The Socio-Economics of Science and Sustainable Development*

by

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1. Technological and Pricing Biases

The pace and direction of science and technology are heavily influenced by the character of public funding in R&D and by financial incentives implicit in the system of prices for goods and services.The Industrial Revolution and its aftermath have been unusually predatory against Nature because societies have regarded Nature to be a free good. Moreover, economists as a profession have gone along that point of view. For example, estimates of socio-economic indicators currently in use for judging the progress of nations (such as Gross National Product (GNP) and the United Nations' Human Development Index (HDI)) are biased because they don't incorporate changes in the natural environment. The price of natural resources on site is frequently zero, even though they are scarce goods. Commercial rates of return on investments relying on such resources are higher than their social rates of return. Resource-intensive projects appear better looking than they actually are. Over time, an entire sequence of resource-intensive technologies is installed. Moreover, people learn by doing and learn by using, not only installed technology, but also research and development. The development and use of technology reflect processes that are path-dependent. The conclusion is depressing: it may require a big push to move us away from the current profligacy in our use of natural resources.

These arguments imply that modern technologies are not always appropriate technologies, but instead are often unfriendly towards those who depend directly on their local resource-base. This is likely to be especially true in poor countries, where environmental legislations are usually neither strong nor effectively enforced. The arguments help explain why the poorest in poor countries, when permitted, have been known to protest against the installation of modern technology. The transfer of technology from advanced countries can be inappropriate even when that same body of technology is appropriate in the country of origin. This is because the social scarcity of natural resources, especially local resources, varies from country to country. A project-design that is socially profitable in one country may be socially unprofitable in another. This may be why environmental groups in poor countries not infrequently appear to be backward-looking, trying to unearth traditional technologies for soil conversation, water management, forest protection, medical treatment, and so forth. To do so isn't to assume an anti-science stance; it could be to infer that wrong prices can tilt the technological agenda in a wrong direction.

The bias towards resource-intensive technologies extends to the prior stage of research and development. When natural resources are underpriced, the incentives to develop technologies that would economize on their use are lower than what they should be. Often enough, once it is perceived that past choices have been damaging to the environment, cures are sought, whereas prevention would have been the better choice.

But customary habits of economic thinking are hard to overcome. Accounting for the natural environment, if it comes into the calculus at all, is an afterthought to the real business of "doing economics". For example, *The Economist* (25 September 1999) carried a 38-page Survey of the World Economy in which the natural-resource base made no appearance in the authors' assessment of what lies ahead. I doubt though that many readers will have noticed this. Even today the natural environment has not entered the common lexicon of economic reasoning. Dasgupta (2001) and Arrow et al. (2004) have shown that assessments of economic performance can be very misleading when the natural-resource base is neglected in the calculus.

In order to show how economics can be made to join the environmental sciences in a seamless way, I want to discuss two issues that are much in the news today. The first is the subject of an acrimonious debate between those who favour free trade and those who are opposed to it on grounds that it often hurts the poorest in Desta's world. The second is the belief that because the economic effects of carbon dioxide emissions into the atmosphere are likely to be felt by a generation or two further down from us, we needn't do anything about climate change now.

2. Trade Expansion and the Environment

There should be little doubt today that, other things being equal, freeing trade enables economies to grow faster. A large body of empirical work testifies to that. There is some evidence too that the poor, *as a group*, also enjoy the fruits of faster growth. However, as the environmental consequences of economic growth are rarely assessed, the case for freeing trade remains unclear. If those consequences hurt many of the poorest in society, there is room for discussion about the merits of freeing trade without at the same time taking precautionary measures. Here is an example of how trade expansion can hurt.

An easy way for governments in poor countries that are richly covered in forests to earn revenue

is to issue timber concessions to private logging firms. Imagine that logging concessions are awarded for the upland forest of a watershed. Deforestation contributes to an increase in siltation and the risk of floods downstream. If the law recognizes the rights of those who are harmed, the logging firm would have to compensate downstream farmers and coastal fishermen. But there is a gulf between the law and the enforcement of the law. When the cause of damage is miles away, when the timber concession has been awarded by the state, and when the victims are a scattered group of poor farmers and coastal fishermen, the issue of a negotiated outcome usually doesn't arise. It can even be that those who are harmed do not know the underlying cause of their deteriorating circumstances. If the logging firm isn't required to compensate those suffering damage, the private cost of logging is less than the true cost of logging, the latter being the sum of the costs borne by the logging firm and all who are adversely affected. From the country's point of view, timber exports are underpriced, which is another way of saying that there is excessive deforestation upstream. It is also a way of saying that there is an implicit subsidy on the export, paid for by people who are evicted from the forest and by people downstream. The subsidy is hidden from public scrutiny; but it amounts to a transfer of wealth from the exporting country to those that import the timber. Some of the poorest people in a poor country would be subsidising the incomes of the average importer in a rich country.

