THE ENVIRONMENTAL REGIME IN DEVELOPING COUNTRIES[1]

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I. INTRODUCTION

This paper responds to the request we received from the conference organizers to produce a piece on the environmental regime in developing countries. By regime, we mean the set of environmental externalities that are commonly found in the developing world, along with the policy responses, if any, to these. Included are the direct effects of industrial emissions, air and water quality impacts of untreated wastes (industrial and human waste), congestion effects of traffic, soil erosion, and common property resource problems (including forests).

We note the many difficulties in characterizing this regime, not the least of which is the heterogeneity in the developing world across both environmental problems and policy responses. Enforcement and compliance (which is typically lax in developing countries) also play a central role in characterizing this regime.In addition are the sharp differences between developed and developing country experience more generally beyond the environmental area.

In the paper we make three main points. The first is that there is a tendency in much literature of the last few years to equate environmental problems in developing countries with pollutants (or emissions). Such an approach has been partly influenced by data availability, including that collected by the Global Environmental Monitoring System (GEMS) supported by UNEP. This has yielded data on a range of environmental indicators including BOD, airborne SO_2 concentrations, heavy metal levels[2], untreated human waste, and other air and water quality indicators. This focus on pollutants has meant that in much literature there is less emphasis on, what others have called degradation. This refers to the effects of uninternalized externalities seen in soil erosion, congestion, common property resource and other problems. The paper argues that

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[2] Lead, arsenic, mercury, lead and cadmium.

to discuss environmental problems in developing countries (or to compare with developed countries) without reference to these problems is incomplete; their effects are large and pervasive, and their severity and interaction with economic process often differs sharply from that of pollutants.

The second point is in many ways an elaboration of the first. We have attempted to review studies of the social costs associated with incomplete internalization of the externalities we list. Studies are limited in coverage, and do not always use consistent methodologies, but the picture they paint is that such costs seem large (perhaps in excess of 10% of GDP on an annual basis in some countries), and that these costs are dominated by degradation rather than pollutant effects (perhaps ¾of the total effect). One implication we draw is that with large cost estimates of inaction, environmental policy in developing countries should perhaps have a higher ranking than currently, especially if these cost estimates substantially exceed those of inaction with regard to more conventional policy reform such as tax or trade policy. The other is that if the balance of costs is skewed more to degradation than to the effects of pollutants, degradation should perhaps receive more attention in the literature.

Our third point concerns the relationships between growth, policy reform and environmental quality, and comparisons of the environmental situation either across economies or through time in recent literature in light of our characterization of the environmental regime to the extent this literature focuses on differences in outcomes across countries or over time in terms of levels of various environmental indicators, the issue is whether degradation effects can give a different picture. We argue that degradation impacts could well behave differently from pollutants; soil erosion problems, for instance, seem to progressively recede as income per capita rises, since the population in agriculture falls and plot sizes rise; while outward oriented trade policies draw labor into urban areas from rural areas, adding to congestion. We discuss literature on the environmental Kuznets curve (Shafik and Bandopadhyay (1992) for the 1992 World Development Report, Grossman and Kreuger (1995), and Andreoni and Levinsohn (1998)) and the literature on trade and environment (Copeland and Taylor (1994, 1995)) and (Antweiler, Copeland and Taylor (1998)). While authors contributing to these literatures are clear in labeling their analyses to be primarily of pollutant levels, users of this research naturally tend to think of the results as giving guidance on the wider environmental situation in the countries discussed, and without discussion of degradation effects the picture once again can be incomplete.

The paper concludes by arguing that welfare gains from moving to full internalization would seem to be the more appropriate comparative measure of severity of environmental problems across countries (or changes through time). The studies referred to in the text seem to suggest that internalization gains relative to GDP are significant for developing countries (and probably larger than for developed countries) raising the issue of why a higher degree of internalization has not occurred. We discuss briefly whether this outcome reflects income elasticities of demand for environmental quality above one; whether it reflects technology and capital intensity of environmental management and policy enforcement, so that abatement costs in developing countries are the barrier; or it is a reflection of the political structure in these countries; or whether it is problems in defining and enforcing property rights. We also discuss the links between poverty and degradation in this connection taken up by Maler (1997).

II. THE ENVIRONMENTAL REGIME IN DEVELOPING COUNTRIES

We interpret the term “environmental regime” applied to the developing countries as meaning the set of externality related problems often characterized as environmental, as well as the policy response they have induced. Individually these cover soil erosion, common property resources (forests, fisheries), congestion (traffic), household emissions (fuel burning), industrial emissions, ground and surface water resources (shared aquifers and water table problems), untreated human and non-human waste, and other problems. Property rights and its lack of clear definition are interconnected with these problems. Policy responses include regulation (command and control), local actions (village level on soil erosion), resource management policies (forests) and infrastructure development (urban congestion).

For the purpose of our later discussion we classify these externalities into two broad headings; pollutants, covering industrial and household emissions of various forms, and untreated waste; and degradation, covering soil erosion, congestion, and common property resources. We could group these in other ways such as agriculture and rural activity externality problems, urban externality problems, and environmental problems associated with varying forms of industrial waste. The reasons for grouping these environmental problems in the way we do relate primarily to measurement issues. They do not reflect any major analytical distinction in terms of the economics, even though, for instance, common property resource problems for renewable resources have a complex analytical literature characterizing both how replacement of the stock occurs, and what constitutes optimal policy across sustainable harvests. Pollutants capture emissions and contaminants of various forms, which can be monitored by such efforts as GEMS. Degradation captures environmental effects for which emissions and contaminants are not the central issue, and direct monitoring is more problematic. For both of the problem areas we identify the classical externality literature applies: a Pigouvian tax will internalize the externality, the Coasian issues of the assignment of property rights and whether partial internalization can take place through bi (or pluri) lateral deals once property rights are established also arise.

