Changing practices in/of science
The context of Intellectual Property Rights (IPRs) in India

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Changes in the practices and norms of research have changed the dynamics of creation of knowledge. Issues of Intellectual Property Rights (IPRs) and proprietary information and knowledge have begun to give rise to new debates on public goods versus private profit. There is growing concern that dominance of a single view of the natural world as expounded by modern science will undermine these civilisational knowledge systems. There is a fear that the process of globalisation would lead to the appropriation of elements of this collective knowledge of societies into proprietary knowledge for commercial profit of a few. Hence, urgent action is needed to protect these fragile knowledge systems through national policies and international legislation, while providing its development and proper use for the benefit of its holders.

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Clearing the ground

The paths in science and technology innovation have undergone a remarkable change. In the pre-World War II scenario, the only driving force was the search for knowledge. No substantial government funding was available. Scientific research was pursued by a handful of small enterprises. There were a very few industrial scientific research laboratories and a very few industries that supported scientific research. Little interaction existed between academics and the industry. The post-World War II scenario saw the parenthood of research change. Research was entirely driven by the search for new knowledge, on one hand, and, by economics, defence and health, on the other. The government became a major funding body for research. The science-based industries, such as biotechnology and information technology, grew. There was also a growth of industrial scientific research, which enabled to initiate an intense industry-academia interaction.

Then the post-Cold War era came in the context of the bi-polarity of forces that raised its eye-brows after the World War II. The defence base for science started declining. Economic growth and health became the primary drivers for generation of new knowledge. Industrial basic research started vanishing. Innovation driven by defence spending and its subsequent diffusion into society through technology "spin-offs" came in for a major revision.

Advances in knowledge during the post-Cold War era also brought in new issues. Genetic engineering and the associated reproductive technologies on plants, animals and human beings brought forth ethical issues calling for greater regulation by involving social scientists and environmentalists. Changes in the practices and norms of research have changed the dynamics of creation of knowledge. Issues of Intellectual Property Rights (IPRs) and proprietary information and knowledge have begun to give rise to new debates on public goods versus private profit. New models of the innovation chain and new paradigms of the science-economy and science-society contracts have begun to emerge.

Science, technology and innovation: changing models

Some of the old models of science, technology and development are giving rise to new models. Francis Bacon, in his book, *Advancement of learning* published in 1605 had established a linear model of scientific discoveries leading to technology development, which in turn, lead to economic development. We now know that this model is certainly not valid today. Technology is not always the off-spring of science. Quite often, technology precedes science. The steam engine came before the laws of thermodynamics were understood. A major part of new technologies indeed evolved from already existing science and technology. Many advances and innovations in technology are essentially

incremental improvements in existing technologies. A technology can give rise to new technologies, the so-called "spin-off" technologies. It is not only that new science gives rise to new technology, but the reverse is also true: new technology gives us new science.

The other important model was put forward by Vannevar Bush in 1954 in his famous document called 'Science: the endless frontier'. It remained the key framework of science policy in the West and was followed by many developing countries. The 'Bush Model' was a linear one, which assumed that "developed science" will eventually spread into society as useful products. This linear chain of innovation disregarded the socio-economic, organisational, cultural and other contexts including such factors as the character of the marketplace, both domestic and global. Hence, pure science was valued above applied science or technology and the connection of science to its societal context was devalued. As a recent evaluation of the Bush Report observed, "Societal benefits (in the Bush mode) result not in spite of isolation from the broader environment, but rather because of isolation, as autonomy is a necessary element of the scientist's ecology".

Subsequent events have shown that the innovation chain is far more complex than this simplistic linear, unidirectional paradigm of science-push based development. Even in the context of the West, particularly with the emergence of Japan as a technological power, a mix of supply-driven and demand-driven science policy doctrines like the OECD reports and the Foresight initiatives modeled on the Japanese experience began to evolve. The boundaries between basic, applied and socially mandated sectors were becoming increasingly blurred and a hybridisation of scientific communities, which divided tasks between the laboratory and the industry through contract research and consultancy, was taking place.

In the post-Cold War era, the second element of the old contract, namely innovation driven by defence spending and its subsequent diffusion into society through technology "spin-offs" has also come in for a major revision in countries like the USA, where defence spending has led to investment in R & D sectors.

