

**Science as an Institution:
setting priorities in a new socio-economic context***

by

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Contents

1. Science and Scientists
 2. Disclosure vs. Secrecy
 3. Institutional Failure in Science and Economics
 4. Institutional Responses to Policy Change
 - 4a. Management of Common-Property Resources
 - 4b. Structural Adjustment
 - 4c. Free Trade and WTO
 5. Technological Development and the Environment
 6. Social Norms and the Research Environment
- References

1. Science and Scientists

A Martian attending this conference would be puzzled. It would wonder why the conference isn't a celebration of the many remarkable scientific achievements that have been realized over the past century, but is instead a lament on the weaknesses of science and scientists and an occasion for expressing collective anxieties of what lies ahead.

Speakers have drawn attention to the social responsibility of scientists. They have deplored what they see as a growing commercialization of science. They have expressed disquiet that scientists today are tempted to ignore the stricture that even new knowledge should be regarded as a public, rather than a private, good, and they have exhorted scientists not to take their discoveries to the market place.¹

These concerns aren't restricted to those who have spoken here. Earlier this week an International Forum of Young Scientists was held at the Hungarian Academy of Science, at which Professor Leon Lederman, Professor Michael Sela, and I chaired the panels on the physical, biological, and social sciences, respectively. The Statement prepared at the Forum by the Young Scientists has been made public at this conference. It expresses concerns similar to the ones being voiced here. To put it bluntly, it is not merely you who are suspicious of your selves, young scientists too are suspicious of you! At the Forum they expressed fear that scientists are not only disinterested in ameliorating the processes which have led to the vast degradation of the ecological landscape and to the persistence of poverty among large segments of populations in South Asia, sub-Saharan Africa and Latin America, but also that the scientific agenda may itself have contributed to fueling the processes.

Such accusations may be untrue, but the fears would seem to be real. Scientists, in the eyes of the young at the Forum, are increasingly the problem, not the solution.

As an economist, I am of course pleurably aware that for once the ills of the world aren't being laid at my doorstep, but are instead being placed at yours. But there is here something to worry about. The young are a mirror for us. It may be that they are more perceptive than us, even if they are no more perceptive than we were when we were ourselves young. So it would pay to explore the source of your own disquiet and that of the Young. This is what I intend to do here.

2. Disclosure vs. Secrecy

The tension research workers experience, between an urge to disclose their findings to the world at large, for free use, and the temptation to restrict their spread so as to earn commercial rents from them, is not new, it is age-old. It may be presumed that the individual researcher in part resolves the tension by comparing the relative benefits and costs to him or her of belonging to an institution where the norm of

¹ I am using the term "public good" to denote anything that is collectively and simultaneously useable by as many as those who wish to use it (e.g., a mathematical theorem, whose use by someone does not reduce the "amount" available for use by others). Use of a "private good", in contrast, is rivalrous (e.g., consumption goods like food). Private property rights to knowledge convert something that is in principle collectively useable into a private good: people wishing to make use of it have to seek permission from the holder of the right.

behaviour is public disclosure (with its attendant structure of rewards), and of belonging to a more impersonal commercial world of patents and secrecy. But, typically, the researcher has to choose before making the discovery. For some, the choice is a lifetime commitment to one way of life rather than another. For others, there comes a time when a switch is made, from the world of "disclosure and priority" to the world of "secrecy and patents" (of course, the reverse migration is also known to occur). Then there are many who reside in both worlds simultaneously. There is evidence that the latter population has grown significantly in recent years. If Industry has maintained Campuses for some time, Industry has entered the Campus in a big way in recent years. The problem is that the relationship between the two is not entirely symbiotic.

