ECONOMICS OF SUSTAINABLE DEVELOPMENT: INTERNATIONAL PERSPECTIVES

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Summary

Sustainable development encompasses concern for the poor and for future posterity. In both cases it has significant international dimensions. Current activities in any one country may influence various other *concurrent* impacts or determine *future* options available in other countries or even worldwide. In the present collection, we supply an analytical structure to aid understanding of such interlinkages and we draw specific conclusions on the basis of economic analysis.

The international dimensions of sustainable development basically arise out of one of two transnational interlinkages. First, environmental media may mix across boundaries or even globally, and thus actions in any one location may have an impact on other cross-border locations via the environmental medium. Second, the economic systems of different nations are interlinked by flows in traded goods and services, and in production factors (migration, foreign direct investment). Also here, individual action and policy (not only environmental) usually has a transboundary or even global impact on livelihood in other locations (in economic, social and environmental terms).

In this article we first review some transboundary and global environmental problems, which are currently seen to be crucial. We then present an economic analysis of their structure and discuss the related policy measures which have so far been taken.

We then show that the responsibility for global environmental damages is shared differently among nations, and that the burden deriving from such damages (vulnerability) is unevenly distributed among countries, and among different social groups within countries.

For future development paths the following becomes evident. By assuming that all nations have the right to comparable levels of prosperity and social development, it does not follow that future paths of development must necessarily replicate the patterns of the past. Nevertheless evidence that industrialising nations are currently following paths of development similar to those of industrialised countries is available, at least for some environmentally sensitive areas. Thus, an intensification of future disputes on the distribution of scarce emission rights is likely to be the consequence.

Regarding issues arising out of the economic interlinkages among nations, we find that environmental and natural resource scarcity may render traditional paradigms of the benefits of economic liberalisation invalid in their pure form. When a policy shortcoming is present for any one trading partner (e.g. insufficiently stringent environmental policy, too low labor standards), we can no longer assert that an overall welfare gain is achieved from economic integration, at least not for all trading partners. Rather, opening up to trade in this case might 'magnify' the pre-existing welfare loss. There are also certain incentives at work which lead to less strict levels of regulation than would be optimal. In empirical terms, however, not many of these links have so far been proven noteworthy at significant levels, possibly a consequence of the fact that environmental regulation does not yet differ sufficiently across the major trading partner countries.

Finally, the relevant institutional issues arising from the international perspectives of sustainable development are discussed in some depth both here and in the more specific related articles. The diffusion of pollutants and of polluting technologies are expanding at a breathtaking pace. Unfortunately, the parallel growth of an international institutional framework, capable of coping with the long-run aspects of international pollution is rather slow. We analyze some of the difficulties in the construction of such a framework and offer suggestions on how they might be overcome.

Also in order to gain momentum for political initiatives in this direction, education in environmental problem-awareness and its promotion appear crucial. They are seen as a fundamental requirement enabling modern societies to respond to the international challenges of sustainability. This overview and the individual articles on this topic are an attempt to move in this direction.

1. Introduction

Worldwide, substantial changes in environmental and social indicators have been observed over recent decades. For example, in a few generations, humankind has embarked upon the process of exhausting fossil fuel reserves that has taken several hundred million years to generate. As a result the carbon dioxide concentration in the atmosphere has increased by more than 30% since the beginning of the Industrial Revolution and that of methane, has increased by 100%. Nearly half the land surface has been transformed by direct human endeavour so far, with significant consequences for biodiversity, nutrient cycling, soil structure, biology, and climate. More than one-fifth of terrestrial ecosystems have been converted into permanent croplands; most of the temperate, old growth forest has been cut. In terms of another crucial resource—water—more than 50% of all accessible freshwater is used directly or indirectly by humankind; our underground water resources are being depleted rapidly.

Nevertheless, some 300 million people worldwide still live on less than 1 US$ a day, with the largest concentration occurring in Africa's poorest countries, where two-thirds of the figure belong to this group, and nine out of ten people live on less than $2 a day (in terms of purchasing power in both cases). But the share of people in poverty has significantly declined since 1970. Even the absolute numbers have too, by some 400 million over the last 3 decades (using the poverty-specification just mentioned). Within-country inequality has most likely gone up during recent decades, as has across-country inequality, at least on average. In 1960 the incomes of the richest 20% were 11 times larger than the incomes of the poorest 20% (in terms of purchasing power), while they were 15 times greater in 1997. Often the market exchange rates are used for this comparison, which do not take account of the lower cost of living in poorer countries. The corresponding ratios are then 30 and 74. Yet, mainly due to two particularly large and presently, poor countries who have improved their situation substantially, primarily China, and to some degree India, when the country variance reported above is weighted by population, we find that recently, inequality has been declining worldwide. Assuming India and China escape poverty, and that no similar escape can be engineered in Africa, worldwide inequality is likely to return to its long-term trend in future, and that will be a rising trend.