Unfortunately, I can give you no idea of the magnitude of those subsidies, because they haven't been estimated. International organizations have the resources to undertake such studies; but, to the best of my knowledge, they haven't done so. The example shouldn't be used to argue against free trade, but it can be used to caution anyone who advocates free trade while ignoring its environmental impacts.

3. Discounting Climate Change

My second example concerns the emission of greenhouse gases and the global climate change it is inducing, the subject of continuing study by the Intergovernmental Panel on Climate Change (IPCC).

The global concentration of carbon dioxide in the atmosphere stood at approximately 260 parts per million (ppm) for 11,000 years until the early 18th century, but is now 380 ppm. (We will ignore the concentration of methane, which is another greenhouse gas.) The most reliable evidence on climate change over geological time comes from ice cores in Antarctica, which reveals that until the early 18th century,

the maximum concentration of carbon dioxide during the previous 600,000 years was 300 ppm. That long interval of time witnessed four glacial-interglacial cycles, each of about 100,000 years' duration. Those cycles are driven by rythmic changes in the amount of solar radiation reaching Earth, the effects of which are amplified by the feedbacks and forces they in turn generate within Earth's environment.

We are living in an interglacial period, which means that Earth is experiencing a warm phase. If current trends in carbon emissions continue, its concentration is expected to reach 500 ppm (which is nearly twice the pre-industrial level) by the middle of this century, and could reach as high a figure as 750 ppm (which is nearly thrice the pre-industrial level) by year 2100. A doubling of present day carbon concentration is expected to give rise to an increase in the mean global atmospheric temperature by 3 to 7 degrees Celsius. With a trebling of concentration, it could rise by 6 to 11 degrees. The temperature that would result even if the rise were limited to 3 degrees is beyond anything that has been experienced on Earth in the past 420,000 years. The *speed* of that change is of particular significance, because it would mean that a good portion of our capital assets will become less than useful long before their planned obsolescence. Some of our infrastructure will even disappear under the rising seas. In order to restructure our assets, Humanity will need to make additional investments, diverting resources from consumption. If we add the impact of rapid climate change on ecosystems (changes in the disease environment to which human populations are not immune; degradation in the composition, geographic distribution, and productivity of ecosystems), the potential costs begin to look huge. Nevertheless, when in 2004 eight eminent economists were invited to Copenhagen to offer advice on how the world community could most usefully spend $50 billion over a 5-year period, they placed climate change at the bottom of their list of ten alternatives.

Why did the economists do that? They did it because their reasoning was based on discounting future costs and benefits at a positive rate. Reducing global carbon emissions or investing in technologies for carbon sequestrtation would involve huge costs now, but the benefits from averting economic disruptions would be enjoyed only 50 to 100 years from now. Long-term interest rates on government bonds in the US have been 3-5% a year. When economists there evaluate *public* projects, they typically use such a figure to discount future benefits and costs, regarding it as the "opportunity cost of capital", the

term being applied to the rate of interest that could be earned by investing in government bonds rather than in the project whose benefits and costs are being evaluated. At discount rates of 3-5%, though, consumption benefits in the distant future look minute today. If you discount at 4% a year, a dollar's worth of additional consumption benefits 100 years from now would be worth less than 3 cents today; which is another way of saying that as a price for giving up $1 worth of consumption today, you would demand that more than $30 worth of consumption benefits be made available 100 years from now. A number of economic models of climate change have shown that if you use an annual discount rate of, say, 4%, the costs (which are negative benefits) are greater than the sum of the discounted benefits from curbing net carbon emissions. Doing something about climate change now, the calculations imply, would be to throw money away in a comparatively bad project.