In a global context, therefore, a major S & T issue of discussion is the "conversion of military to civil technologies" and the new concept of "dual use technologies", rather than "spin-offs". Arguments of the past against a defence-led mode of technology innovation have now given way to economic arguments, based on the successes of the industrial policies of Japan and Europe led by explicitly civilian technology.

For example, the aim of the new US Strategy is to redirect the massive US defence investment so that it will become more effective and more supportive for a broader industrial base. As the 1993 US Technology Policy states, 'We cannot rely on the serendipitous application of defence technology to the private sector. We must aim directly at these new challenges and focus our effort on the new opportunities before us, recognising that the government can play a key role in helping private firms develop and profit from innovations'.

The US Technology Reinvestment Project of 1993 is a strong indicator of how dual-use technology development, instead of the notion of "spin-offs", is intended to be pursued in co-operation with industry as a technology diffusion policy approach. This programme is aimed at stimulating a transition of defence technologies to a growing, integrated national industrial capacity.

Let us now turn the focus on the perspective of the developing world. The process of globalisation, dictated by the new global trade regimes under WTO, rapid advent and influence of information technology on all spheres of life, issues linked to IPRs, the growing awareness of the value of the rich traditional and civilisational knowledge systems are becoming crucial in the new paradigm.

The IPR issues: the North–South philosophical divide

Fedrico Mayor, the Director General of UNESCO, made an interesting statement at a meeting of the Third World Academy of Sciences in Trieste recently. He said, 'Knowledge flows from North to South and wisdom flows from South to North'. Is it really true? "Knowledge" may flow from North to South but "usable knowledge" does not flow that easily from North to South, since usable knowledge has

the potential to create wealth. No country or no corporation gives a competitive advantage to another, excepting at a price. India itself has realised this in the post-liberalisation era.

The basic conflict between the North and the South can be simply summarised by the fact that whereas (usable) knowledge does not flow that easily from the North to the South, the wisdom flows from South to North rather easily. Let us understand what we mean by "wisdom" here. Many societies in the developing world have nurtured and refined systems of knowledge of their own, relating to such diverse domains as geology, ecology, botany, agriculture, physiology and health. We are now seeing the emergence of terms such as "parallel", "indigenous" and "civilisational" knowledge systems. In some sense, the flow of "wisdom" form South to North encompasses all these and more. However, the issues that get linked to economics, such as hypothecation of traditional medicines based on indigenous plant resources, get a heightened and somewhat emotional attention.

There is growing concern that dominance of a single view of the natural world as expounded by modern science will undermine these civilisational knowledge systems. There is a fear that the process of globalisation would lead to the appropriation of elements of this collective knowledge of societies into proprietary knowledge for commercial profit of a few. Hence, an urgent action is needed to protect these fragile knowledge systems through national policies and international legislation, while providing its development and proper use for the benefit of its holders.

The dilemma of the developing world

There was a time when knowledge sharing was easy and crediting the original source of knowledge posed no problems. One can illustrate this by a number of cross-cultural examples. When the Arabs imported tamarind from India, they named it Indian date, because, like the date they knew so well, the new fruit also had a stone. To Europe, the numerals were Arabic, not because the Arabs had invented them but because the Europeans learnt them from the Arab world. For Europe, William Champion was the inventor of the process to produce metallic zinc, because it was he, who introduced it successfully. It did not matter that the process had been long known in China and probably still earlier in India; but this did not cause major conflicts.

India always looked at knowledge and especially usable knowledge in a dispassionate way. It is best exemplified by a controversy that arose in 1998 concerning Jagadis Chandra Bose, who is one of the founding fathers of Radio Physics. A story in *The Telegraph* carried the rather sensational title 'Bose Invented Marconi's wireless'. The story was based on a report that the detecting device, called Coherer, an instrument invented by Bose two years earlier was used by Marconi in his development of wireless. Let us understand the background. As early as 1895, Bose demonstrated to an excited Calcutta audience the wireless transmission of radio waves over a distance of 75 feet through masonry.

An early admirer of the Bose cohere was the British navy, which used it to establish effective radio link between a torpedo boat and friendly ships. In May 1901, he wrote to his friend Rabindranath Tagore: 'The proprietor of a reputed telegraph company came himself with a patent form in hand. He proposed to take half of the profit and finance the business in the bargain. This multi-millionaire came to me abegging. My friend, I wish you could see that terrible attachment for gain in this country, that all engaging lucre, that lust for money and more money. Once caught in that trap, there would have been no way out for me'.