We note in passing that the developing countries in which these regimes occur are far from being a homogenous group of countries. They vary by per capita income, GDP growth rates, size, the volume and pattern of their international trade, their degrees of urbanization, and many other characteristics. They also vary in the form their environmental problems take; some countries are heavily endowed with environmental assets such as tropical forests[3], while others are arid and desert; some are mountainous, others are low lying and flood prone. Generalizing across all developing countries and categorizing the environmental regimes they each face is thus difficult. A few generalizations seem to hold, though: lower income countries have proportionately more significant agricultural and rural sectors, for instance.

Elements of the Regime

Notwithstanding these problems, in Table 1 we have set out what we see as the main elements in our characterization of the environmental regime in developing countries using the broad headings of pollutants and degradation.

Pollutants in the form of toxic contaminants cover effluents of various types which come largely from mines, chemical production, pulp and paper plants, and leather and tanning

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[4]Schatan (1998), for instance, notes that Latin America and the Caribbean account for 50 % of the world's tropical forests, and five of the ten countries richest in biodiversity worldwide are in the region (Brazil, Colombia,

Table 1

A Pollutant/Degradation Classification Scheme for Environmental Externalities in Developing Countries

1. Pollutants	
Toxic contaminants -	Organo-chlorines, dioxins, pesticides, grease and oil, acid and caustic metals; mainly discharges from mines, chemical producers, pulp and paper plants, and leather tanning factories
Untreated fluid waste -	Untreated sewage discharges into rivers, streams, open ditches - water borne disease
Domestic solid waste -	Poorly managed solid waste spreads infectious disease, blocks urban drainage channels, with risk of flooding and water borne disease
Smoke and burning -	Health related effects (respiratory damage, heart and lung disease, cancer) from burning dung, wood, and crop residues; vehicle exhaust; coal burning; smoke
2. Degradation	
Common property resources -	over exploitation of resources due to ill defined property rights - firewood/forests; fisheries; shared aquifers and water tables
Congestion/traffic -	time loss and elevated accident risk from poorly regulated traffic
Soil erosion -	Sedimentary transfer of topsoil to neighboring plots, river estuaries, hydro dams - silting, accompanied by leaching of soil
Soil quality -	Pesticide residues impact on production of neighboring plots

Ecuador, Mexico and Peru).

factories. They include organic chlorines, dioxins, pesticides, grease and oil, acid and caustic metals. These generate health and other problems. The 1998 UN Human Development Report estimates that Asia's rivers, on average, contain lead levels twenty times in excess of those in European/North American countries, and claims, by way of example, that in China most toxic solid waste is disposed of in municipal waste streams without treatment.

A second category of pollutant based externality problems are those associated with water quality. It is common in many countries for there to be untreated sewage discharges into rivers, streams and open ditches. The 1998 HDR suggests that as much as 50% of all discharges into waterways in developing countries are untreated. These in turn generate significant health problems, including water borne diseases, which in some countries are rife. The HDR estimates that diarrhoea and dysentery account for an estimated 20% of the total burden of disease in developing countries; that polluted water generates nearly two billion cases of diarrhoea annually in the developing world, and diarrhoea related diseases cause deaths of some 5 million people annually including 3 million children. They also estimate that contaminated water leads to 900 million cases of intestinal worms and 200 million cases of schistosomiasis, and that Asian rivers carry 50 times as many bacteria from human excrement as is the case in European/North American countries.[4] High levels of arsenic linked to phosphoric fertilizers in ground water killing some of the people who drink such water is a further problem in a number of countries.

[4] This is consistent with Hettige, Mani and Wheeler's (1997) finding that the environmental Kuznets Curve does not hold for water borne pollutants.

A further component of the pollutant category is problems associated with domestic solid waste. In most developing countries there are only limited solid waste disposal systems and the result is the spread of infectious diseases. The 1998 HDR estimates that between 20 and 50 % of domestic solid waste in these countries remains uncollected, even with up to one half of local government spending in some countries going on waste collection. In some areas, given the lack of sanitation, waste becomes mixed with excrement further contributing to the spread of infectious diseases. Uncollected domestic waste is the most common cause of blocked urban damage channels in Asian cities, which in turn increases the risk of flooding and water borne diseases. Poorer households in these countries tend to live near waste disposal sites.

Health related problems (which include respiratory damage, heart and lung disease and cancer) due to smoke from burning, and vehicle exhaust in both urban and rural areas reflect another pollutant-based element of the environmental regime. In lower income countries, these problems come from burning dung, wood and crop residues. The 1998 HDR estimates that 90% of deaths globally due to air pollution are in the developing world and of those 80% are due to indoor pollution.

Of the elements of degradation that we identify as part of the environmental regime in developing countries, soil erosion is a major component; although to identify the externality related component one has to differentiate between on site and off site effects. Erosion arises from a variety of causes. One is population growth which results in progressive division of plot sizes, with spillover of topsoil into neighbouring plots, river estuaries, hydro dams, and, in the case of more heavily desert countries, wind borne soil loss. The 1998 HDR estimates that in Bakina Faso and Mali one person in six has been forced to leave their land as it has turned into desert; and that desertification has a world-wide annual cost of $42 billion in lost income, $9 billion of which arise in Africa. Soil erosion reduces agricultural productivity and in some cases agricultural lands availability per capita. Soil erosion has also had the effect of reducing fodder available for cattle.

