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COMMENTARY

Science & technology in India—An evaluation

Sumit Bhaduri

The spate of articles and letters in recent issues of *Current Science* and in other publications including newspapers has raised a number of issues such as the health and future of Indian science and its societal relevance. Serious concern has been expressed about inadequate Government support and the mechanism for the utilization of the available meagre resources.

It is instructive to note that this is by no means a unique Indian phenomenon. Seven years ago, about fifteen hundred British scientists paid eight thousand pounds of their own money for half a page in *The Times* to express their deep concern about the state and 'management' of British science. More recently, *Time* magazine in an article has bluntly summed up the way a large section of American society views scientists and their profession: they are—'the new villains of Western Society ... engaged in building toys for the rich'.[1]

Though the problems and questions agitating the minds of scientists, technologists, the public, and fund-giving authorities the world over have some common characteristics, they do differ significantly in matters of detail between nations. In fact the differences could be so deep and wide-ranging that, to be effective, the plausible remedial actions and policies would have to be different.

The purpose of this article is to assess the interdependencies and inadequecies of science and technology in the Indian context. However, to begin with, it is necessary to delineate some of those common characteristics of technology and its science base that cut across national boundaries.

A few general points

While science is certainly not identical with technology, the social dimension of science is manifested to a large extent by the level of technological advancement of a given society. Progress in basic science, evolution of superior technology, and economic prosperity are therefore often imagined as following one another in a mechanical and automatic manner. This, however, is not true in today's world: the relationships and interdependencies between the three are exceedingly complex.

First of all, the path from scientific discoveries to commercially useful products or processes—the fruits of *innovation*—is one with lots of bends and curves, and not a linear one as is often assumed. The 'linear model' of innovation is of little relevance in today's world for many reasons, an important one being the highly elastic and arbitrary time span between a given discovery and its final use.[2]

Secondly, while technology development and its successful commercial use definitely require a strong science-base, the converse is not necessarily true. A strong science base does not automatically ensure technological innovations. Most of the 'how' questions of technology could be satisfactorily answered, if and only if, due attention is paid to a crucial set of associated 'why' questions, i.e. if the underlying science is understood and established to a reasonable extent. However, a 'how' question has often been known to lead to a new set of 'why' questions, thereby opening up unexplored areas. The synergistic relationship between science and technology—an aspect often ignored by the 'linear model', needs to be fully appreciated. Technology could feed the engine of economic growth only when this relationship is selectively and consciously nurtured.

The survival and sustainable growth of science and technology require crucial inputs from the socio-economic environment. In most cases it is the nature, extent and mechanism of such inputs that determines the success or failure of a 'science and technology policy'.

It should also be remembered that ideologies and political compulsions play an overwhelmingly important role in determining a nation's socio-economic priorities and goals. The 'trickle down theory' of Reaganomics, the 'flying geese' pattern of shared growth of Japan and the Asian–Pacific countries, or our own vision of 'commanding heights' for the public sector, are broad concepts indicative of the dominant ideologies and their associated visions for economic growth. Notwithstanding the ideological differences, they all envisaged definite roles for science and technology in the overall process, and introduced mechanisms for Governmental encouragement and interventions. Our own once reputed, now much criticised CSIR laboratories, the 'Delphi' exercise undertaken every five years by the Ministry of International Trade and Industries (MITI) of Japan, the 'star-war' programme of the U.S.A., are nothing but vehicles and instances of such Governmental intervention.

The lesson to be drawn from all this is two-fold. First, no science and technology policy would be successful unless it is an integral part of a nation's socio-economic policies with a clear definition of its role. Secondly, this is true not only at a macro but also at a micro-level. The research (and development) objectives of technology-based companies must be derived from their overall corporate objectives. In fact, it may often be observed that lack of clarity in corporate objectives leads to 'failures' of commendable research and development efforts.

The Indian scene

What is the status of scientific research in India? Do today's much talked about 'globalized' economy and trade require some minimum level of scientific and technological capabilities?. If so, do we already have them?. Is there such a thing as 'appropriate technology, or is it best forgotten in a 'market-driven globalized economy'?

