IDSJ Working Paper 165

India and Knowledge Economy

Prospects for Development

Surjit Singh

March 2013

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March 2013

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Printed at : Kumar & Company, Jaipur
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1. Introduction

Knowledge has been of decisive importance in mankind's development and has been always an essential force in economic development[1]. But in present day's increasingly knowledge-based world, more and more countries are embracing knowledge and innovation-related policies to spur growth and competitiveness. At the same time as their institutions are weak, many developing countries are struggling to find ways to produce relevant knowledge and transform it into wealth, as well as to adopt disseminate existing knowledge for their development (World Bank 2007). There is link to traditions in building knowledge base. For instance, traditional knowledge of nomads helps in explaining the movements of dunes and meteorological change. Humans have used restlessness of animal to predict earthquakes. Convergences of traditional and modern equipment like computers and satellites create synergies for advancement. Globalisation and rapid technological change have made knowledge[2] a critical determinant of competitiveness in the world economy. In both developing and developed countries there is an increasing institutional awareness of the importance of knowledge for business performance, economic growth and development (Navaretti and Tarr 2000). With globalisation, the information revolution, and increasing demands for a highly skilled work force, it is clear that nations must accord high priority to building the capacity to effectively utilise technology in education. In the recent times, the study of the forces that shape the rate of economic growth has become one of the most active areas of research in economics (Rebelo 1998)[3]. India had made tremendous strides in its economic and social development in the recent decades or so and lost traditional knowledge base too. Despite its poor show in agriculture sector, growth in industry and services sectors have shown significant potential. Sustained acceleration in growth is required to provide opportunities for India's growing population and its even faster-growing workforce (Dahlman and Utz 2005). Knowledge- base is increasingly determining the future course of growth process of Indian economy. India has a rich choice set in determining its future growth path. Like Ireland and South Korea that have used knowledge effectively to enhance the growth, India too would have to rely much more on knowledge to strengthen the growth trajectories. Knowledge can make a difference between poverty and wealth (Dahlman and Utz 2005). The present paper tries to look at few pertinent issues that relate to knowledge economy and ascertain India's position in this context.

2. Knowledge, Resources and Rent

Knowledge is difficult to get, whether through creation or purchase. Knowledge involves combination of facts that interact in tangible ways. Because of this, it constitutes an entry barrier to growth. The entry barriers then create the rent earned from knowledge, which include technological, human resources, organizational, and marketing and design. These are, however, transitory in nature, but require regular renewal. The table below does show that all sectors would gain from advances in knowledge, be it a traditional sector or a modern sector. Since the theoretical constructs of Adam Smith and Schumpeter, the role of innovation in economic growth has become vital. Technological progress is important for economic growth, which Solow amply demonstrated.

Knowledge and Natural Resource Rents

Type of rent	Previous areas of rent	New and emerging areas of rent
Natural resources	High grade copper deposits	High grade platinum deposits
Knowledge		
Technology	Copy lathes	Computer aided design
	Internal combustion engines	Fuel cells
		Biotechnological applications
Human resources	Tool making artisans	Software engineers
Organisational	Mass production organized by managers, quality inspectors	Continuous learning management of just-in-time supply chains, single-unit flow, and quality at source
Marketing and design	Levi-Strauss(manufacturer-brand)	The Gap (retail chain)
Relational	Short-term and arms-length buyer-supplier interactions	Long-term discussion-rich relationships within supply chains

Source : Adapted from Kaplinsky (2005).

We have modern theories that help in justifying government action and investment in public goods such as education and infrastructure, which facilitate the use of knowledge and innovation (World Bank 2007). The whole gamut of literature on explanation of growth performance and role of total factor productivities leads us to contribution of knowledge. How effective is the use of both human and physical capital is paramount.

3. A Knowledge- based Economy

Knowledge improves nutrition[4], cures epidemics and protects against natural dangers. All economies are knowledge- based, be it traditional or modern depending upon what they have preserved and what they have lost. However, the difference today is that rapidly growing economies depend more on the creation, acquisition, distribution, and use of knowledge. The effective use of knowledge is becoming the most important factor for international competitiveness and for creating wealth and improving social welfare (Dhesi 1989). This does not mean that a country must simply develop high technology. It means that a country must encourage its organisations and people to acquire, create, disseminate, and use knowledge more effectively for greater economic and social development[5]. There are four pillars of a knowledge-based economy (Dahlman and Aubert 2001) viz., (i) an economic and institutional regime that provides incentives for the efficient use of existing knowledge and, the creation of new knowledge and entrepreneurship; (ii) an educated and skilled populace that can create and use knowledge; (iii) a dynamic information infrastructure that can facilitate the effective communication, dissemination, and processing of information; and (iv) an effective innovation system comprising a network of firms, research centres, universities, consultants, and other organisations that can tap into the growing stock of global knowledge, assimilate and adapt it to local needs, and create new knowledge and technology. The economic institutional regime allows organisations and people to adjust to changing opportunities and demands in flexible and innovative ways[6]. In a sense, it is the fundamental pillar of the knowledge-based economy, since only strong economic incentives and institutions can deploy these resources to productive uses and take advantage of a strong educational base and a highly developed ICT (information, communication and technology) and research and development (R&D) infrastructure.

Education is the pre-condition and an enabler for knowledge economy. Any economy essentially requires a well-educated and skilled people for creating, sharing, disseminating, and using knowledge effectively. The knowledge economy of the twenty-first century demands a set of new competencies, which includes not only ICT skills, but also such soft skills as problem solving, analytical skills, group learning, working in a team-based environment, and effective communication. These skills were early expected only of managers, but now they are important for all workers. Fostering such skills requires an education system that is flexible; basic education should provide the foundation for learning, and secondary and tertiary education should develop core skills that encourage creative and critical thinking (Singh 1992). In addition, it is necessary to develop an effective lifelong learning system to provide continuing education and skill upgrading to persons after they have left formal education in order to provide the changing skills necessary to be competitive in the new global economy (Dahlman and Aubert 2001).

A strong basic education system is a necessary precondition to underpinning India's efforts to enhance further the productivity and efficiency of its economy (Singh and Sagar 2004). China's experience in this area is useful, as its emphasis on secondary education has provided it with a firm basis for expansion of manufacturing activities on a global scale. Investments in basic education are thus fundamental for countries to improve the productivity and the quality of labour and deliver the manpower needed for their development efforts (Singh 1997). India has made substantial progress in increasing literacy and increasing primary and secondary enrolments and overall educational attainment (Table 1). But the country still accounts for one-quarter of the world's children out of school. The participation of girls, 6-14 years age group, in elementary education is low[7] and progressively goes down as they move up the schooling grades. There are considerable gaps in access to secondary education, particularly for girls and marginalised sections of the society. There are wide regional differences too. In case of China, the average years of schooling increased from 1.535 in 1950 to 8.167 in 2010 while in case of India the corresponding increase has been from 0.985 to 5.13. This means that educational attainment of population age 15 plus in India has been lower than China throughout. Besides, the India: China ratio was 1:1.56 in 1950, which marginally increased to 1:1.59 in 2010. As regards the female educational attainment, in case of China, the average years of schooling increased from 0.954 in 1950 to 7.606 in 2010 while in case of India the corresponding increase has been from 0.397 to 4.073. This means that female educational attainment of population age 15 plus in India has been lower than China throughout. Besides, the India: China ratio was 1:2.40 in 1950, which declined to 1:1.86 in 2010. Thus, in case of female educational attainment, the gap between India and China has reduced over the years. The percentage of population of age 15 plus with no schooling stood at 74.7 percent in 1950 in India, which declined to 32.7 percent in 2010 and the decline has been faster after 1980; almost halved. In China, in 1950 the percentage of population of age 15 plus with no schooling stood at 69.8 percent (lower than India). It significantly declined to mere 6.5 percent in 2010. Thus, the record of China compared to India has been remarkable in removing illiteracy from its population. In both India and China, the improvement in average years of schooling is mostly on account of higher primary completion and enrolment ratios. The higher secondary and tertiary completion and enrolment ratios are still low in both the countries, though China is performing better than India.

The percentage of female population of age 15 plus with no schooling stood at 89.4 percent in 1950 in India, which declined to 44.7 percent in 2010 and the decline has been gradual over the years (appendix table 1). In China, in 1950 the percentage of female population of age 15 plus with schooling stood at 79.4 percent (lower than India), which significantly declined to mere 10.3 percent in 2010. Thus, the record of China compared to India has been remarkable in removing female illiteracy. The difference, however, is that in China; the improvement in average years of schooling is mostly on account of higher secondary and primary completion and enrolment ratios when in India it is through mostly the higher primary completion and enrolment ratios. The tertiary completion and enrolment ratios are still low in both the countries, though China is performing better than India.

