to obtain market value from environmental resources without destroying them. Emissions trading, the global reinsurance of environmental risks, and the securitization of the earth's biodiversity resources are natural financial instruments that merge the interest of private financial markets with international development policy.² These instruments and institutions should help to redefine economic progress in a way that is compatible with the harmonious use of the world's resources.¹

The imperative suggesting a real change appears clear enough. Industrial society is in the process of transforming itself into a knowledge society; it is not the service economy previously thought. To an increasing extent, humans can now achieve a new form of economic organization where the most important input of production is no longer machines, but human knowledge. Instead of burning fossil fuels to power machines, we burn information to power knowledge. Information is a much cleaner fuel than coal and petroleum, and one that puts humans rather than machines at the centre of economic progress. I propose that economic progress be knowledge-intensive rather than resource-intensive: more could be achieved with less.

The principles discussed in this paper apply very widely to the use of all environmental assets, such as biodiversity, soil and forests. However, the examples and the data used here concentrate on the use of the atmosphere of the planet through the emission of greenhouse gases, mostly derived from the burning of fossil fuels - coal and petroleum—to generate energy.

The International Bank for Environmental Settlements (IBES) proposed in this paper is fundamentally different from a standard financial market, such as a stock exchange. The IBES will have a much larger role than a stock market does, in the many ways which are discussed below. The reason a more sophisticated institution is required is that emissions permits are rights to use a "public good," the atmosphere of the planet.

By contrast, stock markets trade private goods. When private goods are traded, markets are efficient. When trading public goods, however, stock markets may not reach efficient outcomes, and other institutions are needed to complement them, either to set a basic borrowing and lending rate (as the Federal Reserve does in the United States) or to help to establish property rights (as done by the Federal Communications Commission with the help of auctions of the airwaves).

That stock markets must be complemented by other institutions to reach efficiency is a fundamental new fact that is presented in this paper and is a main rationale for the creation of a new Bank. This is explained in detail below and in the Appendix.

I explain below why a new institution may be required to complement the Bretton Woods Institutions, how the IBES will work in practice, and why the role of the IBES complements markets but goes much further than anything that unaided markets can achieve. An appendix presents the results within a model of an international market trading goods and emissions permits, as well as numerical simulations using the PIR-OECD Green model of international trade.

This paper discusses how an IBES could have an impact on developing countries. I show that, contrary to common wisdom, achieving a more even distribution of property rights to environmental assets is more than a matter of equity. Property rights influence market efficiency too, for example. Indeed, I will show that a precondition for market efficiency is that more property rights on the global commons should be given to those regions that own fewer private goods. As a result, developing countries should be assigned proportionately more property rights on global environmental use in order to ensure efficient market solutions.

2. Rio, Berlin, Geneva and Beyond

THE GLOBAL ENVIRONMENT

Widespread concern about ozone depletion, biodiversity destruction and global climate change led to the 1992 Earth Summit in Rio de Janeiro. One hundred nations agreed to consider a treaty to reduce the threat of global warming by rolling back emissions of greenhouse gases in industrialized countries to the 1990 level by the year 2000.

The Earth Summit emphasized the importance of achieving sustainable development. For this purpose, United Nations Agenda 21, adopted in 1992 by one hundred and fifty nations, has as an explicit objective patterns of consumption oriented towards the satisfaction of **basic needs**.⁴

Despite the interest generated by the Rio Summit, the implementation of its goals has been slow. Part of the problem is scientific uncertainty about the impact of greenhouse gases on the atmosphere. But science increasingly supports the view that human activity is causing climate change;⁵ therefore, this justification for inertia is being removed.

A second and more difficult factor hindering the negotiations is the divergence in the perceptions of the industrialized and developing countries.

Most emissions have originated in and continue to originate from the industrialized countries. Many developing countries take the position that

only changes to this pattern can have an impact on the problem, while many industrialized countries see the biggest threat in the harm that developing countries can do in the future.

RIO TARGETS AND BERLIN MANDATE

The next most important international meeting on climate change since Rio was the Berlin Conference of the Parties. It concluded on 7 April 1995 by adopting a call for action. It found that the Rio Articles were not adequate. A mandate adopted in Berlin—the “Berlin Mandate”—requires the negotiation of an emissions-reduction Protocol to set hard, quantified limitations on the greenhouse gas emissions from developed countries in 2005, 2010 and 2020.

Another major decision in Berlin was to establish a pilot phase for **joint implementation**.⁶

Many developing countries had seen joint implementation as a mechanism for transferring responsibility for emissions reduction away from the very countries that account for most of the emissions of the planet—the industrialized countries.

To address this concern, industrialized countries may not take credit for any reduction of their emissions during the pilot phase, in their commitments to 1990-level emissions reduction by 2000. The results of this pilot phase will be reviewed before the turn of the century.

GENEVA 1996 AND THE IBES

Following Berlin, the Second Conference on the Parties of the United Nations Framework Convention on Climate Change (FCCC) met in Geneva in July 1996. In this meeting, the United States adopted a new position which supports for the first time the concerns of developing countries to establish hard targets for the greenhouse gas emissions of industrialized nations.

Taking a leading position, the Hon. Timothy Wirth, Under Secretary for Global Affairs of the United States advocated a market approach for the trading of rights to emit greenhouse gases among the industrialized nations—the very approach originally proposed in this paper as presented

at the third Annual World Bank Conference on Effective Financing for Sustainable Development in Washington, D.C., October 1995.

The United States' approach did not however go as far as recommending the creation of an international bank for environmental settlements (IBES), which is the natural next step, as argued here.

3.

The Need for an International Bank for Environmental Settlements (IBES)

Below I set out policies that can help implement the Rio targets and the protocol resulting from the Berlin Mandate. I will focus on the Berlin decision towards joint implementation and the United States proposal in the Geneva decision, both of which are a prelude to the multilateral trading of emissions rights.

In this context, I will explain the need for an addition to the Bretton Woods institutions: an **International Bank for Environmental Settlements (IBES)**. This Bank will use as collateral the environmental assets of the planet, perhaps the most valuable of all assets known to humankind, and will facilitate the execution and settlement of the trading of global environmental assets and related financial instruments within the global emissions ceilings stipulated by the protocol.

It has been established that at present most forests are destroyed in order to produce minerals⁷ or to grow agricultural products for sale on the international market, see [10]. The IBES will help developing countries, which own most of the forests and biodiversity on the planet, to obtain economic value from these assets without destroying them.

This may include securitization of commercial applications of biodiversity, such as the Merck-INBIO deal in Costa Rica, see [13]. The Bank will help to organize, execute and monitor the trading of emissions permits,

loans on these, and of derivative instruments associated with them. The IBES can also serve to ensure the integrity of markets for emissions trading and their efficiency.

NORTH SOUTH ISSUES

It is useful to start with a brief summary of the issues involved in climate negotiations. Developing countries fear the imposition of limits to their growth in the form of emissions restrictions, on the use of their own resources, as well as unrealistic population targets.

Developing countries observe that most environmental damage currently originates and originated historically in the industrialized countries, whose patterns of development are at the root of the environmental dilemmas we face today, see [10, 35]. The members of the Organization of Oil Exporting Countries (OPEC) are particularly concerned with the changes that the Protocol decisions could precipitate in their export markets if petroleum prices increase. A similar position is taken by other resource-intensive exporters, such as Australia.

Industrialized countries have a different set of concerns: they fear excessive population growth in developing countries and the environmental damage that this could bring. While recognizing their historical responsibility for excessive environmental use, they focus on a long-term future in which global environmental problems could originate mostly in the developing countries.

