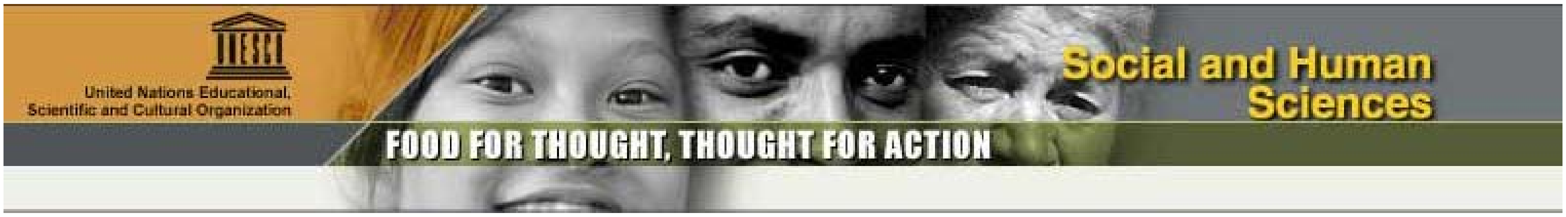

Management of Social Transformations - MOST

Discussion Paper No. 42

Science, Economics and Democracy: Selected Issues

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Prepared for the
World Conference on Science
UNESCO � ICSU
Budapest, Hungary, 26 June-1 July 1999

This document develops and articulates issues of relevance to the Forum II "Science in Society: Towards a New Contract" of the World Conference on Science, held in Budapest, Hungary, 26 June-1 July 1999. These issues deal particularly with the topics and themes to be explored and discussed during several afternoon thematic meetings on 28 June 1999: "Setting priorities in a new socio-economic context"; "Towards a new social contract between for science"; "Science, industry and knowledge as public good", "Science and democracy" and "Science for development". Its purpose is to contribute to the debate on these issues.

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1 - Transformations

Many transformations and evolutions influence today the way science has traditionally been conducted, financed and organized.

In the rich countries, slower economic growth and limited increase in the budgets of central governments have placed severe constraints on public spending on long-term science. Some of the key challenges facing the international community for the 21st century relate to: the decline of national security motivations for fundamental research; the increasingly widespread participation of the private sector in scientific research; the urgent need for enhanced relations between scientists and lay people.

Some issues are also crucial for both developing countries and the transition economies. For the first time in history a scientific revolution is mostly driven by the private sector. There is no doubt that such a privatisation of scientific knowledge (knowledge as a market good vs. as a common good) can exacerbate the gap between developed and developing countries. Privatising knowledge has undesirable effects, because it obstructs the international dissemination of socially important inventions, especially where developing countries are concerned. There is thus an urgent need for devising appropriate science policies and intellectual property rights regimes that give adequate consideration to knowledge dissemination and use by developing countries. A big challenge for the next century is to avoid that the issue of proprietary science becomes a real threat for open science. This is a challenge for both developed and developing countries.

One of the main goals of the World Conference on Science�s (WCS) Forum II is to evaluate such transformations in order to derive potential consequences and policy implications. Because science is a domain which is at the intersection between issues of competitiveness and economic development on the one hand, and issues related to the very foundation of the human nature, on the other, such assessments must be carried out with reference to economics, social equity and ethics.

2 - From a new socio-economic context to a new economic model for science

The emergence of a new model for managing science is firmly linked to the overall economic climate, especially the slower growth of government expenditure over the last decade (see Brown, 1997, for quantitative figures). As a result, the famous "social contract for science" which ensured generous state funding of science in exchange for science helping to increase the security, wealth and health of nations is now being seriously questioned.

The social contract guaranteed science a degree of independence, which was only linked to the market through a long chain of intermediaries, some of which clearly would never function. Science was the distant origin of the process of innovation ("science push"), producing basic knowledge which gradually became practical know-how and finally the basis for material goods. This was called the linear model. Science drew up its research agenda according to its own interests. Although it was appreciated when some of the knowledge produced could generate money, this was not a decisive factor in choosing priorities and allocating resources for science.

