Getting ready for knowledge era*

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Dr. Kakodkar has also given notable leadership to human resource development in the country. Establishment of NISER (National Institute of Science Education and Research), DAE-Mumbai University CBS (Centre for Basic Sciences) and HBNI (Homi Bhabha National Institute) are among several of his initiatives in this direction. He has chaired several national committees and governing boards of many institutions like IIT Bombay and IUCAA.

Dr. Kakodkar has won numerous professional awards and recognitions at the international and national levels and has been bestowed Doctor of Science (Honoris causa) by many academic institutions. For his stellar service to the nation, he received the Padma Shri in 1998, the Padma Bhushan in 1999 and the Padma Vibhushan in 2009.

Preamble

Knowledge evolution has been central to wellbeing and prosperity of societies. In the context of the knowledge era that is fast emerging, this has become crucially important. Economy of nations and societies and their relative competitive advantage is now strongly linked to their capability with respect to knowledge and knowledge products. Raw materials, human resource and technologies are the three basic ingredients to support economic activities and wealth creation. Leveraging latest knowledge is the key to maximise gains in respect of all three. We are now by and large a raw material resource poor country. Our demography is very favourable and is potentially the engine for our growth. Sustaining our growth and our relative competitive advantage however depends on the level of knowledge empowerment of our people and knowledge products they can bring out. This is a major challenge for our education and S&T system. The challenge is even bigger in the context of rural India where two thirds of Indians live.

Introduction

India was known to be the richest country in the world till about 1700 CE. India was also a seat of knowledge with strong cultural and trade influence the world over. The decline of Indian economy in relative terms thereafter roughly coincides with the latter part of Mughal and the

subsequent British rule over India. This was also the period over which the industrial revolution took shape. One can conjecture that India could not withstand the competition posed by industrial era. While there may have been a variety of factors, beyond the control of the Indian society that was under the foreign rule, that led to this situation in a country that was a

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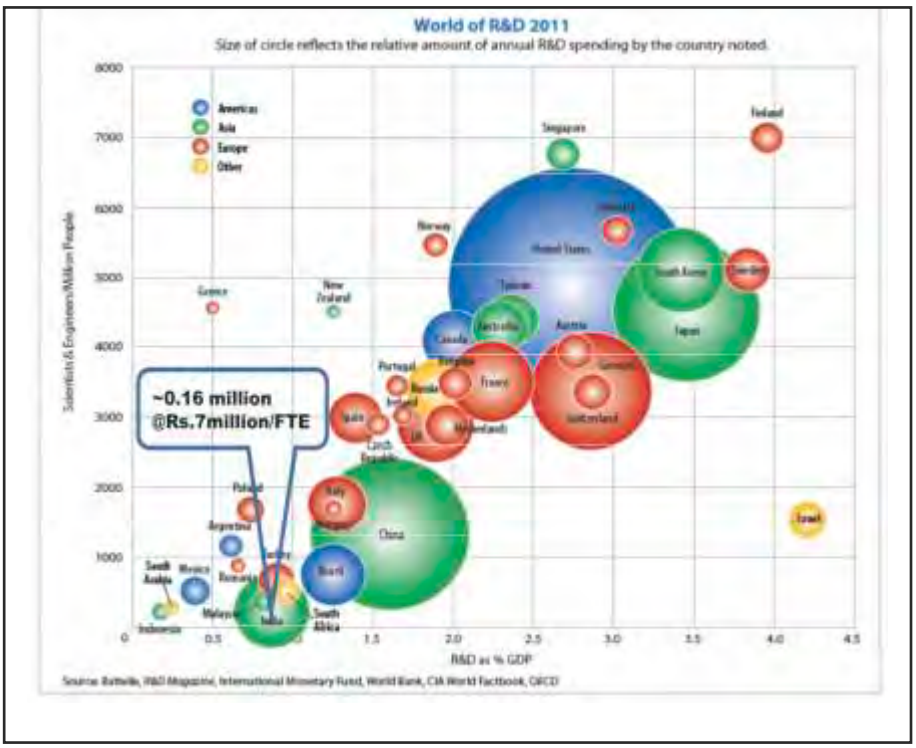
leader in knowledge and technologies of the time; we now need to recognise the new opportunities and challenges of the emerging knowledge era and ensure that independent India does not lag behind in the new competitive environment. We also need to build more robust systems and structures that are not vulnerable to negative influences arising out of external and internal factors that may arise.