We may look at some further social information across countries, e.g. life expectancy and health data as indicators of well-being. The extremes range from a current (2002) 80 years of life expectancy in Japan or Sweden to less than 40 years in Botswana, Mozambique or Malawi. With regard to medical services, we find one doctor for 170 people in Italy, while at the other extreme, some 50,000 people in Chad or Eritrea are served by one doctor only. There are clearly significant potential benefits of economic growth, especially for the poor and disadvantaged, but such growth in turn may destroy the very basis for long term-development, for example in terms of natural resource depletion or climate change.

In response to such challenges, sustainable development is broadly defined to encompass the needs of both the poor and that of posterity. Significant international dimensions are implied in both cases. Current activities in any one country may have *concurrent* impact on other countries or on the *future* options available in other countries or even worldwide. In the present contribution we supply an analytical structure to aid understanding of such interlinkages and we draw specific conclusions on the basis of economic analysis.

Sustainability itself has been defined as a state in which any of the following conditions (or any combination thereof) are met:

- utility or consumption of humankind is non-declining through time,

- resource management is undertaken so as to maintain production opportunities for the future,
- the natural capital stock is non-declining through time,
- resource management is undertaken so as to maintain a sustainable yield of resource services, and/or
- minimum conditions of ecosystem stability and resilience through time are satisfied.

The term **sustainable development**, then, is consequently used to describe a path of development where criteria such as the above are fulfilled. In addition, some authors also use the term **sustainable development** to refer to a path of development that—starting from any current non-sustainable state—brings us closer to a sustainable one. The latter definition, for example, includes a view of sustainable development which is necessarily process-oriented, with the primary focus not on defining a sustainable state but on social capacity and consensus building (for a detailed discussion of sustainable development see *Welfare Economics and Sustainable Development* and *Economics of Sustainable Development: Intertemporal Perspectives*).

The international dimension of sustainable development may arise out of one of two transnational interlinkages: one environmental and one economic.

1 *International environmental interlinkage*: Emissions in any one country may effect a specific (group of other) country(ies), such as sulfur emissions from UK thermal power plants causing acid rain in Scandinavia (transboundary environmental impact). Impacts may even be global, such as the climate change consequences of greenhouse gas emissions (global environmental impact).

2 *International economic interlinkage*: The production and consumption systems of nations are connected (a) by international trade in goods and intermediate products and (b) by flows of production factors, most importantly capital (e.g. foreign direct investment), but also labor (e.g. migration). Thus, economic actions or economic policies undertaken in any one country often trigger consequences for the production and/or consumption system in other countries, resulting in social and environmental impacts in these countries (or beyond). For example, take a country implementing a fossil fuel tax which makes aluminium production within that country uncompetitive. Production shifts to another country, where different production technology and/or labor standards may be used. If the technology in the new production location is less energy efficient, we may observe an increase in global greenhouse gas emissions, basically as a consequence of the unilateral greenhouse policy implementation in the first country (i.e. a very significant unilateral policy leakage effect).

The structure of this paper is as follows. We start with an overview of important transboundary and global environmental issues and their basic economic analysis in section 2. Section 3 then focuses on the distribution of environmental and economic burdens of transboundary and global environmental problems, and compares these with the distribution of benefits stemming from the underlying production and consumption systems. In section 4 we analyse the international economic interlinkage with respect to its environmental consequences. To supply more detailed guidance on the further articles analysing selected and specific subjects dealing with the topic of international perspectives of the economics of sustainable development, section 5 gives an overview of the issues, structure and conclusions of each of these articles. The final section summarizes the main conclusions.

2. Global and Transboundary Environmental Problems

2.1. Economic Analysis of Global and Transboundary Environmental Problems

Two main methods of analysis have normally been used to depict the structure of, and derive economic policy conclusions for, the problem of global and transboundary pollution: (a) optimization analysis and (b) game theory analysis.

2.1.1. Optimization analysis

This line of analysis is based on the construction of an objective function for each country under consideration (usually referred to as a national utility function). There are two ways of optimizing a single country´s behaviour. First, each country can set its environmental policy such as to maximize its own objective function only, assuming that the environmental policy in each of the other countries is given (fixed). This is known as **non-cooperative optimization**. Second, countries may seek to maximise the collective overall benefit, and set their own policy while considering the potential damages of domestic pollution abroad. There will usually be benefits choosing collective optimization, and these can be shared among the countries, on the basis of negotiation (cooperative optimization).

