Economic Growth, Carrying Capacity, and the Environment

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National and international economic policy has usually ignored the environment. In areas where the environment is beginning to impinge on policy, as in the General Agreement on Tariffs and Trade (GATT) and the North American Free Trade Agreement (NAFTA), it remains a tangential concern, and the presumption is often made that economic growth and economic liberalization (including the liberalization of international trade) are, in some sense, good for the environment. This notion has meant that economy-wide policy reforms designed to promote growth and liberalization have been encouraged with little regard to their environmental consequences, presumably on the assumption that these consequences would either take care of themselves or could be dealt with separately.

In this article we discuss the relation between economic growth and environmental quality, and the link between economic activity and the carrying capacity and resilience of the environment (1).

Economic Growth, Institutions, and the Environment

The general proposition that economic growth is good for the environment has been justified by the claim that there exists an empirical relation between per capita income and some measures of environmental quality. It has been observed that as income goes up there is increasing environmental degradation up to a point, after which environmental quality improves. (The relation has an "inverted-U" shape.)

One explanation of this finding is that people in poor countries cannot afford to emphasize amenities over material well-being. Consequently, in the earlier stages of economic development, increased pollution is regarded as an acceptable side effect of economic growth. However, when a country has attained a sufficiently high standard of living, people give greater attention to environmental amenities. This leads to environmental legislation, new institutions for the protection of the environment, and so forth.

The above argument does not, however, pertain to the environmental resource basis of material well-being, a matter we shall return to subsequently.

So far the inverted U-shaped curve has been shown to apply to a selected set of pollutants only (2, 3). However, because it is consistent with the notion that people spend proportionately more on environmental quality as their income rises, economists have conjectured that the curve applies to environmental quality generally (4). But it is important to be clear about the conclusions that can be drawn from these empirical findings. While they do indicate that economic growth may be associated with improvements in some environmental indicators, they imply neither that economic growth is sufficient to induce environmental improvement in general, nor that the environmental effects of growth may be ignored, nor, indeed, that the Earth's resource base is capable of supporting indefinite economic growth. In fact, if this base were to be irreversibly degraded, economic activity itself could be at risk (5).

There are other reasons for caution in interpreting these inverted U-shaped curves. First, the relation has been shown to be valid for pollutants involving local short-term costs (for example sulfur, particulates, and fecal coliforms), not for the accumulation of stocks of waste or for pollutants involving long-term and more dispersed costs (such as CO_2), which are often increasing functions of income (6).

Second, the inverted-U relations have been uncovered for emissions of pollutants, not resource stocks. The relation is less likely to hold wherever the feedback effects of resource stocks are significant, such as those involving soil and its cover, forests, and other ecosystems.

Third, the inverted-U curves, as they have been estimated, say nothing about the system-wide consequences of emission reductions. For example, reductions in one pollutant in one country may involve increases in other pollutants in the same country or transfers of pollutants to other countries (7).

And fourth, in most cases where emissions have declined with rising income, the reductions have been due to local institutional reforms, such as environmental legislation and market-based incentives to reduce environmental impacts. But such reforms often ignore international and intergenerational consequences. Where the environmental costs of economic activity are borne by the poor, by future generations, or by other countries, the incentives to correct the problem are likely to be weak. The environmental consequences of growing economic activity may, accordingly, be very mixed.

The solution to environmental degradation lies in such institutional reforms as would compel private users of environmental resources to take account of the social costs of their actions (8). The inverted-U relation is evidence that this has happened in some cases. It does not constitute evidence that it will happen in all cases or that it will happen in time to avert the important and irreversible global consequences of growth.

Carrying Capacity and Ecosystem Resilience

The environmental resource base upon which all economic activity ultimately depends includes ecological systems that produce a wide variety of services. This resource base is finite. Furthermore, imprudent use of the environmental resource base may irreversibly reduce the capacity for generating material production in the future. All of this implies that there are limits to the carrying capacity of the planet. It is, of course, possible that improvements in the management of resource systems, accompanied by resource-conserving structural changes in the economy, would enable economic and population growth to take place despite the finiteness of the environmental resource base, at least for some period of time. However, for that to be even conceivable, signals that effectively reflect increasing scarcities of the resource base need to be generated within the economic system.