As a result of these differences, the Berlin Conference of the Parties was not able to reach an agreement on rules of procedure. Geneva moved the debate a step forward, but the road ahead is long and steep. International agreements are customarily adopted by consensus. How to achieve this?

THE ECONOMICS OF THE GLOBAL ENVIRONMENT

The implementation of the Rio targets, the FCCC Berlin Mandate and Geneva's goals require a measure of consensus about the policy instruments to be used. The instruments available are new: joint implementation and emissions trading involve the trading of rights to use the planet's atmosphere. These instruments share a novel and unusual characteristic. They trade rights to use the atmosphere of the planet, which are rights to use a **public good**: the quality of the earth's atmosphere is the same

for all and cannot be chosen in different quantities for different people. Although different regions are affected differently, the concentration of greenhouse gases in the atmosphere is fairly even and stable, and is the same worldwide. This puts environmental markets in a class of their own and requires that we complement these markets with more sophisticated financial institutions. As explained below, this means that unaided markets to trade emissions permits cannot reach efficient solutions, and back-up institutions are needed for the trade in public goods.

Another new aspect of the environmental problem is that emissions, although producing a public good in the quality of the atmosphere are not centrally produced by a government, as are public goods like law and order. In contrast with the classic case examined by Lindahl, Bowen, and Samuelson, the public good that interests us here is *privately produced*. Indeed every person on the planet emits greenhouse gases through driving a car, heating their homes, or producing energy by burning fossil fuels. Emissions markets are therefore markets to trade *privately produced public goods*. Such markets are quite different from classical markets.

To understand the issues and develop policy, conceptual advances in economics are needed. The economics of climate change involves challenging questions such as:

- Which policy instruments or combination of instruments—carbon taxes, joint implementation or tradeable emissions permits for CO₂—are preferable for controlling emissions?
- What institutional structures for trading carbon emissions—such as property rights regimes and market structures—will lead to efficient allocations?
- How can an acceptable degree of equity in the use of global commons be ensured?
- How would the notions in this paper impact developing countries? Should developing countries have more property rights on the global “commons,” and if so, why?
- Which institutions may be needed to support and regulate the trading, clearing and settlement of emission rights and related assets, and to ensure the efficiency and integrity of the market?
- What type of environmental accounts will help record and monitor the success or failure of taxes, joint implementation schemes or emissions markets?

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- When do market prices accurately reflect the value of resources, and when should new institutions be created?
 - What is the scope for applying the proposals in this paper—beyond the green-house effect—to tackle other cross-border problems, such as soil erosion and deforestation?

4.

The Role of the IBES: Ensuring Greater Equity and Efficiency

In addressing these questions a main recommendation is the creation of an **International Bank for Environmental Settlements (IBES)**, which will use as collateral the environmental assets of the planet. These assets include the world's forests and bodies of water, its minerals and biodiversity. Today most forests are destroyed to produce minerals or agricultural products for sale in the international market; the IBES will help to realize their value without destroying them. The Bank will help to organize, execute and monitor the trading of emissions permits, loans on these, and of derivative instruments associated with them.

I show below:

- Why a new institution may be required to complement the Bretton Woods Institutions;
- How the IBES will work in practice; and
- Why the role of the IBES complements markets but goes much further than anything that unaided markets can achieve.

Appendix I presents a general equilibrium model of North-South trade, which includes trade in environmental assets. Appendix II reports on simulations using the PIR-OECD Green general equilibrium model of international trade. This model was developed by OECD, and was adapted at

the Program on Information and Resources (PIR) of Columbia University for the purposes of this paper.

COMMON INTERESTS

Implementing the Rio targets and the Berlin Mandate requires a substantial and concerted effort on the part of all parties to communicate and to understand each other's concerns, to address in depth the problems and the possible solutions, and to reach consensus. A better understanding of the economic aspects of the issues is valuable because it can foster that consensus.

In developing consensus, it helps to build from common interests. While the main concerns are ecological and environmental, the principal stumbling blocks in reaching solutions are of an economic nature. To abate carbon emissions means, in the short term, burning less fossil fuel and producing less energy. This means less economic output. Who should abate?⁸

Both industrialized and developing countries face significant abatement costs in the short run because current patterns of development are resource-intensive and it is costly to change them. Although the outcome of our policies is uncertain because we know relatively little about the impact of human activity on the environment of the planet, the risks we face are nevertheless sufficient to make it compelling that precautionary steps are taken now.⁹ How much is it worth paying to improve our environment, and who should pay?

The main findings and policy recommendations of this paper address these questions. I will discuss who should abate and why, and I will seek to explain from this answer how to arrive at a cooperative solution that can help bring about consensus.

RESOURCE-INTENSIVE VS. KNOWLEDGE-INTENSIVE GROWTH

The most dynamic sectors in the world economy today are not resource-intensive but knowledge-intensive: software and hardware, biotechnology, communications and financial markets.¹⁰ These sectors are

friendly to the environment, use relatively few resources and emit relatively little carbon dioxide (CO₂). They are the high-growth sectors in most industrialized countries.

Some of the most dynamic developing countries are making a swift transition from traditional societies to knowledge-intensive societies. Mexico produces computer chips, India is rapidly becoming a large exporter of software, and Barbados has recently unveiled a plan to become an information society within a generation.

There is nothing new about such policies. These were precisely the policies followed by the Asian Tigers—Hong Kong, Republic of Korea, Singapore and Taiwan Province of China, all countries which have achieved extraordinarily successful performance over the last twenty years relying not on resource exports but rather on widespread education and formation of human capital and exports of knowledge-intensive products, such as consumer electronics. By contrast, Africa and Latin America emphasized resource exports and lost ground.¹¹

The lessons of history are clear and incline steeply away from reliance on resource exports as the foundation of economic development. Africa and Latin America must update their economic focus. Indeed, the whole world must shift away from resource-intensive economic processes and products. In so doing, fewer minerals and other environmental resources will be extracted, and their price will rise. This is as it should be because today's low resource prices are a symptom of overproduction and inevitably lead to overconsumption.¹²

Not surprisingly, from an environmental perspective, one arrives at exactly the same answer: higher resource prices are needed to curtail consumption. Producers will sell less but at higher prices. This is not to say that all will gain in the process. If the world's demand for petroleum drops, petroleum producers may lose unless they have diversified into other products that involve fewer resources and higher value. Most international oil companies are investigating this strategy. The main point is that nations do not develop on the basis of resource exports, and at the end of the day development can make all better off. As the trend is inevitable, the sooner one makes the transition, the better.

Economic development means achieving more with less. It does not mean doing more with more.

MARKET INSTRUMENTS FOR INTERNATIONAL POLICY

The Berlin Protocol calls on the international community to establish emissions ceilings. Once the targets on emissions levels have been agreed upon by the FCCC, a wide variety of instruments are available for their implementation. Some are command and control instruments, which establish bounds on economic behaviour and can be cumbersome when they involve restrictions on trading and other economic practices. This translates into inefficiencies at the economic level.

TAXES AND EMISSIONS MARKETS

Other economic instruments are based not on command and control but on prices. The idea is that higher prices deter consumption and induce a more conservative use of resources. Examples are taxes, joint implementation and markets for emissions permits. These are discussed in more detail below. In a nutshell, taxes deter resource use by imposing costs on resource use. Joint implementation and markets do the same but in a different way.

In all cases, one has to pay for emissions, but with markets one pays either by buying permits or, in the case of joint implementation, by finding other mutually agreeable trades with other parties with the attendant opportunity costs. Taxes and emissions permits are therefore very similar. Taxes, however, penalize emissions in a manner prescribed by a central authority. Emissions permits penalize emissions but the effective "rate" is **not** set. Instead this rate is flexible, depending on market forces: it is the price of the permits, and therefore changes through time with supply and demand conditions.