Today, we take it for granted that the Institution of Science has in place incentives which encourage researchers to disclose their findings for public use. But the emergence of those social contrivances which embody those incentives was not inevitable, nor did they emerge easily: It required the collective efforts of scientists and their patrons to establish them. The role of Academies in subjecting scientific claims to independent scrutiny, in adjudicating between rival claims for priority and, more generally, in overseeing the quality of those who enter Science, has been substantial. The social contrivances I am referring to, namely, peer-group esteem, medals, scrolls and the like, are remarkable precisely because they don't involve much resources. In consequence, science has so far come cheap. To enable the contrivances to be effective has required that a considerable part of a scientist's education involves developing a taste for non-monetary rewards. Such taste has to compete against the financial rewards which may be enjoyed from selling research findings in the market place. If the financial rewards increase, and they have increased greatly in recent years, the taste I speak of becomes increasingly a luxury to the research worker, one which he or she feels unable to afford. In short, the Institution of Science embodies a set of cultural values in need of constant protection from the threat posed by the Institution of Technology.

The institutional culture I speak of is relatively new. It has been suggested that, in Europe at least, norms of behaviour requiring disclosure of scientific findings for public use and the concomitant reliance on priority as an incentive for disclosure were established only in the late Renaissance. It wasn't a coincidence that the first scientific Academies were established in several places in the seventeenth century.²

Secrecy (and the allied social contrivance of patents and profits) is older than disclosure (with the allied social contrivance of priority and peer-esteem). The former could be said to be practised in the Institution of Technology (or Technology, for short), the latter in the Institution of Science (or Science for short). Putting it crudely, thus somewhat inaccurately, behaviour is market driven in Technology, while in Science it is norm guided. Of course, both institutions produce knowledge. But in the former it

² See David (1998).

is regarded as a private good, while in the latter it is seen as a public good. The structure of incentives is different in the two places in ways which encourage researchers to regard their produce in accordance with the mores of the institution to which they belong.³ It should then be no surprise that the character of what is produced also differs. The traditional distinction between Science and Technology, which sees the former as being concerned with basic research and the latter with applied research, views the two institutions through differences in their products. The viewpoint I am adopting here, of regarding Technology and Science as social institutions, seems to me to be deeper, because it helps explain why their outputs would be expected to differ.

I don't imagine that Science and Technology were ever as separate as I am making them out to be. My reason for making a sharp distinction between them, nonetheless, is that it has become harder and harder to distinguish the two in recent decades. The gradual merging of the two institutions has had costs, as the underlying norms in Science have come under stress from market pressures applied by Technology. As an institution, Science has strong views on plagiarism, publishing with unseemly haste, or announcing findings to the Press without having subjected them to peer review. Such behaviour are deemed "anti-social", not only because they can mislead fellow scientists (who rely upon one another's work), but increasingly, the public too. Science has had in place self-regulatory mechanisms for discouraging such practice. But if the mechanisms worked well in the past, from all accounts they are not working so well now.

3. Institutional Failure in Science and Economics

Assuming that my framing of the problem at the root of your disquiet is approximately correct, where does it lead us? I believe it leads us away from the thinking that exhortation is of help. As a social scientist, I have found it useful to work with the hypothesis that the ills we see round us are a reflection of institutional failure. If researchers are increasingly joining Technology and, thereby, changing the complexion of the overall research agenda, don't blame the individual researcher, qua researcher; blame instead Science for failing to enforce the norms of Science and the voting public for weakening the incentives for someone to remain in Science. You can do worse than blame the Academies and Government for this state of affairs.

We face similar problems in the social sciences, most especially perhaps, in economics. It may be useful to sketch their character. I know them better than the problems you face in Science. You can then judge if they ring familiar.

Being economical with one's understanding of social phenomena is a constant temptation for social scientists. Not only are the investigator's ethical and political dispositions at play, the desire for

³ See Dasgupta and David (1987, 1994) and Stephan (1996). Patents are a device by which knowledge can be privatised even while publicly available (e.g., the patenting of genes). But as patents were historically not granted to the discovery of "facts of nature", secrecy had to be practised in order to prevent rivals from building round patents.