Table 1: Educational Attainment of the Population Age 15 plus: India and China

Year	Population over age 15 (000's)	No schooling %	First level		Second level		Post-secondary		Average years of schooling
			Total	Completed	Total	Completed	Total	Completed	
Total India			**Percentage of the population age 15 plus**						
1950	218405	74.7	22.6	6.4	2.1	0.1	0.6	0.3	0.985
1955	240942	73.6	23.6	7.0	2.2	0.1	0.6	0.3	1.032
1960	266423	72.1	24.8	8.1	2.5	0.2	0.6	0.3	1.111
1965	295056	70.9	24.0	8.9	4.1	0.1	0.9	0.5	1.287
1970	330552	66.2	27.1	11.6	5.6	0.2	1.1	0.6	1.574
1975	373640	65.9	20.6	10.4	11.7	0.3	1.8	0.9	1.972
1980	423306	66.3	12.6	7.4	18.7	0.5	2.3	1.2	2.339
1985	478056	58.5	16.5	11.0	21.8	0.5	3.2	1.7	2.893
1990	542391	51.6	18.7	13.7	25.6	0.5	4.0	2.1	3.444
1995	538715	47.4	19.4	15.3	29.1	0.7	4.1	2.2	3.800
2000	600511	43.0	19.7	16.4	32.9	0.9	4.5	2.4	4.201
2005	672684	37.2	21.1	18.4	36.7	1.0	5.1	2.7	4.688
2010	749620	32.7	20.9	18.9	40.7	1.3	5.8	3.1	5.130
Total China									
1950	368715	69.8	21.9	5.3	8.0	1.7	0.3	0.2	1.535
1955	383044	64.6	25.5	6.6	9.4	2.1	0.5	0.3	1.825
1960	401694	58.3	28.7	9.7	12.3	2.7	0.7	0.4	2.281
1965	436196	50.9	32.7	12.6	15.5	3.5	0.8	0.4	2.779
1970	500636	41.9	36.9	16.7	20.3	4.6	0.8	0.4	3.432
1975	561430	35.4	38.5	18.7	25.2	5.9	0.9	0.4	3.965
1980	644245	27.1	38.4	20.1	33.6	9.3	0.9	0.5	4.748
1985	745898	23.6	36.9	20.5	38.0	14.5	1.5	0.8	5.248
1990	835430	22.2	34.5	19.9	41.3	21.8	1.9	1.0	5.624
1995	896920	15.9	32.9	19.4	47.9	29.6	3.3	1.8	6.407
2000	958307	11.0	30.4	18.3	54.1	36.2	4.6	2.6	7.106
2005	1034076	8.4	27.5	17.0	57.7	41.6	6.3	3.6	7.622
2010	368715	6.5	24.1	15.0	60.4	46.0	9.0	5.2	8.167

Source : Barro and Lee (2001; 2010).

Table 2 shows that the average years of schooling in India is still below the level which Australia, UK, USA, Sweden, Canada and Japan achieved in 1950. In 2010, compared to India's average years of schooling of 5.13, the corresponding figures for Australia, UK, USA, Sweden, Canada, Japan, China and Brazil were 12.119, 9.754, 13.097, 11.567, 12.083, 11.582, 8.167 and 7.539 respectively.

Table 2: Average years of Schooling of the Population Age 15 plus

Years	Australia	Canada	Japan	Sweden	USA	UK	China	Brazil	India
1950	8.636	7.603	6.894	6.750	8.412	5.904	1.535	1.499	0.985
1955	8.982	7.956	7.386	6.979	8.777	6.104	1.825	1.758	1.032
1960	9.296	8.362	8.007	7.270	9.179	6.299	2.281	2.054	1.111
1965	9.609	8.663	7.825	7.633	10.037	6.830	2.779	2.377	1.287
1970	10.156	8.883	8.199	8.079	10.789	7.297	3.432	2.811	1.574
1975	10.857	9.312	8.743	8.827	11.477	7.599	3.965	2.570	1.972
1980	11.541	9.702	9.251	9.419	12.027	7.749	4.748	2.768	2.339
1985	11.541	10.000	9.753	9.767	12.092	7.998	5.248	3.702	2.893
1990	11.602	10.400	9.965	10.198	12.231	8.214	5.624	4.463	3.444
1995	11.680	10.778	10.559	10.779	12.635	8.554	6.407	5.350	3.800
2000	11.771	11.030	10.923	11.067	12.706	8.930	7.106	6.411	4.201
2005	11.872	12.130	11.261	11.505	12.911	9.345	7.622	7.168	4.688
2010	12.512	12.126	11.362	11.727	13.152	9.980	7.606	7.690	4.073

Source : Barro and Lee (2001; 2010).

Table 3 shows that the average years of schooling in India for females is still below the level which Australia, UK, USA, Sweden, Canada and Japan achieved in 1950. In 2010, compared to India's average years of schooling of 4.073, the corresponding figures for Australia, UK, USA, Sweden, Canada, Japan, China and Brazil were 12.512, 9.98, 13.152, 11.727, 12.126, 11.362, 7.61 and 7.69 respectively.

The performance of India compared to other countries like Australia, Canada, Sweden, USA, UK and Japan in removing female illiteracy is very poor (table 4). In 1950, Australia, Canada, Japan, Sweden, USA and UK had percentage of female population of 15 plus illiterate of 1.5, 1.9, 7.1, 2.6, 2.2 and 2.8 respectively as against India's percentage of 89.4, China's 79.4 and Brazil's 66.2 percent. In 2010, Australia, Canada, Japan, Sweden, USA and UK had percentage of female population of 15 plus illiterate of 0.9, 0.8, 0.1, 1.1, 0.4 and 1.8 respectively as against India's percentage of 44.7, China's 10.3 and Brazil's 10.1 percent. Thus, it is really sorry state of affairs and India still has to travel a long distance to even reach 1950 position of these countries, though China and Brazil would achieve the targets much early.

The performance of India in removing illiteracy compared to others countries like Australia, Canada, Sweden, USA, UK and Japan is very poor (table 4). In 1950, Australia, Canada, Japan, Sweden, USA and UK had percentage of population of 15 plus illiterate of 1.0, 2.0, 4.4, 1.8, 2.2 and 2.8 respectively as against India's percentage of 74.7, China's 69.8 and Brazil's 62.8 percent. In 2010, Australia, Canada, Japan, Sweden, USA and UK had percentage of population of 15 plus illiterate of 0.9, 0.7, 0.1, 1.4, 0.4 and 3.3 respectively as against India's percentage of 32.7, China's 6.5 and Brazil's 10.1 percent. Thus, India still has to go a long distance to even reach 1950 position of these countries, though China and Brazil would achieve the targets much early. But, India is very committed to increasing educational attainment[8]. The RTE Act (right to education) is a step towards universalisation of basic education.

Table 4: Percentage of Population Age 15 plus with No Schooling

Years	Australia	Canada	Japan	Sweden	USA	UK	China	Brazil	India
Female									
1950	1.5	1.9	7.1	2.6	2.2	2.8	79.4	66.2	89.4
1955	1.3	1.6	5.2	2.3	2.1	2.5	73.7	60.9	88.3
1960	1.1	1.3	3.7	2.0	1.9	2.2	66.7	54.9	86.7
1965	0.8	1.2	1.8	1.5	1.6	1.9	57.3	47.8	84.4
1970	0.8	1.1	1.0	1.1	1.4	1.6	46.6	40.6	80.9
1975	1.3	1.5	0.7	1.7	1.1	1.4	39.1	28.8	80.5
1980	0.9	1.7	0.5	1.5	0.9	1.5	31.1	28.6	79.0
1985	0.8	1.1	0.4	1.7	0.9	1.6	25.0	23.7	72.9
1990	0.7	0.9	0.3	1.9	0.8	1.7	20.8	20.0	66.3
1995	0.8	1.0	0.2	1.2	0.5	1.8	18.1	16.8	61.8
2000	0.7	1.0	0.2	1.5	0.4	1.9	16.2	14.9	56.7
2005	0.7	0.8	0.2	1.2	0.5	1.8	12.9	12.3	50.2
2010	0.9	0.8	0.1	1.1	0.4	1.8	10.3	10.1	44.7
Total									
Years	Australia	Canada	Japan	Sweden	USA	UK	China	Brazil	India
1950	1.1	2.0	4.4	1.8	2.2	2.8	69.8	62.8	74.7
1955	1.0	1.7	3.4	1.6	2.2	2.5	64.6	57.6	73.6
1960	0.9	1.4	2.4	1.4	2.0	2.1	58.3	51.8	72.1
1965	0.8	1.3	1.4	1.2	1.6	2.0	50.9	45.3	70.9
1970	0.8	1.1	0.7	1.1	1.4	2.0	41.9	37.8	66.2
1975	1.1	1.4	0.5	1.7	1.2	2.0	35.4	27.0	65.9
1980	0.8	1.6	0.4	1.6	0.8	3.0	27.1	27.4	66.3
1985	0.8	1.0	0.3	2.1	1.0	3.0	23.6	24.7	58.5
1990	0.7	0.8	0.2	2.5	1.1	3.2	22.2	22.3	51.6
1995	0.7	0.9	0.2	2.0	0.6	3.4	15.9	19.5	47.4
2000	0.7	0.9	0.2	2.1	0.4	3.4	11.0	16.0	43.0
2005	0.7	0.8	0.1	1.7	0.4	3.4	8.4	12.4	37.2
2010	0.9	0.7	0.1	1.4	0.4	3.3	6.5	10.1	32.7