Expectedly, thanks to our large youth population presently, the relative GDP of India has started showing signs of improvement in independent India. Ensuring a quality of life of our people at a level commensurate with other developed countries would however necessitate our per capita GDP to match, at least in $ppp terms, with per capita GDP in those countries. There are however a number of structural / policy corrections as well as deep seated socio-cultural transformations, particularly in the education, research and innovation domain; that are necessary to ensure that we can sustain the relative global competition even as India approaches the top slot in just GDP terms to begin with. Efficient translation of new knowledge to competitive products is the key to success in today's interdependent world. We need to be able to build a competitive technological edge to win this competition. Clearly education, research and innovation framework in the country is the crucial factor in our ability to succeed in the new paradigm.

Apart from their impact on economy, technologies bring in several essential strengths to the nation. Technology is the key to comprehensive national power. Technology enables strategic autonomy against restrictive regimes that may be driven by external political, economic and military interests. Sui generis understanding of technologies enables robust decisions that avoid vulnerabilities that can arise out of vendor driven decision making about technology choices and related policies. Most importantly, technology empowers citizens and societies. This however is a double-edged matter. Along with induction of technologies, there is also a need to prepare societies to comprehend impact of new technologies and recognize issues of ethics and value system involved. Sustaining and cultivating constructive mind set in the context of new technologies particularly among the youth must keep pace with emergence of new technologies on the scene.

Current scene

While there is recognition of the importance of high quality in education, high excellence in research and a conducive innovation eco-system for national economy, our education and research outcomes are far short of desirable expectations in this context. 'ASER' reports brought out periodically by Pratham tell us about of the state of our school education. In the context of our higher and more particularly technical education, employers are often not able to find employable candidates even as there are a very large number of unemployed graduates. Most of our higher education institutions do not do any significant research. There are a few institutions where good research does take place. However even here, translation of research outcomes to marketable technology products is far from being satisfactory. There is thus an urgent need to enhance the level of excellence as well as a rethink in orientation in our education, research and innovation eco-systems such that our youth can realise their full potential and simultaneously enable access to such quality education and research opportunities to all, bridging



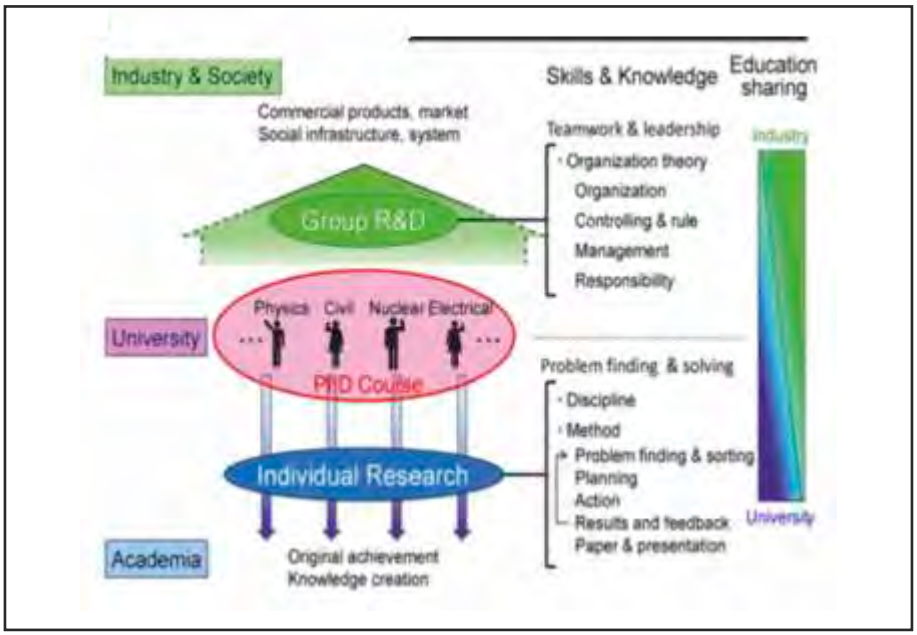
the urban-rural as well as rich-poor divide. Talking about research, thanks to interventions implemented by DST, research output as measured through research publications from India has significantly gone up in recent years. We, at the moment invest around 0.8% of our GDP in R&D. While there is a strong case for enhancement in this level of investment and take it to a level of around 2-2.5% of GDP to make it comparable to countries with whom we would like to compare; we need to be also conscious of the fact that, in absolute terms, we actually spend more or comparable money on R&D as compared to countries like Israel, Canada, Sweden, Switzerland, Finland and even UK. We also need to recognize that our expenditure per full time equivalent S&T professional is actually comparable (in $ppp terms) with the best in the world. We thus need to question our not being able to be comparable with the countries listed above in terms of technological capability that can dominate the market place. Clearly we need to make our investments in R&D much more productive in this context.