The current context is characterized by very tight state budget restrictions, in which the increasing cost of science is a crucial issue. The price of the scientific personnel and the costs of increasingly sophisticated laboratory facilities have been rising faster than the prices of the general run of equipment and structures used in the goods producing sectors. In the absence of other changes, this trend would suffice to absorb an increasing fraction of national income and public expenditures in the budget for science. From now on, in some cases, industry will step in, as with the link-up between Craig Venter and Perkin Ellmer in the area of human genome sequencing. The huge concentration of resources this link-up involves pushes publicly-funded research in the United States and Europe several steps backward.

But industry will enter selectively in the few scientific areas in which expected private returns are high and quite immediate. In most areas, private firms have switched their priorities and have abandoned a large portion of basic research to focus on short-term research and development (R & D) in areas where they can make money quickly. The focus on daily movements of stock prices encourages policies which can produce short-term financial results, to the detriment of long-term projects which would improve a firm's competitive position.

This new situation means that science is to pay much more attention to the needs of the market. The linear model has been criticised for being far too simplistic and for putting a big distance between science and the market. But, as argued by P. A. David (1998), the innovation policies which have gradually developed in the OECD countries are just as simplistic. The new requirement of being "close to market rationale" has turned the linear model on its head and replaced the innocent notion of scientific progress by an equally naive vision of market forces. Like the old linear model, the new approach claims that the driving forces flow in one direction only. However, now the source is the market, which encourages private innovation, which in turn means looking for inventions that will make money. Ultimately, it determines which areas of basic science are economically relevant (David, 1998). Exercises in "technology foresight" became the main instrument in taming scientific activity, and subjecting it to market requirements.

This new model, where science is almost completely at the beck and call of the market, induces university researchers to take the same attitude towards intellectual property as private firms. A turning-point in this was the 1980 Bayh-Dole Act in the United States, which allows universities to patent findings that have been publicly-financed. Thus, public research is being privatised and the area of open science continues to shrink. Such institutional changes, found in most OECD countries, in turn, strengthen the new model by giving universities the means to boost their finances and show they can "play ball."

3 - New relations with industry

This new context has thus caused the increasing involvement of "open science" institutions in market activities, notably closer ties between industry and universities. The share of university research financed by firms has grown significantly. A related trend involves firms learning how to "plug themselves in" more effectively to university research networks.

Such shifts, of course, offer new opportunities for academic research. Basic public research can benefit greatly from improved ties with industry. But universities must adapt to the laws of the market. They are applying for a lot more patents and more knowledge is being held back, which might seem to be a movement away from open science. Argument has arisen about whether the necessary adjustment of academic research to market forces has gone too far (Stephan, 1996). Some experts fear that too close an association between universities and industry will undermine the commitment of universities to basic, curiosity-driven research and erode the principle of full disclosure of research findings which has improved the quality of research and cumulative and collective scientific advance. As Cohen, Florida and Goe (1994) point out: "*Largely to obtain industry funding, universities have weakened their long-held commitment to the free flow of information and the full public disclosure of research findings. Yet the costs associated with the weakening of these traditional academic norms appears to be offset, at least to some extent, by the benefits of more effective mechanisms for advancing commercial technology*."

4 - A first assessment

4.1 - The trend towards private science: ethics and economics

Biomedical research is a good example of the passage from the public to the private domain. In the previous situation, the government funded basic research and required full and speedy dissemination of findings. Biomedical discoveries were not patented and were freely used to develop diagnostic products and medicines. The trend towards privatizing basic research has led to a tremendous number of private rights, especially patents, being established over basic knowledge.

This is an ambivalent phenomenon: on one side, this is good news for the tax payer! Any new commitment of the private sector to undertake research previously funded on a public base relieves the tax payer of the burden. And moreover privatisation has the potential to accelerate the pace of innovation. On the other side, some analysts are convinced that this will lead to innovation being stifled almost automatically and to under-use of knowledge produced, in a scenario known as "the tragedy of anti-commons."

