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India: Towards a Knowledge Superpower? – A View from Outside[†*]

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Introduction

From the very dawn of history, whether it is for matters of the mind or material, India has always been a fertile land. The first references to astronomy are found in the *Rig Veda* which dates back to 2000 BC.[1] Mathematics has its roots in the nearly 4,000 years old *Vedic* literature. Indians developed many important mathematical concepts, including the base-ten decimal system.[2] India's Panini is well-regarded as the founder of linguistics, and his Sanskrit grammar is still considered to be the most sophisticated of any language in the world.[3] Even in manufacturing, India had an important position. According to the Yale historian, Paul Kennedy, India accounted for roughly 25 percent of global industrial output in the 1770s.[4] India's tangible and intangible assets had always attracted external worshippers and warriors alike.

Today, India's economic story is still impressive. The economy has been performing well, growing by an average nine percent in the last three years. Many high-tech industries have emerged and grown in India. These include information technology and communications, defence and space technology, pharmaceuticals and bio-technology. This rapid expansion of the Indian economy has resulted in gross domestic product (GDP) per capita increasing from US$1,378 in 1998 to US$2,777 in 2007 (in purchasing power parity [PPP] terms).[5] Indian scholars have excelled in the areas of literature, physics, medicine, physiology, information technology, and bio-technology, among others. The nation has half-a-dozen Nobel Prize winners to its credit.

Whilst one does not doubt India's economic rise, can one also then conclude that India has the potential to become a knowledge superpower? I shall discuss the question of whether India is a knowledge-based economy, as that will allow us to ascertain if it can become a knowledge superpower. I shall examine the key knowledge-based sectors in India as well as the advantages India has in pushing forward its knowledge-based industries. I shall then compare India with other knowledge-based countries. I shall also highlight the challenges facing India in this regard.

Definition of a Knowledge-Based Economy

I think the first task of this paper is to define the term “knowledge-based economy”. What is a knowledge economy? It is basically an economy that creates, disseminates and uses knowledge to enhance its growth and development. A country’s success in the knowledge-based economy depends on the creation, acquisition, dissemination and application of knowledge.[6]

Knowledge creation depends on the intensity of research and development (R&D) conducted in a country, and the availability of human resources needed for R&D.

Knowledge acquisition is reflected in intellectual content embedded in imports from other knowledge-based economies (or through multinational corporations [MNCs]). Linguistic skills will help to plug into the global knowledge network.

Knowledge dissemination depends on the resources allocated to develop information infrastructure, basic information technology (IT) and linguistic skills to tap into the info-communication technology (ICT) network.

Finally, knowledge application is reflected in an economy’s job market that demands and allows workers to apply knowledge extensively, and its ability to create new business models for generating, acquiring, diffusing and applying new ideas and processes.

The basic difference between a traditional and knowledge-based economy is that the former depends on quantitative factors such as labour, raw materials, premises and bulk transportation, among others, whereas the latter relies more on qualitative factors, namely, qualifications, R&D and good infrastructure. Resource-driven economies sometimes depend on a protectionist environment, whereas knowledge-based economies thrive in a friendly and open policy environment, and on innovation and qualified labour.

India’s Key Knowledge-based Industries

The economic rise of India has seen Indian industries emerging as global players. I shall look at the development of several of the key knowledge-based industries in India.

Information and Communications Technology

The success story of India’s IT and IT-enabled industries (ITES) is well documented. India’s software industry grew at an average annual rate of approximately 50 percent between 1992-93 and 2000-01.

The Indian IT-business process outsourcing (BPO) revenue aggregate is expected to grow by over 33 percent and reach US$64 billion by the end of FY2008. IT exports, (including hardware exports), are expected to cross US$40.8 billion in FY2008 as against US$31.9 billion in FY2007, a growth of 28 percent. The domestic IT market (including hardware) is estimated to reach 23.2 billion in FY2008 as against US$16.2 billion in FY2007, a growth of 43 percent. The direct employment in this sector is expected to reach nearly two million in FY2008, an increase of about 375,000 professionals over FY2007. The services exports, BPO exports and the domestic IT industries provide direct employment to 865,000, 704,000 and 427,000 professionals respectively.[7]

As a proportion of national GDP, the Indian technology sector revenue grew from 1.2 percent in FY1998 to an estimated 5.5 percent in FY2008. In 2007, there were more than 6,000 software exporting companies in the Software Technology Parks of India, spread over 21 cities, with a share of 73 percent of the exports.