On taking a closer look at say top 15 items of our imports and exports, one finds that most of the goods/product categories in both lists are common with imports dominating the exports. Total balance of payment corresponding to these 15 items even after excluding oil imports amounts to around $ 60 billion. Clearly competitiveness of our value addition activities needs to improve a lot with technology having to play a major role. There are of course notable exceptions like the vehicles, pharmaceuticals and clothing. However, industry duly supported by Govt. policies seems to have played a far greater role here. Clearly there is a need to focus on translation of our knowledge and research to technologies that would make value addition in high import areas globally competitive.

Recently Technology Information Forecasting and Assessment Council (TIFAC) has come out with a Technology Vision 2035 that looks at Indians in 2035 and their needs and prerogatives. The exercise has identified a spectrum of technologies for meeting the prerogatives and also worked out road maps in different technology areas for the country. Clearly our R&D efforts need to be geared up to ensure that the future technology needs are met through made in India products specific to our needs.

The way forward

There are several transformations that we need to bring in to make our R&D investments more productive and enhance our national competitive edge. Presently, by and large, a restrictive silo mind set dominates us. This has to change. We need to build strong linkages between education/teaching and research. Further a University or a research institution should become a confluence of academia and industry/society where one seeks original achievement and knowledge creation through individual research on one hand and at the same time promote development of technologies and solutions for industry and society through group research on the other. Pursuing fundamental research devoted to knowledge creation, which could also lead to disruptive technology and applied research necessary for sustained technology evolution, together would need a major cultural shift to be brought in through sustained and painstaking efforts over a significant period of time. While the design of the research framework within a knowledge institution has to be based on institutional mandate, the framework must enable translation of outcome of research effort across the full spectrum of potential benefits ranging from a forward push to knowledge frontiers to creating a sharper technological edge and larger economic gains for the nation/society. Such translation could be done within



the institution or in collaboration with closely linked sister institutions or through other modes of broader networks among institutions. A degree of hand holding over a period of time is however essential in all modes. In any case the nation cannot be deprived of the potential benefits out of investments in R&D simply because of lack of interaction among people or institutions across the research translation chain. The institutional value system thus should create a motivating environment for such translation without in any way diluting excellence with respect to primary institutional mandate. The yardsticks of measuring excellence in diverse set of activities involved would need to be evolved carefully. Basically, we need to be able to account for impact on peers in core area of the individual researcher, impact of applied part of his/her research on downstream partners and impact of his/her efforts in technology translation on the society/industry. The overall assessment should then integrate these impacts with due recognition of overall institutional mandate.

Seen in above context, we have two basic challenges in our higher education and research system. The first one relates to quality in whatever the institutions or its members are doing. Unfortunately, the performance of a larger fraction is inadequate. There are a number of interventions now in place to correct the situation. The second challenge relates to creating and nurturing right ecosystem in our institutions so that the translation of research for economic benefit of the nation is facilitated. While there is awareness on this count and a few good examples do exist, much more needs to be done.

A look at the correlation between the number of PhDs in science and engineering in areas that lead to new technologies and the national GDP, for different countries, underscores the need to enhance the output of such PhDs in our country. We should target reaching around 20,000 such PhDs annually to be competitive with major world economies. At present, we may be around one fifth of this number. There has indeed been a major push to PhD output from IITs, some NITs and other engineering education institutions in last few years. There is optimism that the target would be achieved in next 5-10 years.