publicity is also considerable because the personal gains from publicity are considerable. In the social sciences it is easy to yield to such temptation also because evidence concerning how the social world works is often at best translucent. So you can engage in interpretive battles, not only with others, but with yourself before all else. Who wins depends often on who possesses greater rhetorical skills, frequently too on what the Press or politicians want to hear. In statistical decision theory the value of a piece of information is the greater the more it alters the prior probabilities we attach to events. In contrast, in politics and economic journalism reinforcement of prior beliefs is all too frequently awarded a special place of honour. Since economic journalists wield far greater power over the practice of academic economics than do science journalists over the practice of science (at least in the UK and the USA), the temptations we economists face to ignore uncomfortable possibilities is greater than the temptations faced by scientists. For example, the qualifications which should attend pronouncements on economic policy are frequently absent, even when the pronouncements are made by academic economists. We are able to yield to such temptation because we still don't have the kind of authority structure that was created painstakingly in Science, through such institutions as its Academies. Economists, and social scientists more generally, are not subject to the kind of discipline that comes with strong and consistent institutional self-regulation.

In the next section I illustrate the sort of pitfalls we economists face by means of examples. You may find parallels in science.

4. Institutional Responses to Policy Change

Economic pronouncements frequently amount to recommendations for changes in policy. Policy changes may involve alterations to the prevailing system of property rights, changes in the structure of taxes, investment in projects, and so forth. This means that a policy change can be thought of as a perturbation to an economic forecast: the economic forecast in the absence of the policy change would be different from the forecast that would be made if the policy change were enacted.

Now it is easy enough to say that a policy change is a perturbation, it is a lot harder to say what the perturbation actually consists of. Any system, human or otherwise, should be expected to respond when subjected to a perturbation. The problem is that policy changes create all sorts of effects that ripple through an economy without being noticed by the public offices, for the reason that there may be no public "signals" (e.g., publicly observable prices) accompanying them. Tracing the ripples requires an understanding of the way the economy works. It is a difficult business.

The enterprise is made particularly difficult because many economic transactions take place in "non-market" institutions. A prime set of examples are transactions involving environmental services (e.g., ecosystem services).⁴ In poor countries further examples abound. In recent years "long-term

⁴ Daily (1997) contains an account of such services and Dasgupta (1996) an account of why we should not expect the use of many such services to be subject to market discipline.

relationships" have been studied by economists and political scientists with the same care and rigour they used to invest in the study of markets and the State, respectively. There is now a large and illuminating theoretical and empirical literature on the wide variety of ways in which people cope with resource scarcity when there are no formal markets for exchanging goods and services across time, space, and circumstances.⁵ The literature offers us a lever with which to predict, in broad terms, the way people, both individually and communally, would respond to policy changes. Unfortunately, the literature hasn't filtered through sufficiently to decision-makers. And it hasn't filtered through because, as an institution, Economics hasn't proved sturdy enough to insist that our understanding of non-market institutions is today a great deal more firm than it had been earlier. I want to illustrate what I mean by providing three examples, one a local miniature, the other two altogether grander and near-global.

4a. Management of Common Property Resources

For many years now, the political scientist, Elinor Ostrom, has been studying the management of common-property resources in various parts of the world. In her work on collectively-managed irrigation systems in Nepal (Ostrom, 1996), she has accounted for differences in rights and responsibilities among users (who gets how much water and when, who is responsible for which maintenance task of the canal system, and so forth) in terms of such facts as that some farmers are head-enders, while others are tail-enders. Head-enders have a built-in advantage, in that they can prevent tail-enders from receiving water. On the other hand, head-enders need the tail-enders' labour for repair and maintenance of traditional canal systems, which are temporary headworks built of stone, trees, and mud. This means that both sets of parties can in principle gain from cooperation. However, in the absence of cooperation their fortunes would differ greatly, head-enders being so much better situated. So, cooperative arrangements would be expected to display asymmetries, and they do so display.⁶

In Ostrom (1996), the author reported that a number of communities in her sample had been given aid by donors so that canals would be improved by the construction of permanent headworks. What could be more desirable than such aid, you might ask? But Ostrom observed that those canal systems that had been so improved were frequently in worse repair and were delivering less water to tail-enders than previously. Ostrom also reported that water allocation was more equitable in traditional farm-management systems than in modern systems managed by external agencies, such as government and foreign donors. She estimated from her sample that agricultural productivity is higher in traditional systems.

