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Some Economics of Global Climate Change: The Developing Countries

Nancy Birdsall
and
John A. Dixon

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SOME ECONOMICS OF GLOBAL CLIMATE CHANGE: THE DEVELOPING COUNTRIES

Nancy Birdsall and John A. Dixon*

The authors are, respectively, Chief and Economist, Environment Division, Latin America and Caribbean Region, World Bank. The views in this paper do not necessarily reflect the views of the World Bank. The authors are grateful to Robert Anderson, Patricia Annez, Robin Bates, Charles Feinstein, Emmanuel Jimenez, Robert Kaplan, Andrew Morrison, Ken Newcombe, William Nordhaus, Kenneth Piddington, and especially to Charles Blitzer for comments on earlier drafts and to participants, particularly William Clark, in the symposium "Global Climate Change: The Economic Costs of Mitigation and Adaptation", sponsored by the Air Resources Information Clearinghouse project of the Center for Environmental Information, December 1990, Washington D.C. and to participants at a presentation at Tulane University in April, 1991.

ABSTRACT

This paper examines differences between developing and developed countries as they bear on two questions: Where should actions to reduce greenhouse gas emissions and thus the possibility of global warming take place? Who should pay the costs of these actions? Background information is set out on the relative contributions of developing countries and other countries to current emissions and the stock of emissions. We show that though the developing countries contribute and have contributed relatively little to emissions, in the future they are likely to be the major source of growth in global emissions -- because their populations are growing more rapidly, their per capita emissions are still low, and, for various reasons, they use more energy per unit of output than the developed countries.

However, because the costs of adopting preventive action in developing countries are high, and despite higher welfare losses in developing countries of possible global warming, those countries have little incentive to act unilaterally to reduce sources of global warming. Without some explicit form of international cooperation, the developing countries are not likely to take steps to reduce emissions. At the same time, it is difficult to envision what form international cooperation can realistically take. On the one hand, trade in environmental services, in the form of transfers from developed to developing countries to "purchase" least-cost approaches to reducing greenhouse gas emissions, appears sensible. On the other hand, in the short run there is little scope for reliance on such trade or on negotiated transfers under treaty arrangements. The potential for trade can only be realized after developing countries have undertaken the energy and environmental policies that are in their national interests anyway. There are at least two reasons. First, developed countries will not want to create the moral hazard that international transfers in return for explicit constraints on greenhouse gas emissions would represent -- since such transfers might create a perverse incentive for countries to delay otherwise beneficial policies while negotiating the transfers. Second, until nationally efficient energy and environmental policies are in place in developing countries, feasible least-cost services that could be traded are not likely to exist; for example in a country where coal is underpriced, transfers to finance switching from coal to cleaner fuels are not likely to be used efficiently, and therefore will not be made.

If global warming actually occurs it will have widespread economic effects. These effects will be different in different countries. Some countries will experience economic losses from inundated coastlines, changed and possibly more violent weather patterns, and increased climatic variability. Others may benefit from a milder climate and increased precipitation. As is obvious, there will be no necessary relation between a particular country's contribution to possible global warming in the form of greenhouse gas emissions (including loss of sequestered carbon, for example through forest burning) and the economic costs it bears or the economic benefits it enjoys as a result of global warming. The costs or benefits to a particular country that result independently of its own contribution, constitute externalities -- the effects of actions of other countries that those other countries do not take fully into account. These externalities occur because countries can pass on some of the costs of increased greenhouse gas emissions and cannot capture fully the benefits of prevention of those emissions.

The nations of the world vary greatly in their contribution (both historical and current) to the emission of CO2 and other greenhouse gases, in their vulnerability to the possible effects of global warming, and, given differences in income and welfare, in their willingness and ability to take actions to reduce emissions of greenhouse gases. One obvious set of differences on all these counts is between the developed and the developing countries.

This paper examines these differences between developing and developed countries with the objective of deriving some initial answers to two apparently simple questions: Where should actions to reduce greenhouse gas

emissions take place? Who should pay the costs of these actions? We refer to these two as the "siting" question and the "burden-sharing" question. The siting question does not exclude the possibility of world-wide actions, such as a global carbon tax or a tradable permit system, but allows for the possibility that even world-wide actions can be designed to affect different countries differentially. Addressing these questions in their fullest sense would require a discussion well beyond that presented here, raising issues of moral responsibility and intra- and intergenerational equity. Our goal is much more modest -- to set out some of the facts and suggest some points that might guide a fuller discussion.

In Section 1 we provide background information on the relative contributions of various groups of countries to current emissions and the accumulated stock of emissions. In Section 2 we take the perspective of the developing countries and consider the potential welfare costs in those countries of global warming and the nature of the costs those countries would face were they to undertake steps to reduce their own emissions. In Section 3, we conclude with preliminary answers to the siting and the burden-sharing questions. On the latter, our conclusion, surprising even to ourselves, is that there is currently little scope for the kind of directed burden-sharing that we expected.

In our discussion we address qualitatively the costs and benefits of taking action at the national level from the point of view of developing vs. developed countries -- in effect a crude benefit-cost analysis from the perspective of each set of countries. However, we do not address the question of how much, if anything, should be done by the world as a whole to reduce the potential threat of global climate change. We do not, in short, undertake a

benefit-cost analysis of action at the global level.[1] In fact, given the poor basis for assessing the likelihood and timing of any climate change, the uncertainty about the potential costs of climate change, and the long gestation period for any interventions to make a difference, any international cooperation to reduce greenhouse gas emissions is likely to take the form of some agreement on a global target and on an accompanying schedule for reductions of emissions, perhaps allocated across countries or groups of countries. The search would then be for least-cost approaches to meeting the scheduled global targets. Ideally, least-cost approaches would be compared across as well as within countries. Therefore, for the sake of this discussion, we assume that at the global level we are in a world of cost-effectiveness and thus least-cost analysis.