Source : Barro and Lee (2001; 2010).

India, however, does possess a large pool of highly educated and vocationally qualified people who are making their presence felt, domestically and globally, in science, engineering, information technology (IT), and research and development (R&D). However, they make up of only a small fraction of the population. To create a sustained cadre of knowledge workers, India will need to develop a more relevant educational system and reorient classroom teaching and learning objectives, starting from primary school. However, the elitist bias in education is getting reinforced through enhanced privatisation of education. The new system of schooling is focussed on learning, rather than on schooling, and promoting creativity. It is expected to improve the quality of tertiary education and provide opportunities for lifelong learning.

India does lag behind the top-notch countries in producing tertiary educated population, but its tertiary education is also critical for the construction of knowledge economy. India currently produces a solid core of knowledge workers in tertiary and scientific and technical education[9]. The country needs to do more to create a larger cadre of educated and agile workers who can adapt and use knowledge, shortage of skilled work forces is staring the country across the board. Efforts have been put into establishing a top-quality university system that includes many world-class institutions of higher learning that are competitive and meritocratic, such as Indian Institutes of Technology (IITs), Indian Institutes of Management, Indian Institute of Science, and the Regional Engineering Colleges (RECs) and new set of central universities. There had been mushrooming of management and engineering institutes in the private sector all over the country, which recently have faced a set back; more than half of them are on verge of closure as per some estimates. This is a result of lack innovation and vision. Not all publicly funded universities or other educational institutions in India have been able to maintain high-quality standards or keep pace with developments in knowledge and technology. Major steps are thus needed to ensure that Indian institutions meet high-quality national (and if such services are exported, international) standards. Measures are also needed to enhance the quality and relevance of higher education so that the education system is more demand driven, quality conscious, and forward looking, especially to retain highly qualified people and meet the new and emerging needs of the economy (Chadha 2004; Singh and Sagar 2004).

In the area of scientific and technical education, even though India produces more than 2.0 lakh scientists, engineers, and technicians a year, it has not been obtaining the full economic benefit from this skill base, because of the mismatch between education and the labour market. The professional workforce that is emerging from India's higher education system often cannot find suitable employment due to a growing gap between their knowledge and real practice and to limited job opportunities in their fields, coupled with low salaries. Many professionals also leave the country in search of better opportunities, which leads to brain drain (Singh 2005a). This calls for an effort to promote policy and institutional reforms in scientific and technical education for both public and private institutions to improve the quality and skills of India's current and future pool of technical manpower[10].

Skills matter more than ever in present day's more competitive global market. In large countries such as India and Brazil, where the vast majority of people are unskilled and uneducated, the capabilities of the majority of the population must be enhanced for the economy to show substantial improvements. Firms and farmers alike must be able to learn and develop new skills. While not losing sight of the need for secondary and tertiary education, governments should improve the skill and education levels of the mass of people through primary and vocational education. The success of countries such as China and South Korea in achieving higher growth reveals the importance of a workforce with a basic education that can be trained. This leads to the issue of skills development and training. When technology is changing, enterprises must invest in worker training to remain competitive. India too has to develop various job-training programmes to be globally competitive (Singh 2002). These programmes must be flexible, cost-effective, and able to adapt quickly to new skill demands generated by changing markets and technologies. The National Skill Development Mission initiated in 11th plan is expected to yield good results and since April 2013 National Rural Livelihood Programme has been started, is also based on skill development.

4. The Advances Made

Fast paced development in ICTs in India in the recent years has affected economic and social activities. It has affected acquisition, creation, dissemination and use of knowledge. The innovation system in any country consists of institutions, rules, and procedures that affect how it acquires, creates, disseminates, and uses knowledge. Innovation in a developing country concerns not just the domestic development of frontier-based knowledge (Singh 2012). It relates also to the application and use of new and existing knowledge in the local context. Innovation requires a climate favourable to entrepreneurs, one that is free from bureaucratic, regulatory, and other obstacles and fosters interactions between the local and outside business world and with different sources of knowledge, including private firms, universities, research institutes, think tanks, consulting firms, and other sources (Dalhman and Utz 2005). Tapping global knowledge is another powerful way to facilitate technological change through channels such as foreign direct investment (FDI), technology transfer, trade, and technology licensing (Djankov and Hoekman 2000)[11].

In India, with its relatively small organised sector, a very important part of its innovation system relates to how modern and more efficient practices can be diffused to the greatest number of users. This applies to both domestic and foreign knowledge. India has performed remarkbly well in diffusing knowledge and technology, especially in agriculture in the past. Green Revolution transformed India from a net importer to a net exporter of food grains. India's White Revolution in the production of milk has helped it to achieve the twin goals of raising incomes of rural poor families and raising the nutrition status of the population (Singh 2005b). India needs to build on its innovative domestic strengths and undertake efforts to improve the productivity of agriculture, industry, and services even further. This includes strengthening technology diffusion institutions, such as those related to agricultural extension and industrial extension, productivity-enhancing organisations, and technical information agencies. In India, where large disparity exists between the most and least efficient producers in any sector, considerable economic gains can also be harnessed from moving the average domestic practice to the best domestic practice, not to mention best international practice. This will require a host of efforts, including improving the system for technical norms and standards, such as product quality, work safety, and environmental protection, which can facilitate the proper diffusion of know-how (Dahlman and Utz 2005). Efforts are required to be made to improve the dissemination of technology by strengthening competition so that the most efficient firms expand and improve performance, establishing and enforcing appropriate laws, encouraging more trade among Indian states, allowing for economies of scale and scope, and facilitating the diffusion of best products through price- and quality-based competition.

India also needs to increase its efforts to tap into the rapidly growing stock of global knowledge through channels such as FDI, technology licensing, importation of capital goods that embody knowledge, as well as advanced products, components, and services[12]. International trade leads to faster technological diffusion and higher rates of productivity growth compared with countries such as China (Table 5). India has performed poorly at making effective use of these resources. These channels are important, given the rapid expansion of global knowledge. Even large advanced economies such as the United States are increasingly acquiring knowledge through cross-border transfers. Creditably, India has overtime taken bold steps to strengthen its R&D infrastructure, developing technological innovations and altering the mind-set of its people toward better creation, acquisition, and use of technology[13]. It is endowed with a critical mass of scientists, engineers, and technicians in R&D and is home to dynamic hubs of innovation, such as Bangalore and Hyderabad. It also has vast and diversified publicly funded R&D institutions, as well as world- class institutions of higher learning, all of which provide critical human capital. India is also emerging as a major global R&D platform; more than 100 multinational corporations (MNCs) have already set up R&D centres in the country, leading to the deepening of technological and innovative capabilities among Indian firms (Dalhman and Utz 2005). Several Indian companies are becoming part of R&D alliances with global firms. These collaborations present several benefits for Indian industry, because the linkages among local firms, universities, and research institutes and the worldwide R&D network of multinationals further integrate India into global technology development. Such R&D activities have also been useful in inculcating a commercial culture among scientists, helping them to apply knowledge for productive ends. The outsourcing of high-end R&D to India is yet another new trend that is evident from the large number of established R&D, outsourcing centres in India, from IT and telecom to automotive and pharmaceuticals sectors. India is also developing public-private partnerships to harness the potential of tradition-al knowledge to meet health and welfare needs and to reduce poverty.