In the case of biomedical research, major public institutions and universities have set up arrangements for technology transfer which provide for patenting discoveries and granting production licences. Applying for a patent seems to be considered a right by state-funded researchers, these days. But it creates many obstacles. For example, as Heller and Eisenberg (1998) have shown, one obstacle is caused by breaking up the knowledge, through granting rights to fragments of it before the commercial application has been identified. Previously, a patent concerned the genes involved in the product, such as a therapeutic protein or a diagnostic test. The proliferation of patents on fragments of knowledge, many held by different parties, greatly complicates the co-ordination required for development of a product. If it is too difficult or expensive to acquire all the licences needed, the product will simply not be elaborated.

The argument developed here is not only an ethical one. This is also pure economics: too many private rights will require costly transactions to bundle licenses together before a firm can have an effective right to develop the product. In such a situation, the risk of under-using knowledge and simply abandoning socially desirable fields of discoveries is high. In this perspective, economics and ethics are going hand with hand � each one providing a rationale for regulating property rights.

4.2 - Proprietary science and development issues

The current general tendency of innovation and technical progress is ambivalent. Such an ambivalence is particularly striking from the point of view of developing countries.

On the one hand, the current technological breakthroughs have the potential to provide a great impetus to development and economic growth in many areas. For instance, the new wave of inventions in biological sciences has a great potential to improve agricultural production at the small-holder level in developing countries (the application of biological sciences could lead to plants that are more drought-resistant, more salt-tolerant, more resistant to pests without use of pesticides, etc..).

On the other hand, however, the current technological breakthroughs are, for the first time, driven by proprietary science (by that we mean, for example, enormous biotechnology investments by the private sector) and, of course the private sector would not invest capital on such a large scale if there was no possibility of recouping it with the protection of intellectual property.

The basic rationale for creating intellectual property rights is not disputable; almost everyone accepts that without proper legal protection for innovative ideas, the private sector would not invest in the research needed to produce them, as it would lack the means to secure profits on its investment. But there are cases in which the tendency towards the "privatization of knowledge" is going too far, impeding dramatically the international dissemination of useful knowledge. Writing the international rules in such a way that those who benefit from them are those who are already the most economically powerful is not in the best interests of those who are largely excluded. Indeed, the current rules on intellectual property rights may in fact be hindering the technological development of developing countries. See for example the current discussions between the World Trade Organization (WTO) and the African Intellectual Property Organization, to oblige the latter's members to "protect" plant varieties, which would mean to sign away the right of millions of small farmers to save and exchange crop seed. While such a legislation is in conformity with a provision in the WTO that obliges such plant varieties to be protected, it will create severe problems for developing countries. In such cases, strengthening intellectual property rights and extending exclusive rights to basic or generic knowledge obstructs progress in general and clashes directly with the great opportunities for all, provided by the new technological revolution.

Another problem concerns the fact that private companies may abandon some fields of research when the expected profitability diminishes, even if the expected social return remains very high. Let us give a few examples:

- The pharmaceutical industry has recently abandoned whole areas of basic research into malaria at a time when resistance of mosquitoes to current medicine is making such research much more urgent. The reasoning behind such decisions is obvious, when unprofitable markets are concerned. But we should note that the amount of public and private money spent world-wide on malaria research is only half that spent on cancer research in the United Kingdom alone.
- These days, new hopes in preventing AIDS result from the design and development of a range of microbicides. Such drugs have proven to be particularly effective in killing any infection by the HIV virus that causes AIDS; and this could be particularly crucial in developing countries. But microbicides are not getting the major research push they deserve because drug firms see little chance of making big profits: 90% of the market for this kind of product is in developing countries, where there is no purchasing power.
- There are serious doubts about the value of some of the products of genetic engineering for developing countries needs. Most of the transgenic vegetal varieties have been created for the markets of the North and the genes which generate important properties for agriculture in the South have not yet been identified.

4.3 - The crisis in basic research: short-term policies and restricting knowledge

The growing power of the market over science affects both the principle of disclosure (open science) and the content of research programmes and the kind of knowledge produced.