Exasperated by Bose's approach towards money, two of his lady friends, British-born Margaret Nobel (better known as Sister Nivedita) and American-born Mrs. Sara Bull on their own initiative obtained in 1904 an American patent in Bose's name. The irony of the situation is interesting. Here, in Nivedita, we have a spiritualist advocating the cause of patents and royalties and a physics professor dismissing the idea. The reason must be sought in their backgrounds: Nivedita was a product of industrial Europe while Bose was a child of the orientalised east. To take this point forward, it is interesting to note that while Bose had this attitude, the contemporary scientists in the Western world had a clear mind especially on usable knowledge, and that did not exclude the great Einstein. Many people do not know that with Leo Szilard, Einstein obtained about 40 patents on refrigeration. In a lighthearted way, I might emphasis that neither the refrigerator nor Einstein benefited from this exercise though!

The context decides the content. There is a new context now and the wealth-making prowess of knowledge is being recognised in the new India now. Why do I say this?

The list of 100 top billionaires of Indian industry based on net worth was published recently. The top five did not include the familiar names, except one. All the other four were people, who owned industries, such as Infotech or R & D intensive pharma. A new phenomenon is also beginning to be seen in India. An R & D savvy, Pharma Company has developed a new molecule. It is undergoing experimental trials. Even the news that the molecule has moved up the innovation path from phase-I to phase-II enhanced the share value of this company; even though the actual molecule may not even enter the market for the next few years! What is this phenomenon? This is the emergence of Indian knowledge industry.

World's major growth industries – such as microelectronics, pharma, biotechnology, designer-made materials and telecommunications – are already brainpower industries. These knowledge industries stimulate other industries, in turn, to become knowledge based.

Tomorrow's world will be dominated by knowledge industries. The emphasis in such knowledge industries is not on physical or tangible assets, but on intangible knowledge assets. Increasingly the traditional factors of production – land, labour and capital – have become less important when compared with technology; the economists have termed this as the 'expansion of the production frontier'. The value of intellectual capital of an industry will determine its rank and competitiveness. The nature of intangible assets will include several commonalties such as research and development, patents, proprietary technologies, databases, brands and even relationships, people and so on. In knowledge industries, there will be a major shift from people, who handled information and did routine and unthinking work, to those who will use knowledge at every stage. For such people, information and knowledge will be both the raw material of their labour as well as its product.

Why are the physical assets such as machinery in a factory, becoming less important? Plant and machinery are tradable commodities today. Even capital was a scarce commodity until recently and was used as a competitive advantage. But, with globalised markets, the companies around the world have access to finances at inexpensive rates. So, even capital is no longer a scarce commodity. It is the intangible assets, which are knowledge based and that are non-replicable, unique and proprietary, that will provide the companies with a competitive edge.

For a cash starved but intellectual capital rich country like India, the emergence of the knowledge industry is a good news. But, harnessing the full potential of knowledge industry requires an aggressive and visionary policy framework, creative planning, daring and risk taking. In particular, heavy emphasis on a stronger IP protection will have to be given to reap the full benefit of the emergence of knowledge industries.

TRIPS and technology transfer: The way ahead

Transfer of technology at fair and most favorable terms to the developing world has been highlighted in all discussions and debates on sustainable development. The Rio Declaration of 1992 as well as most of the multilateral environmental agreements emphasise the need for such technology transfers. The preamble of the WTO Agreement affirms the objective of sustainable development in a manner consistent with the respective needs and concerns of members at different levels of development. Thus, an obligation is cast upon the WTO to bring about easy access to and wide dissemination of technology relevant for sustainable development. It is interesting to reflect upon what happened in the recently held Seattle round, and especially, what the US President said while addressing the Ministers attending the WTO meeting in Seattle: 'We also must help these countries avert the health and pollution costs of the industrial age. We have to help them use clean technologies that improve the economy, the environment, and health care at the same time. And, I will just give one example. Today is 'World AIDS day'. And today USTR, our trade representative, and the Department of Health and Human Services are announcing that they are committed to working together to make sure that our intellectual property policy is flexible enough to respond to legitimate public health crises'. But, the real issues, if I may say so, are truly complex.