Over and above high quality education and research institutions with right eco-system, we also need a more conducive environment to support entrepreneurship among university graduates and others to take a technology from the University to market place. In this context, it is interesting to recognize that our IITs

have been ranked (at 4th position) at one stage, among the top 10 universities of the world in terms of producing founders of new ventures that have attracted investments. This however has happened outside India. In principle, we have larger number of IITians back here in India. Further the total number of engineering graduates that India produces is around 200 times more. Founders from IITs during the period Jan. 2009 to July 2014 have attracted more than $ 3 billion investment. Imagine the potential of IITs contributing to India's economy with right environment to support entrepreneurship here. Trends of such a thing happening are already visible. If the quality of all or most of engineering education institutions in the country becomes comparable to IITs, that could become the single largest factor to boost India's economy.

While encouraging the startups and more broadly the culture of taking university research to market place, we need to recognize that such translations have to negotiate a number of valleys of death. This invariably requires efforts which at times are much larger than demonstrating a proof of principle in the laboratory. Our support system for such translation is however much smaller in proportionate terms. While we need larger support systems for this purpose, more importantly such support must be characterised by synergistic symbiosis between academic and commercial domains with the commercial domain playing increasingly greater role as we move from research to development to commercialisation. Academic domain should however remain connected through out although the level of participation may progressively decrease. Over and above the new technology push, for research – technology commercialization translation to move forward, one needs to create a significant policy as well as market pull. Demand driven R&D thus assumes importance not only in creating the necessary pull but also in

shaping our innovation eco-system. This later aspect is important in the context of present state of our R&D system. The areas where such demand driven R&D could be given impetus can be decided on the basis of medium to long term national/ strategic priorities. Our laboratories and industry together, can be challenged to develop products that can meet an identified functional need. While a partial financial support for a few (2 or 3) most attractive proposals can come through public funds, such products if they qualify specified performance criteria could be given assured trial business of reasonable size to begin with. The product must with stand market competition thereafter. It is important that such schemes are driven by user ministries in the Government. As mentioned earlier, demonstrated success in this mode would also motivate industry to invest in product development involving knowledge institutions for their own product development efforts.

Another mode of demand driven R&D could be to work out domains of pre-competitive research based on national priorities in consultation with relevant industry bodies and task our laboratories to work on them on priority and with involvement of the industry. Availability of such public funded relevant open source knowledge base would then enable individual industries to shorten their product development cycle and also reduce development costs.

Market entry of a domestically developed new product is a challenge in itself. There must be strong policy support for at least a limited scale field deployment of any technically well qualified new development, notwithstanding the absence of large scale deployment experience.

While pursuing a domestic product development, one should also pay attention to the entire supply chain and address the issue of vulnerability that can arise as a result of any input element being blocked at a later point in time. Alternative sourcing strategies must be in place. Under the make in India initiative as also under the offset arrangements linked to mega purchase items, a lot of new technology is expected to be deployed in the country. It would be important to link our knowledge institutions to assimilate and internalize these technologies as fast as possible.

For India to develop a competitive edge in technological terms, we need to pay attention to aspects described above. It is clear that while Govt. interventions may be necessary, our scientific community transforming itself is of crucial importance.

Rural Development

Rural development in India needs to be given a special focus. Two third of India lives in villages with less than half per capita income as compared to urban areas. Bridging the urban rural divide at least in terms of livelihood opportunities is thus a matter of urgent necessity in our country. The emerging era of knowledge driven economy that facilitates democratisation and decentralisation of economic activities is thus a great opportunity for transformation of rural horizon. CILLAGE – a knowledge integrated sustainable village livelihood development model, that leverages new and appropriate technologies, aims to eventually create a knowledge society in rural context, even as it starts creating additional livelihood opportunities in villages around a selected knowledge institutions.

In the CILLAGE concept, a local Higher Technical Education Institution (HTEI) serving as a Knowledge Partner (KP) hosts a Rural Human and Resources Development Facility (RHRDF) and linked with local community institutions and NGOs, works for deployment of appropriate technologies for enhanced livelihood and related

educational and knowledge support in the neighbourhood. Technologies chosen are initially in the field of water, power, fuel, new seed multiplication, tissue culture, agro-processing, agro services, health and sanitation through waste management, training and skill development programmes along with ICT enabled infrastructure for constructivist school education with sharable OERs (Open Education Resources). To facilitate sustained and comprehensive engagement between RHRDF and the neighbourhood, a number of AKRUTI (Advanced Knowledge based Rural Technology Initiative) subcentres need to be established in proximity with existing schools. RHRDF and AKRUTIs would be the bridge between HTEI and the neighbourhood to spread technology enabled livelihood, ICT enabled school education etc. on one side and solving problems in implementation of new technologies and search for new R&D problems on the other. The eco-system so created could also participate in deployment of other Govt. Schemes.