Despite these accomplishments, India spends only a small fraction of its GDP on R&D (Singh, 1997). It gets very little in worldwide royalty and license fee receipts. Regarding scientific and technical articles in mainstream journals (per million people), India matches the performance of China, but the contributions of both countries are very low compared with those of developed countries (table 5). FDI, although increasing, is also rather low by global standards; India is way behind China in this regard. The majority of the R&D related inward FDI in India materialised only after the economy had been liberalised. This FDI, however small, has been creating a new competitive advantage for the country, especially in the IT domain and in industries, such as automotive. Venture capital availability is also very limited in India. However, there are some signs of vibrancy. A notable venture capital investment market is emerging. Institutions are in place to facilitate this.

Besides, India's share of global patenting is also small. This is despite having a strong R&D infrastructure. India is weak on turning its research into profitable applications. But, an increasing trend is discernible in the number of patents granted to companies by the Indian Patent Office, indicating greater awareness of the importance of knowledge and the value of protecting it through patents. Of the Indian patents, the drugs and electronics industries have shown a sharp increase in patenting in recent years. In addition, several Indian firms have registered their innovations with the United States Patent and Trademark Office (USPTO). This shows that the focus of research is shifting to patentable innovations, indicating better conceptualisation of research. The recent amendments to the Indian Patent Act adopted in a move toward adhering to the intellectual property norms under Trade-Related Aspects of Intellectual Property Rights (TRIPS) have also boosted confidence among international players.

Table 5: Innovation Performance: Select Variables

Variables	India	China
Gross FDI as % of GDP (average 1993-2002)	0.60	5.40
Royalty and license fees payments per million population (2003)	0.33	2.43
Royalty and license fees receipts per million population (2002)	0.01	0.10
Science & engineering enrolment ratio (% of tertiary level students, 2002)	25.00	43.00
Researchers in R&D per million (2009)	137.00	1071.00
Total expenditure for R&D as % of GDP (2009)	0.80	1.50
Private sector spending on R&D (2003)	3.50	3.80
Manufactured trade as % of GDP (2003)	13.02	41.84
High-technology exports as % of manufactured exports (2007)	5.00	30.00
Scientific & Technical journal articles per million population (1999)	9.23	9.31
Availability of venture capital, scale of 1 to 7 (2003)	3.80	3.00
University/ company research collaboration, scale of 1 to 7 (2003)	3.20	4.20
State of cluster development, scale of 1 to 7 (2003)	4.10	3.70
Telephone mainlines (2009) per 1000 people	30.00	260.00
Cellular mobile subscribers (2009) per 1000 people	300.00	480.00
Internet users (2009) per 1000 people	45.00	225.00

Source: World Bank "Knowledge Assessment Methodology", http://www.worldbank.org./KAM.

It appears that globalisation and the knowledge revolution present challenges and opportunities to developing countries. The knowledge gap has to reduce. Mobile telephone subscribers per 100 inhabitants has grown, though, at a much higher rate in developing would compared to developed world. We do observe that digital gap is reducing internationally (table 6) and it is contributed by global capital and technology flow.

Table 6: Mobile Telephone Subscribers per 100 Inhabitants

Years	Developed World	Developing World	World
1994	5.20	0.19	1.00
1995	8.20	0.40	1.60
1996	12.70	0.60	2.50
1997	17.60	1.10	3.70
1998	24.60	1.90	5.40
1999	35.30	3.20	8.20
2000	49.60	5.40	12.20
2001	58.50	8.00	15.70
2002	64.70	10.80	18.80
2003	69.60	14.20	22.60
2004	76.80	18.80	27.40
CGR%	27.28	46.30	33.55

Source: International Telecommunication Union, http://www.itu.int/ITU-D/ict/statistics/ict/index.html

The role played by mobile phones in poorest parts of the world is significant. In India, this has been the biggest equalizer. Communication network improved significantly. Even in remote villages, mobile phone is in use. It is enabling fishermen and farmers to check prices, receive information, makes it easier to look for jobs and reduce travel costs and time. The transaction cost gets lowered and broadens trade networks. Consequently the economy has observed positive impact.

In India, about 70 percent of R&D is performed by the central and state governments, an additional 27 percent by enterprises (both public and private sector industries), and less than 3 percent by universities and other higher education institutions. In contrast, in most countries in the Organisation for Economic Co-operation and Development (OECD), the private sector finances 50-60 percent of R&D, because it increasingly has the finance, knowledge, and personnel needed for technological innovation (Dalhman and Utz 2005). Firms play an even bigger role in R&D in Ireland, Japan, South Korea, and Sweden. Universities also undertake research to a much larger extent in developed countries and have stronger linkages with the corporate world. University research is hardly linked to industry in India and the main reason for this is that corporate sector hardly sponsors projects in the universities.

Information Technology Sector: India's software industry has become vibrant since the 1990s. India has a lot to gain from the new technologies and is putting efforts to do so. The large pool of skilled manpower in this sector has contributed to both domestic industry and industry abroad. India's recent success in the software and electronics industry is largely due to its vast pool of English speaking engineers, who earn much less than their counterparts in developed countries (20% of the US wage levels, Thomas 2005). The quality of their service is high. In the initial years, most of the work by Indian IT firms was in the form of *body shopping*, but of late, foreign companies have been outsourcing jobs. Tables 7 through 13 detail the progress made by India in this sector. The fixed line and mobile subscribers (per 1000 people) rose from mere 6 in 1990 to 71 in 2003, while cost of 3- minute local call (in $ terms) has stood around 0.02. The penetration of computers is linked to education level of population and the march in this regard is from 0.3 (personal computers per 1000 people) in 1990 to 8.2 in 2002. The weak infrastructure on communications affected Internet usage. In 1990 India had negligible Internet users (per 1000 people), but it touched 17 by 2003. There is rapid increase in internet use in the last few years and would go up significantly, at least, in urban centres in future. The major hindrance to this is the limited availability of bandwidth. Recently it is improving.

Table 7: Telecommunication Infrastructure

Items	1990	2002	2003	2007
Fixed-line and mobile subscribers (per 1000 persons)	0.60	52.00	71.00	4/21#
Cost of 3-minute local call ($)	0.05	0.02	0.02	–
Personal computers (per 1000 persons)	0.30	7.20	–	3#
Internet users (per 1000 persons)	0.00	16.00	17.00	7.2#
High-technology exports (% of manufactured exports)	2.00	5.00	5.00	5.00
GDP ($ billion)	317.00	510.00	601.00	1217*

Note: *- for 2008. #- per 100 persons.
Source: The World Bank, *Little Data Book* 2005.

The people with computer knowledge increased from 1.58 crore in 2000 to 7.2 crore in 2008 recording a growth rate of 22.78 percent. The active users of computers went up during the same period from 0.02 crore to 3.93 crore, observing growth rate of 48.92 percent (table 8). The share of people with computer knowledge in active users of computers was 13.9 percent in 2000 that increased to 54.6 percent by 2008. Thus, there is significant improvement in users of computers in India. By December 2012, there were 2,401 crore internet users with 1.498 crore broadband users. This number was 0.80 crore and 0.20 crore respectively in December 2006.

Table 8: Growth in Knowledge and Usage of Computers (crore)

Year 1	People with computer knowledge 2	Active users of computers 3	2 as % of 3 4
2000	1.58	0.22	13.90
2001	3.08	0.43	14.00
2003	4.22	0.75	17.80
2004	5.29	1.12	21.20
2006	5.90	2.11	35.80
2006	6.50	3.20	49.20
2008	7.20	3.93	54.60
CARG %	22.78	48.92	26.13

Source: *Statistical Outline of India 2004-2005 and 2009-10* Tata Services Limited, Bombay.

India, though improving, lags behind in internet connectivity. The International Telecommunication Union estimated bandwidth availability in India in 2001 at 1475 Mbit/sec compared to 2639 in Singapore, 5432 in South Korea, 6308 in Hong Kong and 7598 in China (table 9). This situation has improved since then, though India still has to catch up with its neighbours. India had 0.32 crore internet subscribers (484.6 crore in 2007-08) and 0.7 crore internet users. In terms of internet spread or the number of users per 100 inhabitants, India with 0.7 was behind China (2.6) and way behind Hong Kong (38.5), Korea (52.1) and Singapore (36.3). Then there are disparities regionally in India- rural-urban and within urban areas. There still is inadequate spread of connectivity. Urban tele-density by March end 2012 was 169.55 while the rural tele-density was mere 39.22. The share of urban subscribers was 65.23 percent compared to just 34.77 percent of rural subscribers. The broadband subscribers reached 1.379 crore in March 2012. The total number of telephone subscribers in March 2012 stood at 65.134 crore. The overall tele-density varied between a low of 46.61 in Assam to a high of 120.67 in Delhi (116.47 in Himachal Pradesh).