First, less "open" practices, such as patents and the habit of secrecy, are appearing in some areas of state-funded basic research. There are many signs of such a shift. Leaving aside the frequent lapses and rule-bending which have always been part of open science, what is important today is establishing new norms of behaviour entailing significant restrictions on the disclosure and distribution of scientific knowledge. This is a consequence of the effort to move basic scientific research closer to the market. These new policies have, thus, considerable potential to increase the exclusivity of academic research results and to reduce the distribution of knowledge. The institution of open science is an incentive system that differs markedly from commercial incentive systems in its implications for knowledge distribution. The institutions of commercial research and the way it is organised inevitably clash with the principles of "open" research.

Second, growing links between universities and industry can modify the nature of university research, which is also coming under pressure from demands for short-term work and immediate commercial applications. Three US economists looked at patents granted to US universities and found that the research done was less and less important and less general, suggesting a trend to more applied research (Henderson, Jaffe and Trajtenberg, 1998). Stronger university-industry ties are likely to push university research towards shorter term, less risky activity.

What should be quite clear is that the future is not predictable. The function of a university is not carved in stone and the way it changes depends very much on how institutions are regarded in each country. Some universities will become a straight offshoot of industry, while others will retain a degree of independence, as places where independent, long term research is still carried out, even though they forge strong links with industry. But those that bind themselves too closely to industry will undergo a change: "*For example, it turns out that when compared with faculty that did not have as much* *industrial support, those with 65% or more industrial support tend to carry out research that is more often secret, that is more often oriented toward commercial interests, and that is less academically productive. Surprise, surprise!"* (Kurland, 1997, 761).

4.4 - Efficient in the short term, but...

How efficient is the new world of privatised science? It depends whether the assessment is for the short, or the long term.

Efficiency definitely increases in the short term. In a firm, it means a tighter choice of projects, dropping the most doubtful ones, incorporating R & D into the product development division and establishing stricter cost controls, all of which automatically leads to a more efficient short-term allocation of resources. The growing tendency to farm out research is part of this trend. The cosiness between industry and universities encourages the latter to adopt more effective ways to market their "products."

Prediction is harder when it comes to the long term. The switch towards short-term research projects involving little risk and very quick returns can be extremely harmful to long-term growth, which is greatly influenced by science and basic research. In theory, short-term research, aiming at small differentiation between products, turns up fewer positive "externalities" than research which aims to come up with basic knowledge which has broad applications and leads to further developments. The risk of under-using discoveries, due to the obstacles caused by multiple rights of ownership, is already evident in some sectors (see below). The "closing off" of knowledge � the narrower dissemination of it � also harms the accumulation and progress of knowledge and innovation, as well as co-operation between parties involved.

4.5 - Towards the creation of a new job market in science

This new situation, where science is increasingly market-dependent, needs a job market for scientists to help scientific firms cope with the constant adjustments they have to make to keep abreast of the market. A popular book (Gibbons et al., 1994) deals with this question and recommends more flexibility in assembling, reshuffling and quickly disbanding research teams. This, the book notes, contrasts with the earlier model based on rigid, hierarchical elements, such as a central research laboratory, a specialised scientific institution or a university department based on a strictly defined scientific field. The old model, the authors say, is quite out of date and efforts to justify keeping it alive are very backward-looking. Attributes of the new model are worded attractively, while those of the old model are often oversimplified and sound less attractive (Kazancigil, 1998). This attempt to come up with a new model aims especially to make the scientific jobs market work more like the general labour market, as it features in neo-liberal style employment policies. As Gibbons et al. suggest:

> "*An alternative model [to large university-based institutes with tenured faculty, or mission-oriented government laboratories, and permanent research units with tenured research staff set up for specific monocultural research] might involve the creation of lean �centres� employing few administrators with a budget to stimulate networks of innovators, in units attached to diverse institutions, agencies or firms. They would be periodically evaluated in terms of their effectiveness in process management. When their jobs were completed, or when decreasing returns became evident they would be disbanded... Any policy that tended to entrench institutions, or encourage autarkic*

attitudes, is anachronistic." (Gibbons et al., 1994, 162).