We note that Article 7 of the TRIPS Agreement states, **'**the protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations'. Furthermore, Article 8.2 states, 'appropriate measures, provided they are consistent with the provisions of the Agreement, may be needed to prevent the abuse of intellectual property rights by right holders or the resort to practices which unreasonably restrain trade or adversely affect the international transfer of technology'.

Facilitating the access of developing countries to technologies required by them constitutes one of the key elements in accelerating the pace of their economic and social development. Such access is generally the result of licenses and technology transfer agreements. The fact of the matter is that the prospective technology seekers in developing countries face serious difficulties in their commercial dealings with technology holders in the developed countries. These difficulties arise for a variety of reasons. Some arise from the imperfections of the market for technology. Some are attributed to the relative lack of experience and skill of enterprises and institutions in developing countries in concluding adequate legal arrangements for the acquisition of technology. Some arise due to government practices, both legislative and administrative, in both developed and developing countries, which influence the implementation of national policies and procedures designed to encourage the flow of technology to, and its acquisition by, developing countries.

Some of these difficulties may be overcome by suitable safeguards in the domestic IPR laws of developing countries. In addition, the transfer and dissemination needs of the developing countries have to be seen from the point of view of the capacity of those in need of accessing technologies, particularly where the cost of technology may be prohibitive due to economies of scale and other reasons. In such cases, in order to implement the related provisions of the TRIPS Agreement, commercially viable mechanisms need to be found.

The denial of dual-use technologies, even on a commercial basis, to developing countries is another aspect that leads to widening of the technology gap between developed and developing countries. Under this guise, a variety of technologies and products is being denied, which could otherwise have helped accelerate their growth process. This issue also needs to be carefully examined and seriously dealt with as a trade distorting and restrictive measure.

Intellectual Property Rights, biodiversity, TRIPS, ethics and equity

Harmonisation of the intellectual property rights with the TRIPS Agreement, on one hand, and, implementation of the Biodiversity Conservation Act, on the other, is going to be rather crucial in times to come. Both raise serious questions on ethics and equity borne out of inherent tensions between dominant concerns and value systems of the societies of the North and that of the South. In the perception of the South, the principal concern of TRIPS is the strengthening of patentee's rights in the global market. This arises from the TRIPS' requirements to extend the scope of patentability to all inventions, whether of products or processes, in all fields of technology. How some of these will serve the public interest, particularly in vital areas like availability and price of medicines and agro-products and protecting the domestic industry from unequal competition is a matter of concern that many developing countries worry about; India being no exception.

The issue of biodiversity is even more complex, contentious, and tends to get emotional. It is inextricably linked with the means of daily survival (food, health, shelter, energy, etc.) of about 70 per cent of India's population and thus to the rights of the communities. Here, one has a clash between two very different value systems. The traditional societies in the developing world value diversity of life and plurality of knowledge systems besides plant-animal symbiosis and a harmonious adjustment to the environment as the cherished way of living. The information as contained in nature is their principal property and they view the unlimited community as the rightful beneficiary of human knowledge and endeavour. In contrast, a modern, developed society in the typically Western mould recognises only one valid knowledge system, based on rigorous demonstration of causation and a common framework of

communication. The nature of knowledge is intellectual and it is recognised as private property. The beneficiary is one who can pay according to market forces. Diversity is no more than a raw material. The patentee has monopolistic rights, and though there is a sea change in the items sought to be patented, the criteria of patentability have not changed for over hundred years. The concerns of the indigenous populations concerning the loss of both their material and knowledge, as biodiversity is increasingly appropriated by a few, and natural resource stocks deplete and disappear, will have to be addressed urgently and seriously.

Recognising the impossibility of preventing cross-border flows of genetic material in the age of globalisation, one school of thought considers it prudent to build strong data bases on biodiversity and use them to levy charges on bio-prospecting and royalties for their commercial use for sharing the benefits. This stand of opinion would welcome inflow of S & T inputs from outside to add value to resources and export for global market share. The counter-viewpoint sees this reasoning as succumbing to a colonialist option under pressure and argues that in the absence of legal rights for traditional innovators and the collective right of the communities as owners of biodiversity, bio-prospecting degenerates into 'bio-piracy'. The truth surely lies in between. In order to change the notion of 'bio-piracy' to the notion of 'bio-partnership' between the North and the South, we need to move towards TRIPS PLUS which implies TRIPS plus ethics and equity, the latter taking care of the concerns mentioned earlier.