⁵ See the essays in Dasgupta and Stiglitz (1999).

⁶ A general finding from studies on the management of common property systems is that entitlements to products of the commons is, and was, almost always based on private holdings. See McKean (1992) and Ostrom and Gardner (1993).

Ostrom has an explanation for this. She argues that unless it is accompanied by counter-measures, the construction of permanent headworks alters the relative bargaining positions of the head- and tail-enders. Head-enders now don't need the labour of tail-enders to maintain the canal system. So the new sharing scheme involves even less water for tail-enders. Head-enders gain from the permanent structures, but tail-enders lose disproportionately. This is an example of how well-meaning aid can go wrong if the institution receiving the aid is not understood by the donor.

Resource allocation rules practised at the local level are not infrequently overturned by central fiat. A number of States in the Sahel imposed rules which in effect destroyed communitarian management practices in the forests. Villages ceased to have authority to enforce sanctions on those who violated locally-instituted rules of use. State authority turned the local commons into resources to which there is free access. The tragedy of the commons has often followed in the wake of such conversion. I find it difficult to imagine that such not-so-subtle effects of policy change could not have been foreseen by policy analysts.

4b. Structural Adjustment

My second example is altogether more grand and fiercely debated. So, of course, I will be a lot more tentative in what I say. It has to do with the experience people in poor countries have had with the so-called "structural adjustment programmes" devised by the World Bank and the International Monetary Fund, which involved reductions in the plethora of economic distortions that had been introduced by domestic governments over decades.

Many have criticised the way structural adjustment programmes have been carried out. They have pointed to the additional hardship many of the poor have experienced in their wake. But it is possible to argue that structural adjustments, facilitating as they did, the growth of markets, were necessary. And it has been so argued by proponents of the programmes. What I want to suggest is that both proponents and opponents of the programmes may be right. Growth of markets benefit many, but they can simultaneously make vulnerable people face additional economic hardship and so increase the incidence and intensity of poverty and destitution in an economy.

How and why might this happen? There are a number of pathways by which it can happen. Here I will sketch one that I have developed in previous writings (e.g. Dasgupta, 1993, 1999).

Long-term relationships in rural communities in poor countries are typically sustained by the practice of social norms, for example, norms of reciprocity. This isn't the place to elaborate upon the way social norms should technically be viewed. The point about social norms which bears stressing, however, is that they can be reliably practised only among people who expect to encounter one another repeatedly in similar situations.

Consider then a group of "far-sighted" people who know one another and who prepare to interact indefinitely with one another. By a far-sighted person I mean someone who applies a low rate to discount future costs and benefits of alternative courses of action. Assume as well that the parties in question are

not separately mobile (although they could be collectively mobile, as in the case of nomadic societies); otherwise the chance of future encounters with one another would be low and people (being far-sighted!) would discount heavily the future benefits of current costs associated with cooperation.

The basic idea is this: if people are far-sighted and are not separately mobile, a credible threat by all that they would impose sufficiently stiff sanctions on anyone who broke the agreement would deter everyone from breaking it. But the threat of sanctions would cease to have potency if opportunistic behaviour were to become personally more profitable. This can happen during a process in which formal markets grow nearby and uncorrelated migration accompanies the process. As opportunities outside the village improve, those with lesser ties (e.g., young men) are more likely to take advantage of them and make a break with those customary obligations that are enshrined in prevailing social norms. Those with greater attachments would perceive this, and so infer that the expected benefits from complying with agreements are now lower. Either way, norms of reciprocity could be expected to break down, making certain groups of people (e.g., women, the old, and the very young) worse off. This is a case where improved institutional performance elsewhere (e.g., growth of markets in the economy at large) has an adverse effect on the functioning of a local, non-market institution. To the extent local common-property natural resources are made vulnerable by the breakdown of communitarian control mechanisms, structural adjustment programmes would have been expected to be unfriendly also to the environment and, so, to those who are directly dependent on them for their livelihood. This is because when the market value of a resource-base increases, there is especial additional pressure on the base if people have relatively free access to it.⁷ Structural adjustment programmes devoid of safety-nets for those who are vulnerable to the erosion of communitarian practices are defective. They can also be damaging to the natural environment unless the structure of property rights, be they private or communitarian, is simultaneously made more secure. We should not have expected matters to have been otherwise.⁸