Section 1. Contributions to Possible Climate Change Across Countries

Table 1 shows shares of population, GDP and annual carbon emissions from commercial sources grouped by developed, developing and Eastern Europe and the USSR. As the data on emissions cover carbon only, they probably understate the relative share in emissions of greenhouse gases by developed countries. Though they omit deforestation (of which 95% of the carbon emissions are from developing countries), and emissions from noncommercial energy, mostly wood fuels, they also omit chlorofluorocarbons and other greenhouse gases, which are emitted primarily from the developed countries. The basic point is obvious. With only 15% of world population, developed countries account for

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[1] But see, for example, Nordhaus, 1990.

Table 1.

Shares of Population, Gross Domestic Product (GDP) and Annual Carbon Emissions,[a/] 1988 (in Percent)

	GDP[b/]	Population	Emissions
Developed Countries	82.2	15.4	52
Eastern Europe and USSR	N/A	9.0	28
Developing Countries	17.8	75.6	20

Source: World Bank, 1990 (columns 1 and 2); Boden et. al., 1990.

a/ Carbon emissions from commercial energy sources; excludes emissions due to deforestation and noncommercial energy. Shares of emissions are based on data available for 20 countries with the highest emissions; these 20 countries account for 82 percent of total global emissions.

b/ GDP data for Eastern Europe and USSR are not available.

more than 50% of carbon emissions. The Soviet Union and Eastern Europe, with less than 10% of world population, account for slightly more than a quarter of world carbon emissions.

Table 2 shows the change in annual carbon emissions from commercial energy sources between 1960 and 1988 for various groups of countries. The top line includes the six largest emitters in 1960, excluding the Soviet Union. For these high-emitting developed countries, the share of world emissions declined over the period, from 54% to 39%. The share of the Soviet Union and Poland together increased almost 25%, from 17% to 21%. The share of the three large developing countries increased 50%, from 10% to 15%.

There are at least four explanations for the decline in the share of the developed countries. First, population grew in those six countries about 25% over the period, while it doubled or more in the developing countries. Second, in the developed countries, the shift from industry to services probably helped to reduce energy use per dollar of GDP; in the developing countries, the shift out of agriculture into industry probably increased energy use per dollar of GDP. Third, higher incomes in developed countries accelerated the decline in the use of such traditional energy sources as coal and woodfuel in favor of cleaner fuels, oil and natural gas, which developing countries were less able to afford. Across the countries shown, there were and are differences in fossil fuels used; China (as well as Poland and the Soviet Union) relies more heavily on coal which generates more emissions per unit of energy produced than do natural gas and oil. Fourth, there was more rapid adoption of new energy-saving technologies in developed countries, especially after the oil price shock of the early 1970s. As a result, there are differences across countries in energy efficiency, with the developing

Table 2. Shares of Carbon Emissions,[a/] 1960, 1988 (In Percent)

	1960	1988	
6 Major Developed countries [b/]	54	39	
USA	31	22	60%
Soviet Union	17	21	
Poland			
China	10	15	
India			
Mexico			

Source: Boden, et al., 1990.

a/ Includes carbon emissions from all commercial energy generation (gas, liquid, solid) plus cement manufacturing plus gas flaring; does not include emissions due to deforestation and to noncommercial energy, primarily wood burning.

b/ In order of 1960 carbon emissions: United States, greater Germany, United Kingdom, France, Japan, Italy.

countries using more fuel input for given energy output. Developing countries are probably also less efficient in energy use in an economy-wide sense; in many developing countries, underpricing of energy itself and underpricing of factors such as physical capital which appear to be complements of energy in production, induce greater demand for energy than is optimal given their overall endowment. For a given technology, developing countries are likely to pick a more emissions-intensive combination of inputs than developed countries. We return to the issue of energy efficiency below.

Table 3 shows the same data as Table 2 in absolute terms for selected countries. Though the U.S. share declined, its total emissions did increase. But much larger percentage increases occurred elsewhere; in Japan and Korea, countries whose economies grew rapidly, the increases were fourfold and tenfold respectively. In China and India, the tripling or more of emissions is associated with some economic growth combined with large absolute increases in population size.

Table 4 shows annual per capita emissions from commercial energy sources in 1960 and 1988 for selected countries. It captures the huge differences in per capita emissions between the developed and developing countries, especially in 1960 -- when there was for example a 50-fold difference between the U.S. and Korea. It also shows the generally much greater percentage increases in per capita emissions in the developing countries over the period. The 13-fold increase in per capita emissions in Korea suggests what success in economic growth can imply for increases in per capita carbon emissions. In the case of Korea, some of the rapid increase in carbon emissions may be a direct result of the government's active promotion of public investment in a

Table 3. Total Carbon Emissions,a/ Selected Countries, 1960, 1988

	1960	1988
United States	800	1,310
Greater Germany b/	221	272
United Kingdom	161	153
France	75	87
Japan	64	270
Canada	53	119
Italy	30	98
USSR	396	1,086
Poland	55	125
China	215	609
India	33	164
Mexico	17	84
Brazil	13	55
Korea	4	56
TOTAL GLOBAL	2,586	5,893

Source: Boden et al., 1990.

a/ Millions of metric tons of fossil fuels.

b/ The percentage increase was similar in East and West Germany.

Table 4. Absolute and Per Capita Annual Carbon Emissions,a/ 1960, 1988

	Absolute b/		Per capita b/	
	1960	1988	1960	1988
United States	800	1,310	4.40	5.30
United Kingdom	161	153	3.10	2.70
West Germany	149	183	2.70	3.00
China	215	609	0.33	0.56
India	33	164	0.10	0.20
Brazil	13	55	0.20	0.40
Korea	4	56	0.10	1.30
TOTAL GLOBAL	2,586	5,893	0.90	1.20

Source: Boden et. al., 1990.

a/ Millions of metric tons.

b/ Metric tons.

number of energy-intensive manufacturing sectors including petrochemicals, iron and steel, shipbuilding and motor vehicle manufacturing.