A recent survey paper on studies of the cost of soil erosion in developing countries (Barbier (1996)) places the annual losses by country in a range from 1 to 15% of GDP. Knut et.al. (1996) in a study of Nicaragua estimate annual productivity losses due to soil erosion by crop in coffee of 1.26%, beans 2.52%, maize 2.41%, and sorghum 1.35%. Magrath and Arens (1989) in a study of soil erosion losses in Java in 1985, estimate annual losses of around 4% of the value of crops harvested. Cruz, Francisco, and Conway (1988)[5] examining two watersheds in the Philippines and focussing only on additional sedimentary costs for hydro power installations (reduced water storage capacity for hydro power, reductions in the service life of the dam, and reduced hydro power) estimate annual costs of $27/hectare of agricultural land in the watershed, a significant portion of the value of crop yields per hectare. Soil quality problems arise from leeching of pesticides to neighbouring plots, contaminating neighbours soil.

In addition to soil erosion and soil quality other degradation type externalities arise with common property resources; resources for which the property rights are ill-defined and over exploitation of resources occurs. These include deforestation associated with land clearing, slash and burn cultivation, squatting, and, in some countries, the collection of firewood. These problems are especially severe in Africa, and Central and Latin America; Schatan (1998), for instance, identifies land degradation as the most serious environmental problem facing Latin and Central America. For Ghana, one of the less severe cases, Lopez (1997a) estimated that over cultivation of land at the

5 This is cited by Barbier (1996).

expense of forests runs at 25% of land use. Over exploitation of fisheries is a further problem. Shared access to water through common aquifers and ground water is a yet further problem; this results in reduced water tables, causing especially severe problems in the North China plain.

Finally, within this regime under the heading of degradation come urban congestion problems. Rapid growth in vehicle densities, especially in high growth economies, leads to congestion, high accident rates, and noise. A 1990 study by Japan's International Cooperation Agency[6] produced the estimate that road congestion in Thailand (one of the worst cases) reduces potential output in the Bangkok region by 1/3.

In closing this discussion we also note that the environmental regime in developing countries it is characterized by policy measures which frequently exhibit lax enforcement. As in the developed world, the primary form that developing country environmental policy towards industrial emissions takes is the use of command and control instruments of various forms. These involve the setting of standards, monitoring with penalties for violators, but a common feature is the presence of only limited compliance due to weak enforcement. For household waste water, soil erosion and other non-industrial environmental problems there is little or no abatement of damage in many countries.

[6] This was cited in **The Economist**, September 5, 1998, although we should note that that the estimate is substantially in excess of those in other studies we mention later.

The Costs of Environmental Damage in Developing Countries

If this is the regime, what are its consequences? In Table 2 we report some estimates of the costs of environmental damage for a number of countries, each associated with the elements of the regime we identify. Cost estimates of this form are relatively few and are scattered over the literature. The methods and data used to construct them are not always fully available. Most of these estimates do not directly refer to the welfare costs of the environmental damage, but instead use some other measure (such as value of work time loss due to health impacts). We have relied here heavily on a synthesis of studies of environmental damage for a sample of Asian economies that have recently been drawn together by the Asian Development Bank, and are reported in the 1998 HDR. This, together with a related study by the World Resources Institute, is cited in Table 2.

In the case of China, these studies suggest that annual productivity losses due to soil erosion, deforestation and land degradation could be as high as 7% of GDP for the early 1990's. If the health and productivity losses from pollution in cities are added (in the region of 1.7 to 2.5% of GDP), combined annual cost estimates from environmental damage are in the region of 10% of GDP. Even this estimate excludes a number of key components of environmental damage, such as those due to congestion from traffic related problems. A further study of China by Smil (1992) based on 1988 data puts losses due to environmental degradation (farmland loss, nutrient loss, flooding, timber loss) at around 10% of GDP, as against losses from pollutants of perhaps 2 % of GDP (water borne pollutants which reduce crop yields, reduced fish catches, reduced industrial output, airborne pollution which results in higher morbidity, reduced plant growth, damage to materials, and soil pollution which reduces crop yields).

Estimates of the costs of damage from a series of environmental sources in India in 1992 are put at about 6% of GDP in the ADB studies. The elements included cover urban air pollution, health costs from water quality, soil erosion, and deforestation, while the study excludes traffic related costs, pollution costs from toxic wastes, and biodiversity losses.

The other studies included in Table 2 are less complete in their coverage of environmental damage. Studies for Indonesia of the health costs of particulate and lead levels (gasoline related) set at levels above those laid down as standards by the World Health Organization are put at around 2% of GDP in 1989. In Pakistan the health impacts of air and water pollution along with productivity losses from deforestation and soil erosion were around 3½% of GDP in the early 1990's as per these studies. The ADB studies of the Philippines concentrate on the Manila area alone and look at the effects of lowered air and water quality, and produce cost estimates for this component of damage of around 1% of GDP. In Thailand, health effects of particulates and lead levels (gasoline related) in excess of WHO standards are put at 2% of GDP.

Table 3 reports estimated time loss costs from traffic congestion for a sample of Asian cities. These are also cited in the 1998 HDR, and are in addition to those costs listed in Table 2. For Bangkok time related costs from traffic are estimated at 2% of local product in 1994; these estimates fall to 0.4% for Seoul in the same year. Health related costs are already included in studies referred to in Table 2, but a number of further elements of costs excluded from Table 3 remain.

Table 2

Some Estimates of Environmental Costs in Selected Asian Countries

China

- Productivity losses due to soil erosion, deforestation and land degradation, water shortages and destruction of wetlands in 1990 put at US$ 13.9-26.6 billion annually or 3.8-7.3% of GDP
- Health and productivity losses from pollution in cities in 1990 put at US$ 6.3-9.3 billion, or 1.7-2.5% of GDP

India

- Total environmental costs of US$ 13.8 billion in 1992, or 6% of GDP; urban air pollution costs $1.3 billion; health costs from water quality at $5.7 billion; soil erosion costs at $2.4 billion; deforestation costs put at $214 million. Traffic related costs, pollution costs from toxic wastes, biodiversity losses excluded.