4c. Free Trade and WTO⁹

Recent happenings in Seattle and the response of those who regard free trade as being good for everyone offer an example similar to the one concerning structural adjustment programmes. Public discussions on the appropriate role of the World Trade Organization (WTO) are now routinely conducted

⁷ See Reed (1992) for an empirical investigation in three poor countries of some of the effects of structural adjustment programmes on resource bases.

⁸ As I am wholly inexpert on the matter, I am not offering even a sketch of the kinds of argument that can be advanced to show that the reforms that were urged upon Russia in the early 1990s suffered from a lack of acknowledgement of the role that governance plays in the operation of markets. In an illuminating body of work, Richard Rose (see, for example, Rose, 1999) has been investigating the way social networks there have entered spheres of activity they would not have if citizens were to have enjoyed reliable governance.

⁹ This example has been added to the revised version of the lecture.

in terms of an alleged battle between multi-national companies and hapless governments in poor countries. But the poor in poor countries are not the same as the governments who rule over them. To be sure, increased international trade has benefited many and arbitrary restrictions on trade have harmed also many. But freeing trade in the presence of incompletely-specified and only partially-enforced property rights can be predicted to hurt segments of the population and has been known to hurt them. Economic analysis is today capable of identifying the kinds of people who would be expected to get hurt when trade expansion occurs in the absence of appropriate safety nets or compensations.

Consider, for example, the ecological pathways by which deforestation in the uplands of a watershed inflict damage on people in the lowlands.¹⁰ It pays to study the pathways in terms of the assignment of property rights. The common law in many poor countries, if we are permitted to use this expression in a universal context, in principle recognizes pollutees' rights. So it is the timber merchant who, in principle, would have to pay compensation to the farmers for the right to inflict the damage that goes with deforestation. However, even if the law sees the matter in this light, there is a gulf between the "written" law and the enforcement of law. When the cause of damage is hundreds of miles away, when the timber concession has been awarded to public land by government, and when the victims are a scattered group of impoverished farmers, the issue of a negotiated outcome does not usually arise. If the timber merchant is not required to compensate the downland farmers, the private cost of logging is less than its social cost. So, from the social point of view, we would expect excessive deforestation of the uplands. We would also expect that resource-based goods would be underpriced in the market. The less roundabout is the production of the final good, the greater would this underpricing be, in percentage terms. Put another way, the lower is the value that is added to the resource in the course of production, the larger is the extent of this underpricing of the final product. In short, when property rights are not enforced in countries which export primary products, there is an implicit subsidy on the exports, possibly on a massive scale. Moreover, the subsidy is paid not by the general public via taxation, but by some of the most disadvantaged members of society: the sharecropper, the small landholder or tenant farmer, the fisherman. The subsidy is hidden from public scrutiny, that is why its isn't acknowledged officially. But it is there. It is real. We should be in a position to estimate such subsidies. As of now, we have very few official estimates. Since expansion of trade could be expected to increase the commercial value of such primary products as timber, the link between the gains and losses from international trade and the enforcement of property rights should be made to rear its head when discussions on the role of WTO are undertaken. Modern economic analysis can identify scenarios where the gains would be less than the losses. In such circumstances increased trade without a concomitant improvement in the enforcement of property rights would be harmful to a nation, in the aggregate.

Even for WTO governance is at the heart of the matter, not trade.

¹⁰ The example is taken from Dasgupta (1990).