Table 5, in the last column, shows emissions per dollar of GNP across selected countries. In general, the developing countries have higher emissions per GDP dollar. China is the most obvious, at over 2000 grams per dollar in 1987 compared to 276 in the U.S. and just 133 in France. Much of the difference across the two groups of countries is due to some combination of the factors noted above, including differences in fuel mix, economic structure, use of energy-saving technology and efficiency in energy use at the economy-wide level.

Finally, we estimate very roughly that over the last 30 years, the relative contribution of the developing countries to the total accumulated stock of greenhouse gases in the atmosphere is at most 20% to 25%.[2] Greenhouse gases are retained in the atmosphere over long periods; annual emissions contribute relatively little to the accumulated stock, which is what matters for possible global warming.[3] This implies some logic to the idea

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[2] In the period from 1960 to 1990, the share of annual carbon emissions from commercial sources for developing countries (including the Soviet Union and most of Eastern Europe) increased from less than a quarter to about half of total emissions. Since the initial stock in 1960 largely came from the presently developed countries, the slow removal of pre-1960 carbon must be balanced against the large and growing post-1960 annual additions.

Since an increasing share of annual carbon emissions over the past 30 years has come from developing countries, a rough estimate of the developing country contribution to total accumulated stock would be an increase from less than 15% in 1960 to 20 to 25% in 1990. These estimates are for carbon emissions from commercial energy sources and do not include emissions from deforestation, which would increase the relative contribution from developing countries.

[3] Eckaus, 1990, points out that because stock matters and accumulatesslowly, the conventional procedure of computing present discounted values to assess the present significance of a future event, makes little sense. Any positive discount rate would imply that global warming is not a problem. However, that implies putting off action to reduce emissions until a time when that action

Table 5. FOSSIL FUEL CARBON EMISSIONS, 1987

	TONS/YEAR PER CAPITA	GRAMS PER $GNP
U.S.	5.03	276
CANADA	4.24	247
AUSTRALIA	4.00	320
SOVIET UNION	3.68	436
POLAND	3.38	492
W. GERMANY	2.98	223
JAPAN	2.12	156
FRANCE	1.70	133
S. KOREA	1.14	374
MEXICO	0.96	609
CHINA	0.56	2,024
EGYPT	0.41	801
BRAZIL	0.38	170
INDIA	0.19	655
NIGERIA	0.09	359

Source: Flavin (1990).

of assigning rights across generations to use the earth's atmosphere as a sink for emissions, literally as a global commons. An obvious simple extension of the idea of allocating rights across generations is that of allocating rights across countries in the current generation. Were such rights assigned on a per capita basis, the facts above would imply large immediate trading in such rights between developed and developing countries, with large transfers to the latter -- whether those rights were assigned on a current flow basis or on the basis of accumulated deficits and surpluses.[4]

In summary, it is clear that though the developing countries contribute and have contributed relatively little to emissions, they are also the likely source of future growth in emissions -- because their populations are growing more rapidly, their per capita emissions are still low, and they use more energy per unit of output.

Section 2. The View from the Developing Countries

In this section we examine the relative costs of adapting to changes brought about by global warming in developed compared to developing countries, and the relative costs of unilateral preventive action in developing countries.

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would make no difference (and might be difficult and much more costly to undertake). To get around this problem some analysts have set some fixed future constraint on accumulated stock and then modelled how fast the stock should grow given that constraint and other factors (e.g. Nordhaus, 1977).

[4] Actual size of trades and transfers would depend not only on the allocation rule for rights, but on costs. If emissions were constrained at the current global level, an efficient system would move emissions around globally in a way that minimized deadweight losses, also affecting financial transfers.

High Welfare Costs of Global Climate Change in Developing Countries

Global climate change is likely to produce some winners and some losers at the country level; the current state of scientific understanding is certainly not sufficient to establish how developing countries as a group might fare.[5] Some developing countries would clearly be worse off, e.g. some Pacific island nations that could literally go under water as a result of sea level rise.[6]

Assuming that the net impact is negative at the global level, there are at least two reasons to expect that developing countries would be worse off compared to developed countries. First, the developing countries have as a group less flexible, less responsive economies, making adaptation to any change more costly in welfare terms, i.e. in terms of the potential losses in human welfare. Second, developing countries have larger shares of production and labor force in agriculture and it is plausible that agriculture will be more disrupted.

Agriculture. The world rate of growth of agricultural production is as likely to increase as to decrease with global warming. It is possible that with increased variability of weather, the variance of production from harvest to harvest in particular settings will increase. It seems also almost certain that there will be changes in the location of agricultural production and the production of different crops. Some settings will have higher agricultural

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[5] See IPCC, 1990, for a recent assessment of scientific thinking on climate change effects.

[6] Bangladesh is often cited as another example of a country that would lose land. Recent work suggests, however, that in fact Bangladesh would not be flooded and lose land, because the amount of sediment deposited in Bangladesh would increase in line with the rise in sea level. Peter Rogers, personal communication, 1991.

production and others lower production as crop mixes shift. Parry (1990) maintains that although total world food production may not change, the cost of achieving the same level may be higher as the location of production shifts.[7]

Table 6 shows the percent of the labor force in agriculture in 1980, percent of gross domestic product (GDP) of agriculture, and gross national product (GNP) per capita for selected developed and developing countries. Productivity per worker in agriculture is clearly lower in developing countries. Any increase in local climate variability over time and over space implies costs of adaptation. In the absence of perfect capital markets (discussed further below), insurance costs to allow for variability over time in production will be high, for example if farmers are forced to reduce risks by adopting less efficient cropping patterns. If labor and capital must move to other sites, these adaptation costs will be relatively more costly in terms of effects on human welfare where productivity and thus income are lower. Even where mean production is stable, an increase in variance will raise costs -- if there are more frequent periods of drought for example.