Re-looking at National Innovation Policy

With increasing globalisation, privatisation and corporatisation, a question that is engaging the attention with regard to the process of innovation is as to where do the capabilities for innovation reside. Till the other day, it was believed that they reside in nation-states. Certain nation-states were able to create the climate and provide the infrastructure, which spurred the innovative genius; certain other states failed to do so. This led countries to devote thought to building up a National Innovation System and evolve a National Innovation Policy going beyond the National Science policy or National Technology policy. A national innovation system was seen to be embedded in larger institutions, labour market, government policies and biases, regulatory framework, legal system and the way these elements related to and interacted with each other. While the idea of the Innovation System has not become invalid, the National part of it is losing relevance, as R & D gets increasingly internationalised, the world becomes more and more integrated and the idea of the autonomous nation-state starts fading.

Different nations regard innovative capabilities as residing essentially in firms as these are characteristically a function of the intertwining of scientific and technological capabilities of a firm with its organisational and management capabilities and strategies. Some even thought that innovation flourishes in certain geographical regions with special attributes of history or talent, like Silicon Valley in the USA, or Bangalore in India, while some view global networks as the essential seat of innovative capabilities in the emerging R & D paradigm. These rival views are not necessarily mutually contradictory and they may be valid within their limited contexts. However, they do not point to the fact that while it may be appropriate to think in terms of "technology systems" that encourage or inhibit a culture of innovation, it may be a bit artificial to seek such systems within the political boundaries of a nation. I will deal with this important point a little later again.

Innovation in global economy

Advances in communication and information technology have connected the people and the places of the world as never before. It made the vision of a global village a physical possibility. This was aided by the end of a bi-polar world following the collapse of the Soviet Union and the aggressive pursuit of its economic interests and ideology by the developed world. The reality of globalisation is very evident in the sphere of economy. International economic integration has proceeded apace as seen by the galloping world trade, integration of financial markets and the changing character, increasing clout and expanding activities of the multi-national corporations (MNCs).

An interesting feature of the world trade is the emergence of three powerful economic groupings, viz. The USA-led NAFTA, the European Community and the Far Eastern Group of Countries led by Japan. All the three groups are technological powerhouses. That leaves out most of the developing and underdeveloped countries, which have to evolve their own strategies to survive in a ruthlessly competitive world. The most far-reaching changes for global integration are, however, being wrought in the area of international finance. It has made 24-hour global trading a reality; it has also made it easy for foreign institutional investors to follow market developments and respond. It has facilitated internationalisation of portfolios and helped the banks and securities houses in their role as managers of large-scale capital flows. The international finance sector has been extremely innovative creating entirely new financial products like Swaps, Futures, and Options for the market. The economical globalisation obviously needs effective regulatory structures for global finance but such political structures at the international level have not yet emerged.

One would do well to take note of the geographic dispersal of R & D activities by multi-national corporations (MNCs). It is important to understand the causes, nature and implications of this trend because technological change is central to economic growth. It is also necessary to comprehend the corresponding structural changes that would be necessary to capitalise on the emerging opportunities. A fundamental change seems to be taking place in the nature of the MNCs. They are no more tied down to a home country in terms of a base for organisation, capital and R & D. Increasingly, they are ceasing to be the controlling and co-ordinating centres for a set of peripheral and independent national subsidiaries and acquiring the character of a network where national units are viewed as sources of ideas, skills, capability and knowledge to be harnessed for the total good of the company. International exploitation of national technological capabilities by major firms is on the rise. Let us discuss this issue further.

Research as a global business

The compulsions of international trade and commerce and the phenomenal advances in information and communication technology have made a globally integrated world a reality, and there can be no sequestered islands in today's world. As technology is the prime mover of modern economy, the economic integration of the world cannot be complete, if industrial research is not globally integrated. The globalisation of R & D implies that the premium will be on research as a means of wealth creation, pursued as a business proposition, seeking exploitable knowledge in worldwide collaboration.