Should the global community discount future consumption benefits at a positive rate? There are two reasons why it may be reasonable for the global community to discount future benefits at a positive rate. First, a future benefit would be of less value than that same benefit today if the global community is impatient to enjoy the benefit now. Impatience is a reason for discounting future costs and benefits at a positive rate. Second, considerations of justice and equality demand that consumption per capita should be smoothed across the generations. So, if future generations are likely to be richer than us, there is a case for valuing an extra dollar's worth of their consumption less than an extra dollar's worth of our consumption, other things being equal. Rising consumption per capita provides a second justification for discounting future costs and benefits at a positive rate.

Philosophers have argued that societal impatience is ethically indefensible, because it favours policies that discriminate against future generations merely on the grounds that they are not present today. Once we accept their argument, we are left with only the second reason for discounting future costs and benefits. But if rising per capita consumption provides the global community with a reason for discounting future consumption benefits at a positive rate, declining per capita consumption would provide it with a reason for discounting future consumption benefits at a *negative* rate.

Economists use positive discount rates in their models of climate change because the models *assume* that global consumption per head will continue to grow over the next 150 years and more even if

net emissions of greenhouse gases follow current trends; which is to assume that climate change poses no serious threat to the future. But an increase in the mean global temperature by 3-5 degrees Celsius would take the biosphere into a climatic zone that has not been visited in *millions* of years on Earth. The possible consequences of such changes to our productive base are so huge, that it isn't to be an alarmist to question forecasts of continual economic growth even after Earth enters that zone. Suppose you fear that if nothing substantial is done today to discover ways to sequester carbon and to find alternatives to fossil fuels as sources of energy, there is a sizeable chance that global consumption per head, suitably weighted across regions and income groups, will decline - owing, say, to a big increase in the frequency of extreme weather events, more severe droughts in the tropics, the emergence of new pathogens, and degradation of vital ecosystems. You should then use a negative rate to discount future consumption benefits. Notice though that applying a negative rate *amplifies* benefits in the distant future when viewed from the present, it doesn't attenuate them.

Let us perform a quick calculation to get a feel for orders of magnitude. Empirical evidence from societal and personal choices suggests that the rate a society ought to use to discount future consumption benefits is about 3 times the percentage rate of change of consumption per capita. Imagine that carbon emissions follow their current trends (which is often called "business as usual"). Consider a scenario in which global consumption per capita increases at an annual rate of 0.5% for the next 50 years and declines at 1% a year for the following 100 years. Under that scenario the global community ought to discount future consumption benefits at 1.5% a year for the next 50 years (3 times 0.5) and at *minus* 3% for the subsequent 100 years (3 times minus 1). A simple calculation now shows that a dollar's worth of additional consumption 150 years from now is worth $9 of additional consumption today. To put it another way, the global community should be willing to forego $9 worth of additional consumption today for an extra dollar's worth of consumption benefits 150 years in the future. The calculation reverses the message that has been conveyed by economic models of climate change.

There should be little doubt that private investors would be using a positive rate to discount their personal earnings even under the above scenario. They would be doing so because the interest rate offered by commercial banks on deposits would most likely remain positive. But there is no contradiction here.

Under "business as usual", the atmosphere is an open access resource. So long as people are free to emit carbon dioxide, there will be a wedge between private rates of return on investment and the rates the world community ought to use to discount collective costs and benefits. The former could be positive even while the latter is negative. That wedge is a reason for controlling carbon emissions into the atmosphere and bringing the two rates closer to each other; it isn't a reason for claiming that the problem of global climate change should be shelved for the future.

4. Including Nature in Economics

The pace and direction of science and technology are heavily influenced by the character of public funding in R&D and by financial incentives implicit in the system of prices for goods and services.The Industrial Revolution and its aftermath have been unusually predatory against Nature because societies have regarded Nature to be a free good. Moreover, economists as a profession have gone along that point of view. In this paper I have argued not only that it is high time that Nature is placed fairly and squarely in economic calculations, but also that it can be done.

References

Arrow, K.J., P. Dasgupta, L. Goulder, G. Daily, P.R. Ehrlich, G.M. Heal, S. Levin, K.-G. Maler, S. Schneider, D.A. Starrett, and B. Walker (2004), "Are We Consuming Too Much?", *Journal of Economic Perspectives*, 18(1), 147-172.

Dasgupta, P. (2001), *Human Well-Being and the Natural Environment* (Oxford: Oxford University Press).