Towards an Environmental Macroeconomics

Herman E. Daly

I. INTRODUCTION

Environmental economics, as it is taught in universities and practiced in government agencies and development banks, is overwhelmingly microeconomics. The theoretical focus is on prices, and the big issue is how to internalize external environmental costs so as to arrive at prices that reflect full social marginal oportunity costs. Once prices are right the environmental problem is "solved"—there is no macroeconomic dimension. There are, of course, very good reasons for environmental economics to be closely tied to microeconomics, and it is not my intention to argue against that connection. Rather I want to ask if there is not a neglected connection between the environment and macroeconomics.

A search through the indexes of three leading textbooks in macroeconomics (Barro 1987; Dornbusch and Fischer 1987; Hall and Taylor 1988) reveals no entries under any of the following subjects: *environment, natural resources, pollution, depletion*. Is it really the case, as prominent textbook writers seem to think, that macroeconomics has nothing to do with the environment? What historically has impeded the development of an environmental macroeconomics? If there is no such thing as environmental macroeconomics, should there be? What might it look like?

The reason that environmental macroeconomics is an empty box[1] lies in what Thomas Kuhn calls a "paradigm," and what Joseph Schumpeter more descriptively called a "preanalytic vision." As Schumpeter emphasized, analysis has to start somewhere—there has to be something to analyze. That something is given by a preanalytic cognitive act that Schumpeter called "vision." One might say that vision is what the "right brain" supplies to the "left brain" for analysis. Whatever is omitted from the preanalytic vision cannot be recaptured by subsequent analysis. Schumpeter is worth quoting at length on this point:

> In practice we all start our own research from the work of our predecessors, that is, we hardly ever start from scratch. But suppose we did start from scratch, what are the steps we should have to take? Obviously, in order to be able to posit to ourselves any problems at all, we should first have to visualize a distinct set of coherent phenomena as a worthwhile object of our analytic effort. In other words, analytic effort is of necessity preceded by a preanalytic cognitive act that supplies the raw material for the analytic effort. In this book, this preanalytic cognitive act will be called Vision. It is interesting to note that vision of this kind not only must precede historically the emergence of analytic effort in any field, but also may re-enter the history of every established science each time somebody teaches us to *see* things in a light of which the source is not to be found in the facts, methods, and results of the pre-existing state of the science. (Schumpeter 1954, 41)

The vision of modern economics in general, and especially of macroeconomics, is the familiar circular flow diagram. The macroeconomy is seen as an isolated system (i.e., no exchanges of matter or energy

Environment Department, World Bank, Washington, DC.

The views here presented are those of the author and should in no way be attributed to the World Bank.

[1]The box is not entirely empty. Recent work on correcting national income accounts, along with applications of input-output models to environmental problems, should be noted.

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with its environment) in which exchange value circulates between firms and households in a closed loop. What is "flowing in a circle" is variously referred to as production or consumption, but these have physical dimensions, and the circular flow does not refer to materials recycling, which in any case could not be a completely closed loop, and of course would require energy which cannot be recycled at all. What is truly flowing in a circle can only be abstract exchange value—exchange value abstracted from the physical dimensions of the goods and factors that are exchanged. Since an isolated system of abstract exchange value flowing in a circle has no dependence on an environment, there can be no problem of natural resource depletion, nor environmental pollution, nor any dependence of the macroeconomy on natural services, or indeed on anything at all outside itself (Georgescu-Roegen 1971; Daly 1985).

Since analysis cannot supply what the preanalytic vision omits, it is only to be expected that macroeconomics texts would be silent on environment, natural resources, depletion, and pollution. It is as if the preanalytic vision that biologists had of animals recognized only the circulatory system and abstracted completely from the digestive tract. A biology textbook's index would then contain no entry under "assimilation" or "liver." The dependence of the animal on its environment would not be evident. It would appear as a perpetual motion machine.