5. Technological Development and the Environment

Economists are tempted not to take economics seriously when their political predisposition or personal ambition assumes centre stage. The examples I have just presented illustrate faults that are contained in policy prescriptions when economics is abandoned. There may be parallels in the practice of science. But the examples don't illuminate why the Young Scientists are suspicious of the enterprise called Science. I believe their disquiet has to do with the fact that Science and Technology are not working in tandem with best-practice economics. Let me illustrate this by another example taken from humanity's use of environmental natural resources. I think the choice is apt, because the Young Scientists spoke frequently of contemporary environmental degradation and the inability (possibly even unwillingness) of scientists and technologists to prevent it from happening.

As you know, in recent years ecologists and economists have been urging governments and international agencies to make available funds for estimating the worth of ecosystem services in monetary terms. The question arises, why. Why is there a special need to value those services? Why can we not rely on market prices to guide decisions on the use of global and local ecosystem services, in the way we do for so many other goods and services? Or to put the matter in another way, why aren't markets an adequate set of institutions for protecting the environment?

The reason is that for many environmental resources markets simply do not exist. In some cases they do not exist because the costs of negotiation and of monitoring the use of these resources are too high. One class of examples is provided by economic activities that are affected by ecological interactions involving long geographical distances (as in the previous example of the effects of uplands deforestation on downstream activities hundreds of miles away); another, by large temporal distances (e.g., the effect of carbon emission on climate in the distant future, in a world where forward markets are non-existent because future generations are not present today to negotiate with us). Then there are cases (e.g., the atmosphere, aquifers, and the open seas) where the nature of the physical situation (*viz.*, the migratory nature of the resource) makes private property rights impractical and so keeps markets from existing; while in others, ill-specified or unprotected property rights prevent their existence, or make markets function wrongly even when they do exist (e.g., biodiversity; see Perrings *et al.*, 1994, 1995). In short, environmental problems are often caused by market failure.¹¹

Since markets cannot be relied upon to provide us with prices which would signal social scarcities, there is a need for techniques which would enable us to determine social scarcity values of environmental resources. A great deal of work in environmental and resource economics has been directed at discovering methods for estimating notional prices, often called accounting prices by economists, which reflect the true social scarcities of natural resource stocks and of the services they

¹¹ There are other types of institutional failure responsible for environmental degradation (e.g., government failure; Dasgupta, 1996), but here I concentrate on market failure.

provide. The problem is that for the most part practical methods have been developed for estimating the accounting prices of "amenities" (e.g., places of scenic beauty or recreation sites), relatively few for the multitude of ecosystem services which constitute our life-support system. Much remains to be done in developing techniques for estimating the accounting prices of natural resources in different institutional settings.

However, this much is clear. Indicators of social well-being in frequent use by governments and international agencies (e.g., gross national product per head [GNP], life expectancy at birth, infant survival rate, and literacy) do not reflect the impact of economic activities on the environment. Such indices of the standard of living as GNP per head pertain to commodity production. So they don't properly take into account the use of natural resources in the production process. Statistics on past movements of GNP tell us nothing about the resource stocks which remain. Such statistics do not make clear, for example, whether increases in GNP per head are being realized by means of a depletion of the resource base (e.g., if increases in agricultural production are not being achieved by "mining" the soil). Over the years environmental and resource economists have shown how national accounting systems need to be revised so as to include the value of the changes in the environmental resource-base that occur each year due to human activities (Lutz, 1993; Vincent *et al.*, 1998; Dasgupta and Mäler, 2000). We should be in a position to determine whether resource degradation in various locations of the world has yet to reach the stage from which their current economic activities are unsustainable. But the practice of national-income accounting has lagged so far behind its theory, that we have little idea of what the facts have been. It is possible that time trends in such commonly used socio-economic indicators as GNP per head, life expectancy at birth, infant survival rate, and literacy give us a singularly misleading picture of movements of the true standard of living.