Indonesia

- Health costs of particulate and lead levels above WHO standards in Jakarta put at US$ 2.2 billion in 1989, or 2.0% of GDP

Pakistan

- Health impacts of air and water pollution and productivity losses from deforestation and soil erosion put at US$ 1.7 billion in the early 1990's; or 3.3% of GDP

Philippines

- Health and productivity losses from air and water pollution in the Manila area put at US$ 0.3-0.4 billion in the early 1990's, or 0.8-1.0% of GDP

Thailand

- Health effects of particulate and lead levels in excess of WHO standards put at US$ 1.6 billion, or 2% of GDP

Source: Agarwal (1996), ADB (1997), and UN (1998)

Table 3

Estimates of time losses due to traffic congestion in Asian cities, 1994

City	**Annual cost of time delays (US$ millions)**	**Cost as % of local (city-wide) product**
Bangkok	272	2.1
Kuala Lumpur	68	1.8
Singapore	305	1.6
Jakarta	68	0.9
Manila	51	0.7
Hong Kong	293	0.6
Seoul	154	0.4

Source: WRI (1996) and UN (1998)

What is striking from these two sets of studies is that in the case of the two more comprehensive country studies (China and India), estimates for combined environmental damage are large; in the region of 10% of GDP in the China case, neglecting damage from additional sources such as time loss in traffic. Given that model based analyses of the gains from more conventional policy reform (such as tax or trade reform) in those countries often produce estimates which are lower (perhaps 1-3% of GDP), this suggests that environmental policy should perhaps receive a higher weighting in the over policy stance in these countries than currently.

In addition, the composition of the environmental damage costs in these countries is striking. The China studies in the ADB compendium suggest that perhaps 70-80% of environmental damage occurs through degradation, largely in rural areas; a range echoed in the study by Smil we cite above. While the numbers for India are perhaps less dramatic, the high estimates of costs of soil erosion outside Asia[7], to us at least, support our contention that degradation of the environment rather than damage caused by pollutants may well be the more important environmental issue in developing countries.

Transborder Environmental Externalities and the Developing Country Environmental Regime

Developing countries both contribute to and are affected by a range of transborder and global externality problems. In Table 4 we list some of the more major transborder and global environmental externalities, both those affecting and contributed to by developing countries. These also form part of the typical developing country environmental regime, and although we do not emphasize them here we should mention them nonethless.

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[8]See Barbier (1996) and Schatan (1998).

<u>Table 4</u>

Transborder/Global Environmental Externalities Affecting Developing Countries

1.	Global warming	-	Temperature rise and micro climate change, combined with increasing frequency of extreme weather events
2.	Ozone depletion	-	Thinning of ozone layer increases ultraviolet light penetration of the atmosphere. Effect more severe in temperate climates
3.	Biodiversity/ Deforestation	-	Loss of gene pool through forest and wildlife erosion - mangrove losses linked to shrimp farming - loss of forests affects local populations who use non-timber forest products, reduces carbon absorption by forests, increases water run off in flooding
4.	Acid rain	-	Airborne acid depositions; high in areas such as South - East China, North - East India, Korea, Thailand. Wheat yields halved in areas in India close to sulfur dioxide emissions

Global warming is perhaps the more major transborder environmental issue for the developing countries, with temperature rise and micro climate changes the projected outcome, to be combined with increased frequency of extreme weather events. The possible impacts on developing countries with increased frequency of extreme weather events. The possible impacts on developing countries are thought to be potentially more significant for low terrain countries such as Bangladesh, as are the adjustment problems faced by smaller countries as micro climates change (such as in Western Africa) and labour flows across borders.

Further transborder elements forming part of the environmental regime in these countries include the thinning of the ozone layer, which increases ultraviolet light penetration of the atmosphere. These effects are more severe in developed country temperate climates than in the developing countries, but the ability of the developing countries to abate damage of this form is more limited than that in the developed world; especially as much of the population spends a larger fraction of their time out of doors.

We include problems associated with biodiversity and deforestation as part of the transborder/global part of the regime. For biodiversity, the issue is losses from the gene pool through flora/fauna damage. The environmental effects of economic activities which affect resources with global existence value (including species and biodiversity) is one aspect. Shrimp farming, for instance, has grown in the last two decades from initially low levels in Thailand and other countries, and with it has come significant loss of mangroves and a resulting loss of biodiversity. Many pharmaceutical products sold worldwide each year are generated from forest related sources in developing countries. Global impacts of forest loss occur through many channels including carbon sink reduction and impacts on existence value abroad. But there are also the effects of forest loss on local populations who use non-timber forest products; and increased water runoff in the event of flooding.

Acid rain problems reflect airborne acid depositions affecting buildings and agricultural yields; these problems are especially significant in such areas as South and East China, North and East India, Korea and Thailand. The 1998 HDR report that areas in India close to sulfur dioxide emissions (admittedly mostly originating within India) are estimated to have halved wheat yields due to these emissions. While these global and transborder externalities are also part of the developing country environmental regime, but both their impact on individual countries and the contribution of countries through them to global damage remain poorly quantified.

III. GROWTH, POLICY REFORM AND THE ENVIRONMENTAL REGIME IN DEVELOPING COUNTRIES

The discussion in the previous section emphasizes the wide range of externalities which comprise the environmental regime in developing countries, along with the seeming quantitative dominance of environmental problems associated with degradation more so than with pollutants. But how does this regime change as countries grow; does environmental quality improve or worsen, in what dimension and for what reasons? And what policy measures contribute to the environmental situation, either positively or negatively?