What should one think of this proposal? The book's authors advocate some redeployment of public resources which have been used to support the major traditional institutions of science and divert them to "networks" which would put together multi-disciplinary teams to work on once-off problems. A recent article (David et al., 1998) tried to describe the scientific system this would eventually produce. Aside from positive, modern-sounding words like transdisciplinarity, fluidity, hybridisation and heterogeneity that the authors use, the new system would resemble a market comprised of inexpensive "research motels" which could temporarily "house" transdisciplinary teams put together by managers working within "stripped down" structures. The system of incentives suitable here � which concern researchers as well as the head-hunters who serve as the temporary intermediaries needed in such flexible scientific job markets � are not the kind that would attract scientists to long-term research programmes or encourage them to take risks. Researchers would have to show their skills and abilities concerning once-off applications, without the professional security offered by an "anachronistic", permanent job in an academic institution.

5 - Perspectives: building a new social contract

During the period of the cold war, the model of science and basic research established by V. Bush, the US Presidential Science Adviser (1945), was widely accepted. This "social contract for science", a postulate about the social benefits of science, was, moreover, combined with the argument that the market cannot guarantee an optimal allocation of resources to research. This set of arguments opened a large avenue for the public funding of science. This era is now past. All developments identified and discussed above undercut the traditional public good economic rationale for the public support of science. Scientific knowledge becomes, in many cases, a private good. The "close to market" rationale is used to select areas for scientific explorations according to their commercial relevance. All those evolutions can have perverse effects.

There is, thus, a need for constructing a new social contract � taking into consideration the key features of the scientific enterprise (openness, long-term research, equity issues), while recognizing the importance of increasing the collaboration with industry, as well as the need for joint research agendas between the natural and social sciences acting as equal partners (the interaction between the natural sciences and technology, and the society cannot be optimized unless social sciences participate in the game, on their own rights, with adequate resources). Such a social contract also needs to specify certain new targets (to take precedence over the objective of reinforcing military power). It should allow to build, above all, richer relations between scientists and lay people as well as between rich and developing countries.

5.1 - A new target

In a path-breaking paper, J. Lubchenco (1998) speaks in favour of the building of a new social contract for science oriented towards the production of scientific knowledge to understand and manage the biosphere. Arguments she provides about the consequences of human domination of Earth are so convincing that no one could dispute the point made in that paper: we need more science and technology in a broad spectrum of areas as well as through interdisciplinary research, to cope with most of the environmental challenges of the new century. It is, however, important to note that environment should not be the only issue for the new social contract; development matters equally. This is important to consider, because most of the policy discussions in international fora increase the perception of at least a tension between the environmental challenge and the development issue; environmental challenges are often being perceived as an obsession for rich countries, whereas the priority of developing countries is to struggle against poverty. Now, the point is that science and technology are unique in offering the possibility to reconcile and make compatible the need for environmental strategies and the need for economic development in the global world. This is to be the substance of a new social contract for science: managing in an integrative manner both issues, avoiding that environmental objectives be detrimental to economic development. In other words, socio-economic sustainability should be considered on an equal footing with environmental sustainability. In this *problématique*, the unsustainable consumption patterns of the North is a central issue to be tackled.

5.2 - Keeping the basic principles of knowledge openness and research for the long term

On openness

It is important to recognize that a major part of basic scientific research is carried out under an open principle � new knowledge is disseminated largely and quickly. Distributing scientific information is one means of increasing the efficiency of scientific investigation since it can serve to reduce duplicative or wasteful lines of research and to increase the probability of new fruitful combinations of ideas and projects. Economists explain that the principle of open science provides private incentives to generate public goods and has demonstrated its effectiveness as an incentive system (Dasgupta and David, 1994). Thus, standards of conduct regarding disclosure and investigation of the efficacy of the distribution of knowledge become the first priority in attempting to ensure that public expenditures on science generate value for the tax payer (David, Foray and Steinmueller, 1996).

But the new context, where proprietary science and intensive privatization of knowledge clash directly with the conditions for knowledge dissemination and access, make it very difficult to meet such a challenge.