To state the matter succinctly, current-day estimates of socio-economic indicators are biased because the accounting value of changes in the stocks of natural resources is not taken into account. Because their accounting prices are not available, natural resources on site are frequently regarded as having no value. This amounts to regarding the depreciation of natural capital as of no consequence. But as these resources are scarce goods, their accounting prices are positive. So, if they depreciate, there is a social loss. It means that profits attributed to economic activities which degrade the environment are frequently greater than the social profits they generate. In other words, commercial rates of return on investment are higher than the social rates of return on investment. Resource intensive projects appear to be better than they actually are. So wrong investment projects get chosen, in both the private and public sectors. We may conclude that investment projects earning high commercial returns could well be contributing to a reduction in the social wealth of nations (Dasgupta and Mäler, 2000). It should be no surprise then that installed technologies are often unfriendly towards the environment and, so, toward those whose lives depend directly on the local natural-resource base. This is likely to be especially true in poor countries, where environmental legislations are usually neither strong nor effectively enforced.

The installation of modern technology can harm the poorest in ways that often are not reflected in commercial costs.

The above account explains why "modern technology" isn't necessarily "appropriate technology" and why the poorest of the poor in poor countries have, when they have been permitted to, 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 structure of accounting prices, most especially that of the local natural-resource base, varies from country to country. A project design which is socially profitable in one country may not be socially profitable in another. Our analysis helps explain why environmental groups in poor countries frequently appear to be backward looking, unearthing as they try to do on occasion traditional technologies for soil conservation, water management, and so forth (see, e.g., Agarwal and Narain, 1996).

The extent to which inappropriate technology is adopted varies from case to case, and from country to country. But it can be substantial. In their work on the depreciation of natural resources in Costa Rica, Solorzano et al. (1991) estimated that in 1989 the depreciation of three resources — forests, soil, and fisheries — amounted to about 10 percent of gross domestic product and over a third of gross capital accumulation.

So far I have talked about biases in the adoption of established technology and so in biases in technology transfer. One can go farther: the bias toward wrong technology extends to the prior stage of research and development. When natural resources are underpriced (in the extreme, when they are not priced at all), there is little incentive on anyone's part to develop technologies which would economise their use. So the direction of technological research and technological change are systematically directed against the environment. Often enough, environmental "cures" are sought once it is perceived that past choices have been damaging to the environment, whereas "prevention" would have been the better choice. To give an example, Chichilnisky and Heal (1998) compared the costs of restoring the ecological functioning of the Catskill Watershed ecosystem in New York State, to the costs of replacing the natural water purification and filtration services the ecosystem has provided in the past by building a water-purification plant costing 8 billion US dollars. They have shown the overwhelming economic advantages of preservation over construction: Independent of the other services the Catskill watershed provides, and ignoring the annual running costs of 300 million US dollars for a filtration plant, the capital costs alone showed a more than 6-fold advantage for investing in the natural-resource base. Their investigation offers a rough estimate of the social worth (or accounting price) of the watershed itself.

6. Social Norms and the Research Environment

If philosophers and sociologists of science in earlier days studied mostly the epistemological problems facing scientific research, today they study as well the institutions within which research is conducted. The structure of incentives in Science and Technology, viewed as social institutions, affects the research agenda and also research practice. In this lecture I have suggested that the disquiet being

expressed at this conference and the one voiced at the International Forum of Young Scientists have two sources, one bearing on both Science and Technology, the other on Science alone. The first is reflected in the feeling that modern technology is environmentally rapacious. I have offered a reason why the feeling may be a reasonable one: the environment is underpriced, so scientific and technological research is not directed at economising on the environment. The way forward would be for scientists and technologists to be more engaged in collaborative work with social scientists, even at the stage of the design of the research endeavour.

The second source of the disquiet stems from problems facing Science, which is increasingly under threat from Technology. The threat has arisen because Science, unlike Technology, requires for its survival a strong system of self-regulation and public support. Now public support is itself a "public good". When the public begin to regard science as being less valuable than before, Science contracts. Something like this may well have happened among the public in the North in recent years. Since self-regulation too is a "public good", it would be under-supplied unless, collectively, scientists were willing to put in the time and effort to make the institution work. I have tried to illustrate the way the quality of research suffers if there isn't a strong self-regulatory system at work by discussing three examples from economics, the subject I know best. Academies are of the utmost importance at this juncture. If my analysis is correct, part of the disquiet being voiced at this conference is in effect an expression of disappointment that the structure of authority within the institution of Science has weakened in recent decades.