The Environmental Kuznets Curve

One of the more prominent of the recent discussions on these issues focuses on the so-called environmental Kuznets curve (EKC). The EKC refers to the relationship between environmental indicators of certain types and per capita incomes of countries; its origins in Kuznets work in the 1950's on income inequality measures across developing countries, which documented a clear trend initially towards increased inequality as per capita income grows, with a subsequent fall. This gave an inverted U shape for a cross country plot of an inequality measure such as a Gini coefficient against income per capita. The EKC hypothesis is that environmental indicator levels first rise (pollutant levels per capita rise) as per capita income rises; then the relationship reverses after some threshold level of income.

The implication drawn by some in the literature from EKC plots is that growth need not be inconsistent with the objective of improving environmental quality in the medium to longer run: a de-linkage of environmental concerns from growth objectives. Indeed, some authors have gone further and argued that the best way to improve environmental quality is to follow policies that make countries rich in the shortest possible time, since in the long run there is no conflict between growth and environmental protection. Andreoni and Levinson (1998) have recently provided microfoundations for the EKC, arguing that the characteristics of clean-up technology are key to the EKC.

The first paper in this area by Shafik and Bandopadhyay (1992) (a background study for the 1992 World Development Report (World Bank (1992)) with results given prominent profile in the Report itself) examined a range of environmental indicators. These included lack of clean water, lack of urban sanitation, ambient levels of suspended particulate matter, ambient sulfur oxides, change in forest area, during the period 1961-86, the annual rate of deforestation between 1961 and 1986, dissolved oxygen in rivers, fecal coliforms in rivers, municipal waste per capita and carbon emissions per capita. Their sample consisted of observations on up to 149 countries for the period 1960-90, although their coverage was incomplete. Some of the dependent variables were observed for cities within countries, other for countries as a whole. Only in the case of air pollutants was an EKC type relation found. Lack of clean water and lack of urban sanitation were found to decline uniformly both with increasing income and over time. Deforestation seemed to be unrelated to income. River quality tended to monotonically worsen with income.

Selden and Song (1994) following Safik and Bandopadhyay focussed exclusively on air pollutants in their examination of possible EKC relationships. They studied emissions of SO_2, NOx, SPM and CO. Emissions were measured as kilograms per capita on a national basis with pooled cross-section and time-series data drawn from World Resources Institute (1991). The data were averages for 1973-75, 1979-81 and 1982-84. There were 30 countries in their sample: 22 high income countries, 6 middle income and 2 low income. Their results indicated that emissions of CO were independent of income, whereas emissions of other pollutants followed an EKC pattern. However, the turning points occurred at much higher levels of income than in the Safik and Bandopadhyay study.

Grossman and Krueger (1995) subsequently investigated EKC relationships using the GEMS cross country data on air quality over the period 1977-1984 and isolated a series of environmental indicators: SO_2 concentration in selected cities, smoke, dissolved oxygen in water, biological oxygen demand (BOD), chemical oxygen demand (COD), nitrates, fecal coliform, total coliform, lead, cadmium, arsenic, mercury and nickel. The data measured ambient air quality at two or three locations in each of a group of cities in a number of countries over the period 1977-88. The number of observations varied over time (52 cities in 32 countries in 1982, but only 27 cities in 14 countries in 1988). The authors claimed that the data were representative of countries at varying levels of economic development and with different geographical conditions, and found an EKC type relation for SO_2, smoke, dissolved oxygen, BOD, COD, nitrates, fecal contamination of rivers and arsenic. The evidence was less compelling for total coliform and heavy metals.

In later literature Panayotou (1993) estimated EKC type relationships for SO_2, NO_X, SPM and deforestation using cross section data for 1985 and, as in Seldon and Song, pollutants measured in emissions per capita on a national basis. He found EKC type relations for SO_2, NO_X and SPM. Turning points were at levels of income lower than those in Seldon and Song. Cooper and Griffiths (1994), in contrast, estimated three regional (Africa, Latin America and Asia) EKCs for deforestation only, using pooled cross-section, time-series data for each region for the period 1961-91, and for 64 countries. They found no EKC relationship.

These findings are such that it is widely accepted that attempts to estimate EKC type relationships should now be confined to air pollutants alone, and, in particular, to SO_2 emissions. As a result, drawing conclusions from any EKC plot as to how overall environment damage behaves as income change is fraught with problems.

But even for SO_2, the EKC does not also appear to be a particularly robust description of the behavior of environmental pollutants vis a vis income per capita in current literature. Kaufman et.al. (1998) point out a number of econometric problems with EKC estimates, including violations of homoskedasticity, the non-use of random and fixed effects methods in panel data, improper definition of dependent and independent variables and other problems. Kaufman et.al. try to circumvent these difficulties in their attempt to identify a EKC type relation in the case of SO_2; defining SO_2 concentrations as annual average concentrations in ground level atmosphere at a particular location within a city. Using a panel of 23 countries (13 developed, 7 developing and 3 centrally planned) over the period 1974 to 1989, their analysis shows an EKC type relation between emissions per capita and spatial intensity of economic activity, as well as between emissions per capita and GDP per capita. However, they also find evidence that still further increases in incomes per capita lead to a further increase in emissions per capita; an *N* type rather than inverted *U* type relation between emissions per capita and GDP per capita.

Unruh and Moomaw (1998) evaluate whether the transition from a high emission to a low emission state occurs mechanically at a particular income level as suggested by earlier papers. They identify some industrialized countries that seem to have gone through EKC type transitions discovering that these transitions span a broad range of income levels[8]. Furthermore, the transitions

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[8]In a recent paper, Torras and Boyce (1998) take the existence of the EKC at face value and ask whether it is

occur abruptly and co-temporally, and do not appear to be the consequence of endogenous income growth. Rapid and co-temporal historical events, technological progress and the need to react to external shocks seem to drive the EKC structure. Ekins (1997) argues that the pattern of emissions of selected air pollutants does not indicate the environmental impact of such emissions, and examines an aggregate indicator of environmental impact developed by the OECD. Examining the relationship between this indicator and income per capita, Ekins find no evidence in favor of an EKC.