The electronics production in India improved from Rs.52450 crore in 1999-00 to Rs.58850 crore in 2000-01 but increased to Rs.273530 crore in 2008-09; multiplied more than 4 times in 8 years (table 10). The contribution of computer software improved significantly from 46.43 percent in 1999-00 to 74.28 percent in 2008-09. Within computer software group, software for exports constituted 70.43 percent in 1999-00, but went up to 78.33 percent in 2003-04 and then to 79.1 percent in 2008-09. Consumer electronics form a major group among electronic hardware. Thus, Indian electronics industry has done remarkably well since 1990-00.

Table 9: Asia- Pacific Internet Economy (2001)

Countries	No. of ISPs	Total (000s)	Per 100 inhabitants	No. of subscribers (000s)	Broadband	International internet bandwidth (Mbit/sec)
Australia	603	7200	37.1	4181	123	7000
Bangladesh	60	250	0.2	100	-	40
China	936	33700	2.6	17364	203	7598
Hong Kong China	258	2601	38.5	2631	623	6308
India	90	7000	0.7	3200	50	1475
Indonesia	60	4000	1.9	600	15	343
Japan	4000	55930	43.9	24062	3835	22705
South Korea	99	24380	52.1	8956	7806	5432
Malaysia	6	6500	27.3	2115	4	733
New Zealand	80	1092	28.6	660	17	1900
Pakistan	70	500	0.3	200	-	225
Philippines	51	2000	2.6	600	10	237
Singapore	42	1500	36.3	927	151	2639
Sri Lanka	29	150	0.8	62	-	18
Taiwan	185	7820	34.9	6316	1130	7228
Thailand	18	3536	5.8	1500	2	642
Vietnam	4	1010	1.2	252	-	34
Asia- Pacific	6654	160217	4.6	74290	13979	64955

Source: www.itu.int/itunews/issue/2002/10/indicators.html, accessed February 2013.

Table 10: Electronic Production Profile (Rs. crore)

Items	1999-00	2000-01	2001-02	2002-03	2003-04	2008-09
Electronic Hardware						
Consumer electronics	11200	11950	12700	13800	15200	25990
Industrial electronics	3750	4000	4500	5550	6100	12740
Computers	2500	3400	3550	4250	6800	13490
Communication & broadcast equipment	4000	4500	4500	4800	5350	26000
Strategic electronics	1450	1750	1800	2500	2750	6840
Total*	28100	31100	32750	37500	43800	94690
Computer software						
Software for exports	17150	28350	36500	46100	55500	216300
Domestic software	7200	9400	10874	13400	15350	57230
Grand total	52450	58850	80124	97000	114650	368220

Note : *- Includes figures for components- 5200, 5500, 5700, 6600, 7600 and 9630 respectively for years under consideration.
Source : *Statistical Outline of India 2004-2005 and 2009-10* Tata Services Limited, Bombay.

As India has done well in software component of electronics goods sector, it is pertinent to look at the size of software and services industry in India in the recent times. Table 11 shows that since the mid-nineties, software and services industry has continuously grown from Rs.6594 crore to Rs.346567 crore in 2009-10; almost 53 times increase in size. Increasingly Indian software and services industry is gearing towards export market. In 1996-97, the share of export market was 59 percent and it went up to 68.54 percent by 2009-10, a significant increase. On the other hand, the domestic market has shrunk from 41 to 31 percent during the period.

Table 11: Growth of Indian Software and Services Industry

Years	Industry Size		Export Market		Domestic Market	
	Rs. crore	US$ billion	Rs. crore	US$ billion	Rs. crore	US$ billion
1996-97	6594	1.859	3900	1.100	2694	0.759
1997-98	10899	2.936	6530	1.759	4369	1.177
1998-99	16879	4.011	10940	2.600	5939	1.411
1999-00	23980	5.539	17150	3.962	6830	1.577
2000-01	55730	12.200	28322	6.200	27408	6.000
2001-02	63905	13.400	36244	7.600	27660	5.800
2002-03	77924	16.100	47916	9.900	30008	6.200
2003-04	98879	21.600	61114	13.300	37465	8.300
2004-05	126254	28.100	81773	18.200	44481	9.900
2005-06	165569	37.400	107133	24.200	58436	13.200
2006-07	202378	47.900	133933	31.700	68445	16.200
2007-08	253110	62.900	164582	40.900	88528	22.000
2008-09	318685	69.400	218120	47.500	100565	21.900
2009-10	346567	73.100	237524	50.100	109043	23.000
CGR%	29.82	28.68	30.80	29.67	28.24	27.11

Note : Figures for 2009-10 are provisional.

Source : *Statistical Outline of India 2004-2005 and 2009-10* Tata Services Limited, Bombay.

As software exports have become important for Indian industry, table 12 reveals that of the three components viz., onsite service, off shore service and products & packages, onsite services are more important, but losing ground. In 1995-96, the share of onsite services in total software exports was 43.2 percent and it fell to 40.5 percent by 2003-04. The onsite services in quantum terms during the period increased by almost 15 times. Off- shore services have become important because local skilled workers have dried up in North America and other major developed countries and companies are increasingly looking for skilled workers abroad. India is a very suitable site with English speaking engineers who are willing to work at much lower wages. The share of offshore services improved from 22.6 percent in 1995-96 to 59.5 percent in 2003-04. In absolute terms, the increase is more than 41 times. India has to further capitalise on this trend and create centres other than Bangalore, Hyderabad and Pune. For this both central and state governments have to create adequate infrastructure and growth oriented policy regime. Recently, foreign companies are showing interest in Chandigarh as it has very well developed infrastructure of educational institutions, hospitals, environment and highly educated workforce.

Table 12: Profile of Software Exports (Rs. crore)

Year	Onsite Service	Offshore Service	Products & Packages	Total
1995-96	1520 (43.2)	797 (22.6)	203 (5.8)	3520
1996-97	2289 (58.7)	1178 (30.2)	433 (11.1)	3900
1997-98	3853 (59.0)	2103 (32.2)	575 (8.8)	6530
1998-99	6365 (58.2)	3710 (33.9)	865 (7.9)	10940
1999-00	9850 (57.4)	5950 (34.7)	1350 (7.9)	17150
2000-01	15900 (56.1)	10950 (38.6)	1500 (5.3)	28350
2001-02	16500 (45.2)	18500 (50.0)	1500 (4.1)	36500
2002-03	19700 (42.7)	24900 (59.5)	1500 (3.3)	46100
2003-04	22500 (40.5)	33010 (59.5)	Na	55510
CGR%	35.10	49.13	28.02	38.06

Note : Figures in ( ) are share of total. Figures for 2003-04 are provisional.
Source : same as table 11.

Table 13 shows the manpower in Indian IT industry. It is estimated that in 2001-02 there were 5.22 lakh knowledge professionals employed in Indian IT industry and this number stood at 22.86 lakh in 2009-10. Most of these knowledge professionals are employed in software exports sector (32.57% in 2001-02 and 43.44% in 2009-10). The next important employer is software captive in user organisations. In case of new entrants, the number has stood around 1.58 lakh in 2001-02 and most of them are IT graduates and diploma holders. By 2009-10, the number went up to 3.69 lakh. So there is a steady addition to knowledge professionals and this has held promise for expanding IT industry in India.

Table 13: IT Manpower Estimates (000's)

Items	2001-02	2002-03	2003-04	2006-07	2009-10
Knowledge professionals employed					
Software exports sector	170 (32.57)	205 (31.01)	260 (31.94)	690 (42.57)	993 (43.44)
Software captive in user organisations and Software domestic sector	246 (47.13)	285 (43.12)	308 (37.84)	378 (23.32)	525 (22.97)
IT enabled services	106 (20.31)	171 (25.87)	246 (30.22)	553 (34.11)	768 (33.60)
Total	522	661	814	1621	2286
New entrants					
IT graduates	57 (36.08)	47 (31.97)	55 (36.67)	143 (51.07)	204 (55.28)
IT diplomas	34 (21.52)	25 (17.01)	25 (16.67)	76 (27.14)	92 (24.93)
Others	67(42.40)	75 (51.02)	70 (46.66)	61 (21.79)	73 (19.79)
Total	158	147	150	280	369

Note : () percentages of respective total.
Source : same as table 11.