Carrying capacities in nature are not fixed, static, or simple relations. They are contingent on technology, preferences, and

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the structure of production and consumption. They are also contingent on the ever-changing state of interactions between the physical and biotic environment. A single number for human carrying capacity would be meaningless because the consequences of both human innovation and biological evolution are inherently unknowable. Nevertheless, a general index of the current scale or intensity of the human economy in relation to that of the biosphere is still useful. For example, Vitousek *et al.* (*9*) calculated that the total net terrestrial primary production of the biosphere currently being appropriated for human consumption is around 40%. This does put the scale of the human presence on the planet in perspective.

A more useful index of environmental sustainability is ecosystem resilience. One way of thinking about resilience is to focus on ecosystem dynamics where there are multiple (locally) stable equilibria (*10*). Resilience in this sense is a measure of the magnitude of disturbances that can be absorbed before a system centered on one locally stable equilibrium flips to another (*11*). Economic activities are sustainable only if the life-support ecosystems on which they depend are resilient. Even though ecological resilience is difficult to measure and even though it varies from system to system and from one kind of disturbance to another, it may be possible to identify indicators and early-warning signals of environmental stress. For example, the diversity of organisms or the heterogeneity of ecological functions have been suggested as signals of ecosystem resilience. But ultimately, the resilience of systems may only be tested by intelligently perturbing them and observing the response with what has been called "adaptive management" (*12*).

The loss of ecosystem resilience is potentially important for at least three reasons. First, the discontinuous change in ecosystem functions as the system flips from one equilibrium to another could be associated with a sudden loss of biological productivity, and so to a reduced capacity to support human life. Second, it may imply an irreversible change in the set of options open both to present and future generations (examples include soil erosion, depletion of groundwater reservoirs, desertification, and loss of biodiversity). Third, discontinuous and irreversible changes from familiar to unfamiliar states increase the uncertainties associated with the environmental effects of economic activities.

If human activities are to be sustainable, we need to ensure that the ecological systems on which our economies depend are resilient. The problem involved in devising environmental policies is to ensure that resilience is maintained, even though the limits on the nature and scale of economic activities thus required are necessarily uncertain.

Economic Growth and Environmental Policy

We conclude that economic liberalization and other policies that promote gross national product growth are not substitutes for environmental policy. On the contrary, it may well be desirable that they are accompanied by stricter policy reforms. Of particular importance is the need for reforms that would improve the signals that are received by resource users. Environmental damages, including loss of ecological resilience, often occur abruptly. They are frequently not reversible. But abrupt changes can seldom be anticipated from systems of signals that are typically received by decision-makers in the world today. Moreover, the signals that do exist are often not observed, or are wrongly interpreted, or are not part of the incentive structure of societies. This is due to ignorance about the dynamic effects of changes in ecosystem variables (for example, thresholds, buffering capacity, and loss of resilience) and to the presence of institutional impediments, such as lack of well-defined property rights. The development of appropriate institutions depends, among other things, on understanding ecosystem dynamics and on relying on appropriate indicators of change. Above all, given the fundamental uncertainties about the nature of ecosystem dynamics and the dramatic consequences we would face if we were to guess wrong, it is necessary that we act in a precautionary way so as to maintain the diversity and resilience of ecosystems.

Economic growth is not a panacea for environmental quality; indeed, it is not even the main issue. What matters is the content of growth—the composition of inputs (including environmental resources) and outputs (including waste products). This content is determined by, among other things, the economic institutions within which human activities are conducted. These institutions need to be designed so that they provide the right incentives for protecting the resilience of ecological systems. Such measures will not only promote greater efficiency in the allocation of environmental resources at all income levels, but they would also assure a sustainable scale of economic activity within the ecological life-support system. Protecting the capacity of ecological systems to sustain welfare is of as much importance to poor countries as it is to those that are rich.

