" In reality, the pace of inventions and innovations in a country is not only determined by the stock of knowledge and skilled manpower that it commands, but also by its ability to recognize unfulfilled wants and the potential market for new and improved products and processes. India now has an elaborate Science & Technology system with a network of several specialized institutions that can enrich invention, Innovation and diffusion of commercially viable knowledge. "

Economics and Innovation

By Surajit Sinha

With limited supply of resources in a country, economic principles and innovations together can mitigate some of the unfulfilled human wants. Economics outlines the principles of production and distribution of goods and services for the development of a country. However, *sustained* economic development of any country requires innovations in the form of new and improved products and processes. Traditionally, economists have recognized the importance of technological innovation for economic development. It partly requires specialized knowledge, and partly economic principles. If technology is defined as the social pool of knowledge of industrial arts, consisting of scientific and engineering knowledge, technological innovations simply utilize this stock of knowledge for the satisfaction of human wants. It is necessary that economic principles ensure profitability of innovations, and innovators make sure that consumers obtain the maximum possible satisfaction from their output.

However, neither economic principles nor innovations can ever guarantee that the society as a whole is better off from its affiliation with either of them. In economics social welfare improves only when someone is made better off without making someone else worse off! Suppose the social costs of producing a product like nuclear energy exceed its private costs, the implied negative externalities associated with the good will reduce welfare of some. In such cases, the net gain to society from innovations will be difficult to measure. Beside environmental costs that are often associated with new and improved products and processes, innovations are also criticized for their labour displacing proclivity. Computers for example have increased labour productivity, at the same time replaced labour intensive production processes in many spheres of economic life. These adverse effects of innovations are more painful in a developing country where the existing unemployment level is too high and firms are more worried about profit margins than social issues like environment.

Therefore, innovations in a country will have to meet two social requirements:

(i) innovations should suit local conditions; and
(ii) social costs associated with these products must lie closer to their private costs.

Among the recent initiatives in the energy sector in India, utilization of biomass to generate electricity for local residents and development of some other forms of energy like solar energy seem to meet these two fold requirements. However, the current trend in macroeconomic policy in India suggests that adopting the western models of development is the best way out of extreme poverty. We see more foreign products in the country and hear about more foreign companies that have entered the country, either through collaborations or on their own. Keeping aside the rising demand for these products from Indians at home and lucrative jobs that these firms offer to our bright graduates, *can this process provide sustained growth in real income in all spheres of economic life in India*? Although one does not wish to question the free market approach to development given the failures of socialist economies the world over, something more beyond liberalization and privatization holds the key to holistic development in India in the coming years.

Invention, Innovation and Imitation

Sometimes, economists have preferred to draw a distinction between invention and innovation. Although it is not very clear how invention differs from innovation, briefly one gets the impression that invention contains a breakthrough in the knowledge content of a product or process, whereas innovation requires at least one step further where the invention or new knowledge has acquired a commercial value. In reality, it is usually a continuum of activities even after the major intellectual breakthrough has been achieved.

Economists' conceptualization of invention and innovation can be traced to Adam Smith. In one of the simplest conceptualizations possible Smith recognized the role of 'division of labor' for growth in labor productivity and specialized inventions, way back in the 18^{th} century. In today's modern economies, division of labor alone cannot enable firms to acquire the edge that they require to survive the continual onslaught from rival firms. Survival entails innovations; innovations lie at the core of success and failure of firms.

In Schumpeter's early writings we find the charismatic entrepreneur performing the most important role in firm inventive and innovative activities. The entrepreneur had the vision to foresee future changes that are necessary for the survival and growth of the firm. The entrepreneur, therefore, must be willing to take the risk of investing in uncertain projects to develop new and improved products and processes. However, in his later writings, Schumpeter shifted towards a market theory of innovation where monopoly position of firms and monopoly profits of firms lie at the core of firm level innovative activities. A related position in his writings brought out the similarities of modern oligopoly markets with monopoly markets where large firms possess the distinct advantage over small firms in such activities.

Inventions expand the knowledge base of a society, and innovations utilize these inventions for the development of mankind. There are some studies that attempted to demonstrate that economic and social factors solely determine inventive and innovative activities in a society. However, both are also determined by the supply side factors that take into consideration the developments in modern science and engineering principles. Inventors are often guided by his or her intellectual ambitions with motivations not always connected with the commercial world. The chance factor also finds mention in the literature.