Knowledge Management for Enterprises: Individual industry and firms have played a major role in creating knowledge and diffusion of new knowledge. Firms have captured knowledge for years, but there has not always been an emphasis on accessibility, dissemination, and use of knowledge within the enterprise. The issue here is how successful knowledge management can be accomplished. Studies show that strategies are independent of industry or firm size. Firms that use a top-down approach are generally unsuccessful. Effective organisations create demand for knowledge through financial and other rewards for employees to create, tap and use internal and external knowledge resources. Knowledge management is most effective when it is a part of the corporate culture, and every function of the company maximises efficiency of knowledge creation, distribution, and application; and storage of knowledge is common across all firms, but distribution and application of that knowledge are not. Successful companies create cross-functional and vertically integrated project teams. They synchronise firm strategies and goals across functions, use internal and external benchmarking, pull in experts from outside, and create user-friendly, regularly updated databases that allow all actors in all functions and regions to tap a firm's knowledge (Hauschild, Licht and Stein 2000). Multinational companies are the major channels of transferring technologies. UNCTAD (1997) reported that more than 80 percent of royalty payments for international technology transfers were made from subsidiaries to their parent firm. These companies often have high R&D expenditures relative to sales, a larger level of scientists and technicians, new and technically complex products, and high levels of product differentiation and advertising (Navaretti and Tarr 2000). Thus, at the enterprise level synergies can be easily created for innovations.

5. ICT and Knowledge: Correlates of Development

Indicators for knowledge and ICT measure the relative position of each country with respect to others in these key areas of development. In order to understand the whole process, Ferranti *et al.* (2002) analysed the nexus between ICT and development. Using eight most appropriate indicators. Among these eight indicators, four reflected innovation activity and R&D in each economy, and four revealed the level of ICT development. These indicators were: research and development as share of gross national income (GNI); scientists in R&D per million people; patent applications by residents and non-residents per 1000 people; patent applications in the United States by country per 1000 people; telephone mainlines per 1000 people; mobile phones per 1000 people; personal computers per 10000 people; and internet hosts with active internet Protocol (IP) addresses per 1000 people. The definitions and relevance are self-explanatory for most of these variables. Mobile phones and telephones measure the depth of connectivity in a country. The other two ICT variables were personal computers and Internet hosts. In the knowledge area, R&D as share of gross national income and scientists working in R&D was included. Patent applications filed by nationals and non-nationals were an indicator of both innovation activity and a measure of the need and ability of the state to protect intellectual property. Patent applications in the United States by country of origin of the inventor was a variable that helps control for the variability in the previous variable caused by differences in the institutional development of each country. Grossman and Helpman (1991) had held that patent applications are also determined by the size of the domestic market where the patented products are sold. Consequently, neither indicator was a perfect proxy for innovation output.

Based on averages for 1995 to 2000 or 1990 to 1999 (Ferranti *et al.* 2002), table 14 shows the country variables expressed as a percentage of the U.S. levels. The most striking feature is that for development in knowledge and ICT is very shallow in China, Thailand and India compared to other countries. South Korea almost spends as much as United States of America on R&D despite the fact that the number of scientists in R&D in South Korea is about half that in the United States. In China and India, knowledge and ICT are almost exclusively led by R&D, which in both cases is about 25 percent of that in the United States. India has meagre 4 percent of scientists in R&D, which is one-third of China's scientists' manpower in R&D. Patent applications in the United States are minimal across countries and India, Thailand and China fare very badly on this count. India has only 3.66 telephone mainlines compared to 11.73 in China. In case of mobile phones, the number is just 0.34 in India, 0.01 in case of Internet host, and only 0.50 personal computers per 1000 people. Thus the relative position of India vis-à-vis its important competitors are poor in both knowledge and ICT.

Table 14: Indicators of ICT and Knowledge as Percentage of the United States Levels

Country	Information & Communication Technology					Knowledge		
	Telephones mainlines	Mobile phones	Internet host	Personal computers	R&D as % of GNI	R&D scientists (per million people)	Patent residents & non residents (per 1000 people)	Patent application in US (per 1000 people)
China	11.73	5.02	0.02	1.34	24.85	10.33	5.50	0.03
India	3.66	0.34	0.01	0.50	28.35	3.89	1.08	0.04
South Korea	65.74	73.70	4.04	35.11	87.76	56.18	285.36	20.88
Thailand	12.77	16.08	0.38	4.61	5.63	3.01	9.61	0.09
Germany	83.29	21.08	70.72	61.74	87.76	73.32	232.99	34.86
Japan	79.03	18.40	151.66	51.83	108.02	138.52	371.80	72.87
USA	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source : Adapted from Ferranti *et al.* (2002).

Literature also reports that there is a positive and non-linear relationship between knowledge and ICT and the level of development as measured by GDP per capita across countries Ferranti *et al.* (2002). Communications, computer penetration, and access to the Internet are highly correlated with income per capita[14]. Table 15 explicitly supports this. India lags behind all listed countries in the table. It has the lowest per capita income and lowest cellular subscribers.

Productivity Related Issues: Over the last half a century, the world has increasingly being divided into two clubs, those of rich and of poor countries. The increasing bimodal distribution of income is due primarily to knowledge rather than concentration of factors of production (Ferranti *et al.* 2003). New technologies drive economic growth. The study *From Natural Resources to the Knowledge Economy* (Ferranti *et al.* 2002) did brings out explicitly that successful resource-abundant countries (Australia, Canada, and the Scandinavian countries) marched ahead of others because of ability to learn from abroad, their national innovative capacity. These countries engaged themselves in one of the most rapid and dramatic build-ups of national human capital in human history. Education has been critical complement to technological advance. Technological change in the 20th century has been increasingly biased in favour of skilled workers.

Skills upgrading, technological change and their interaction are major factors behind total factor productivity growth (Ferranti *et al.* 2003).

Table 15: Cellular Subscribers Statistics (Select Countries)

Countries	Cellular subscribers (000s)			As % of total telephone subscribers	
	1995	2003	2009	1995	2003
World	90695	1340668	4676174	12.2	53.9
South Korea	1641	33592	47944	55.0	59.5
India	76	26154	525090	9.9	34.8
China	3629	269000	747000	37.2	50.6
USA	33785	158722	298404	36.3	46.6
Japan	11712	86659	114917	47.3	54.9
Germany	3725	64800	105000	49.4	54.4
UK	5735	49677	80375	55.3	58.7
France	1302	41683	59543	46.0	55.1
Canada	2589	13222	23081	29.6	39.9
Australia	2242	14347	24220	46.0	57.0

Source : same as table 8.

Also literature argues that imports and openness to trade are vital to learning, which is achieved through reverse-engineering, direct inputs into production, and communication with foreign partners (Djankov and Hoekman 2000). Foreign investment is associated with the transfer of both hard and soft technologies. Policy regime in a given country is also responsible for technology flow and adoption. Gill (2002) in the Latin American context (Brazil, Costa Rica, Chile, Peru and Mexico) and five non-Latin American countries (China, South Korea, Finland, Spain and Singapore) illustrated how and why some policy regimes have proven to be more successful than others in capturing the complementary environment in which skills and technology can boost productivity. He concluded that countries that neither increase education levels nor approach the technological transition in a sequenced manner suffer poor productivity outcomes. The opening up to foreign technology in this situation will not help much in aggregate productivity, if education levels are kept low (or highly skewed), given the complementarities between technology and skills. These countries run the risk of not only facing skill bottlenecks, but also of exacerbating earnings inequality. Besides, heavily investing and subsidising R&D would not pay back in higher productivity growth either in closed economies (which do not provide competitive pressures for firms to innovate and do not facilitate transfer of technologies through trade and FDI or in those with low levels of education of most of the working force (Brazil's past history is a prime example of such an imbalanced educational and technological policy that did not payoff in the last decades). Gill (2002) also reported that countries that have increased their average education levels but do not institute policies that facilitate technology transfers also experience low productivity growth. However, it is easier for such countries to increase productivity, an opening up of the economy to foreign trade, investment, and knowledge flow results in increased productivity growth almost immediately. The contrasting experience of Peru in the 1980s and 1990s is a case in point. Countries that both increase education levels and increase technology transfers, but do so mostly through direct public sector provisions (of education, training, and R&D) also appear to do poorly in productivity outcomes. These countries face a difficult challenge of increasing private sector participation in developing new technologies and delivering education and training. Mexico is a prime example, where the main challenge today is to effectively link the high levels of public R&D with a boost to private R&D. Countries that have increased education levels and that have done so by building a broad base of primary and secondary schooling, and at the same time have encouraged the adoption and adaptation of new technologies by private sector firms through openness, should focus most of their attention on strengthening their support to private R&D and stimulating knowledge networks, through improved linkages between universities and firms and among firms, both within the country and internationally, extending tertiary schooling, and supporting post-graduate programmes, particularly in sciences and engineering. Chile is a good example of a country in this stage. India is beginning to pick up its threads. It was for long caught in low growth path in controlled policy regime. The improved growth rate has been the result of improvements in labour productivity.