Things are no better when we turn to the advanced chapters at the end of most macroeconomics texts, where the topic is growth theory. True to the preanalytic vision the aggregate production is written as $Y = f(K,L)$, i.e. output is a function of capital and labor stocks. Resource flows (R) do not even enter! Neither is any waste output flow noted. And if occasionally R is stuck in the function along with K and L it makes little difference since the production function is almost always a multiplicative form, such as Cobb-Douglas, in which R can approach zero with Y constant if only we increase K or L in a compensatory fashion. Resources are seen as "necessary" for production, but the amount required can be as little as one likes!

What is needed is not ever more refined analysis of a faulty vision, but a new vision. This does not mean that everything built on the old vision will necessarily have to be scrapped—but fundamental changes are likely when the preanalytic vision is altered. The necessary change in vision is to picture the macroeconomy as an open subsystem of the finite natural ecosystem (environment) and not as an isolated circular flow of abstract exchange value, unconstrained by mass balance, entropy, and finitude. The circular flow of exchange value is a useful abstraction for some purposes. It highlights issues of aggregate demand, unemployment, and inflation that were of interest to Keynes in his analysis of the Great Depression. But it casts an impenetrable shadow on all physical relationships between the macroeconomy and the environment. For Keynes this shadow was not very important, but for us it is. Once the macroeconomy is viewed as an open subsystem, rather than an isolated system, then the issue of its relation to its parent system (the environment) cannot be avoided. And the most obvious question is how big should the subsystem be relative to the overall system?

II. THE MACRO-ECONOMICS OF OPTIMAL SCALE

Just as the micro unit of the economy (firm or household) operates as part of a larger system (the aggregate or macroeconomy), so the aggregate economy is likewise a part of a larger system, the natural ecosystem. The macroeconomy is an open subsystem of the ecosystem and is totally dependent upon it, both as a source for inputs of low-entropy matter-energy and as a sink for outputs of high-entropy matter-energy. *The physical exchanges crossing the boundary between system and subsystem constitute the subject matter of environmental macroeconomics*. These flows are considered in terms of their scale or total volume relative to the ecosystem, not in terms of the price of one component of the total flow relative to another. Just as standard macroeconomics focuses on the volume of transactions rather than the relative prices of different items traded, so environmental macroeconomics focuses on the volume of exchanges that cross the boundary between system and subsystem, rather than the pricing and allocation of each part of the total flow within the human economy or even within the nonhuman part of the ecosystem.

The term "scale" is shorthand for "the physical scale or size of the human presence in the ecosystem, as measured by population times per capita resource use." Optimal *allocation* of a given scale of resource flow within the economy is one thing (a microeconomic problem). Optimal *scale* of the whole economy relative to the ecosystem is an entirely different problem (a macro-macro problem). The micro allocation problem is analogous to allocating optimally a given amount of weight in a boat. But once the best relative location of weight has been determined, there is still the question of the absolute amount of weight the boat should carry, even when optimally allocated. This absolute optimal scale of load is recognized in the maritime institution of the Plimsoll line. When the watermark hits the Plimsoll line the boat is full, it has reached its safe *carrying capacity*. Of course if the weight is badly allocated the waterline will touch the Plimsoll mark sooner. But eventually as the absolute load is increased the watermark will reach the Plimsoll line even for a boat whose load is optimally allocated. Optimally loaded boats will still sink under too much weight—even though they may sink optimally! It should be clear that optimal allocation and optimal scale are quite distinct problems. The major task of environmental macroeconomics is to design an economic institution analogous to the Plimsoll mark—to keep the weight, the absolute scale, of the economy from sinking our biospheric ark.

The market of course functions only within the economic subsystem, where it does only one thing: it solves the allocation problem by providing the necessary information and incentive. It does that one thing very well. What it does not do is to solve the problems of optimal scale or of optimal distribution. The market's inability to solve the problem of just distribution is widely recognized, but its similar inability to solve the problem of optimal or even sustainable scale is not as widely appreciated.[2]