On long term research

We are living in an economic world in which the present value of future benefits are very low. Real rates of interest have been at historically high levels since the early 1990s, reflecting a social preference for current consumption instead of investment for the future. Science, like other activities oriented towards long term-achievements thus has difficulty in getting a large basis for investment.

In such a context (in which the present value of future benefits are very low), the use of cost-benefits (c/b) analysis cannot provide a relevant basis for decision-making (Steinmueller, 1995): since long-term benefits are worth little to the present generation, there is little basis for investment. C/b analysis is, therefore, highly opportunistic: past generations cannot revoke their bequests and future generations cannot protest against our failure to provide for their welfare.

There is, thus, a need for new approaches such as the one based on inter-generational equity: future generations have the right to demand a knowledge legacy, just as we currently benefit from knowledge produced by past generations. Bequest results from a substitution of current consumption by an accumulation of resources to be passed on to future generations. Our current ability to produce and consume reflects past contributions to the current stock of scientific knowledge. The issues addressed by Steinmueller (1995) are of great importance: Should our contributions to future generations be smaller, the same or larger than past generations� (partially inadvertent) contributions to our own age? What kinds of allocation mechanisms can guarantee the respect of such rights? How to warrant those social functions dealing with the generation and preservation of diversity, the maintenance of access rights to critical knowledge and data (such as human genome data), the service of non-solvent markets?

It is well known that the market is not the appropriate institution to solve such questions and that it is a responsibility of the public institutions to facilitate this inter-generational and inter-spatial distribution of resources.

5.3 - The need for new governance structures

On international co-operation

The global science system has been strained by the rising costs of maintaining the capability to do basic science, which have pressed against tightening national budgets. Given this trend as well as the new context of slower growth of public budget and given the inherent limitations of industry funding and charity mechanisms, there is an urgent need for generating new mechanisms for funding science and, in more general terms, for implementing more effective governance structures.

The issue of improving international co-ordination and co-operation must be considered here. This is particularly important in the case of certain kinds of research, requiring large facilities (experimental research in the field of high energy particle physics) or large programmes (human genome project). The size of certain large facilities has made it simply unfeasible for many nations to maintain research activity or to run sensibly university training for their own graduate students in a growing number of fields � except by entering into co-operative arrangements for the construction and operation of large scientific facilities.

In fact, there is much less basic research and big science collaboration than might be expected given the presumed benefits of and incentives for co-operation, although there is substantial and growing international collaboration among industrial firms. International co-operation requiring substantial and/or reliable funding have not grown in scale commensurate with the increasing costs of research, the international nature of emerging science and technology-rich issues, the spread of scientific competence, or the growing ease of communications.

International co-ordination must involve developing countries. Until now, scientific priorities were not decided through international co-ordination and major conflicts on the final use of the products of science occurred. In February of this year, the U.N. Conference on Biosafety held in Cartagena (Colombia) failed to reach an agreement on international rules to regulate the huge trade in genetically modified foods and crops. This conference was characterized by a sharp polarization between industrialized and developing countries over the Biosafety Protocol. The U.S.A. joined by other top grain-exporting countries, rejected calls by other nations for stricter controls on such foods and crops.

The time is gone when developing countries were content with financial compensation. They now request to contribute to the writing of the rules.

On the use of information and communication technologies (ICTs)

The extensive use of ICTs in the conduct of science as a collective enterprise should also be considered here. In economic terms, they have helped reduce research costs by making collectively available experimental data, much of which is extraordinarily expensive to gather (e.g. space missions) or which represents a unique resource for studying dynamic systems (e.g. satellite and oceanic observation). Collective use of this data is leading to new institutional configurations while at the same time, on the more interpersonal level, new communication infrastructures are being set up to support direct electronic exchanges amongst researchers. In short, science can now be considered as a test-bed for addressing some of the most complex technical, economic, social and organizational issues of teleworking. Despite the enormous potential of ICTs for facilitating and enhancing scientific investigation, it is important to note that there are great differences among disciplines and national research communities in the actual use of these technologies. While the growing use of ICTs is creating considerably larger stocks of scientific knowledge, much of this knowledge may remain inaccessible to other researchers, even if they were granted free and unlimited access to this scientific information. A clear distinction is generally made in academic circles between information and knowledge; this often becomes blurred in talk about the emergence of the information society, and the new tools it is developing for knowledge management. It is also recognized that the potential of ICTs supporting remote access to large scale facilities has not yet been exploited to define more efficient patterns of scientific specialization for each country respectively.