Thus, even taken within its own confines, the relation between economic growth and environmental damage seems more complex than that portrayed by the EKC. There appears to be nothing automatic about this relation, nor is any inference on causality necessarily justified. Once degradation effects are added in, drawing conclusions as to how overall environmental quality changes with income is even more treacherous. Soil erosion problems, measured relative to aggregate income, would seem to recede as growth occurs, and in (relative terms) the agricultural

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merely the level of income or also its distribution that affects emissions per capita. They argue that a more even distribution of income, higher literacy rates and other indicators of power lead to lower emissions per capita.

sector shrinks. But with growth come urbanization and congestion problems, which relative to income perhaps recede after a transitional period when growth and new infrastructure come on stream.

The Environmental Effects of Policy Reform

A further strand of recent literature attempts to assess how environmental quality changes with policy changes, including trade liberalization; in particular how various kinds of pollutant concentrations can be affected. Copeland and Taylor (1994), for instance, evaluate the role of trade where environmental quality is a local public good (damage from pollutants remain in the country). They consider a two country single period equilibrium, where goods differ in pollution intensity in production. Countries differ in endowment of a primary factor (human capital); environmental quality in both countries is a normal good in preferences, and with assumed endogenous setting of pollution policy the higher income country has higher environmental standards. They find that free trade shifts pollution intensive production towards human capital scarce countries and raises world pollution levels.

Copeland and Taylor (1995) consider a different case where environmental quality is a pure public good to which all countries are exposed. Trade effects are different in this case, since relocation of pollution intensive industries to countries with less stringent environmental protection can increase the exposure of residents in the home country, and works against more conventional gains from trade. Since there are transborder externalities in this case, nationally based pollution regulation does not lead to Pareto Optimality, and free trade need not raise welfare.

More recently, Antweiler, Copeland and Taylor (1998) first generate and then test a series of propositions as to how economies behave in terms of their trade and environment linkages. They assume a small open economy formulation, the economy has a number of agents, produces two final goods and uses two primary factors. One product is labor intensive and involves no pollution, whereas the other is capital intensive and causes pollution. They assume producers have access to an abatement technology, which, for simplicity, only uses the polluting good as an input. It is also assumed that the government uses emission taxes to reduce pollution, and given the pollution tax rate they generate a firm level profit function.

The level of the actual tax used is an increasing function of what an optimally set tax would be. This treatment allows government behavior to vary across countries, and also allows for environmental policy to respond to differ by country. On the demand side, consumers maximize utility taking pollution as given; they assume preferences over goods are homothetic, while there is constant marginal disutility of pollution.

The model allows them to decompose a total change in pollution levels into scale, composition, and technique effects. This, in turn, allows them to generate a number of theoretical propositions to test. Thus, if economies differ only with respect to the degree of trade openness, if both countries export the polluting good, then pollution will be higher in the country which is less open. Where the world price is fixed, then for a given level of income and for certain settings of key model parameters, they show that the composition effect associated with trade liberalization in such countries is to increase pollution. These and other propositions as to how the links between trade and environment operate emerge from their analysis and focus on emissions associated with trade related polluting activity.

However, as our earlier discussion indicates, emissions are likely to constitute only a portion of the overall welfare cost of environmental externalities, and other environmental externalities may well have different interactions with trade. Thus, if with increased trade labor moves from rural to urban areas, and if this generates increased congestion, these adverse consequences linked to trade can easily dominate the overall environmental impact compared to changes in emissions. Impacts on soil erosion from agricultural trade liberalization abroad can be adverse, while at home beneficial. Liberalization in the manufactured sector can produce opposite implications for soil erosion. A wider view of the environmental regime in developing countries can thus also produce different conclusions as to what the key linkages between policy changes and the environment.

V. MEASURING THE DEGREE OF DEVELOPING COUNTRY ENVIRONMENTAL FAILURE

Given the preceding discussion, if pollutant levels across economies do not provide complete picture for the evaluation of comparative environmental performance across countries or through time either in analytical or empirical work, what is a more appropriate way to proceed? Unfortunately, the problem is not only the incomplete coverage of environmental externalities in developing countries; one also needs damage functions, which allow the losses, involved to be computed in welfare terms. Thus, for instance, even if economies have high levels of emissions per capita, if the ability to abate differs across economies (such as health care capabilities to deal with adverse effects of emissions) then differences in emission levels across countries do not necessarily map into comparable differential welfare losses due to environmental failures. In the appendix to the paper, we show for the special case of a stock externality that, even if an EKC relationship is followed in emissions per capita, this need not map into a comparable relationship in terms of welfare.

For these reasons some alternative approach is, therefore, needed to evaluate the significance of environmental failures across economies or through time, and hence to assess the impact of the environmental regime in developing countries. The appropriate concept to us would seem to be some distance measure implied by departures from Pareto optimality associated with externalities; how far away are economies from Pareto optimality in a welfare sense, and what would be the potential welfare gains from moving from the current allocation of resources with uninternalized or partially internalized externalities to complete internalization. The implied measure would seem to be a money metric measure (say a Hicksian measure) of the gain from internalization relative to a current non internalized equilibrium. Income effects associated with different assignments of property rights would affect the precise fully internalized equilibrium, although we put these issues on one side for now. Such a measure of gain is implicit in the literature discussed in section II, which produces estimates of the costs of various kinds of environmental failures in terms of GDP per capita; but much of this literature is not explicit about the precise welfare formulation used.