An example of the confusion that can result from the nonrecognition of the independence of the scale issue from the question of allocation is provided by the following dilemma (Pearce et al. 1989, 135). Which puts more pressure on the environment, a high or a low discount rate? The usual answer is that a high discount rate is worse for the environment because it speeds the rate of depletion of nonrenewable resources and shortens the turnover and fallow periods in the exploitation of renewables. It shifts the allocation of capital and labor toward projects that exploit natural resources more intensively. But it restricts the total number of projects undertaken. A low discount rate will permit more projects to be undertaken even while encouraging less intensive resource use for each project. The allocation effect of a high discount rate is to increase throughput, but the scale effect is to lower throughput. Which effect is stronger is hard to say, although one suspects that over the long run the scale effect will dominate. The resolution to the dilemma is to recognize that two independent policy goals require two independent policy instruments—we cannot

[2]This can be illustrated in terms of the familiar microeconomic tool of the Edgeworth box. Moving to the contract curve is an improvement in efficiency of *allocation*. Moving along the contract curve is a change in *distribution* which may be deemed just or unjust on ethical grounds. The *scale* is represented by the dimensions of the box, which are taken as given. Consequently the issue of optimal scale of the box itself escapes the limits of the analytical tool. A microeconomic tool cannot be expected to answer a macroeconomic question. But so far macroeconomics has not answered the question either—indeed, has not even asked it. The tacit answer to the implicit question seems to be that a bigger Edgeworth box is always better than a smaller one!

serve both optimal scale and optimal allocation with the single policy instrument of the discount rate (Tinbergen 1952). The discount rate should be allowed to solve the allocation problem, within the confines of a solution to the scale problem provided by a presently nonexistent policy instrument that we may for now call an "economic Plimsoll line" that limits the scale of the throughput.

Economists have recognized the independence of the goals of efficient allocation and just distribution and are in general agreement that it is better to let prices serve efficiency, and to serve equity with income redistribution policies. Proper scale is a third independent policy goal and requires a third policy instrument. This latter point has not yet been accepted by economists, but its logic is parallel to the logic underlying the separation of allocation and distribution.

Microeconomics has not discovered in the price system any built-in tendency to grow only up to the scale of aggregate resource use that is optimal (or even merely sustainable) in its demands on the biosphere. *Optimal scale, like distributive justice, full employment, or price level stability, is a macroeconomic goal.* And it is a goal that is likely to conflict with the other macroeconomic goals. The traditional solution to unemployment is growth in production, which means a larger scale. Frequently the solution to inflation is also thought to be growth in real output and a larger scale. And most of all the issue of distributive justice is "finessed" by the claim that aggregate growth will do more for the poor than redistributive measures. Macroeconomic goals tend to conflict, and certainly optimal scale conflicts with any goal that requires further growth, once the optimum has been reached.

III. HOW BIG IS THE ECONOMY?

Probably the best index of the scale of the human economy as a part of the biosphere is the percentage of human appropriation of the total world product of photosynthesis. Net primary production (NPP) is the amount of solar energy captured in photosynthesis by primary producers, less the energy used in their own growth and reproduction. NPP is thus the basic food resource for everything on earth not capable of photosynthesis. Vitousek et al. (1986) calculate that 25 percent of potential global (terrestrial and aquatic) NPP is now appropriated by human beings. If only terrestrial NPP is considered, the fraction rises to 40 percent.[3] Taking the 25 percent figure for the entire world it is apparent that two more doublings of the human scale will give 100 percent. Since this would mean zero energy left for all nonhuman and nondomesticated species, and since humans cannot survive without the services of ecosystems, which are made up of other species, it is clear that two more doublings of the human scale is an ecological impossibility, although arithmetically possible. Furthermore, the terrestrial figure of 40 percent is probably more relevant since we are unlikely to increase our take from the oceans very much. Total appropriation of the terrestrial NPP is only a bit over one doubling time in the future. Perhaps it is theoretically possible to increase the earth's total photosynthetic capacity somewhat, but the actual trend of past economic growth is decidedly in the opposite direction. If the above figures are approximately correct, then expansion of the world economy by a factor of four (two doublings) is not possible. Yet the Brundtland Commission calls for economic expansion by a factor of five to ten. And the greenhouse effect, ozone layer depletion, and acid rain all constitute evidence that we have *already* gone beyond a prudent Plimsoll line for the scale of the macroeconomy.

