

In order for technology to become a major force for economic growth and human development, it has to be marketed for common causes and should be linked to industry. Mere development of technology and applying for patents will not help the economy unless it is marketed. Einstein himself obtained more than a dozen patents including refrigeration, but none of them was found commercially viable from the consideration of efficiency or cost effectiveness. Closer home, basic academic sciences, which comprise the main force behind technological innovations, have not been encouraged to become the major force of progress for India's economy.

After the Second World War, the United States was able to simultaneously develop a huge military research establishment and an important system of academic (basic) research working under different principles and assumptions. This enabled the link between academic research with technological innovation and Industry. The big technological projects of the cold war era were very important sources of support for the academic sciences, and long-term research done in universities and other research centres. It is not a coincidence that with the end of the cold war, academic sciences are suffering.

India missed the chance of augmenting the link between science, technology and industry during the post World War period due to her freedom struggle movement and associated political problems. After independence Jawaharlal Nehru gave tremendous importance to science and technology. Nehru was confident that investment in science will help the development process and will benefit our economy although the effects may not be immediately apparent. Indeed, it did help in building the scientific temper in the country. His focus was on building science and technological institutions, but these institutions lacked strong links to the industry and therefore to the economy. There is no denying the fact that the link between science, technology and industry was very poor in India, although attempts are now being made to reduce the gap between science and technology.

The whole scenario of the relationship between science and technology has significantly changed in recent years. If we look at the international scene today, what is changing is not just that science is becoming more linked with technology but it is a change in the whole idea or ideology of pure science. Research is getting more linked with short-term economic interests and entwined with industry. These transformations expand opportunities and increase the social and economic rewards for creating and using technology. However, whether achievement of science can be expressed in terms of money is still an open question.

Today's technological advances are faster and more fundamental. Leading these transformations are the following emerging technologies: information and communications technology, biotechnology and nanotechnology. India is making progress in all these emerging technologies. However, progress in information and communication technology is spectacular in terms of employment generation and driving down costs at a pace never seen before. As an example e-mailing a 40-page document from India to USA costs about ten rupees, faxing it costs about three hundred rupees and sending it by courier costs about eighteen hundred rupees. In India employment in the software industry is projected to rise from 1.8 lakh in 1998 to 22 lakh in 2008 accounting for 8% of India's formal employment. We all know that information and communication technologies have created new outsourcing opportunities which benefited India immensely. The global outsourcing market is worth more than \$100 billion. At present India has about 1500 companies exporting software.

In spite of our tremendous progress in science and technology, it will be worthwhile to assess where we stand in terms of technical achievements compared to other countries. The United Nations Development Programme has developed a 'technological achievement index' based on eight indicators in four dimensions: technology creation, diffusion of recent innovations, diffusion of old innovations and human skills. The technological achievement index is the average of these four indicators. Technology creation index is calculated on the basis of number of patents received per capita and the amount of royalties and license fees received in dollars by a country. Diffusion of recent innovations is estimated on the basis of number of internet hosts per capita and the share of high and medium technology exports in total goods exports. Diffusion of old innovations is estimated on the basis of number of telephones (landline and cellular combined) per capita and the energy consumption per capita. Human skills is measured by the mean number of years of schooling in the population aged 15 and above and the gross tertiary science enrolment ratio. Tertiary education refers to education at such institutions as colleges, universities or professional schools where minimum requirement is the secondary level of education.

According to the published report of 2001, India's position is sixty-third on the basis of this technological achievement index. The top five rankers are Finland, United States, Sweden, Japan and the Republic of Korea. Before globalization, Indian industry enjoyed market protectionism in the name of 'self-reliance'. The policy of self-reliance imposed tight control on import of technologies, which impeded progress and improvement of manufacturing

efficiencies of Indian industry. With globalization, technological development is becoming more and more competitive. In order to remain in the competition, technological activities in our industries and R&D systems need to focus on increasing productivity, reduction of input resources (raw material and energy), continual upgradation of product design and human skill.

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In order to become a technologically developed country, India needs to build up an interface in universities and research institutes to refer potential scientific discoveries to experts or institutes for their technical development. Conversely, the interface will also place technological problems before the scientists to solve. There are hundreds of capable scientists in the country whose talents have not been tapped properly for technology

innovation. It is important to promote links between universities and science institutes with industry. As an example, the Tampere University of Technology in Finland is linked with Nokia. Industrialists in science and technology spend 20% of their time at universities giving lectures to students in their areas of expertise. These "adjunct professors" work on a challenging interface between industry and academia and students learn the relevance of technology to industry. Closer home in China, Tsinghua University established the Chemical Engineering and Applied Chemistry Institute jointly with Sino Petrochemical Engineering Company which has given more than \$3.6 million to support the university's research activities and recruited more than 100 of its graduates. Chinese universities have also established technological parks which act as incubators for the rapid application of scientific and technological work in industry. In a similar manner, the Government of India should provide fiscal benefits to private firms for research and development to improve the quality and orientation of education at each level, and impart training to workers to remain competitive. It is to be remembered that future lies in technological innovation, not imitation. □

S. C. Roy

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