This type of analysis shows the direction and magnitude of additional environmental policy necessary to cope with transboundary and global pollution. When comparing the resulting emission levels of non-cooperative and cooperative optimization, we can determine the amount by which an individual country's emissions would need to be reduced to compensate for the impact of its domestic emissions on other countries. The baseline result is a quantification of the benefits of joint regulation and coordinated environmental policy. Furthermore, conclusions on the policy stringency level can be derived. For example, if the policy instrument is a pollution tax, the analysis indicates the amount by which a pollution tax correcting only for the intra-national pollution problem would need to be raised to guarantee the international overall best outcome (i.e. the international overall minimization of environmental damages and abatement costs). For one application of this method presented in some detail see *International Environmental Agreements and the Case of Global Warming*.

2.1.2. Game theory analysis

For many transboundary environmental problems the number of (relevant) actors (i.e. actors within the affected number of countries)) is relatively small: i.e. governments of each country, the business sector and consumers (i.e. a representative firm and consumer for each country). Further, the consequences of one country's decision significantly depend on all the other countries' decisions. In this situation matters of strategic choice may become relevant. Such mutual dependency is analysed in game theory. For example, if any one country reduces greenhouse gas emissions, this might lead it to incur economic costs. However, the corresponding benefits arising from the country's greenhouse gas reduction are dependent on both said country's own emission reduction and on any consequent reductions in the other countries, especially those accounting for substantial emission shares.

Conversely, the benefits of one's own greenhouse emission reduction accrue to all countries worldwide. If a country chooses not to reduce its own emissions, it will still obtain benefits from others doing so. There is thus an incentive to free-ride on global pollutant emission reduction.

The core characteristic of such decision problems is that in your own decision-making you do not know in advance how the other player(s) will decide. Each player can, however, seek to find out whether there is a best strategy for any of the players, including himself. To do so, the pay-offs for each player under each combination of their own choice/others' choices needs to be determined (or estimated). Then, as in optimization analysis above, there are two basic approaches to the game. First, each player can seek to maximize his own benefit only, without cooperating with the other player(s) (non-cooperative game). Second, a joint best strategy can be sought (cooperative game). For the more complete exploration of the differences in these strategies see *International Cooperation to Resolve International Pollution Problems*.

One baseline result here is similar to the above, in that it indicates that cooperation *may* involve benefits. That is, each country can do at least as well from cooperation and subsequent sharing of the cooperation benefits as it can do with non-cooperative behaviour. Game theory analysis places particular emphasis on the decision and incentive structure upon which each country is acting. For example, it provides us with two of the main reasons why cooperation (and thus a collective benefit) often does not materialize:

- first, at the hierarchical level above nation states, there is no supranational institution with enough authority to impose a cooperative solution,
- second, in the absence of this supranational institution, a cooperative solution necessitates bargaining and negotiations between individual countries. To organize such a process successfully is all the more difficult and complex, (a) the more parties are involved, (b) the more diverse the weight of these parties are, (c) the more expected gains and losses differ, and (d) the larger the costs of bargaining relative to the overall and individual benefits of cooperation.

For an analysis of the obstacles to and potential for international cooperation in environmental issues, both theoretically and empirically, see *International Cooperation to Resolve International Pollution Problems*. On the specific issues surrounding one of the most crucial global environmental problems, global warming, see *International Environmental Agreements and the Case of Global Warming*.

In the remainder of this subsection we develop a general starting base by reviewing three of the more important global and transboundary environmental problems and their economic characteristics.

2.2. Stratospheric Ozone Depletion

Ozone builds up in the upper layers of the atmosphere in a chemical process involving oxygen molecules, various catalysts and ultraviolet light. There are many significant variations of ozone concentration in time, location and altitude which occur naturally. Humans also have an impact on the stratospheric ozone concentration in many ways. The dominant impact is ozone depletion triggered by chlorofluorocarbon (CFC) emissions. CFCs drift for years in the environment until they eventually reach the stratosphere, where intense UV solar radiation severs chlorines off the CFCs. These chlorines are able to catalytically break up ozone molecules (i.e. convert them into oxygen molecules). Acting as a catalyst, it is estimated that one chlorine atom can convert 100 000 molecules of ozone into oxygen before that chlorine becomes part of a less reactive compound, such as HCl, and eventually is precipitated out of the stratosphere by water vapor.