HOW DO EMISSIONS MARKETS WORK?

The simplest forms of emissions markets restrict total quantities and allow free economic agents to make choices about how to implement these limits and within these limits to trade quotas among themselves. A country will buy permits if it wishes to emit more than its quota and will sell them otherwise.

Prices are flexible: they are determined by supply and demand. Total emissions in the world remain unchanged. Such practices are often called "market instruments" because they mimic market solutions.

For example, a limit is placed on one or more agents' emissions (such as the Rio targets, which aim at the "rolling back" of the emissions of industrialized countries to 1990 levels by the year 2000). Within this overall target, however, industrialized countries could be allowed to adopt their own economic policies towards compliance and also be allowed to trade among themselves if this is desirable for achieving their targets.

WHO SHOULD ABATE?

Underlying the policy issue is the question: Who should abate? Who should contribute most to the improvement of the atmosphere, to the recovery of the "global commons"? One answer often heard is the developing countries because they have lower abatement costs. OECD has argued for this because it would equate marginal costs of abatement across countries and therefore bring about efficiency.¹³

This answer is based on the belief that abatement of carbon emissions costs less in developing countries. In this view, abatement would be carried out in developing countries where the cost of achieving the same goal is lower in dollar terms. This would ensure efficiency. Is this argument valid?

This argument is true in markets for private goods. Here efficiency can be obtained by equating marginal costs. However, the argument fails in markets with privately produced public goods. This failure shows an important difference between standard markets and environmental markets.

In markets with privately produced public goods, it is not the dollar value of the abatement that counts for efficiency but rather the opportunity cost of that dollar value in terms of the utility that it can provide. The point is that the same dollar brings about very different utility gains in a rich country than in a poor country. Marginal utility gains are what count to determine efficiency. Chichilnisky and Heal [21] establish the point rigorously.

For example, suppose that abatement of an extra ton of carbon costs \$1.00 of output in India and \$2.00 in the United States. Abatement of an extra ton of carbon costs less in India. Who should abate?

In this example, the real loss of utility from abatement in India can be much higher than in the United States because the \$1.00 of goods can have a major impact on the average citizen in India, while a \$2.00 loss in the United States has only a marginal impact for the average citizen. The point

is simple: the marginal utility of income decreases with income. The more income we have, the less our utility increases with the additional dollar.

These matters do not count in economies with private goods because everyone chooses independently from each other and traders can adjust their consumption to equate the marginal gains they derive from all markets.¹⁴

However, with privately produced public goods, they do not. In these cases, the condition of equal marginal costs is not appropriate for efficiency.¹⁵ It is appropriate only when all countries have the same marginal utility of income.

Only when (free) transfers are made between countries so as to equate their marginal valuations of private consumption does efficiency require that marginal abatement costs be equal.

Such transfers are not realistic.¹⁶ In general, efficiency implies that abatement will come proportionately more from those countries that have higher income because they have a lower marginal utility from increased consumption than poorer countries.¹⁷

Under general conditions, the proportion of income dedicated to abatement should increase with the level of income. Who then should abate? First of all, the industrialized countries.¹⁸ This has been the position of the developing countries for many years. As reported above, even the United States agreed with this position in Geneva in June 1996.

Requiring abatement from the developing countries first would be a regressive measure, like taxing the poor the most. There are other concerns about regressive measures. They can cause problems because environmental degradation and poverty are closely connected. Anything that worsens poverty is likely to lead to further environmental degradation and to increased rates of population growth.¹⁹

In other words, a policy that lowers the price of wood and therefore the income of harvesters can lead to more rather than less extraction of wood. Since the purpose of taxing the price of wood is to discourage extraction of wood, by decreasing the income of the harvesters the tax could achieve the opposite effect from that which was intended.²⁰

JOINT IMPLEMENTATION

Article 4 of the Rio Convention allowed for cooperative solutions, in which an industrialized country could satisfy its target of decreasing emis-

sions to 1990 levels either within its territory or in the territory of a cooperating country. A major decision of the 1995 Conference of the Parties in Berlin was to establish a pilot phase for **joint implementation**. An industrialized country can barter with another, with the final aim of reducing carbon emissions in financial terms or in kind.

Projects of this nature have already been executed in Mexico and Poland on an experimental basis. To ensure that the pilot does not discourage the shift of industrialized countries to a more sustainable use of resources, their reduction of emissions during the pilot phase will not be credited to their existing commitments to return emissions to 1990 levels by the year 2000.

When the results of the pilot phase are reviewed before 2000, the issue of credit will be revisited at that time, if not earlier, in combination with the adoption of a reductions protocol.

Joint implementation schemes are bilateral trade agreements and a natural extension of the economic practice of barter trading. However, bilateral trading is typically inferior to multilateral trading since, in the case of the latter, all parties have access to all possible deals and could in principle reach substantially more favourable trades and better terms of trade.²¹

MULTILATERAL AGREEMENTS

Bilateral trading eventually leads to multilateral trading. Yet a widely expressed concern is that during the development of a multilateral market, the prices may turn against the developing countries. Developing countries will typically be sellers of permits initially, when prices are lower. If they buy permits later in order to industrialize, they may be paying much more for the same permits they initially sold. Selling a country's rights to emit is the same as selling its right to industrialize. There is a chance that the first buyers could reap unfair "rents" or "bargains" over later buyers.

A response to this is a proposal for "leapfrogging" into multilateral trading sooner rather than later and attempting to establish fair trading practices, such as uniformly distributed price information and other practices that are widely adopted in the most successful markets in order to ensure equal access to information and trading opportunities, efficiency, market integrity and depth.

One problem remains: in contrast to other markets, one would be trading a public good that we all must "consume" in the same quantities. How to ensure efficiency and integrity of such a market? What additional steps must be taken to achieve the Rio goals and the goals of the Protocol mandated in Berlin within a trading-based strategy?

HOW SHOULD THE RIGHTS TO EMIT BE DISTRIBUTED?

Emissions trading has as a goal an efficient allocation of emissions within the global limit. However, in order to trade, one must know who owns what. This means that property rights must be established: one must establish who has the right to emit and how much. This is not necessary for taxes; it is for markets.

Until now the issue of property rights on emissions has been left to the political arena, with the understanding that it involves exclusively a transfer of wealth between countries. An implicit assumption was that markets themselves always function efficiently; the matter to be decided was the distribution. The two issues, efficiency and distribution, were seen as separate. The latter, distribution, was seen as a major political hurdle and a divisive issue that complicated matters and interfered with the development of consensus.

However, recent advances in the economics of climate change have disclosed a somewhat unexpected source of common interest among industrialized and developing countries.²² There is a new role for distributional issues: the appropriate equitable distribution is needed for markets to function efficiently. Somewhat surprisingly, a measure of equity can lead to efficient allocations.²³

THE ECONOMICS OF CLIMATE CHANGE

The new source of common interest between industrialized and developing countries originates in a recently discovered link between the *efficiency* of an emissions market and *equity* in the allocation of property rights on emissions traded in this market. Efficiency is often favoured by industrialized countries that have the most developed markets, while equity is an issue that concerns the developing countries most. The close connection between these issues indicates that a new source of common interest may be developed.

5. How the IBES Would Work

There may be little intersection between the interests of the two groups of countries in markets for private goods. But this is different in markets for public goods. To trade efficiently the rights to emit greenhouse gases into the atmosphere requires a good distribution of rights to emit across countries. Only relatively egalitarian distributions will lead to market efficiency. Efficiency and distribution are no longer divorced: they reinforce each other. Through this unique characteristic of markets for public goods, a common interest emerges between the two groups of countries.