In reality, the *pace* of inventions and innovations in a country is not only determined by the stock of knowledge and skilled manpower that it commands, but also by its ability to recognize unfulfilled wants and the potential market for new and improved products and processes. Financing of inventive activities is another important issue. If the inventor is allowed to function without any financial constraint, his creativity will occupy the center stage of inventive activity. However, in the presence of financial constraints, creativity will have a restricted influence on the final outcome of a project; in that situation, compromises will have to be made, and at most a second best solution will be achieved.

Inventions and innovations require protection from imitation. Patents, copyrights and other forms of intellectual property rights are sought to protect new and improved products and processes. Otherwise, firms or even individual inventors will have less incentive to participate in such activities. Inventions themselves are not of much use to society. Unless inventions are innovated, neither firms can recover the costs of invention and reap the extra profit from the new knowledge, nor will consumers receive the services from them.

Imitation or dissemination of knowledge in a society is equally important for its development. Although it is true that all inventions and innovations (including sub-inventions) are not patented, patents and other forms of intellectual property rights delay dissemination of knowledge in a society. Society truly benefits from its inventions and innovations when the new knowledge is widely used by firms. Some of the gains from dissemination of knowledge are as follows. As the number of participating firms increase, monopoly position of existing firms decline. Excessive profit margins shrink and market prices fall. Size of national market is another important factor affecting the imitation process. On the other hand, if firms find it difficult to adapt the new technology in their businesses, either due to lack of skilled manpower or shortages of funds, the benefits to the society from such advancement will remain sub-optimal.

Even in the presence of intellectual property rights, enterprising firms and countries like Japan can innovate sufficiently and successfully around the basic knowledge that has been patented. Generic drugs are suitable examples of such innovations and imitations where patent laws are not violated; still, substitute products are made available to the consumers at relatively low prices even in developing countries like ours. In such situations, it is relatively easy to disseminate new knowledge in society. Further, licensing agreements with patent holding companies or research bodies like government laboratories often expedite the diffusion process. This also helps the inventor to earn large sums of money in the form of royalty and other forms of income that can help mitigate the costs of inventing. Authors have reported substantial income from sale of technology by the inventor even after the expiry of a patent because the inventing firm has kept on making minor but important improvements to the product.

Science and Technology Policy

According to Christopher Freeman, inventions and innovations in textiles, metal industry and railroad during the eighteen and early nineteen century owed little or nothing to scientific research. They were based on the practical experiences of engineers and craftsmen. Scientists and individual - entrepreneurs played an important role only in some industries like the chemical industry and some branches of mechanical engineering. The relationship between science and industry started changing with the growth in electrical engineering industry in the later part of nineteen century. This new relationship became more established in the twentieth century industries of electronics and synthetic materials where products and processes depended almost entirely on scientific discoveries. Today, even improvements and modifications in products and processes depend to a large extent on the understanding of scientific principles and laboratory experiments.

The new style of invention and innovation in modern industries requires professional R&D department within the firm, regular contacts with government R&D laboratories, educational institutions, other centers of fundamental research, and above all an acceptance of science-based technical change as a way of life. The rise of science-based technologies altered the production engineering in firms, sales methods, management techniques and employee training. In these firms, more personnel are involved in non-production activities like R&D, marketing, training, technical services, marketing research, patents, etc. Collection of information and data processing and data storage has acquired more importance than production itself. With the advent of information technology industry, consultancy firms have come to exist who do not produce goods; they simply generate, process and distribute information for other firms.

In a market economy firms undertake the bulk of the innovative activities. In most industries, commercialization of new and improved knowledge remains the focus of attention.

Firms also undertake inventive activities. In India, in-house R&D activities of firms are mostly concerned with minor improvements in an existing production process or product. Innovations are often customer driven. Since research is uncertain and expensive, Indian firms feel more confident in spending on development and design rather than get stuck with a long research project! Current data shows that firms in India on an average spend less than one percent of their sales revenue on R&D. Overall competitiveness in Indian industries is still at a very low level; survival does not require the cutting edge technology. In a developing country like India private firms are more reluctant to spend in frontier areas like biotechnology because of the market uncertainty. In addition, traditional industries like the cottage and small industries are often looked down upon because of their inability to compete with modern goods.