The globalisation strategy now includes taking over of R & D intensive corporations. Japanese, for instance, have promoted a new concept of "techno-globalism", which is being interpreted as 'the strong interaction between the internationalisation of technology and the globalisation of the economy'. It actually implies 'widening cross-border inter-dependence between individual technology-based firms as well as economic sectors, especially through the restructuring of high and medium-tech industry'. Incidentally, it is interesting to note that the intensity of such transnational co-operation and setting up of R & D facilities is the highest in high-tech areas, such as electronics, biotechnology, automotive industries, etc.

The innovation chains will increasingly cross-transnational boundaries today. Companies realise that to gain competitive advantage, they have to leverage their capabilities. Many companies across the world today consider it to be rather unwise to attempt self-sufficiency in technology development, particularly in an era, where the R & D costs are increasing rapidly. With trade barriers among countries disappearing fast, companies have to provide the best technology globally to their customers. As a part of the global innovation strategy, several companies world over are scouting for new ideas and patents, which the originator is unable to exploit for a variety of reasons.

There is another interesting and subtle aspect to the whole game. The globalisation of R & D is closely linked to globalisation of business and consequently to global competition of skills. The competitive advantage in high-technology business increasingly depends on underlying technical skills of the business rather than on particular products. As product-life cycles keep on becoming shorter, skill-life cycles become longer. The product then is merely an intermediary between company's skills and the market it serves. Rather than being the focus of corporate activity, products are actually transient

mechanisms by which the market derives value from a company's skill-base and the company derives value from the market. The high technology companies are, therefore, asking as to what skills, capabilities and technologies should they build up, rather than asking a stereotype question, as to which markets they should enter and with which products.

Several factors are helping to accelerate the globalisation of industrial R & D, but the most important factor that is helping the process of creation of "seamless laboratories" around the world is the evolution of global information networks. In this emerging scenario, India is well poised to become the global R & D platform of the 21st century. Why is this so? The first and foremost factor pertains to the lower costs of doing research in India. It is remarkable that the entire S & T budget of India in a year, which included space, defence, atomic energy research, did not exceed 2.5 billion US dollars, whereas the budget of Siemens alone is 5 billion dollars! This cost-effectiveness gives India a strong competitive position. Secondly, the high quality science base prevalent in India in certain select areas is a big attraction especially when one recognises that industrial R & D is becoming increasingly science-based. Thirdly, the companies perceive that such collaborations provide specific mutants of an existing technology or a new technology that is fully adaptable to the distinctive conditions prevailing in India. The fourth factor is the perception of the new environment in the post-liberalisation era in which Indian R & D institutes and industrial firms will operate, where factors such as improved freedom and flexibility, better communication and IPR protection, improved consciousness about quality and time of delivery, will improve dramatically. Paradoxically, the prospects for North-South partnerships in research and technology are thus looking more attractive than ever before.

The politics of a global village

With the integration of global economy, the world is on its way to integration in other spheres. Some features of the post-bipolar world are already distinguishable.

There are already enough pointers to indicate that only certain political philosophies and structures are acceptable to global community. Human rights are understood in the Western context, and a democratic polity is the prescribed dispensations. Concerns of national, regional and global security are coming to the fore and new alliances are in the making. The threat of an all out nuclear war seems to have receded, though there is a proliferation of the nations having possession of or access to nuclear power. The number of regional conflicts has expanded, and though the super power arms race has stopped, the motivation of smaller powers to acquire military might through acquisition, or by indigenously developing weapons and systems of modern warfare has increased. The UN is on decline as an overarching global mediator.

A net result of the strivings for globalisation is the weakening of the nation-state and a dilution of the concept of national sovereignty. States are becoming increasingly less important as political units to control whatever phenomena – economic, sociological, environmental or technological – is taking place in the world. The erosion of national sovereignty is seen in the proliferation of regional trade and economic agreements, growing economic power of the MNCs and the conditionalities imposed by international financial institutions for accessing resources under their control. These developments are redefining issues of power and authority over the control and management of resources for development and bringing to the fore inherent ideological and cultural tensions.

Information technology and democracy

We are in the early stages of a digital revolution that is changing the way information is generated, owned and used. This revolution will enable democracy to be more integral to all human endeavours, our government, our business and our personal lives.