PROPERTY RIGHTS ON GREENHOUSE GAS EMISSIONS

A recent discovery is a property rights regime that leads to efficient allocations. This is similar to a system of licenses to use intellectual property, for example, software. To see how this works, some background is needed.

The CO₂ concentration in the atmosphere is not a classic public good that is produced by a centralized agent (as are law and order or bridges). Every individual and every firm in the world causes emissions of CO₂ through the consumption and production of goods that burn fossil fuels in production.

Every individual and firm is therefore engaged in the production of the atmosphere's carbon concentration, which is the public good. This is quite different from the classic case such as law and order where the public good is produced in a centralized fashion by the government. Typically, individuals cannot produce law and order.

The quality of the atmosphere is a public good that is produced privately, by all consumers and producers, in a manner which is concomitant with and impossible to disassociate from the rest of their economic actions. This changes the analysis of optimality and leads to new insights and policy recommendations.

One insight is that the equalization of marginal costs of abatement across countries is no longer a sufficient condition for efficiency in these markets. Since competitive trading of permits leads to the equalization of marginal costs of abatement, it follows that competitive trading of carbon emissions will not by itself lead to efficient allocations and other forms of market allocations may be needed.

The policy implication is that a market for emissions trading must be complemented by other institutional arrangements to reach efficient solutions.²⁵

In practical terms, this means that of all possible ways of allocating a given total of emissions rights across countries, only a small number of allocations will lead to efficient patterns of resource allocation. **These property rights regimes are called efficient property rights** and have points in common with licenses and or patents in the realm of intellectual property rights.

Not all allocations of a given total number of permits are compatible with an efficient functioning of markets. Intuitively, the reason is that redistribution of a given total number of permits to emit, redistributes wealth, and thus typically changes the desired levels of consumption and abatement for each trader, see Appendix I.

ENVIRONMENTAL MARKETS AND GLOBAL FINANCE

The same principles and institutional mechanisms suggested here can be used to induce efficient limitations on the emissions of many other environmentally harmful substances or in the use of the earth's biodiversity. The IBES should provide the backbone of global environmental markets,

extending existing institutions to the global level and ensuring their efficiency and integrity.

Indeed, some of these principles have been applied to sulphur dioxide (SO₂), nitrous oxides and various water pollutants.

In 1993, the Chicago Board of Trade (CBOT) introduced SO₂ emissions trading, following the United States Clean Air Act, which introduced ceilings and rights to emit for United States utilities.

These markets are less appropriate than CO₂ markets because as opposed to CO₂, SO₂ does not mix uniformly in the atmosphere. As a result, trading between states can lead to violations of the United States Clean Air Act. Thus, localized trading is necessary in some cases limiting market depth.

Water markets are emerging now in Southern California. Other environmental markets have emerged for trading weather risks, such as hurricanes, which have become more unpredictable and violent owing to the global climate change, believed to be associated with an increasing concentration of greenhouse gases in the atmosphere. The Intergovernmental Panel on Climate Change (IPCC) has recently agreed that there is a discernible effect of anthropogenic emissions of greenhouse gases on climate change. In 1992, G. Heal and I proposed in [20] the creation of an instrument that is now traded on the Chicago Board of Trade under the name of *Catastrophe (CAT) Futures*.

The creation of a more sophisticated instrument, which is obtained by "bundling up" mutual insurance contracts as well as securities, called *Catastrophe Bundles*, has also been suggested recently in Chichilnisky [16],[17], [18] and Cass, Chichilnisky and Wu [6]. In Chichilnisky [13], I studied the use of profit sharing agreements to obtain value from biodiversity without destroying it, using the Merck-INBIO deal as an example, and proposed deeper access to capital by securitizing such deals. A Wall Street report on these financial instruments appears in [4].

SIMULATIONS OF EMISSIONS TRADING

At the Program on Information and Resources of Columbia University, we have carried out computer simulations of the OECD Green model, modified to incorporate the possibility of trading emissions permits between the countries. This has confirmed the results discussed above;

the runs are reported in the appendix at the end of this document. The most efficient runs, in terms of minimizing the loss of economic growth that abatement induces, are those in which the distribution of permits favours the developing countries.

INTERNATIONAL BANK FOR ENVIRONMENTAL SETTLEMENTS

We have seen that financial markets for trading emissions may not by themselves reach efficient solutions because the atmosphere of the planet is a public good.

Since more sophisticated market structures are required to trade emissions, one may wish to consider a bank with the role of regulating the market and ensuring its integrity.

This bank could also fulfill the role of a clearing and settlement institution, such as the Bank for International Settlements.

The bank could offer credit enhancements for the carbon emissions permits sold by adding credit-worthiness to contracts sold, and perhaps by ensuring that the counterpart to each contract is the bank rather than another country or corporation, as is the case in a commodities clearing house.

The bank could also determine which types of instruments will be traded—for example, derivative securities (options, futures)—and if so, how.

In addition, the bank could serve as a forum for recording environmental accounts that could be used to monitor the successes and failures of implementation.

The bank could regulate the relationship between primary and secondary markets, a matter of great importance in ensuring market liquidity.

The bank could run open market operations and, in general, have an impact on borrowing and lending conditions and rates.

The name proposed here, the International Bank for Environmental Settlements (IBES), is suggestive of the type of institution envisioned.

The research carried out at the Program on Information and Resources at Columbia University has led to some unique insights into the structure of the CO₂ emission abatement problem and has led to the preliminary policy conclusions and recommendations outlined below.

The policy conclusions and recommendations have been discussed with members of the FCCC, of the United States Council of Economic Advisors, the GEF and with OECD members.

- **Recommendation 1.** A migration from "joint implementation" to multilateral procedures involving global markets for emissions rights. The emissions market would involve only industrialized countries initially. This recommendation was supported by the United States in Geneva in June 1996.
- **Recommendation 2.** Emissions rights will be generally *loaned*, not *sold*, with the lending and borrowing managed by the International Bank for Environmental Settlements. The key aspect of a loan rather than a sale of an emissions right is that developing countries need not be concerned about unforeseen long-term consequences of an irreversible transfer of their emissions rights to other countries nor need they be concerned that they will make irreversible deals today at prices that will subsequently look unreasonable. Lending rather than selling these rights avoids many uncertainties faced by developing countries entering into an emissions abatement agreement. Lending rates can be regulated by the IBES.
- **Recommendation 3.** Developing countries are likely to want to lend emission rights for limited periods until their needs for these are clear, whereas industrialized countries are likely to want to borrow for longer periods. The bank managing this market would match these positions by "borrowing short and lending long" in the traditional manner of financial intermediaries. In exchange for the risk involved, it would charge a borrow-lend spread. Commercial capital and international financial institutions, private or not, would undoubtedly be attracted to such an operation.
- **Recommendation 4.** In order to ensure fair prices to developing countries, it may be desirable for the bank to establish a market rate of interest on emissions permits in a market open only to industrialized countries and then to pay this rate on deposits from developing countries.
- **Recommendation 5.** The securitization of the planet's biodiversity, and global reinsurance of environmental risks that are associated with developing areas could be equally handled by the IBES.
- **Recommendation 6.** A similar treatment of the earth's airwaves would be desirable.

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- **Recommendation 7.** The establishment of a system to monitor and account for the successes and the failures of the trading agreements will be developed.