5.4 - Science and Democracy

Democracy within the global scientific community

The opportunities for constructive change in the global scientific community appear to be very large, despite growing financial pressures and some diminution of the public commitment to the scientific enterprise. The growth of international co-operative arrangements in science and the increasing use of information and communication technologies will increase linkages within research networks and reduce the distance between researchers. There seems little doubt that this process will lead to a growing interest in reforms aimed at increasing the integration of resource allocation, research planning and scientific information distribution. Perhaps the most significant international challenge is the improvement in the global cohesion of the scientific community, in ascertaining that the division of labour among researchers reflects their ability to contribute to the scientific enterprise rather than the wealth or dominance of their country. The aim of policies in this area should, in the first instance, be to avoid increasing the disparities and disadvantages that are already present. In the second instance, the aim is to develop realistic and practical policies for lessening disadvantages, particularly where these disadvantages interfere with the transmission and use of scientific information.

Important policy issues deal with the questions: how can access and participation be broadened to include researchers from countries that are outside the main coalitions of the scientific power? What methods can be adopted to improve the international distribution of scientific information and reduce the barriers to the participation of researchers in global scientific networks? A dilemma in this area is the policy of making major scientific equipment and research programmes available to scientists from countries which do not help to pay for such resources. Should these countries pay an access fee or should the best possible balance be struck between the supply of equipment and the supply of expertise, regardless of the cost? The argument is between those who favour a small charge, which could lead to under-use of the resources, and those who want to maximise the social benefit by giving free access (David, 1997). The interest of the global community of nations and of scientists would be that the latter practice prevail.

Towards richer relations between scientists and lay people

In a recent paper, M. Callon (1997) identifies three steps in the progressive involvement of societies into the scientific debate. At the first stage, there is a strong separation between scientists and citizens. At this stage, knowledge is universal and general (scientists do not recognize the value of local know-how as a source for learning); the dynamics of science is characterized by internal agreements and conflicts among scientists. At the second stage, a space for public debate is built and groups of citizens can be involved in some decision processes (energy policy, environment, health); local knowledge is recognized as valuable for elaborating scientific knowledge. The problems here lie in the representativeness issue; that is, who is going to speak in the name of society? The third stage is characterized by an active participation of citizens in the production of knowledge (as in the process of collecting clinical data). By participating in the collective action of production and dissemination of the knowledge concerning it, the group of lay people (for instance the parents of children suffering from a rare genetic disease) does not experience its relationship with specialists in a mode of trust or mistrust since it is on an equal footing with them. Nor does it, as in the second stage, merely re-affirm a threatened identity; rather, it participates in the construction of the scientific knowledge.

Such an evolution towards the three stages is clearly shaped (accelerated, impeded) by the level of development of countries, by the existence of a strong democratic tradition and also by the perception of the government of science as a "way to political power". It is also clear that the third stage seems to be limited to few scientific domains � such as some kinds of medical investigations requiring decentralized and permanent collection of data about disease. Richer relations between scientists and lay people can develop by promoting such evolutions towards stage 2 and, in a few cases, by reaching the stage of collective action (between scientists and non scientists) to produce the scientific knowledge.

More generally, there is a need to make the policy-making and resource-allocation processes, as well as research choices of scientific communities much more transparent. The public at large should be better informed about and allowed to participate in the "politics" of science. Certain recent initiatives, such as the "Consensus Conferences", consultations of citizens, including through popular referenda, on some issues where public health is involved (such as biotechnologies and the dissemination of genetically modified organisms), constitute models to be generalized.

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