The basis for democracy and a pre-requisite for its long-term success is an informed public. The fundamental political changes in Eastern Europe, Ireland, East Timor, and South Africa were all possible because, try as they might, those governments were unable to control the generation and distribution of

economic, political and social information within their societies. Once that control is lost, democracy is inevitable. Chinese students found that fax machines were more powerful than rifles.

First, the people must be literate enough to be able to read and understand the information that is relevant to their lives. Television and radio have been revolutionary tools in this sense. But the written word, plastered on a wall, passed out on the street corner, remains an essential tool for social change. People must be able to read and write in order for democracy to succeed. We need to take note of this in India.

Secondly, democracy requires that people have open access to certain basic economic and political data and to a diversity of opinions. This requirement means an access of information to all.

People must be able to share their ideas with others. Information technology is making it possible to reach beyond time and place to a wider community of citizens. The content creation is, therefore, going to be a crucial part of the strategy, since information could be now used for a variety of purposes, from propaganda to enlightenment.

Despite the crucial importance of access to basic social and political information in the democratic process, there is no public agreement concerning what information should be broadly accessible. Maybe, we need to develop a Bill of Rights on Information, which will establish the public policy concerning the accessibility of certain basic information to all citizens, dealing with both our rights of access and our rights to privacy.

Proponents of the current intellectual property system maintain that only the market economy can provide the appropriate incentives for efficient and effective distribution of information. They argue that large international publishers have contributed to making information a global commodity; that without the investment of these companies, there would be less information, it would be of lower quality, and would cost even more than it does, and that which did exist would be less accessible to potential users.

Not all information, however, is adequately served by the market economy. The basic infrastructure of knowledge, including history, philosophy and the arts, as well as minority opinions are essential to a healthy democratic society. These areas require a “social investment”, on the part of the community.

A monitoring system to measure the quantity, quality, and impact of different kinds of information upon the economy and society is needed. We have such information with regard to literacy today but not with regard to the issues of access and interaction. We need a set of indicators to serve as a basis for regular monitoring and reporting on the state of our information systems. Technology is not value-neutral. Certain technical developments are more likely to serve open democratic processes than others. Government should create and implement a development strategy for information technologies that is supportive of democratic processes. Such a system should explicitly address the three goals of literacy, access and interaction and the roles of the private and public sectors in promoting those processes.

Finally, it is important to note that the advance of information technology will not only force a review of the legal and practical meaning of the notion of individual privacy, but also that of the ‘privacy’ of nations. Furthermore, the existence of inexpensive, multiple and worldwide network for communicating information will shift power from government to individuals. The netizens will have a world of their own. While information technology will vastly increase the power of a government to monitor its people, the government’s control over the information distribution will be diminished. Information will still be power – but it will be a shared power. The increased worldwide distribution of information will also lead to increased awareness in less developed countries of how the people with superior life styles live. This will provide interesting driving forces, both nationally and globally. The availability of information network will diminish the reliance on elected representatives and technical experts to make decisions on behalf of the public, at large. The forum of public opinion rather than ministerial negotiation will control the final decision. This will also mean that greater attention to ‘quality’ of information available to electorate will be important.

Towards conclusions

As we come to the end of this millennium, it has become mandatory for every speaker to speak about the new millennium scenario. With the rate of knowledge doubling every five years, it is becoming difficult to predict the future. As someone has said 'A technology of the 20th century' symposium held in 1895, based on the level of knowledge that existed at the time, might not have mentioned aeroplane, radio, antibiotics, nuclear energy, electronics, computers or space exploration! What are the equivalents of this that will be missing when we make predictions in technology, at the dawn of the next century?

In the first half of the 20th century, physics occupied a dominant position. But, bio-sciences displaced physics in that leading role now. It is not cellular and molecular biology alone, but also ecology, that is taking biology to a different level of impact. The technological potential of biology will pose a new challenge due to its intimate connection with agriculture and health, areas of great political sensitivity and social importance. Technology transfer in biological fields does not relate to just sharing the luxuries of a consumer society but also to sharing the means of survival. The issues in trade and technology negotiations thus become far more complicated. The new shifts in the coming century will be hard to predict, but it is quite clear that the continuing wars of information revolution and the felt impact of the 'gene revolution' is shaping the future of the mankind, which will have a profound impact on global economic and socio-political scenario, that will be hard to anticipate today in its full measure.