IMPLEMENTING RIO TARGETS AND THE BERLIN MANDATE

The following items will be part of the proposed IBES mandate:

1. The trading of greenhouse emissions rights should not compromise the future ability of developing countries to grow.
2. The trading of emission rights should not conflict with humanitarian aid or other international flows.
3. The IBES should provide more access to capital for development. It will not induce selling of emissions rights under less favourable prices.
4. The trading of emissions rights will initially be between industrialized countries. It should not enforce ceilings on developing countries' rights to emit which are neither required by the 1992 Rio Convention nor by the 1995 Berlin Conference of the Parties.
5. The IBES will have the role of ensuring fair markets and equal access to information and to trading; it will also ensure market integrity and depth.
6. Deals will be structured so that they can be reversed without undue penalty to the traders for countries which may revise their priorities in the future.

Appendix I

International Trade and Permits Markets

This section presents a general equilibrium model of international trade in which the findings of this paper have been formally established. The next section reports on simulations using the PIR-OECD Green general equilibrium model of trade.²⁶

The model presented in this section is a simplified version of the general equilibrium model in Chichilnisky [9], Chichilnisky and Heal [21] and [28] and Chichilnisky, Heal and Starrett [24], to which the reader is referred for the general form and for the proofs of the theorems reported below.

A general equilibrium model with environmental markets

There are two traders, North and South, denoted by the index $i = 1$ and 2, respectively, each producing two goods: one private good (x) and one privately produced public good (a) representing *abatement*—the negative of emissions—of greenhouse gases. The production of x requires energy, and thus the burning of fossil fuels. Therefore, more production of x leads to more emissions, and there is a trade-off between abatement and production—the more one produces, the more fossil fuels are burned and the more one emits. This trade-off is represented for each region i by a function with a negative slope:

$$x_i = g_i(a_i), g_i' < 0.$$

Each region has a utility function depending on its consumption of private goods, x_i , and the total quality of the atmosphere a . The utility increases on both variables:

$$u_i(x_i, a),$$

The quality of the atmosphere a depends on the total level of emissions, which is the sum of what both regions emit:

$$a = a_1 + a_2.$$

A limit on the total amount of emissions originating from both regions is postulated, \bar{a} . For example, this limit is given by the Rio target or by those limits to be reached pursuant to the Berlin Mandate.

Each trader is assigned property rights on the environmental asset, namely, rights to emit gases into the planet's atmosphere. For each trader i , denote its property rights on the environmental asset as \bar{a}_i . Then

$$\sum_{i=1}^2 \bar{a}_i = \bar{a}.$$

International markets with emissions trading

How does a market with emissions permits work? The regions trade private goods and rights to emit. Each region uses some of its permits to produce private goods and trades any left-over emissions rights in the international market in exchange for private goods. A *competitive market equilibrium* determines market prices π and also the levels of emissions that maximize each region's utility and clear the markets. Assuming that the private good is the "numeraire," i.e., $p_1 = 1$, then the (relative) price of the permits obtained by equating supply and demand in the international market is π , the "terms of trade" between permits and private goods.

Formally, a competitive equilibrium is defined as follows. Given the technologies g_i , the utilities $u_i(x_i, a)$ and the property rights on atmospheric use \bar{a}_i , a competitive equilibrium is given by a price π and a choice by each region i of how many permits to use for production, a_i , and how many permits to trade internationally ($a_i - \bar{a}_i$), so as to maximize utility subject to a budget constraint:

$$\text{Max } u_i(x_i, a)$$

subject to

$$x_i = g_i(a_i) + \pi(a_i - \bar{a}_i).$$

and simultaneously, markets clear:

$$\sum_{i=1}^2 a_i = \sum_{i=1}^2 a_i = \sum_{i=1}^2 \bar{a}_i.$$

Observe that a competitive equilibrium determines endogenously eleven relevant prices and quantities: the level of production and of consumption of private goods x_i by each region, the level of emissions of each region, a_i , and the level of trade of private and public goods between the two regions ($a_i - \bar{a}_i$). The equilibrium also determines the terms of trade between the private and public good, π , which is the international price of the permits. This price π can be thought of as a market determined "tax" on emissions.

Equity and efficiency results

The main results are as follows (see Chichilnisky [9], Chichilnisky and Heal [21], [28] and Chichilnisky, Heal and Starrett [24]):

Theorem 1 (Chichilnisky, Heal and Starrett). *Given a total level of emissions \bar{a} , there exists a finite number of ways to allocate property rights on emissions among the two regions, i.e., there is a finite number of emissions rights \bar{a}_1, \bar{a}_2 , with $\sum_{i=1}^2 \bar{a}_i = \bar{a}$, so that at the resulting competitive equilibrium, the allocation of resources in the world economy, a_1, a_2, x_1, x_2 , is Pareto efficient. When both traders have the same preferences, then the region with more private goods should be given fewer property rights on the public good.*

This theorem is illustrated in the figure below.

Theorem 2 (Chichilnisky). *By allowing world emissions \bar{a} to vary, one obtains a one-dimensional manifold of property rights from which the competitive market with permits-trading achieves a Pareto-efficient allocation of the world's resources.*

Theorem 2 identifies the set of all "efficient" allocations of property rights on the use of the global commons.

The intuition behind these results is simple. Competitive markets in which public goods are traded have more stringent criteria for efficiency than markets for private goods. In addition to the standard marginal condi-

tions (i.e., marginal rates of substitution must equal the marginal rates of transformation), the allocations must also satisfy the Lindahl-Bowen-Samuelson conditions for efficient levels of the public good, requiring that the sum of the marginal rates of substitution equals the (common) marginal rate of transformation between the private and the public good. Since more conditions are needed, standard competitive allocations are not generally "first best" Pareto efficient. In addition, it can be shown that they are not "second best" efficient either. Generally, the total amount of the public good is lower in competitive markets than the "first best" Pareto-efficient level. Therefore it is possible to make everybody better off by raising the total level of abatement.

There is another way of looking at the same problem. Lindahl showed that efficiency with public goods requires the use of so-called "personalized" markets, i.e., as many markets as the number of people times the number of goods. In our case, for example, rather than two markets, one would need four. These personalized markets are unrealistic, as they could lead to arbitrage across traders. In any case, lacking personalized markets, the solutions provided by competitive markets are typically inefficient, as Lindahl pointed out.

These results have proved surprising to those who interpret Coase's propositions as implying that allocating property rights always leads to efficient markets. Nothing in Coase's work ensures such a result when one of the goods traded is a privately produced public good, as happens here. Coase's results, in addition, explain that Pareto-efficient allocations are the rest point of trading activity when all possible Pareto-improving positions are traded. There is nothing wrong with his result, but it is not applicable to markets in which all traders face the same prices and trade according to competitive markets rules. With private goods, the first welfare theorem does ensure that the competitive equilibrium is Pareto efficient. But this theorem does not ensure Pareto efficiency of competitive equilibrium with privately produced public goods.

The results presented above have also been surprising to general equilibrium theorists, but for the opposite reasons. They establish that a judicious selection of property rights can recover first best efficiency in markets with public goods. In the general equilibrium literature, it is well understood that markets with public goods are generally inefficient. Indeed, our

results show that one can replace personalized markets, which is Lindhal's solution, by the appropriate choice of property rights. This is an innovative result which can lead to more international cooperation. Figure 1 illustrates this.