Consequently, government spends substantially on fundamental research in India. Its priorities are in the areas of national importance like defense and other public goods, and also in areas of national prestige like space research. Due to

(a) lack of initiatives at firm level,
(b) lack of sufficient funds with firms for fundamental research,
(c) threat of rivals from abroad in an era of globalization,
(d) the need to modernize and develop economically, and
(e) the urgency to reduce poverty,

there has to be a comprehensive public policy regarding sharing of cost of R&D in India and effectively utilizing the usable output from such efforts. National Science and Technology (S&T) policy is not uncommon in western countries. Often it has been argued that only the government can undertake socially gainful R&D projects and make everybody aware of the environmental consequences of their innovations through a co-ordinated S&T policy.

The first systematic effort of the central government was outlined in its Scientific Policy Resolution, 1958. The emphasis in this declaration was two fold:

(i) cultivation of science and scientific research in all its aspects - pure, applied, and educational, and
(ii)training of scientific and technical personnel on an adequate scale.

The next round of formal deliberations on science and technology development in India was laid out in the Technology Policy Statement, 1983 after 30 years of plan failures and controlled economy. It was felt that India had created adequate skilled manpower, hence the emphasis shifted from cultivation of science and development of manpower to the *development of indigenous technology and efficient absorption and adaptation of imported technology appropriate to national priorities and resources.* Some of the broad objectives to be met were as follows:

(a) attain technological competence and self-reliance
(b) gainful employment for all strata in society
(c) make traditional skills more commercially competitive
(d) identify obsolescence and modernize
(e)develop internationally competitive technology
(f) reduce energy demand from non-renewable sources, and
(g)ensure harmony with environment and preserve ecological balance.

There were short discussions in this S&T policy statement that dealt with the need for perspective planning to identify priority areas as well as to suggest time frames for implementation of specific projects particularly where large investments were required. It promised formation of structured S&T groups to provide appropriate support in areas like food, health, renewable energy, housing and drinking water, and diffusion of technology to all beneficiaries. The S&T policy proposed to create suitable financial mechanisms and fiscal incentives for commercialization of technologies developed in laboratories, inventions, adaptation of imported technologies, in-house R&D, and use of indigenous technologies. Finally, it spelt out the need to evolve a system of guidelines for Ministries and government agencies as well as for industries and entrepreneurs to implement effectively the various facets of the policy.

This S&T policy statement of 1983 despite being quite elaborate compared to the first one had guarded statements regarding technology acquisition from abroad. It called for appropriate mix of indigenous and imported technologies to create self-reliant technological development at home that should accord primacy to national interest. Import of technology and foreign investment in this regard would be allowed only on a *selective* basis. Government would identify the priority areas from time to time where import of technology would be allowed, provided indigenous capabilities did not exist.

It is only in 1996 that the Technology Development Board (TDB) was set up with the dual purpose of (i) development and commercial application of indigenous technology, and (ii) adapting imported technology to wider domestic application. The Board has provided assistance in the form of soft loans and equity participation to industry in areas like medicine, engineering, information technology, communications, health and so on.

Central government initiatives towards development of suitable enabling institutions and systems have primarily concentrated on setting up of various committees, e.g. Science & Technology Advisory Committees (STACs) in all socio-economic Ministries, and several independent and specialized research institutions throughout the country, like the Centre for Liquid Crystal Research (CLCR) in Bangalore. Some of these institutions also act as enabling institutions, for instance the Technology Information, Forecasting and Assessment Council (TIFAC). The main objectives of TIFAC include generation of Technology Forecasting/Technology Assessment/ Techno- Market Survey documents, developing on-line nationally accessible information system, promotion of technologies and evolving suitable mechanism for testing of technology and enabling technology transfer as well as commercialization.

Irrespective of the mushrooming of new research institutions all over the country since the Technology Policy Statement of 1983 was released, it is being increasingly felt that the *quality* of skilled people in India is not commensurate with the present and future requirements. Even on a per capita basis, the numbers are poor irrespective of their quality. One estimate shows that India has 22 scientists and engineers and 8 technicians per 10,000 people, whereas the corresponding numbers in the US are 83 and 43. Further, hardly 6 per cent of our engineers and scientists are engaged in research, as compared to 32 per cent in the US.