6. India and KEI Ranking

The KEI is based on a simple average of four sub-indexes, which represent the four pillars of the knowledge economy viz., economic incentive and institutional regime (EIR); innovation and technological adoption; education and training; and information and communications technologies (ICT) infrastructure. India's KEI fell 4 spots to 110th in the 2012 KEI ranking, mainly because of growth in USPTO patents (table 16). India's innovation pillar has leaped up 20 places to 76th. India's EIR and ICT pillars have registered slight declines, falling 4 and 8 spots respectively. With significant improvements in its EIR, innovation and education pillars, China has jumped 7 spots to a KEI rank of 84th. Its innovation pillar has made the largest gains because of rapid increases in all three key indicators. However, its ICT pillar dropped 14 positions because of relatively slow progress on all three indicators since 2000 compared to other countries. Sweden tops the list of 146 countries in KEI ranking in 2012. It had 4th rank in EIR, 2nd in innovation, 6th in education and 2nd in ICT. On the other hand, USA does not figure in the top 10 countries in KEI ranking. It has a rank of 12. It fell 8 spots down from 2000 position of 4th rank[15]. The most significant change is observed by Serbia, which improved its KEI rank from 144th in 2000 to 49th rank in 2012. All this indicates that India has to improve its performance in case of secondary and tertiary education (gross enrolment has to go up significantly) and do remarkably well on innovation front in terms of royalty payments and receipts, science and engineering (S&E) journal articles and patents. On ICT front, telephone and computer penetration requires quantum jump and efforts have to be made to improve this in rural India.

Singapore with strong performance in all three indicators, took 1st place in the EIR rankings. Singapore's normalized scores for tariff and non- tariff barriers and regulatory quality are 10.0 (table 17). Switzerland, ranking number 1 in the innovation pillar index, took the lead mainly because of the number of S&E journal articles published per million people: 1218, the highest of any country. Australia and New Zealand are strong performers in the education pillar. The former has the highest gross secondary enrolment rate of 133 percent, and the latter registered the highest average years of schooling (12.7 years) of all countries in 2012. ICT pillar's top spot was taken by Bahrain, as its number of internet users per 1000 population was 820 in 2012. Its telephone and computer penetration stood at 2290 and 750 respectively.

Table 16: KEI in India and China

Index	1995		2000		2012	
	India	China	India	China	India	China
KEI	3.57 (106)	3.99 (100)	3.14 (104)	3.83 (91)	3.06 (110)	4.37 (84)
Economic Incentive Regime index	3.57	3.46	3.56 (95)	2.82	3.57 (99)	3.79 (97)
Innovation Index	3.70	4.07	3.83 (96)	4.35	4.50 (76)	5.99 (54)
Education Index	2.51	3.68	2.30	3.36	2.26 (111)	3.93 (95)
ICT Index	4.50	4.77	2.85 (114)	4.80 (80)	1.90 (122)	3.79 (94)

Note : () ranks.
Source : World Bank- www.worldbank.org/kam.

Table 17: Top Ten Economies in Each Pillar: 2012

Rank	EIR	Innovation	Education	ICT
1	Singapore	Switzerland	New Zealand	Bahrain
2	Finland	Sweden	Australia	Sweden
3	Denmark	Finland	Norway	Luxemburg
4	Sweden	Singapore	Republic of Korea	UK
5	Hong Kong China	Denmark	Greece	Netherlands
6	Switzerland	USA	Sweden	Finland
7	Canada	Netherlands	Iceland	Switzerland
8	Norway	Israel	Taiwan China	Germany
9	Luxemburg	Taiwan China	Ireland	Taiwan China
10	Austria	Canada	Spain	Hong Kong China

Source : World Bank- www.worldbank.org/kam.

7. Conclusions

India has a long way to go to fully cherish the fruits of knowledge. There is great potential for increasing productivity by shifting labour from low productivity and subsistence activities in agriculture, informal sector, both industry and services, to more productive modern sectors, as well as to new knowledge based activities. This would help in reduction of poverty and enhance societal welfare. India should concentrate its strengths to become a leader in knowledge creation and use. This may require promoting new institutions and strengthening the existing ones. Policy shift may also be necessary especially in the case of education sector. The policy regime has to focus on strengthening the economic and institutional regime, developing educated and skilled workforce, creating an efficient innovation system and building a dynamic information infrastructure. The select growth path India treads in future will depend on how government, private sector, and civil society can synergise their efforts to create a common understanding of where the economy should be headed. They have to decide on what is required to get there. India is in a position to reap significant economic gains by developing policies and strategies that focus on making effective use of knowledge to increase the overall productivity of the economy and welfare of people. In this process, India will be able to perk up its international competitiveness. It can join the ranks of countries that are making a successful transition to the knowledge economy, an economy that creates, disseminates and uses knowledge to enhance its growth and development. India has to build on its critical mass of skilled, English-speaking knowledge workers, especially in sciences. Secondary and tertiary education requires attention so that average years of schooling goes up; gross secondary enrolment rate goes up; gross tertiary enrolment rate goes up; telephones and computers penetration improves; internet users increase manifolds; S&E journal articles publication (performance of CSIR alone would not help) goes up; innovations get patents enhancement and regulatory quality improvement and re-look at its tariffs & non-tariff barriers regime. India has a long way to go before it can rest. China has surged ahead in the recent times. Knowledge creation and its effective use would lead to higher growth and development. The hindrances to knowledge creation have to be reduced. R&D and innovation are the main drivers of the growth and to achieve these, investments in quality human capital is necessary along with correct and effective incentive system. India would have to use judiciously globalisation, outsourcing, off shoring, FDI and so on. It would also require strengthening the institutional regime and improvement in governance. This would mean strengthening the rule of law and IPR protection; establishment of a monitoring system to enhance government accountability and transparency (RTI is right foot forward); improvement in labour market flexibility (encourage free flow of labour and better allocation of human capital and reduce income gap etc); boost innovation capacity (improve efficiency and quality of domestic R&D, strengthen technology diffusion, strengthen financial support for innovation) and promote greater use of ICTs (more than AADHAR).

Acknowledgement

This is a revised and updated revision of the paper presented in an International Conference on "Knowledge and Development" organised by Punjabi University, Patiala, February 19-20, 2013.

Notes

1. The Greeks had developed investigative approach to nature that led to important discoveries in astronomy, physics and mathematics.
2. Knowledge is a public good with property rights that are rarely enforceable. It is seldom quantified or priced; it is sometimes codified, but more frequently tacit; and in any case it is difficult or impossible to observe. All measures of knowledge are indirect, either inputs to (years of schooling, manuals) or outputs of (human capital, patents, the unexplained residual in growth accounting) its accumulation (Navaretti and Tarr 2000).
3. See for instance, Barro and Sala-i-Martin (1995), Aghion and Howitt (1998), Grossman and Helpman (1991), Jones (1988) among others.
4. The best example is of green revolution in India.
5. The knowledge economy is usually taken to mean only high-technology industries or information and communication technologies (ICTs). The broader concept should cover how any economy harnesses and uses new and existing knowledge to improve the productivity of agriculture, industry and services and increase overall welfare.