Poorly Developed Insurance Markets. Poorly developed insurance markets in most developing countries mean that risk-sharing is difficult to carry out and insurance is costly to purchase. Not only farmers but others reliant on natural resources in developing countries, including such industries as pulp and paper, mining, fishmeal and so on, are thus less able to weather increased

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[7] Although higher atmospheric CO_2 levels are expected to have a "fertilizing" effect and enhance the growth rates of certain staple cereal crops such as wheat and rice, other crops, including millet, sorghum and maize may not be helped (Parry, 1990). When compounded by locational shifts and changes in precipitation, the net effects are unclear.

Table 6. Agricultural Share in Labor Force (1980), Agricultural Share in GDP (1988) and Per Capita GNP (1988), Selected Countries

	Agricultural Labor Force Share (%)	Agricultural Share of GDP (%)	Per Capita GNP ($)
United States	4	2	19,840
West Germany	6	2	18,480
United Kingdom	3	2	12,810
France	9	4	16,090
Japan	11	3	21,020
Canada	5	4	16,960
Italy	12	4	13,330
Poland	29	--	1,860
China	74	32	330
India	70	32	340
Mexico	37	9	1,760
Brazil	31	9	2,160
Korea	36	11	3,600

Source: World Development Report 1988, 1990.

climate-induced fluctuations than producers in more developed countries with better insurance markets (either private or government run).

Of course, improved insurance markets could develop over the lengthy period during which global climatic effects would begin to be felt. However, in those countries heavily dependent on agriculture, risk-sharing may not ever be viable at the national level because of concentrated vulnerability (or covariance in exposure to risk). In the face of changes in the global climate, a world insurance market would almost surely need to be developed -- and on grounds of vulnerability to risk, it is possible that developing countries would in principle face higher premium rates.

Poorly Developed Capital Markets. Poor local capital markets limit the ability of developing countries to raise and allocate the capital needed to adapt to economic changes induced by climate change. International capital markets are also inefficient in dealing with developing countries. All other things the same, this raises the costs of investments, both to the public and the private sector. Typical costs of adaptation would be the construction of dikes or other safeguards in urban coastal areas, and the development of irrigation in agricultural areas no longer able to rely on rainfed agriculture.

Weak Public Sectors. We can describe at least three types of public sector failure in developing countries.

o In many developing countries, government has little capacity for effective intervention -- these countries are what Myrdal referred to many years ago as "soft states." Rules and policies are generally ignored and government inaction is the norm. This is particularly true in much of Africa and parts of South Asia.

o Public policy is driven less by public needs than by private interests, and rent-seeking is common.[8] Though this is also a problem in developed countries, in parts of Latin America and Asia the effect on policymaking is relatively greater in the absence of countervailing public interest groups.

o Political regimes in many parts of the developing world are less stable than in most developed countries. This encourages short planning horizons on the part of those in power, vitiating their incentive to plan ahead in the event of foreseeable but distant problems such as might arise with global warming.

In many developing countries, already weak public sectors also must cope with greater constraints to good policy. For example in much of Latin America, fear of inflation makes raising energy prices more difficult than it would otherwise be. In fact, energy prices, to which we return below, provide a straightforward example of the inability of governments in developing countries to take appropriate action -- even when such action would reduce their fiscal problems as well as increase aggregate efficiency. (Though many governments in developed countries are equally ineffective in some policy areas, we are arguing here that in general, public policy making is even less effective in developing countries.)

Poverty. Finally, poverty itself assures that the welfare costs of adjusting to changes due to global warming will be relatively high. Assuming declining marginal utility of income as income rises, there are greater

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[8] Krueger, 1974, has characterized the problem as it affects development. For a discussion of effects on social programs in developing countries, see Birdsall and James, 1990.

welfare losses from marginal reductions in income at low levels. In the extreme, the changes associated with global warming could increase mortality in developing countries -- e.g. if urban sanitation collapsed due to changes in water availability or the level of the water table -- illustrating the point all too well.[9]

High Costs of Prevention in Developing Countries

The high potential welfare costs of global warming for developing countries are unlikely to induce unilateral action by them to reduce their own emissions. For one thing there is the externality problem -- their damage is not caused primarily by their own emissions. Moreover, these high potential welfare costs may not be sufficient to induce agreement on their part to internationally coordinated efforts that would include some preventive policies. The reason: the costs to them of preventive policies are high, and probably higher than the costs to developed countries.

First it may or may not be true that economies go through various stages of development -- and that the transition from agriculture to industry is inevitably energy-intensive. Developing countries need not necessarily follow as energy-intensive a path as did the now-industrialized countries, if new, more efficient technologies are available. However, to the extent it is more difficult to reduce energy use while industrializing, the apparent costs of measures to reduce emissions in developing countries could be high indeed in terms of foregone structural economic change.[10]

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[9]The recent rapid spread of cholera in Peru and neighboring countries is an example of the vulnerability of poor populations to external shocks -- in this case the introduction of a new pathogen.

[10] For an illustration of this point, see Blitzer et al., 1991.