References

- Agarwal, A. and S. Narain (1996), Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems (New Delhi: Centre for Science and Development).
- Chichilnisky, G. and G.M. Heal (1998), "Economic Returns from the Biosphere", Nature, 391, 629.
- Daily G, ed. (1997), Nature's Services: Societal Dependence on Natural Ecosystems (Washington, D.C.: Island Press).
- Dasgupta, P. (1990), "The Environment as a Commodity", Oxford Review of Economic Policy, 1990, 6, 51-67.
- Dasgupta, P. (1993), An Inquiry into Well-Being and Destitution (Oxford: Clarendon Press).
- Dasgupta, P. (1996), "The Economics of the Environment", Environment and Development Economics, 1, 387-428.
- Dasgupta, P. (1999), "Economic Progress and the Idea of Social Capital", in P. Dasgupta and I. Serageldin, eds., Social Capital: A Multifaceted Perspective (Washington, D.C.: World Bank).
- Dasgupta, P. and P. David (1987), "Information Disclosure and the Economics of Science and Technology", in G. Feiwel, ed., Arrow and the Ascent of Modern Economic Theory (London: Macmillan Press).
- Dasgupta, P. and P. David (1994), "Toward a New Economics of Science", Research Policy, 23, 487-521.
- Dasgupta, P. and K.-G. Mäler (2000), "Net National Product, Wealth and Social Well-Being", Environment and Development Economics, 5.
- Dasgupta, P. and I. Serageldin, eds. (1999), Social Capital: A Multifaceted Perspective (Washington, D.C.: World Bank).
- David, P.A. (1998), "Common Agency Contracting and the Emergence of "Open Science" Institutions", American Economic Review, 88 (Papers & Proceedings), 15-21.
- Lutz, E., ed. (1993), Toward Improved Accounting for the Environment (Washington, DC: World Bank).
- McKean, M. (1992), "Success on the Commons: A Comparative Examination of Institutions for Common Property Resource Management", Journal of Theoretical Politics, 4, 256-68.
- Ostrom, E. (1996), "Incentives, Rules of the Game, and Development", Proceedings of the Annual World Bank Conference on Development Economics, 1995 (Supplement to the World Bank Economic Review and the World Bank Research Observer), 207-34.
- Ostrom, E. and R. Gardner (1993), "Coping with Asymmetries in the Commons: Self-Governing Irrigations Can Work", Journal of Economic Perspectives, 7, 93-112.
- Perrings, C., K.-G. Mäler, C. Folke, C.S. Holling, and B.-O. Jansson, eds. (1994), Biodiversity Conservation: Problems and Policies (Dordrecht: Kluwer).

Perrings, C., K.-G. Mäler, C. Folke, C.S. Holling, and B.-O. Jansson, eds. (1995), Biodiversity Loss: Economic and Ecological Issues (Cambridge: Cambridge University Press).

Reed, D., ed. (1992), Structural Adjustment and the Environment (Boulder, CO: Westview Press).

Rose, R. (1999), "Getting Things Done in an Antimodern Society: Social Capital Networks in Russia", in P. Dasgupta and I. Serageldin, eds., Social Capital: A Multifaceted Perspective (Washington, D.C.: World Bank).

Solorzano, R. et al. (1991), Accounts Overdue: Natural Resource Depreciation in Costa Rica (Washington, DC: World Resources Institute).

Stephan, P. (1996), "The Economics of Science", Journal of Economic Literature, 34, 1199-1235.

Vincent, J., R.M. Ali, and Associates (1997), Environment and Development in a Resource-Rich Economy: Malaysia under the New Economic (Cambridge, MA: Harvard Institute for International Development).