While stratospheric ozone depletion has been predicted since the early 1970s, the discovery of the so-called ozone-hole over Antarctica (a decline in ozone concentration of some 60%), reported in 1985, placed the issue high on the political agenda. Translated to one average number for the whole globe, the loss of stratospheric ozone by the year 2000 due to human impact has been about 5% of the levels existing in the late 1960s. A higher decrease is occurring in winter and spring, and towards the poles. Stratospheric ozone absorbs ultraviolet (UV) radiation. A reduction in concentration thus exposes living organisms to higher doses of harmful UV radiation. For example, a 1% depletion in the ozone concentration is estimated to increase some types of skin cancers by more than 3%. Other potential impacts currently discussed include effects on the human immune system, genetic damage to crops, and other damage to plants and animals, with the decline triggered in marine plankton growth being particularly relevant as the latter represents an important element in many food chains. CFCs not only reduce stratospheric ozone, they also act as greenhouse gases, and contribute to global warming (more on this below).

Side by side with the international diplomatic efforts to agree on a reduction and phasing out of CFC production, it became evident that even unilateral reductions in CFCs—even from substantial levels—involve overwhelming net benefit to cost ratios, even for individual countries (see Table 1) The consumer benefits due to reduced UV radiation strongly exceed potential production and export losses. Thus, international cooperative action can be seen foremost as an indicator that the problem was acknowledged, and action by the then main CFC producers would have been almost certain to take place even without any international agreement. From the Vienna Convention in 1985, up to the Montreal Protocol in 1988 and, finally, to the London Amendments in 1990, it was ultimately agreed upon by the industrial world to phase out CFCs by 2000. Furthermore, financial support was made available for developing countries to assist them in replacing ozone-depleting substances. For developing countries the agreed freezing of CFC emissions by the year 2000, the 50% cut by 2005, and the complete phase-out by 2010, to date, seems to be generally on track. Nevertheless, the very long life of these molecules implies that the ozone layer will continue to be damaged for about another century, with even further decrease in protection from ultraviolet radiation over the next few decades.

Level of control	Discounted benefits [$ bill.]	Discounted costs [$ bill.]
80% cut	3533	22
50% cut	3488	13
20% cut	3396	12
Freeze	3314	7

Source: Lashof, D., and D. Tirpak (eds.), 1989. Policy options for stabilizing global climate. Draft Report of the U.S. Environmental Protection Agency to Congress. Washington, D.C.: Government Printing Office. ISBN 9990298300.

Table 1. Costs and benefits of CFC control estimated for the United States in 1989 by the EPA

2.3. Climate Change

Solar energy reaching our planet is to a large degree absorbed by land mass and the oceans and partially radiated back into the atmosphere as infrared radiation. This infrared radiation in turn is largely reflected back to the land mass and oceans by the so-called greenhouse gases in the atmosphere (e.g. carbon dioxide) and by water vapour. This natural greenhouse effect keeps the earth some 33 degrees Celsius warmer than it would otherwise be, a temperature giving rise to the complex interplay in current climate and to which current forms of life have adjusted. Human emissions of greenhouse gases since the late eighteenth century have increased the concentration of these greenhouse gases in the atmosphere, and thus the warming effect. For the most important greenhouse gas, carbon dioxide, the pre-industrial atmospheric concentration of 275 parts per million (ppm) has increased to a current 380 ppm. As it is concentration that is relevant (i.e. a stock measure), emissions (i.e. a flow measure) would need to decline substantially to really reduce concentration—albeit this would happen only with some time lag. For example, in order to ultimately stabilize carbon dioxide concentration at 450 ppm, emissions would need to be reduced by some 90% by 2300 relative to current levels. Most people in fact would argue for larger reductions in the industrial North in order to allow the South to catch up.

The impacts of climate change are manifold and current knowledge is becoming increasingly available even on a regional scale. The Intergovernmental Panel on Climate Change (IPCC), formed under the auspices of the UN, reports regularly on findings in this area, and is the largest body to do so. The most recent (Third) IPCC Assessment Report states that "*these changes in atmospheric composition are likely to alter temperatures, precipitation patterns, sea level, extreme events, and other aspects of climate on which the natural environment and human systems depend.*" Following the structure of this report, climate change influences the hydrological cycle and water resources; ecosystems and their goods and services; coastal zones and marine ecosystems; human settlements, energy and industrial systems; and human health. For example, on climate extremes it is concluded that *"vulnerability of human societies and natural systems to climate extremes is demonstrated by the damage, hardship, and death caused by events such as droughts, floods, heat waves, avalanches, and windstorms. While there are uncertainties attached to estimates of such changes, some extreme events are projected to increase in frequency and/or severity during the 21st*

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Biographical Sketches

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