To reap the comparative advantages offered by the Indian software industry, about 250 of the Fortune 500 companies are now clients of Indian IT. As in December 2006, a total of 90 Indian companies have received the Software Engineering Institute, Capability Maturity Model certificate. This is higher than any other country in the world.

India started by offering simple software solutions. It now is the favoured destination for high skilled, knowledge intensive activities. A majority of the Fortune 500 and Global 2000 corporations are sourcing IT-ITES from India. HCL and Wipro carry out outsourcing for innovation through MNCs like Boeing. IBM, Motorola, Hewlett-Packard, Cisco Systems and Google have set up R&D centres in Indian cities. General Electric's research centre in Bangalore is equal to its global research headquarters in New York. All the top 10 global fables design companies have operations in India. Fables designs are hardware devices implemented on semiconductor chips.

Having made an ineffaceable mark in the BPO business, India has now become an important Knowledge Process Outsourcing (KPO) destination. According to a recent report released by KPMG,[8] India will continue to be the preferred location for the global KPO destination and the industry is projected to be worth between US$10 billion and US$17 billion by 2010. However, the same report reveals that the shortage of skilled workers, Rupee appreciation, and under resourced and inadequately empowered legal framework and compliance within KPO providers are costing the competitiveness in this sector.

Defence and Space Technology

Although India has been starved of imported nuclear technology for almost three decades now, it has developed a competitive advantage in thorium-led nuclear technology. It has the world's second largest reserve of thorium just falling behind Australia. By producing the world's first U233-fuelled prototype reactor, Kamini, India has not only entered into Stage Three of its Nuclear Power Programme, it could also become the largest supplier of radioactive thorium by 2011. Incidentally, Kamini, with 30 kilowatt capacity, is the only operating reactor in the world with U233 fuel.[9]

As the Indian Department of Atomic Energy progresses in the harnessing of fusion energy and in the development of thorium-based Fast Breeder Reactors, it is believed that India may well develop the capabilities to be nuclear self-sufficient. This has made it the world leader in thorium technology. The technology that has been used to operate the Canadian reactor CIRUS and to develop the 900 Mega Watt Pressurized Heavy Water Reactors is Indian as well.

India has come a long way in the development of nuclear technology. It began modestly with the commissioning of a Cirus 40 Mega Watt heavy-water-moderated research reactor from Canada in 1960.[10] Now, India provides the services of its scientists for expert assignments to other countries through the auspices of the International Atomic Energy Agency and through bilateral agreements for cooperation in the field of peaceful uses of atomic energy. This highlights India's leading position in nuclear technology in the world.[11] It also underlines

India's self-reliance as it has mastered the expertise covering the complete nuclear cycle from exploration and mining to power generation and waste management.

In space technology, India too has developed advanced capabilities. Its seven communication satellites, the biggest civilian system in the Asia-Pacific region, now reach some of the remotest corners of the country, providing television coverage to 90 percent of the population. The system is also being used to extend remote healthcare services and education to the rural poor.[12] For instance, it has already linked 69 hospitals in remote areas of India to 19 hospitals in India's main cities. This allows a health worker in a rural location to transmit a patient's medical information to a specialist in seconds and, as in many cases, a video consultation is sufficient for diagnosis. This reduces the need for the patient to travel long distances unless it is absolutely necessary.