Developing countries could reduce emissions without reducing energy use by switching to cleaner fuels. However, fuel switching could be costly in the short run; the developing countries have generally lower levels of absolute investment and smaller markets and resource bases, making expansion into natural gas or nuclear use difficult. In any event, there are almost surely real limits on how much substitution is possible between fuels, between technologies within a sector, and across sectors in a growth path.[11]

Second, there seems little doubt that developing countries have a higher opportunity cost of capital, and thus higher relative costs of investing in preventive action. For example, social rates of return to primary education are estimated to be as high as 24% in developing countries.[12]

Third, the greater poverty that is the distinguishing characteristic of developing countries as a group implies that a higher discount rate is applied to all calculations of costs and benefits of various actions. This higher discount rate implies a higher relative cost to any preventive action that would be taken. Lower levels of income on average explain lower willingness to pay to preserve amenities in developing countries, and to reduce uncertainty; lower willingness to pay translates into a limited political mandate to any government to address the emissions issue.

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[11] For a review of country-level models designed to assess the costs of reducing carbon emissions, see Hoeller, Dean and Nicolaisen, 1991. The model of Blitzer, et al., 1991, on Egypt, suggests particularly high costs -- amounting to as much as a 20 to 30 percent drop in GDP with fairly modest, 15 percent or less, reductions in carbon emissions.

[12] See Psacharopoulos, Tan and Jimenez, 1986. It is likely that these high returns to education primarily reflect insufficient allocation of investment to education relative to other investments. However, with international capital markets imperfect, some portion of higher returns in developing countries is probably also due to a higher overall opportunity cost of capital.

Finally, the weakness of the public sector, noted above, implies that the administrative and political costs of preventive action would be higher in developing countries. A limited supply of administrative and regulatory skills also implies higher costs of enforcing any policies that are adopted to reduce emissions.

The developing countries also have reason to delay preventive actions. First, any tradeoff with economic growth will be easier to absorb later, when average incomes will be higher. Second, the costs of any tradeoff are likely to fall as new, cheaper technologies are developed in the developed countries.

There is one reason why preventive action might occur in developing countries. Where there are policy failures (e.g., poor energy pricing), developing countries have opportunities to reduce emissions at no economic cost. There is probably more scope for such no-cost reductions in developing than in developed countries. These we discuss in the next section.

In general, despite relatively higher welfare losses that might be associated with global warming in developing countries, those countries have little incentive to act unilaterally to incur costs to reduce sources of global warming. Outside the context of some explicit form of international cooperation, including transfers to them, the developing countries are not likely to place priority on reducing their own greenhouse gas emissions.

Section 3. The Siting and Burden-Sharing Questions

The questions of siting and burden-sharing can of course be treated separately. The bulk of actions to reduce emissions could take place in developing countries, on the basis of financial transfers from developed countries. Does this approach make sense?

The Siting Question

It should be clear from the data in Section 1 that if accumulated emissions are not to grow beyond, say, an additional 20%, there must be some reduction from the path of increasing emissions on which the developing countries are now set.[13] Figure 1 illustrates in highly notional terms the paths of total and per capita emissions for the two groups of countries. As the bottom half of the figure shows, it is unlikely that per capita emissions in developing countries will, even well into the next century, have risen to the projected per capita level for developed countries by that time (even assuming a decline in per capita emissions in the developed countries). However, even with the relatively low per capita emissions in the developing countries, because population size and growth are so much greater in those countries achievement of a reduction in total emissions at the global level does depend heavily on whether their per capita emissions rise at a relatively slow or a relatively rapid rate.