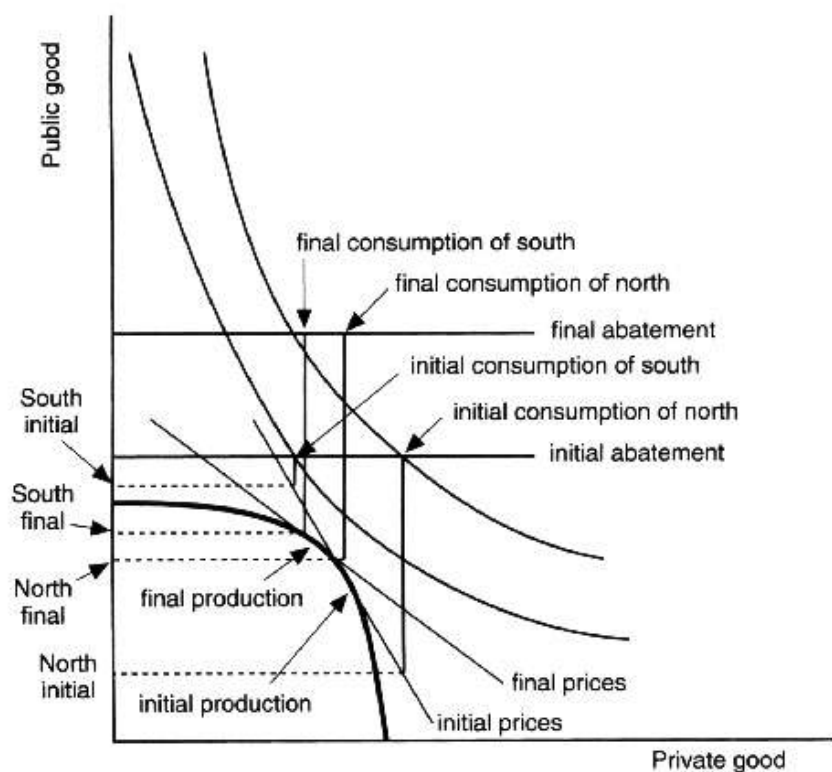


Figure 1

Appendix II

Simulations with the PIR/OECD Green General Equilibrium Model

The OECD Green model is a general equilibrium model of trade and economic growth covering 12 regions (of which six represent developing regions) and eight sectors of production. Columbia University's Program on Information and Resources (PIR) adapted this model to the trading of emissions permits on greenhouse gases across the regions. The specification is available from the author on request.

Notes on Simulation Results

In all figures the abbreviations for country names are: JPN = Japan, OOE = other OECD, EEX = energy exporters, CHN = China, FSU = former Soviet Union, IND = India, EET = Eastern European Economies in transition, DAE = Dynamic Asian Economies, BRA = Brazil, ROW = rest of world.

"World emissions" shows total world emissions of CO₂, measured in millions of tons, under three alternative scenarios: "business as usual" (BaU), an agreement between the major emitters to stabilize emissions at their 1990 levels by the year 2000 and .5% reduction after the year 2000.

"Real income loss over 2000-2050" shows the impact of alternative ways of stabilizing emissions at their 1990 levels on individual countries. Costs are measured in terms of the loss of real (i.e., constant price) consumer expenditure over the period 2000 to 2050 relative to the BaU scenario.

Column 1 (individual stabilization) shows the welfare costs to each country of the use by that country of a carbon tax to cut back emissions to 1990 levels. In this scenario there is no policy coordination across countries: each country separately and independently cuts back its emissions to 1990 levels.

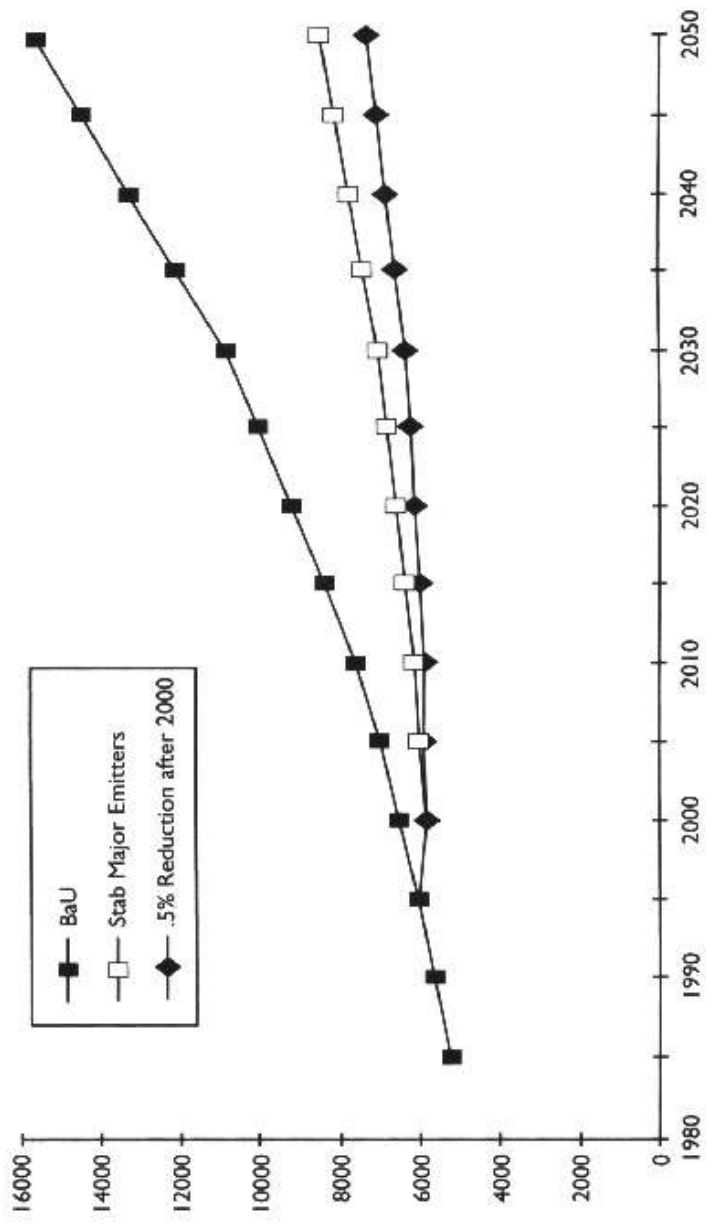
Column 2 shows the results of using a uniform carbon tax across all countries at a level at which total global emissions are cut back to their 1990 levels: on a country-by-country basis the cutbacks need not be to the 1990 levels.

Columns 3, 4 and 5 show the costs of cutting global emissions to 1990 levels by use of tradeable permits, with three different allocation rules, as discussed in the text.

As is to be expected on basic principles, the total costs are highest in column 1, where each country independently cuts emissions back to their 1990 levels. Of the three tradeable quota scenarios, it is of some interest that the most obviously egalitarian—a population-based allocation—is the least costly. As noted in the text, different quota allocations lead to very different income levels in the world's most populous countries, China and India.

"Emission rights trade": these three figures show which countries are importers (negative) or exporters (positive) of emissions permits under alternative permit allocation rules.

World Emissions (in mill. tons of Carbon)