IV. HOW BIG SHOULD THE ECONOMY BE?

Optimal scale of a single activity is not a strange concept to economists. Indeed mi-

[3]The definition of human appropriation underlying the figures quoted includes direct use by human beings (food, fuel, fiber, timber), plus the reduction from the potential due to degradation of ecosystems caused by humans. The latter reflects deforestation, desertification, paving over, and human conversion to less productive systems (such as agriculture).

croeconomics is about little else. An activity is identified, be it producing shoes or consuming ice cream. A cost function and a benefit function for the activity in question are defined. Good reasons are given for believing that marginal costs increase and marginal benefits decline as the scale of the activity grows. The message of microeconomics is to expand the scale of the activity in question up to the point where marginal costs equal marginal benefits, a condition which defines the optimal scale. All of microeconomics is an extended variation of this theme.

When we move to macroeconomics, however, we never again hear about optimal scale. There is apparently no optimal scale for the macro economy. There are no cost and benefit functions defined for growth in scale of the economy as a whole. It just doesn't matter how many people there are, or how much they each consume, as long as the proportions and relative prices are right! But if every micro activity has an optimal scale then why does not the aggregate of all micro activities have an optimal scale? If I am told in reply that the reason is that the constraint on any one activity is the fixity of all the others and that when all economic activities increase proportionally the restraints cancel out, then I will invite the economist to increase the scale of the carbon cycle and the hydrologic cycle in proportion to the growth of industry and agriculture. I will admit that if the ecosystem can grow indefinitely then so can the aggregate economy. But, until the surface of the earth begins to grow at a rate equal to the rate of interest, one should not take this answer too seriously. The indifference to scale of the macroeconomy is due to the preanalytic vision of the economy as an isolated system—a view the inappropriateness of which has already been discussed.

Two concepts of optimal scale can be distinguished, both formalisms at this stage, but important for clarity.

1. *The anthropocentric optimum.* The rule is to expand scale, i.e., grow, to the point at which the marginal benefit to human beings of additional manmade physical capital is just equal to the marginal cost to human beings of sacrificed natural capital. All nonhuman species and their habitats are valued only instrumentally according to their capacity to satisfy human wants. Their intrinsic value (capacity to enjoy their own lives) is assumed to be zero.

2. *The biocentric optimum.* Other species and their habitats are preserved beyond the point of maximum instrumental convenience, out of a recognition that other species have intrinsic value independent of their instrumental value to human beings. The biocentric optimal scale of the human niche would therefore be smaller than the anthropocentric optimum.

The notion of sustainable development does not specify which concept of optimal scale to use. Sustainability is a necessary, but not sufficient condition for optimal scale and the further elaboration of an environmental macroeconomics.

References

Barro, Robert J. 1987. *Macroeconomics*. 2d ed. New York: John Wiley and Sons.

Daly, H. E. 1985. "The Circular Flow of Exchange Value and the Linear Throughput of Matter-Energy: A Case of Misplaced Concreteness." *Review of Social Economy* 43(3):279–97.

Dornbusch, Rudiger, and Stanley Fischer. 1987. *Macroeconomics*. 4th ed. New York: McGraw-Hill.

Georgescu-Roegen, Nicholas. 1971. *The Entropy Law and the Economic Process*. Cambridge: Harvard University Press.

Hall, Robert E., and John B. Taylor. 1988. *Macroeconomics*. 2d ed. New York: W. W. Norton.

Pearce, David, et al. 1989. *Blueprint for a Green Economy*. London: Earthscan, Ltd., p. 135.

Schumpeter, Joseph. 1954. *History of Economic Analysis:* New York: Oxford University Press, p. 41.

Tinbergen, Jan. 1952. *On the Theory of Economic Policy*. Amsterdam: North-Holland Press.

Vitousek, Peter M., Paul R. Ehrlich, Anne H. Ehrlich, and Pamela A. Matson. 1986. "Human Appropriation of the Products of Photosynthesis." *BioScience* 34(May):368–73.