Such measures need not behave in any way, which is necessarily collinear with levels of emissions, or intensity of environmental failure. Figure 1 shows schematically how a comparison across two economies with differing levels of emissions may yield larger gains to the economy with smaller emissions. Here, we represent marginal benefit and marginal cost of abatement functions for two economies. Economy A has more steeply sloped functions, and in Pareto optimality has smaller abatement than B. But the gains from abatement (internalization) are larger in A than in B because of the more shallowly sloped functions in B. Comparing pollutant levels across economies need give no guide as to the relative size of gains from internalization.

Figure 1 here.

The seemingly large estimates we report earlier of the gains from internalizing environmental externalities in developing countries also suggest the perhaps obvious question of why is it that if internalization gains are so large, more internalization has not occurred.

It would be wrong to say that no internalization has occurred in these countries. At village level, terracing and other schemes are designed to remedy some of the ills of soil erosion. National environmental regulation often approaches levels of stringency seen in regulation in developed countries, but is accompanied by problems of enforcement and compliance. In many developing countries, environmental NGO groups are also extremely active, generating a rising profile for environmental issues in local policy debate. On the other hand, large potential gains from internalization still seem to remain.

Various explanations abound for the presence of these seemingly large potential gains. One is that the technology of internalization is both capital intensive and high cost for low income countries. Monitoring devices, administration of environmental fees and fines all require inputs on a scale not easily attained in low income countries. Another is that if environmental quality is costly to provide, then models with traditional preferences and technology would naturally imply that abatement levels are lower in low income countries. These effects, in turn, would be exacerbated by income elasticities of demand for environmental quality exceeding one, as is often claimed.

Another direction explored in recent literature (see Lopez (1997b) and Maler (1997)) is that it is outside shocks to social systems that are a significant compounding factor either disrupting or delaying internalization and producing lowered environmental quality. Particularly important in this discussion is the observation that environmental management systems in developing countries commonly rely on informal social norms, which can partially or wholly break down under rapid population growth, technological innovation, or changes in market outcomes. Previously reasonably well-managed resources can become open access poorly managed resources, with worsened environmental quality the result. Dasgupta and Maler (1991) have argued that, viewed in these terms, poverty and degradation can even be reinforcing. Thus, if deforestation moves available firewood from forests progressively further from villages, families may have more children to offset the increased time required to collect firewood[9]. Population growth is higher, and with it the demand for firewood producing further degradation.

9 This hypothesis is tested empirically by Filmer and Pritchett (1996) using household data for Pakistan for 1991-92. They conclude that households living in areas in which the distance from firewood is greater have more children.

VI. CONCLUDING REMARKS

This paper discusses the environmental regime in developing countries, stressing both the complexity of the regime and the wide ranging nature of environmental externalities which go beyond more conventional literature discussion of pollutant levels. It suggests that a full characterization of this regime needs to focus on such externality problems as soil erosion, common property resources and congestion problems in urban areas. The paper stresses that gains from internalization of these externalities from available studies seems to be large; potentially exceeding numerical (model based) estimates of gains from conventional policy reforms (such as trade or tax reform) by substantial orders of magnitude. Also, the majority of such gains seem to arise from internalizing externalities associated with degradation (soil erosion, common property resources, congestion) more so than pollutants. We also stress how existing literature discussing how the environmental situation changes with growth (the environmental Kuznets curve) covers only part of the environmental situation; a point which also applies to other literatures such as that on policy reforms (trade liberalization) and environmental quality.

Having developed this picture of the environmental regime in the developing countries the paper concludes by suggesting that a measure is needed of overall environmental performance in terms of departures from Pareto optimality so as to give a money metric welfare measure of the internalization gains of moving to complete internalization. It also discusses some of the reasons for the lack of internalization, citing recent literature which argues that social conventions defining implicit management regimes come under stress as rapid urbanization, rapid population growth, and other shocks to social systems occur. The overall theme of the paper, repeated throughout, is that in discussing the environmental situation in developing countries, a more comprehensive sense of what comprises this regime is needed.

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Appendix

Internalization Gains and the Environmental Kuznets Curve

The EKC literature discussed in the text of this paper seemingly points to the conclusion that there is no clear evidence in favor of the EKC. Even though the EKC itself may empirically be dubious, its welfare interpretation also has to be highly qualified. Here, we develop a model where optimality is defined as internalization, and since such internalization is, in principle, independent of the level of emissions, the EKC even if it were to exist lacks any welfare content. We use an amended version of the growth with stock externalities model, showing that alternative technological assumptions can give us different (optimal) relations between emissions and income, and each such relation is consistent with perfect internalization. The emphasis in the model is on shadow pricing the external effect appropriately (Ko et.al. (1992)).

In the model:

(i) Labor is normalized to equal 1

(ii) Output, *y*, depends upon capital, *k*, and emissions, *e* :

y = f(k,e). An important point here is the nature of the relation between *k* and *e*. We assume that $f_{ke} > 0$, i.e. capital and emissions are substitutes. We further assume that there exists a level of emissions $\bar{e}$ such that the marginal product of emissions for a given level of capital is zero.

(ii) Capital accumulates according to the equation

$$\dot{k} = f(k,e) - c - dk \qquad (1)$$

where *c* is consumption and *d* is the rate of depreciation of capital.

(iii) Pollution accumulates according to the relation:

$$\dot{S} = -bS + e \qquad (2)$$

where b is fixed.

The social planner's problem is to choose non negative consumption and emission paths that solve the infinite horizon maximization problem:

$$\int_0^\infty e^{-rt} U(C,S)dt \qquad (3)$$

subject to (1) and (2). Here U(.) is the instantaneous utility of the representative consumer and r is the discount rate.

The Hamiltonian for this problem is:

$$H(k,S,c,e) = U(c,S) + q_1(t)[f(k,e) - c - dk] + q_2(t)(e - bS) \qquad (4)$$

where θ_1 and θ_2 are costate variables.