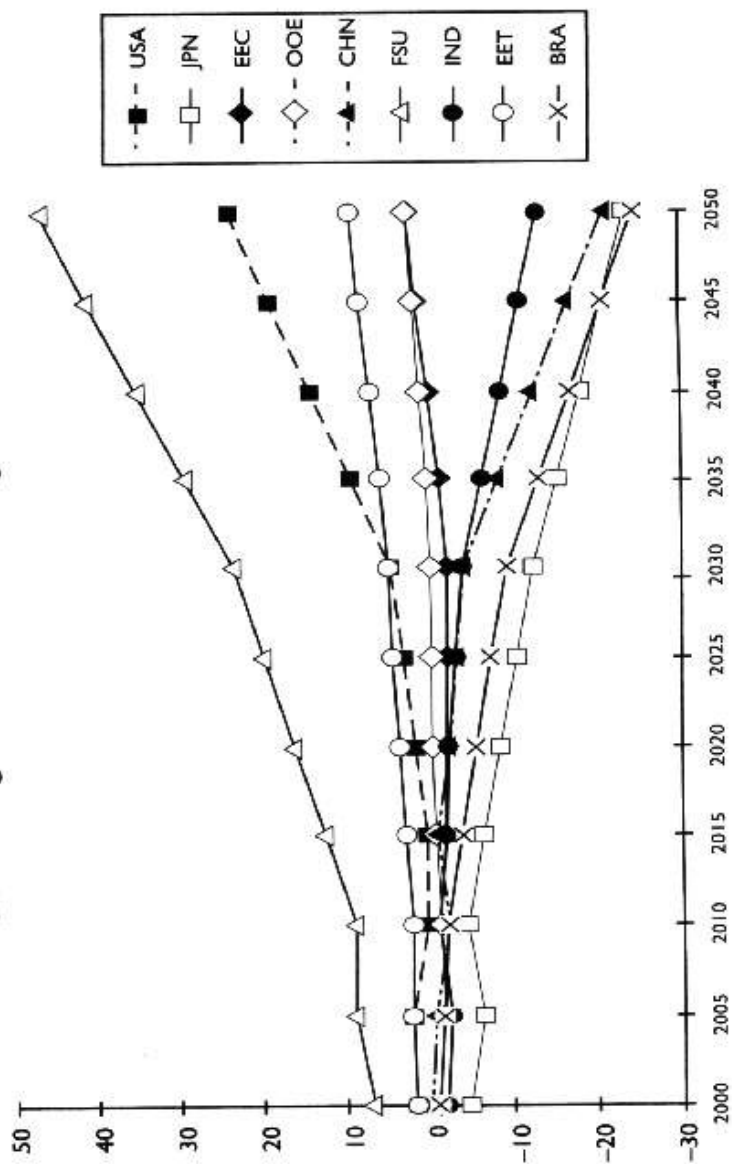


Real Income Loss over 2000–2050**(in percentage deviation relative to BaU)**

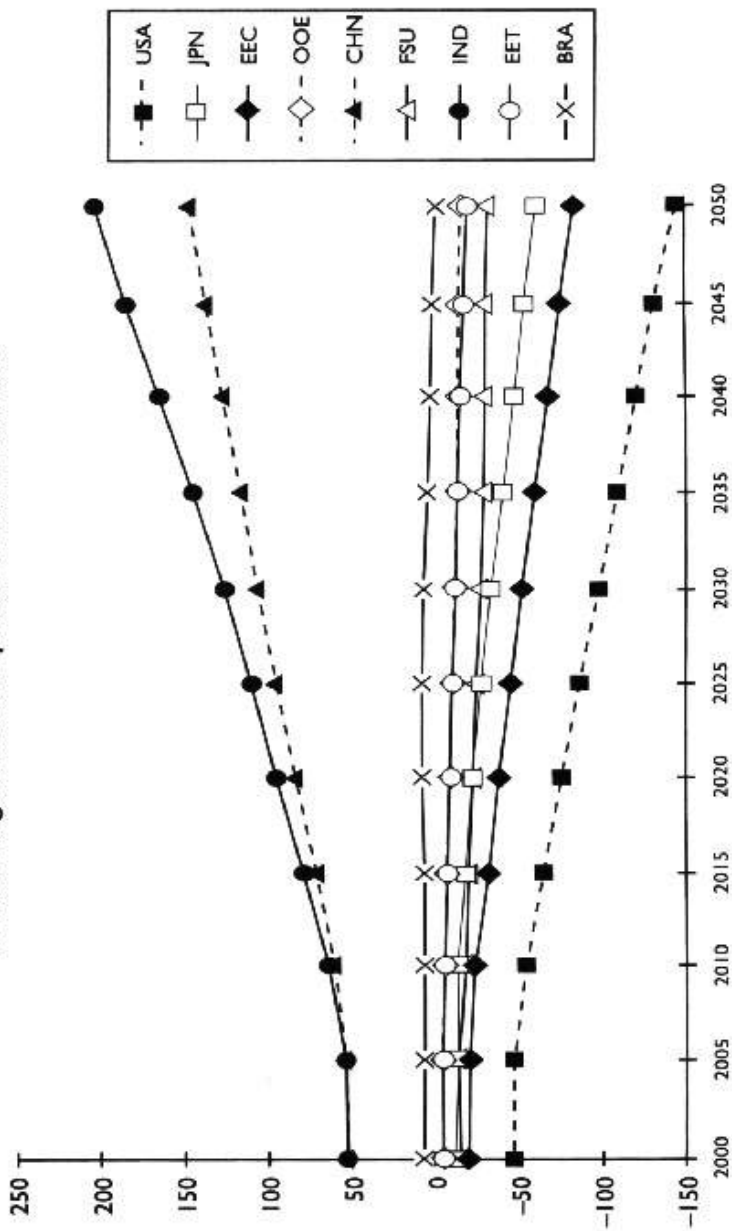
| | <i>Indiv. Stab.</i> | <i>Uniform Tax</i> | <i>Grandfathering</i> | <i>Pop. Based</i> | <i>Mixed</i> |
|-------|-------------------------|------------------------|-----------------------|-----------------------|--------------|
| USA | -0.79 | -0.90 | -0.76 | -2.94 | -1.84 |
| JPN | -2.41 | -1.24 | -1.83 | -2.84 | -2.34 |
| EEC | -1.23 | -1.16 | -1.22 | -3.13 | -2.19 |
| OOE | -0.58 | -0.55 | -0.54 | -1.53 | -1.04 |
| EEX | -3.39 | -0.83 | -0.78 | 0.09 | -0.39 |
| CHN | -3.88 | -3.47 | -4.14 | 6.02 | 1.04 |
| FSU | -1.42 | -2.66 | 1.08 | -7.13 | -2.92 |
| IND | -2.61 | -2.00 | -2.94 | 14.62 | 7.00 |
| EET | -0.33 | -1.09 | 0.81 | -5.94 | -2.51 |
| DAE | -0.29 | 0.16 | 0.20 | -0.19 | -0.05 |
| BRA | -1.60 | -1.78 | -4.40 | -0.55 | -2.45 |
| ROW | -0.40 | -0.01 | 0.05 | 0.21 | 0.12 |
| World | -1.65 | -1.16 | -1.17 | -1.06 | -1.07 |

Note: World Emission Stabilized at 1990 Level after 2000.

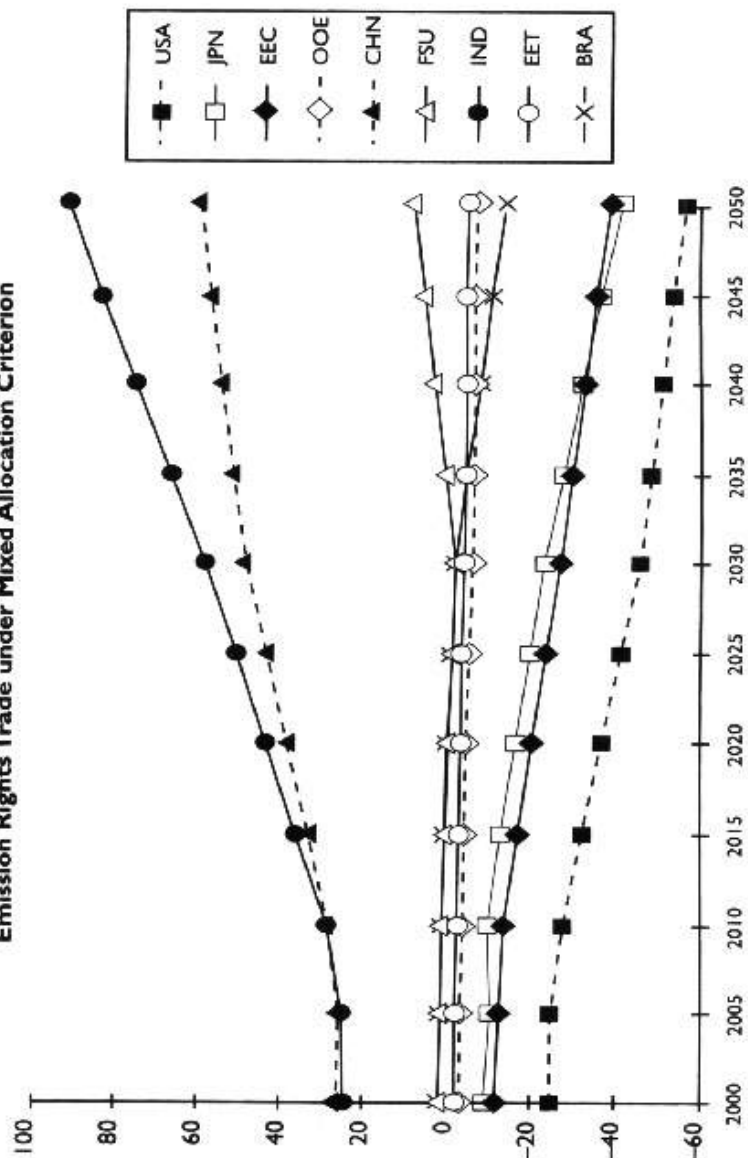
Emission Rights Trade: Grandfathering Allocation