The mood in the country today is quite different. To quote our present Prime Minister

> "We take satisfaction from the fact that over 100 global companies have come to India to set up R&D Centres …"

Therefore, the stringency in our policy towards import of foreign technology has started receding from our mindset. In an era of globalization and privatization, the Science and Technology Policy, 2003 was announced with some fundamentally different objectives and policies as compared to the previous two S&T policies of the Government of India. *It aims at integrating all participating agents in science and technology activities in the country with the support of appropriate enabling institutions and cross funding of research and teaching activities, as well as through international co-operation.*

Some of the objectives of this latest S&T policy statement of the central government are to

1. promote international science and technology co-operation
2. integrate scientific knowledge with insights from other disciplines and develop inter-disciplinary research

3. establish an Intellectual Property Rights (IPR) regime which will maximize the incentives for the generation of intellectual property by all types of inventors

4. modernize the infrastructure in science, engineering and medical education, from schools and colleges to universities and institutions of academic excellence like the IITs

5. promote basic research in academic institutions

6. give special importance to information technology, biotechnology and material science, and

7. network the existing infrastructure in S&T, investments and intellectual strength, and developments in S&T.

function autonomously. However, they will be reviewed on a continuous basis so that the challenges of changing needs of the country can be accommodated effectively.

(c) Every effort will be made to achieve synergy between industry and scientific research elsewhere like academic institutions and research laboratories.

(d) And, industry will be encouraged to support educational and research institutions.

Therefore, S&T policy in India has come a full circle since its inception in 1958 when creation of adequate and suitable scientific and technical manpower in the country was considered one of the two most important objectives. India now has an elaborate S&T system with a network of several specialized

Science and Technology System in India

Central Government
S&T
Departments

Central Socio-Economic and Other Ministries

Independent Research Institutes

State Government S&T Departments

In-house R&D in private firms

S&T in NGOs

Source: www.dst.gov.in

The proposed implementation strategy in this policy statement contains some new features as well.

(a) Inputs will be sought from the academic world, industry and other professional bodies on a continuous basis for planning and implementation of S&T programs at the center and states, and government decision making in socio-economic sectors.

(b) The academic and administrative systems in science and technology will be allowed to

institutions that can enrich invention,Innovation and diffusion of commercially viable knowledge. Expectations from academic institutions are growing; India's future can be significantly influenced by their teaching and research activities. Economics is being taught in these institutions in the traditional mode where economic models put technology-related assumptions under the umbrella of 'other things remaining constant'. This is practiced worldwide; India is no exception. The theory of firm cannot be replaced completely with new dynamic models of firm behavior, where firms undertake a continuum of technical changes besides maximizing profit. Or, consumer theory cannot be altered sufficiently overnight to incorporate the effects of product modifications and new products on consumer preferences. In the short run, a blend of technical courses from several engineering and science disciplines can be coupled with some traditional and some non-traditional courses in Economics. Such hybrid curriculum may enable the modern student of economics to understand how firms operate in the real world, so that he can communicate effectively with the managers who are busy managing as well as with the firm's R&D department. However, it is the entrepreneur who will always have the final say in the success of a firm in the long run. He is more than a technologist, or a scientist, or even an economist. Schumpeter will call him an entrepreneur because he has the business acumen to foresee the future, undertake risks, and provide leadership such that firms innovate sufficiently and survive well, irrespective of threats from his rivals. Neither education alone can create an effective leader, nor is a national document on S&T sufficient for invention, innovation and dissemination of knowledge in society.

References

- Freeman, Christopher (1982), The Economics of Industrial Innovation.
- Schumpeter, Joseph (1934), The Theory of Economic Development.
- Schumpeter, Joseph (1950), Capitalism, Socialism and Democracy.
- www. dst.gov.in

About the author : Dr. Surajit Sinha is a Professor of Economics in the Department of Humanities and Social Sciences at the Indian Institute of Technology Kanpur. He received his Ph.D in Economics from McMaster University. His research interests include Monetary Economics, Macroeconomics and Industrial Economics.