First order conditions imply

$U_c = \theta_1$ (5), assuming we always have an interior solution; and

$q_1(\partial f / \partial e) + q_2 \leq 0$ (6)

with equality if e*(t) > 0.

The canonical equations are :

$$\dot{q}_1 = (r + d - (\partial f / \partial k))q_1 \qquad (7)$$

$$\dot{q}_2 = \{(r + b)q_2\} - \partial U / \partial S \qquad (8)$$

and transversality conditions apply, i.e.,:

$\lim_{t \to \infty} e^{-\rho t} \theta_1(t) = \lim_{t \to \infty} e^{-\rho t} \theta_2(t) = \lim_{t \to \infty} e^{-\rho t} k(t) = \lim_{t \to \infty} e^{-\rho t} S(t) = 0$ (9)

which require that the present value of capital and pollution becomes negligible at infinity.

The above welfare exercise refers to the optimal solution obtained in a command economy. From the first order conditions we can solve for optimal consumption and optimal emissions as: $c^* = c(k, S, \theta_1,\theta_2)$ and $e^* = e(k, S,\theta_1,\theta_2)$. If we assume that the production and the utility functions are strictly concave in this case then for given values of parameters, c* and e* would be unique. The EKC in this case refers to the relationship between c* and e*; the issue is how this may be expected to vary with *c*. If we use the above result on θ_2 then it follows that, from a welfare point of view, the relationship between consumption and emissions would be monotonically falling. Richer countries would have higher θ_2 and, therefore, lower emissions, *ceteris paribus*, than poorer countries.

In a competitive market economy the representative consumer takes as given time paths $\{w(t), r(t), \pi(t)\}$ for $t\varepsilon [0,\infty)$, of wages, interest rates, and profits. The instantaneous utility of the consumer is defined by U(c,S) as before. The consumer sells the fixed labour input (normalized to unity) to a representative firm at the market-determined wage rate, and rents out capital (k(t)) at the market rate of interest to the firm. The representative firm maximizes profits under competitive conditions. It generates emissions e(t) per unit time and pays a tax $\lambda(t)$ on these emissions. Total tax proceeds collected by the government are redistributed to the consumer. The consumer maximizes utility and has perfect foresight about market wage rates and other variables.

The consumer maximizes:

$$\int_0^\infty e^{-rt}U(c(t),S(t))dt \text{ subject to} \qquad \text{(CP)}$$

$\dot{k} = p(t) + rk(t) + l(t)e(t) - c(t) - dk(t)$

and treats *S* as a parameter. ρ is the consumer's discount rate and δ is the rate of depreciation of capital.

The firm takes as given (and has perfect foresight about) time paths of emission taxes {λ(t), t ε [0,∞)} along with the times paths of wage and interest. The firm can reduce its tax liabilities by reducing output. Output is produced according to a standard neoclassical production function so that the firm chooses k(t) and e(t) to solve the problem:

Max π(t) = f(k(t),e(t)) - r(t)k(t) - λ(t)e(t) (FP)

Given that the consumer perfectly predicts the time paths of {w(t), r(t), π(t)} and the firm perfectly predicts the time paths of {w(t), r(t), π(t)}, then the consumer will determine consumption demand (c^d) and capital supply (k^s) whereas the firm will determine consumption supply (c^s) and capital demand (k^d) and the emissions e(t). The paths {w(t), r(t), π(t), λ(t)} are a perfect foresight competitive equilibrium with emission taxes if the solution {c^s(t), k^d(t), e(t)} of the FP is such that if profits are defined by

π(t) = f(k(t),e(t)) - r(t)k(t) - λ(t)e(t) for each *t* and if {c^d(t), k^s(t)} solves the CP then for all tε [0,∞) we have:

(i) $c^d(t) = c^s(t)$ goods market or flow equilibrium;

(ii) $k^s(t) = k^d(t)$ capital market or stock equilibrium;

(iii) $e^c(t)$ is the competitive emission;

(iv) $\dot{S} = e^c(t) - bS(t), S(0) = S_0$ (evolution of pollution stock).

An examination of the planner's problem in (1) immediately reveals that if the emission tax is defined as $\lambda(t) = -\theta_2(t)/\theta_1(t)$, the competitive equilibrium solution for CP and the firm's FP are identical to the solution of the social optimization problem. To see this, assume that the FP has an interior solution, then we must have:

$\partial f/\partial k = r$ (10)

$\partial f/\partial e = \lambda$ (11)

These determine the demand for capital and competitive supply of emissions. Given this, then the consumer maximizes the following Hamiltonian:

$H = U(c,S) + \gamma(t)(\pi + rk + \lambda e - c - \delta k)$ (12)

The first order conditions are:

$\partial U/\partial c = \gamma$ (13)

$\dot{g} = (r + d - r)g$ (14)

$\dot{k} = p + rk + le - c - dk$ with $k(0)=k_0$ (15)

The transversality conditions are:

$\lim_{t\to\infty} e^{-rt} g(t) = \lim_{t\to\infty} e^{-rt} g(t)k(t) = 0.$ (16)

If we compare this solution to that for the planner's problem, it is clear that for $\gamma=\theta_1$ and $\lambda = -\theta_2/\theta_1$ the solutions to the two problems are identical. Hence, by solving the social optimization problem and using an optimal and flexible emission duty the planner can induce profit-maximizing firms to follow the socially desirable emission policy.

An important implication of the solution to the market problem is that if we have incomplete Internalization ($l \neq -q_2/q_1$) then this carries a welfare cost. The EKC, even if it is observed, then does not give any indication of the welfare cost of non internalization across countries.

Figure 1

Abatement Levels and Welfare Gains in Two Economies