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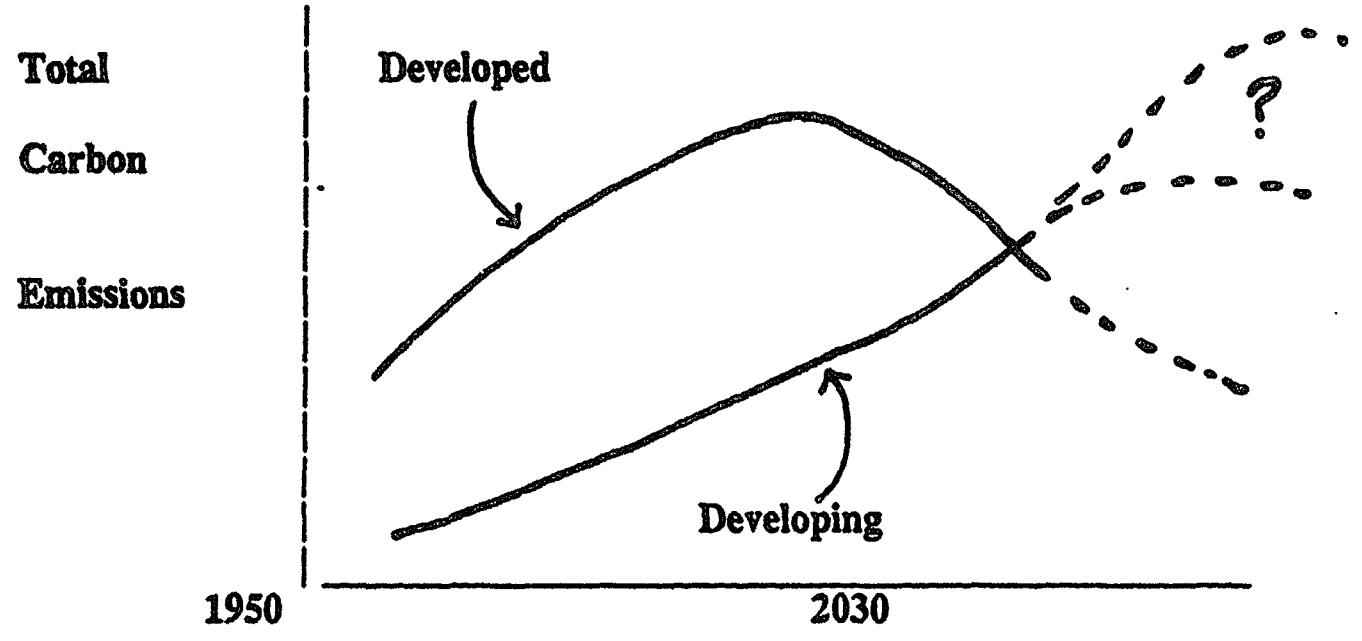
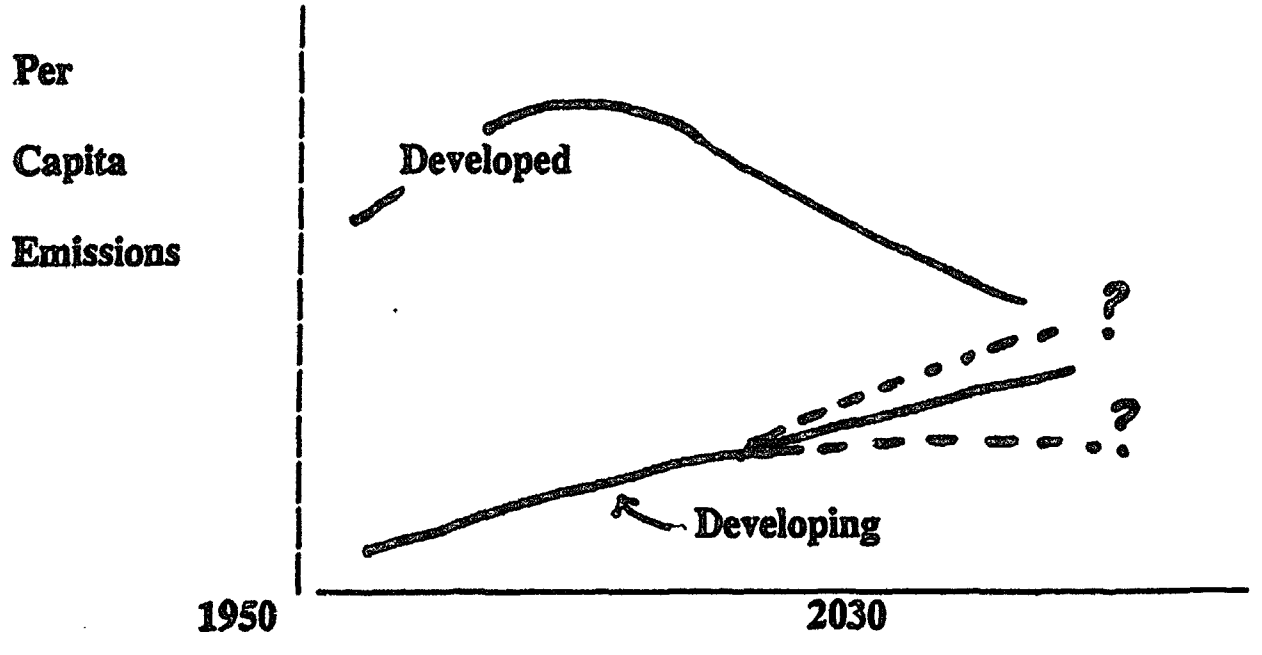
[13] The European Community (EC) has set a goal of reducing emission levels in the year 2000 to the level of 1990. Even if EC emissions are kept at the 1990 level, the increases in U.S. and Eastern Europe/Soviet Union emission levels and the continuing rapid growth in the rest of the world will make a net 20 percent increase a difficult, although obtainable target.

Figure 1.
Notional Total and Per Capita Carbon Emissions, Developed and Developing Countries, 1950 to 2030





The Burden-Sharing Question

On the one hand, there should be room for trade in global environmental services between developed and developing countries. Generally opportunities for trade in environmental services exist if the marginal costs of reducing emissions in one country are below the marginal benefits of such reduced emissions to another country, and below the marginal costs of the next cheapest solution within the second country.[14] There probably are at least some low-cost approaches to reducing emissions in developing countries -- for example it can be shown that reduced burning of forests in the Amazon would reduce carbon emissions at much lower cost than reducing emissions in developed countries through a carbon tax.[15] At the same time, the willingness to pay for reduced emissions is much higher in developed countries, implying room for purchases of the global "service" of reduced emissions by the developed countries from the developing countries.

On the other hand, the scope for such trade, and thus for burden-sharing through mutually desirable "purchases" or "transfers", or through mutually agreed treaty arrangements, is limited at present. To understand why, consider a simple taxonomy of environmental policies and investments that might reduce emissions of greenhouse gases in developing countries:

Type 1. These are "win-win" or "no regrets" policies and investments, i.e. those that would yield a positive economic rate of return even without

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[14] Oates, 1990, sets out this point formally.

[15] Schneider, 1991, uses Nordhaus's estimate that a reasonable expenditure to reduce carbon emissions, given the costs in economic growth, is $3-$13 per ton to show that the equivalent reduction in emissions can be obtained at much lower cost by preventing forest burning in the Amazon. Nordhaus, 1990, also concludes that reducing deforestation is among the lowest-cost options at the global level for reducing emissions.

taking into account any national or global environmental benefits -- and which also have direct environmental benefits at the national level. One example is increased fuel prices in many countries, especially oil exporters, which subsidize domestic petroleum product prices.[16] Increased prices would raise revenues, relieving the fiscal burden, would reduce energy inefficiency, with positive allocational effects as well as direct savings, and would simultaneously reduce emissions and local air pollution, by some combination of increased energy efficiency and reduced overall energy consumption.

A second example would be to increase the price of electricity, a commodity which most developing countries underprice. In a recent World Bank study, it is estimated that correcting underpricing in Brazil would save US$10-27 billion over an 11-year period, i.e., US$1-2.5 billion per year.[17] Correcting underpricing would reduce the fiscal burden of subsidies to state enterprises that provide electricity, with economic benefits in terms of reduced inflationary pressure. The resultant reduction in energy use (either through reduced demand or more efficient use of energy to meet the same level of demand for electricity) would have environmental benefits at the national as well as global level.[18]

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[16] Egypt is an example. See Blitzer, et al., 1991, for a description of various policy options and the costs to the Egyptian economy of reducing carbon emissions.