These are only some of the questions that need to be discussed in depth for identifying the role of science and technology in achieving the socio-economic goals.

The quantity and quality of Indian scientific output can be gauged with some reliability by using Eugene Garfield's 'Bibliometric' techniques. The basic finding is that on an average, in terms of quality our scientific research leaves much to be desired. For example, in the chemical sciences, India, Japan and Egypt are among the top twenty nations in terms of the total number of papers published. (Japan ranks third, India seventh, and Egypt last). However, in terms of citations per paper, a reasonably objective indicator for judging the importance of the reported scientific findings, India and Egypt do not figure in the list of top twenty whereas Japan does[3].

In fact, as may be expected, all the Group Seven nations are present in *both* the lists—and so are countries such as the Netherlands, Switzerland, Belgium, Australia etc. In today's world it is overwhelmingly the quality, rather than the quantity, that gives the competitive edge to a nation's scientific capabilities.

The second point that needs to be made about Indian science is the glaringly inadequate level of financial support that it receives. The Government spends less than a thousand crore for basic research[4]. The only other possible sponsor, i.e. Indian industry, without exception views such research with suspicion, and as nothing more than a wasteful luxury.

In spite of several incentives offered by the Government, the response from industry has so far been disappointing. Indian industry as a whole has failed to appreciate the importance of a national science-base. This is evident from the fact that the private-sector contributes only about 13% to the total research and development expenditure of the country[4].

Furthermore, though such expenditure is classified under research and development, the effort made very often does not amount to anything more than quality control and technical service; activities that are necessary but which do not add substantially to our technological capabilities. It is revealing that in a country of the size of India, with several industrial houses boasting of turnovers greater than or close to a thousand crores, barring one premiere scientific institute, there has been no institutional support of 'basic' or 'oriented-basic' science by the industry!

While it is clearly recognized that, to an industrialist, the yearly bottom-line of 'profit-after-tax' has an over-riding importance, long-term investment in research should not be seen as a philanthropic or money-wasting activity. Such a perception often arises out of an inability to quantify the benefits—direct and indirect—associated with long-term research. An apt example from the developed world is the benefits reaped from research initiated 15–20 years ago which was primarily guided by environmental considerations.

Twenty years ago, research driven by environmental considerations would have appeared an activity tinged with the vague and wooly hues of 'social responsibility', something which had little to do with profitability. In the developed countries, due to social pressures, such research has now become necessary in virtually all industrial sectors.

It should be mentioned here that in the developed countries and in Japan a long-term view of research is routinely taken, even when such research is aimed at very specific applications. As early as 1980, MITI started sponsoring collaborative research for Advance Battery Electric Power Storage Systems that involved laboratories of industrial giants such as Hitachi and Toshiba[5]. This indeed is an ideal example of effective Government intervention, with long-term thinking and commitment on the part of industry.

It is fashionable these days to give the market-driven economy and its ideological implications the status of a universal truth, seeing it as the glorious climax of the progress of human society. The limitations and distortions implicit in such a world-view are beyond the scope of this article. However, even assuming knowledge to be a commodity with a market-determined price, in tomorrow's 'global economy' it is this commodity which is going to fetch the highest profit. The 'know-hows' and the 'know-whys' of tomorrow's world would be available to the developing nations, if at all, only on the payment of a price with an enormous profit margin. The buying of technology may be unavoidable under certain circumstances. In certain situations it may also be the best option. Successful absorption of future technologies however would not be possible without a national science-base of substantially increased capabilities.

It is worth pointing out that science, like any other social practice, reflects the strengths and weaknesses of the social ethos within which it is contained. Indian scientists may have little control over many of the problems mentioned in this article. However, they can and should critically examine their own level of professionalism and commitment; their priorities and role models—categories about which we, as a nation, have been largely lackadaisical.

1. As quoted in *Science*, 1993, **261**, 143.
2. *New Scientist*, 16th November, 1991, 35.
3. *Science*, 1993, **260**, 1738.
4. Address by Dr P. Rama Rao to the Bombay Chamber's Science & Technology Sub-Committee (15th May 1993).
5. *New Scientist*, 10th July 1993.

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