Spread of technology adoption and continuous access to new technologies could create better livelihood opportunities in rural domain that eventually compare well with opportunities in urban domain thus leading to convergence of best of city (i.e. opportunities for self-progress, modern infrastructure around HTEI etc.) with best of a village (i.e. clean, calm and eco/human-friendly environment). Thus, the selected cluster of villages (Cillage) around a vibrant knowledge institution can be expected to become preferred working destination for young innovative and creative generation for leveraging local human and raw material resources on one side and new knowledge technologies on the other. Cillages could thus become places, better than both cities and villages and may become the preferred habitats for the new age society in most of emerging India.

This approach is being tried out on an experimental basis at Pandharpur Cillage in Maharashtra.

Nurturing culture of innovation in schools and colleges

To prepare young generation to be effective participants of the emerging knowledge society and nurture a spirit of innovation, we need to pay attention to them right from their time in schools and colleges. The learning environment around them should be fully capable of nurturing their inquisitiveness and addressing their curiosity. For this purpose, apart from their formal structured engagement for learning science, students should have access to science & innovation activity centres (SIACs) that enable self-learning and understanding of science concepts through unstructured hands on experimental science activity under the guidance of mentors. Such SIACs should be established at least one in every district and be accessible to students in a time-sharing mode. Spirit of innovation not only entails ideas to address a challenge or to create a new improvement but more importantly the ability to successfully implement the idea to its logical end. Today we have a large number of MSME units that have a number of technical problems that they are not able to attend to because of their difficulties either related to working capital or availability of qualified engineer. Most of these problems are within the capability of engineering college students who in any way are required to do project work in industry as a part of their curriculum requirements. It is thus important that as a part of this requirement, the students are mentored to actually solve a problem in industry. Quite apart from meeting an important industry need, such opportunity for students would be a valuable learning experience in terms of solving real life problems leveraging the knowledge acquired by them in the college. Such MSME internship schemes, aimed at actual problem solving in industry, for engineering college students has been piloted by TIFAC as well as Rajiv Gandhi Science and Technology Commission. There is a need to scale this activity up to reach throughout the country through appropriate Govt. schemes.

I have earlier mentioned about the link between the number of PhDs in science and engineering in areas that lead to new technologies and the national GDP. Clearly, there is a need to encourage connections between such research and relevant industries. CII-Prime Minister's fellowships for PhD scholars has been designed with this objective in mind. The number of such fellowships should become commensurate with our national needs. Finding such PhD scholars in adequate numbers is however a challenge at present. Concerted efforts are required on part of both academia and industry to translate new knowledge into new technology on a massive scale.

Research Parks located in or around a University where industry carries out its own R&D with close two way linkages, between industry researchers and university faculty as well as students, facilitate nurturing an ambiance of high tech innovation that benefits both the students as well as the industry. Together with incubators and research activities in

the university, they contribute to a comprehensive innovation eco-system in which students can be nurtured through real life innovation experience while they acquire knowledge. The number of such research parks in the country are few. Their number is growing. However, we need them in large numbers, say in hundreds.

Closing remarks

It is clear that we need to do a lot in terms of knowledge empowerment of our society. Taking into account our large youth population, large disparities in terms of learning opportunities, rapidly growing influence of knowledge on economy and imperatives of our being competitive in view of our large domestic market; there is an urgent need to prepare our society to be ready to meet challenges and benefit from opportunities of the emerging knowledge era. We can't afford to lose out the way we did during the industrial era. Knowledge, society and economy together form a threelegged stool. Society and economy invariably remain connected. That's an imperative of human survival. While that may sustain trade, without knowledge linkages, the values and wisdom could be a casualty. Knowledge is therefore an essential element for stabilisation and sustenance. A deeper engagement of knowledge with society and economy also contributes to technology that makes both society and the economy stronger through deeper values and wisdom.