[17] World Bank, 1990, "Brazil: Energy Strategy and Issues Study," p. 48. Arrenhius and Waltz, 1990, cite an estimate of a $10 billion investment in end-use efficiency in Brazil that could offset demand for new capacity the investment cost of which would be $40 billion.

[18] Brazil is a complicated example. Because much electricity there is generated by hydropower, subsidizing it may actually be reducing demand for alternative, more emissions-intensive means of generating power.

A third example would be elimination of subsidies provided to some agricultural inputs (especially water, fertilizer and chemicals). Elimination of subsidies would discourage overuse of these inputs, reduce the financial drain on the economy (because of the subsidy), and reduce air, soil and water pollution. All of these policy changes would also have some benefits at the global level, by reducing consumption or production and thus emissions of greenhouse gases.

Presumably, political and institutional constraints and macroeconomic problems inhibit these win-win (even at the national level) policy changes. It is not at all clear that specific transfers under a treaty arrangement in the manner of the Montreal Protocol Interim Multilateral Fund for financing reductions of ozone-depleting substances, could affect these constraints. Indeed, the possible availability of such specific tied transfers may already be having a perverse effect -- inducing countries to delay win-win reforms in the hope that such reforms will later be subsidized.[19] The existence of these constraints does however provide some logic for general development assistance tied to pricing and other policy reforms that are anyway in the interests of the countries concerned -- much as is already done through the auspices of the international financial institutions and bilateral donors.

The potential for trade for type 1 policy changes would rest entirely on a political economy argument, i.e., that international transfers for type 3 policies might help reduce political and institutional obstacles to type 1 (and 3) policies.

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[19] We are grateful to our colleague Charles Blitzer for pointing this out.

Type 2. These are policies and investments, also with global benefits, that yield a positive economic rate of return once environmental externalities at the country level have been taken into account. Examples include pollution taxes (at some cost to economic growth) but which have a positive return because they will reduce the local health costs of air pollution (note that the health benefits of reduced pollution would be calculated based on the local not the global demand for health); and policies to reduce deforestation which imply some cost in foregone income but an overall positive return due to watershed protection.

As is the case with type 1 policies, there is no obvious room for trade via "purchases" of services, nor a rationale for transfers from developed to developing countries specifically tied to reduced emissions of greenhouse gases under a negotiated treaty arrangement. Given that such policies are in the best interests of the countries anyway, the same issue of perverse incentives arises as with type 1 policies.

There may be some rationale for including in the envelope of development assistance support for reform of national environmental policy and strengthening of environmental institutions -- to hasten the process of policy development and enforcement. Donors may see some merit in affording this kind of assistance higher priority than assistance based on achieving maximum economic returns or maximum alleviation of poverty -- because of their own direct interest in the reduction of emissions -- as, for example, currently in Eastern Europe. However, implementing an approach to development assistance based on such preferences then has its own costs.

Type 3. These are policies and investments with benefits at the global level which yield a positive economic rate of return only when those global

benefits are taken into account. Their economic returns, even taking into account environmental benefits at the national level, would be insufficient to warrant national-level policy change. A carbon tax or a quantitative limit on emissions that reduced emissions more than warranted in terms of reduced local air pollution are examples. In some countries, such as China, Poland and Bangladesh, where coal is relatively abundant, switching away from coal to cleaner fuels might not make sense given costs and benefits (including local environmental benefits) at the country level.[20] Other examples would be the use of solar and biomass energy before these are economically viable; and carbon sequestration through reduced deforestation even when deforestation would be economic.

In these examples, trade in environmental services is in theory possible, and arrangements for international transfers on an agreed basis are analogously likely.

Indeed, such arrangements are already in place at a modest level in the form of the recently created Global Environment Facility (GEF). This Facility is specifically directed to financing policies and programs in developing countries which would not otherwise be financed because their returns occur at the global level, i.e. they are not in the interests of the recipient country itself relative to alternative investments.

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[20] Recent World Bank analysis (World Bank, 1991a,b) in fact suggests that correct pricing of coal and natural gas in Poland would lead to a switch to gas, even without taking into account the benefits of reduced pollution from gas. In short, it appears to be economically efficient in the narrow sense for Poland to switch to gas, despite its coal abundance. Thus correct pricing would actually be a type 1, "win-win" policy.

However, in practice there are likely to be limits on the use of such facilities as a mechanism to finance type 3 policies and programs.[21] In most developing countries, the moral hazard or perverse incentive problem noted above pertains, since type 1 and type 2 policies are not fully exploited. In addition, wherever type 1 and type 2 policies and investments are not in place, feasible least-cost "trades" in the form of transfers to finance type 3 investments are not likely to exist. For example, in a country where coal is underpriced, a transfer to finance switching from coal to cleaner fuel will probably not be used efficiently, and therefore is not likely to be made.[22]

The potential for trade based on type 3 policies seems greatest in settings where insufficient knowledge about the costs and benefits of emissions reductions at both the national and global level blurs the boundary between type 2 and type 3 policy changes. An example might be international financing, e.g., through the GEF, of a new technology (solar or thermal), the long-run costs of which are not fully known, in a country already taking

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[21] The statement here regarding limits applies to the reduction of greenhouse gas emissions. For the time being, the potential for trade (in this case purchases of environmental services by developed from developing countries) appears much greater in the case of protection of biodiversity. Though still in its early days, the Global Environment Facility includes more projects in support of biodiversity than in support of reduced emissions of greenhouse gases. This may be due to greater prior pent-up demand for funding for protection of conservation areas in developing countries, given considerable prior involvement of nongovernmental organizations; or to a longer gestation period for "global warming" projects. However, it may also be due to restrictions on use of GEF funds to finance investments with positive rates of return at the national level, i.e. investments that can and should be financed on more conventional terms. I.e. since in many countries there is still room for type 1 and type 2 policies, it is difficult to achieve trade based on type 3 programs.