6. There is a serious literature on learning and growth. The models look at learning as essentially a domestic affair and also knowledge imported from abroad (see Grossman and Helpman 1995 for comprehensive survey).
7. Human Resource Ministry supports single girl families in terms of tuition fee scholarships and is being implemented in CBSE schools.
8. The national programme for universal elementary education, Sarva Shiksha Abhiyan or Education for All, was initiated in 2001, and the constitution was amended in 2002 to make elementary education a fundamental right of every child. In addition, some private Indian companies such as Tata are using advances in ICTs to deliver education more efficiently. University Grants Commission also has a daily programme on education. Distance education is increasingly finding place in Indian education sector
9. In India, the plan-wise ratio of investment in physical capital to investment in education and R&D has continuously increased since the First Plan till the Sixth Plan and declined thereafter. Investment in human capital (education plus expenditure on health and family planning) more than doubled since the First Plan.
10. The classical example is of CSIR. Between 1997 and 2002, CSIR reduced its laboratories from 40 to 38 and its manpower from 24000 to 20000. At the same time, its output increased noticeably. Technical and scientific publications in internationally recognized journals tracked by the Science Citation Index rose from 1576 in 1995 too 2900 in 2005; their average impact factor increased from 1.5 to 2.2. Patent filings in India increased from 264 in 1997-98 to 418 in 2004-05. Patent filings abroad increased from 94 in 1997-98 to 500 in 2004-05. CSIR accounted for 50-60% of US patents granted to resident Indian inventors. Contract income grew from Rs.1.8 billion in 1995-96 to Rs.3.1 billion in 2005-06 (Bhojwani 2006).
11. The recent debate of FDI in retail sector articulated use of modern technologies to reduce food wastage.
12. There are strong views on this. Keller (2000) argues that countries benefit more from domestic R&D than from R&D of the average foreign country.
13. Government of India has set up a Knowledge Commission headed by Prime Minister.
14. As per the estimations of International Telecommunications Union, bandwidth available for connectivity to the Internet in India was 1475 megabits per second in 2001. This was 2639 Mbps in Singapore, 5432 Mbps in South Korea, 6308 Mbps in Hong Kong and 7598 Mbps in China (Chandrasekhar 2003).
15. The regression between knowledge index and development is: Y= 0.4257X sq - 5.5257X + 16.436; R sq= 0.6246.

    The regression between development and ICT is: Y= 0.2882 X cube – 6.2365 X sq + 44.969 X – 108.89; R sq = 0.7936 (Source: Ferranti *et al.* 2002).
16. For instance if India has to get 4th rank in 2000, then: average years of schooling has to be 12.2; gross secondary enrolment rate of 93.57; gross tertiary enrolment rate of 85.93; telephones per 1000 people of 1470 (30%); computers per 1000 people of 810; internet users per 1000 people of 780; S&E journal articles/ million people of 695.99; patents granted by UPSTO/ million people of 308.84; royalty payments and receipts (US$/ population) of 374.65; rule of law of 1.53 points; regulatory quality of 1.36 points and tariffs & non-tariff barriers of 86.4 (USA had these points in 2000 to rank 4th).

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Appendix Table 1: Educational Attainment of the Population Age 15 plus: India and China

Year	Population over age 15 (000's)	No schooling %	First level		Second level		Post-secondary		Average years of schooling
			Total	Completed	Total	Completed	Total	Completed	
			Females: Percentage of the population age 15 plus						
India									
1950	105423	89.4	9.8	2.7	0.7	0.2	0.2	0.1	0.397
1955	116521	88.3	10.8	3.1	0.8	0.3	0.2	0.1	0.445
1960	129083	86.7	12.3	3.8	0.9	0.2	0.2	0.1	0.501
1965	143057	84.4	13.8	4.7	1.6	0.4	0.3	0.1	0.642
1970	160013	80.9	16.1	6.0	2.5	0.5	0.5	0.2	0.834
1975	180533	80.5	12.0	5.0	6.6	0.5	0.9	0.4	1.101
1980	204436	79.0	9.0	4.1	10.8	0.3	1.2	0.6	1.370
1985	231149	72.9	11.9	6.1	13.6	0.3	1.7	0.8	1.783
1990	260669	66.3	14.6	8.4	16.7	0.3	2.3	1.2	2.250
1995	291052	61.8	16.0	10.2	19.6	0.4	2.5	1.3	2.601
2000	327010	56.7	17.4	12.0	22.5	0.5	3.3	1.8	3.034
2005	365710	50.2	19.7	14.7	25.9	0.6	4.2	2.2	3.561
2010	405900	44.7	20.3	16.0	30.0	0.7	5.1	2.7	4.073
China									
1950	179224	79.4	15.4	1.3	5.0	1.7	0.1	0.1	0.954
1955	185816	73.7	20.5	2.0	5.6	1.8	0.2	0.1	1.182
1960	195095	66.7	25.3	4.5	7.6	2.3	0.3	0.2	1.590
1965	211574	57.3	32.2	7.1	10.1	3.0	0.4	0.2	2.102
1970	243360	46.6	38.8	11.6	14.1	3.9	0.4	0.2	2.779
1975	272770	39.1	42.6	14.3	17.8	4.9	0.5	0.2	3.294
1980	312588	31.1	43.1	16.7	25.3	8.0	0.5	0.2	4.039
1985	362165	25.0	42.6	18.7	31.5	13.1	0.9	0.5	4.743
1990	406309	20.8	41.3	19.8	36.3	20.1	1.5	0.8	5.341
1995	437770	18.1	37.7	19.3	41.7	26.4	2.4	1.3	5.879
2000	469291	16.2	32.7	17.9	47.5	32.2	3.6	2.0	6.420
2005	506729	12.9	30.0	17.6	51.8	37.5	5.2	3.0	7.006
2010	535035	10.3	26.7	16.5	55.4	42.3	7.6	4.3	7.606

Source: Computed from Barro and Lee (2001) and (2010).

Appendix Table 2: Educational Attainment Across Age Groups- India: 2010

Age group	Population (000's)	No schooling %	First level		Second level		Post secondary		Average years of schooling
			Total	Completed	Total	Completed	Total	Completed	
All									
15-19	115383	10.13	17.31	17.31	66.96	0.44	5.60	0.80	7.04
20-24	109275	9.04	28.59	28.59	46.59	1.15	15.78	5.84	7.53
25-29	100009	23.48	20.90	20.90	45.44	1.12	10.19	5.88	6.27
30-34	86338	28.62	20.65	20.65	43.08	1.07	7.65	4.51	5.68
35-39	81433	40.65	16.39	16.39	37.31	0.92	5.66	3.75	4.64
40-44	73015	42.21	18.29	18.29	33.93	0.84	5.58	3.69	4.45
45-49	64010	47.94	19.58	19.39	26.32	0.65	6.16	4.10	3.98
50-54	54712	50.69	18.54	15.21	24.93	0.62	5.83	3.89	3.69
55-59	44012	52.01	20.25	13.76	22.53	0.60	5.20	3.41	3.42
60-64	33839	56.78	18.24	10.27	20.29	0.54	4.69	3.16	3.02
65-69	25691	59.74	20.29	9.46	16.51	0.61	3.46	2.29	2.58
70-74	18770	64.22	17.16	6.63	15.39	0.57	3.22	2.14	2.30
75+	22588	66.96	17.87	5.49	12.94	0.40	2.24	1.47	1.95
25+	604417	42.22	19.14	16.60	32.28	0.84	6.37	4.07	4.43
15+	829075	33.38	20.13	18.18	38.99	0.91	7.50	4.01	5.20
Female									
15-19	55959	11.62	18.68	18.68	65.61	0.28	4.09	0.55	6.78
20-24	52871	17.68	29.90	29.90	39.33	0.58	13.10	5.30	6.60
25-29	48373	33.23	24.14	24.14	33.54	0.51	9.10	5.48	5.29
30-34	41759	40.45	22.22	20.50	30.11	0.48	7.22	4.42	4.59
35-39	39403	50.67	17.53	14.37	26.99	0.45	4.82	3.25	3.66
40-44	35375	56.17	16.03	11.69	23.43	0.40	4.38	2.94	3.21
45-49	31037	61.69	16.66	10.80	17.74	0.32	3.91	2.52	2.67
50-54	26576	65.41	15.05	8.67	16.02	0.28	3.53	2.29	2.39
55-59	21569	67.74	16.28	8.34	13.40	0.33	2.59	1.56	2.06
60-64	17109	73.61	13.31	6.07	10.96	0.27	2.12	1.31	1.67
65-69	13404	77.43	13.61	5.52	7.75	0.28	1.21	0.74	1.28
70-74	10040	81.03	11.00	3.96	6.90	0.25	1.07	0.66	1.09
75+	12425	83.76	10.23	3.13	5.39	0.21	0.61	0.37	0.86
25+	297070	55.70	17.74	12.67	21.76	0.44	4.81	3.04	3.22
15+	405900	44.67	19.45	15.38	30.10	0.52	5.79	3.09	4.14

Source: computed from Barro and Lee (2010).