REFERENCES AND NOTES

1. This is a report of the Second Askö Meeting, held 31 August to 2 September 1994, in the archipelago outside Stockholm, Sweden. The meeting was organized by the Beijer International Institute of Ecological Economics, Royal Swedish Academy of Sciences, Box 50005, S10405 Stockholm, Sweden. The aim of the meeting was to establish a substantive dialogue among a small group of ecologists and economists to gauge whether an interdisciplinary consensus exists on the issues of economic growth, carrying capacity, and the environment and to determine what could be said about the joint development of economic and environmental policy.
2. Phenomena for which the relation holds most clearly include poor sanitation, impure water supplies, suspended particulates, SO_2, NO_x, and CO (*3*) [G. M. Grossman and A. B. Krueger, in *The U.S. Mexico Free Trade Agreement*, P. Garber, Ed. (MIT Press, Cambridge, MA, 1993), pp. 165–177].
3. N. Shafik and S. Bandyopadhay, "Economic growth and environmental quality: time series and cross country evidence" (background paper for the World Development Report, World Bank, Washington, DC, 1992).
4. W. Beckerman, *World Dev.* **20**, 481 (1992).
5. A. M. Jansson, M. Hammer, C. Folke, R. Costanza, Eds, *Investing in Natural Capital: the Ecological Economics Approach to Sustainability* (Island Press, Washington, DC, 1994).
6. N. Shafik and S. Bandyopadhay (*3*) find that CO_2 emissions are an increasing function of per capita income. W. Moomaw and M. Tullis [in *Industrial Ecology and Global Change*, R. Socolow, C. Andrews, F. Berkhout, V. Thomas, Eds. (Cambridge Univ. Press, Cambridge, 1994), pp. 157–172] show that while cross-sectionally CO_2 emissions per capita rise with income per capita, the experience in individual countries over time is highly variable, depending on the structure of individual economies. They conclude that there are many different development paths, some of which can de-link economic growth from CO_2 emissions, but adequate institutions are required and it is by no means an automatic consequence of growth.
7. R. Lopez, *J. Enivron. Econ. Manage.* **27**, 163 (1994); T. M. Selden and D. Song; *ibid.*, p. 147; K. Anderson and R. Blackhurst, Eds, *The Greening of World Trade Issues* (Harvester Wheatsheaf, Hemel Hempstead, Herts, UK, 1992).
8. A related issue is the measurement of economic growth at the macro level. The conventional measure, GNP, is far from adequate as a measure of true economic performance. We need a more comprehensive index that includes the flow of environmental services as well as the value of net changes in the stocks of natural capital so that the true social costs of growth can be internalized. With this improved index, many of the apparent conflicts between "growth" and the environment would disappear because environmental degradation would be subtracted from the index. [See, for example, P. Dasgupta and K.-G. Mäler, *The Environment and Emerging Development Issues*, Proceedings of the Annual Bank Conference on Development Economics, 1990 (Supplement to the World Bank Economic Review, 1991).
9. P. M. Vitousek, P. R. Ehrlich, A. H. Ehrlich, P. A. Matson, *BioScience* **36**, 368 (1986).
10. Another way is to focus on ecosystem dynamics in the neighborhood of an equilibrium. The object here is to measure the resistance of a system to disturbances and to determine the speed with which it returns to equilibrium. [See S. L. Pimm, *Nature* **307**, 321 (1984).]
11. C. S. Holling, *Annu. Rev. Ecol. System.* **4**, 123 (1973).
12. Adaptive management views regional development policy and management as "experiments," where interventions at several scales are made to achieve understanding, to produce a social or economic product, and to identify options. [See, for example, C. S. Holling, Ed., *Adaptive Environmental Assessment and Management* (Wiley, London, 1978); C. J. Walters, *Adaptive Management of Renewable Resources* (Macmillan, New York, 1986); K. Lee, *Compass and the Gyroscope* (Island Press, Washington, DC, 1993).

13. We thank the two anonymous referees for helpful comments.