[22] Another reason why transfers and trades are not easy to negotiate now is the vast sums that could be involved. Annual transfers from rich to poor countries under scenarios set out by the International Panel on Climate Change (IPCC, 1990) could be in the hundreds of billions of dollars.

policy steps to address local pollution (and thus already exploiting low-cost options to reduce emissions).[23]

In short, although there is some scope for burden-sharing, there is also a compelling argument for starting with the "win-win" policy changes described above. They make good economic sense, they help to change the pattern of resource use, they lead to more efficient use of available resources, and they can lead to measurable greenhouse gas emission reduction benefits. Not the least, these policy changes are probably implementable and will buy time while improved understanding of the actual likely costs, if any, of global warming, and thus of the appropriate level of preventive effort, accumulates.

In addition, there is an important contextual issue. In a world where many policy distortions already exist, it is necessary to lay a solid foundation before attempting to leap to a program of global siting decisions based on international burden sharing. At a minimum, therefore, countries should enact the first set of policy changes and begin to introduce the second set, those based on incorporation of national level externalities. All of these changes will mean increased private costs for energy and other forms of resource use but will begin to establish an economic framework within which global cooperation is both feasible and not unduly burdensome.

If the first and second sets of "win-win" policy changes can be introduced at the country level, the third policy set could be enacted more slowly at the global level, as increased information about the actual costs of any global warming accrues and, if it portends high costs, helps to build a

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[23] This would be consistent with an objective of the GEF, i.e., to obtain significant demonstration and learning value from the projects it finances, and to improve understanding of the actual costs and replicability of alternative technological "solutions."

global constituency for greenhouse gas reductions. This process will take time but some delay may well allow us to make better decisions and wiser investments.

This approach to the matter returns us ineluctably to the more general issues of development, and the integration of environmental concerns into the development policies of developing countries -- and thus to the more mundane yet difficult challenge of development itself rather than the negotiation of burden-sharing agreements.

References

Arrhenius, E. and T.W. Waltz (1990). The Greenhouse Effect: Implications for Economic Development, World Bank Discussion paper No. 78. Washington, D.C.: The World Bank.

Birdsall, N. and E. James (1990). "Efficiency and Equity in Social Spending: How and Why Governments Misbehave", Revised version of World Bank Working Paper Series No. 294. Washington, D.C.: The World Bank.

Blitzer, C.R., R.S. Eckaus, S. Lahiri, and A. Meeraus (1991) "A General Equilibrium Analysis of the Effects of Carbon Emission Restrictions on Economic Growth in a Developing Country" in D.O. Wood and Y. Kaya, eds, Proceedings of the Workshop on Economic/Energy/Environmental Modeling for Climate Policy Analysis. Washington, D.C.: University of Rokyo, MIT.

Boden, T. A., P. Kanciruk, and M. P. Farrell (1990). Trends 90 : A Compendium of Data on Global Change, Carbon Dioxide Information Analysis Center. Oak Ridge: Oak Ridge National Laboratory.

Eckaus, R. S. (1991). "Economic Issues in Greenhouse Warming", Center for Energy Policy Research. Cambridge: M.I.T.

Flavin, C. (1990). "Slowing Global Warming" in L.R. Brown, ed. State of the World - 1990. New York: W.W. Norton and Co.

Hoeller, P., A. Dean and J. Nicolaisen (1991). "Macroeconomic Implications of Reducing Greenhouse Gas Emissions: A Survey of Empirical Studies," OECD Economic Studies No. 16 (Spring), pp. 45-78.

IPCC (International Panel on Climate Change) Scientific Assessment, edited by J.T. Houghton, G.J. Jenkins, and J.J. Ephraums (1990). Climate Change: The IPCC Scientific Assessment. Cambridge: Cambridge University Press.

Krueger, A. (1974). "The Political Economy of the Rent-Seeking Society," American Economic Review, 64, 3 (June), pp. 291-303.

Nordhaus, W.D. (1977). "Economic Growth and Climate: The Carbon Dioxide Problem", American Economic Review, 67, 1 (February), pp. 341-346.

Nordhaus, W. D. (1990). "Economic Approaches to Greenhouse Warming", paper prepared for a conference on Economic Policy Response to Global Warming, 4-6 October, Rome.

Parry, M. (1990). Climate Change and World Agriculture. London: Earthscan.

Oates, W.E. (1990). "Reflections on an 'Optimal Treaty' for the Global Commons Involving Industrialized and Developing Nations", mimeo. College Park: University of Maryland.

Psacharopoulos, G., J.P. Tan and E. Jimenez (1986). Financing Education in Developing Countries. Washington, D.C.: The World Bank.

Rogers, Peter (1991). Personal communication.

Schneider, R. (1991). "Brazil: An Economic Analysis of Environmental Problems in the Amazon", Draft report, Country Department 1. Washington, D.C.: The World Bank.

Whalley, J and R. Wigle (1989). "Cutting CO2 Emissions: The Effects of Alternative Policy Approaches", Background paper for the World Bank Seminar on Global Warming, 25 May. Washington, D.C.: The World Bank.

World Bank, 1990. "Brazil: Energy Strategy and Issues Study." Washington, D.C.: The World Bank.

———, 1991a, "Poland: Energy Market Development." February. Washington, D.C.: The World Bank.

———, 1991b, "Poland: Environmental Strategy." October. Washington, D.C.: The World Bank.

———, 1988. World Development Report. New York: Oxford University Press.

———, 1990. World Development Report. New York: Oxford University Press.