Emission Rights Trade: Population Based Allocation



Emission Rights Trade under Mixed Allocation Criterion



Notes

1. See Chichilnisky [15].

2. The author's proposals were recently reported in "The Greening of Bretton Woods," by G. Chichilnisky, *The Financial Times*, 10 January 1996, Business and the Environment Section and in "Environmental assets and derivatives," by C. Bernardes, *Derivatives Week*, 3 June 1996, vol. V, No.22.

3. During the May 1994 Seminar on Joint Implementation organized with the support of GEF and the Framework Convention on Climate Change (FCCC) at Columbia University, New York, by the author and by Professor Geoffrey Heal of Columbia Business School and in various FCCC meetings, I have benefitted from discussions with several members of the Intergovernmental Negotiating Committee (INC) of the FCCC, who provided important insights: Minister Raul Estrada Oyuela, Chair of the INC/FCCC, H.E. Ismail Razali, Ambassador, Permanent Mission of Malaysia to the United Nations (UN), Mr. Xialong Wang, Third Secretary, Chinese Permanent Mission to the UN, Mr. James Baba, Deputy Permanent Representative of Uganda to the UN and Dr. John Ashe, Counsellor, Permanent Mission of Antigua and Barbuda to the UN.

4. The concept of **development oriented towards the satisfaction of basic needs** was introduced theoretically and developed empirically by this author in 1974, Chichilnisky [7], in the context of studies of sustainable development in five continents. The Brundlant Report's definition of sustainable development is also anchored to **basic needs**: sustainable develop-

ment satisfies the needs of the present without compromising the needs of the future, [5], chapter 2, para. 1.

5. See the report of the 1996 Intergovernmental Panel on Climate Change (IPCC).

6. **Joint implementation** refers to one or more parties taking actions—or financial actions—in the territory of other parties, and it is seen as a prelude to emissions trading by a number of governments and observers.

7. For example, in Ecuador the Amazon forest is being destroyed for the purpose of the exploration and extraction of petroleum by international corporations—petroleum that is destined for sale in the United States.

8. See Chichilnisky [9], Chichilnisky and Heal [20] and [21].

9. See [9] and [21].

10. See [25] [26] and [27].

11. See [10], [25], [26].

12. See Chichilnisky [10].

13. See Coppel [29], and the response in Chichilnisky [9] and Chichilnisky and Heal [21].

14. Marginal rates of substitution must all be equal across markets, and must equal the marginal rates of transformation in those markets.

15. See Atkinson and Stiglitz [1]. The rule is typically that the sum of marginal rates of substitution equals the marginal rate of transformation when the government produces the public good. See Chichilnisky, Heal and Starrett [24] for the case where free international trade in permits is allowed. The answer is the same.

16. Paid transfers, such as those which occur within international markets, need not equate the marginal utility of consumption across trading regions.

17. See Chichilnisky and Heal [21].

18. See Chichilnisky and Heal [21].

19. See, e.g., *World Development Report* [34], 1992, and Chichilnisky [11].

20. See Chichilnisky [11].

21. See Chichilnisky and Heal [28].

22. See Appendix I and Chichilnisky [9], Chichilnisky and Heal [28], Chichilnisky, Heal and Starrett [24].

23. A distribution is efficient (or Pareto efficient) if it cannot be improved so as to make everyone better off, or to make some better off and none worse off.

24. For a formal presentation, see Appendix I, Chichilnisky and Heal [28] and Chichilnisky, Heal and Starrett [24].

25. See appendices I and II.

26. The OECD model is referred to as GREEN.
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The unexpected link between efficiency and equity emerges from an idiosyncratic economic property of markets for *public goods*, that is, goods whose consumption is not rival.²⁴

Emissions trading is the trading of the rights on a public good: the rights to use the atmosphere as a sink to absorb emissions. Public goods are typical of environmental problems; examples are the total biodiversity of the planet and the quality of the planet's climate. These are different from standard private goods because they are available to everyone in the same quantity. Private goods, on the other hand, allow more choice: one person can consume quite independently of others. This is not so in the case of public goods for which everyone's consumption is connected.

Markets in which private and public goods are traded simultaneously can lead to efficient allocations. However, recent advances in economics show they cannot achieve this goal unaided. It turns out that for efficiency, global emissions markets require relatively egalitarian distributions of emissions rights. The appendix provides details.

The reason is that efficiency in a competitive market requires that the total amount emitted across the globe, which determines the quality of the atmosphere for all, be precisely the choice that individual traders themselves would make independently, given their other holding of private goods.

The connection between distribution and efficient operation of the world economy stands in sharp contrast with markets for *private goods*, where the issues of efficiency and of distribution are divorced from each other. With private goods, no matter what the distribution of property rights, an efficient allocation is always reached by a competitive market. When markets trade private and public goods simultaneously, then only certain allocations of property rights are consistent with efficiency. To achieve efficiency, those traders who own fewer private goods should own more property rights on the environment than those who own more private goods. Market efficiency requires a somewhat flexible but inverse relationship between property rights in private goods and property rights in public goods.

In practice, this means that industrialized countries, which have a much larger initial allocation of property rights on private goods, should initially be given relatively smaller endowments of property rights on public goods as a precondition for market efficiency. This unique property of markets

with privately produced public goods will be developed in the following section. It leads us to the main policy proposal of this paper: the creation of an **International Bank for Environmental Settlements**.

WHY ARE FINANCIAL MARKETS INSUFFICIENT?

There is a point that bears repetition. The atmospheric concentration of gases (such as CO₂ or the other greenhouse gases contemplated by the Rio Convention) is a *public good* because of its physical characteristics. These gases diffuse uniformly across the world so that atmospheric concentration is similar for all countries. This property is what differentiates the trading of emissions rights from the trading of standard private goods. In the latter, consumers may choose the quantities they wish to consume independently of each other while in the former this is impossible. In markets for private goods, the problem of distribution of welfare is divorced from the problem of economic efficiency in the sense that no matter who owns what, a market solution is efficient. As already discussed, this is not true in markets which trade public goods. Stock exchanges are standards markets. When trading emissions permits, stock exchanges will not reach efficient allocations in general as explained above. Therefore, other institutions are needed to complement them—either to set borrowing and lending rates (as the Federal Reserve does in the United States) or to help establish property rights (as the Federal Communications Commission does in the United States with the help of auctions of the airwaves).