India's space programme is a money-earner as the Indian Space Research Organisation (ISRO) sells infrared images from its remote-sensing satellites to other countries, including the United States, where they are used for mapping.[13] Although India's initial few rocket launches ended tragically, its Polar Synchronous Launch Vehicles (PSLV) have been successful since September 1993. Three percent of the ISRO's US$3.3 billion five-year budget is devoted to the planned moon mission. This features a reconfigured PSLV rocket which will lift the Chandrayan to 36,000 kilometres, after which the craft's own engines will take it to the moon. The Chandrayan will create history by producing 3D maps of the moon's surface at a resolution of between 5 and 10 metres.[14] The Madras School of Economics estimates that the ISRO's projects have increased India's GDP by about three times the organisation's budget. As India becomes a model for its space programme, which meets its societal demands for the needy in a cost effective manner, developing countries around the world seek the ISRO's consultative assistance.

Pharmaceuticals

Today India is recognised as one of the leading global players in pharmaceuticals. It is internationally recognised as one of the lowest-cost-producers of drugs. India is the fourth largest producer of pharmaceutical in the world.[15] The value of the pharmaceutical industry's output is reported to have grown more than ten-fold from Rs.50 billion in 1990 to Rs.650 billion in 2006-07.[16] In 2005, there were 84 manufacturing units in India approved by the United States' Food and Drug Administration (FDA) – this was the largest number of FDA-approved manufacturing facilities in any country outside the United States. Indian companies are reported to be seeking more Abbreviated NEW Drug Approvals in the United States in specialised segments like anti-infectives, cardiovasculars and central nervous systems.[17]

In 2006-07, India exported drugs and pharmaceuticals worth US$1.3 billion. India exports pharmaceutical products to a large number of countries, including the United States, the United Kingdom, Germany, Russia and China. Several indicators suggest that this success is due to its excellent qualities.

In 2005, the Indian pharmaceutical industry consisted of 300 large to moderate firms and approximately 5,000 smaller firms. Some of the key players in this field are Biocon, Dr.Reddy's Laboratories, Ranbaxy and Piramal Pharmaceuticals. Leading pharmaceutical firms in India have been making higher allocations for R&D spending and trying to acquire patents abroad. In the case of Dr.Reddy's Laboratories, R&D charges, as a proportion of sales revenue, increased from 0.6 percent in the three-year period ending in 1987 to 2.8 percent and

11 percent respectively in the three-year periods ending in 1994-95 and 2005-06. Ranbaxy made 698 patent filings in the first nine months of 2005, compared to 428 patent filings in the first nine months of 2004. Ranbaxy has set the target of becoming 'one of the top five generic drug makers in the world by 2012' and spends approximately seven percent of its global revenue on R&D.

Multinational companies have started outsourcing clinical trials to India as the cost reduction involved is substantial. Given the need for skilled manpower in this sector, the Indian government has decided to set up six new National Institutes of Pharmaceutical Education and Research.[18]

The R&D expenditures at the aggregate levels has recorded a 40 percent increase from 2000-2006.[19] But, in terms of innovation capabilities, even if firms develop new modules, the skills for advancing such modules to clinical trials and regulatory stages are limited. Hence, a major challenge for the Indian firms will be to focus on advanced research and to collaborate with developing markets.

Biotechnology

Biotechnology is an emerging knowledge-intensive sector in India. Within the biotechnology sector, the key opportunity segments are bio-pharmaceutical, bio-agriculture, bio-industry, bio-informatics and bio-services, namely, R&D, clinical trials and manufacturing on contract. According to the Journal of Commercial Biotechnology, the sector crossed the US$2 billion mark during 2006-2007. While this figure accounts for only roughly one percent share of the global biotechnology market, this sector has grown by over 35 percent annually over the last five years. It could reach to US$25 billion by 2015. As support for this sector, the Indian government increased the Department of Biotechnology's budget by four-fold from US$30 million to US$120 million between 1999 and 2005. Inspite of the increase in funds, fears have been expressed that the firms deal only with contract research, clinical trials and validation studies for MNCs and that adequate emphasis has not been given for the development of innovation skills.

The Indian biotechnology sector today comprises over 325 companies.[20] Many Indian biotechnology firms have achieved global reputation and have brought the cost of drugs and other life-saving medicines down significantly. For instance, Shantha Biotechnics of Hyderabad today supplies 40 percent of the United Nations Children's Fund's global Hepatitis B vaccine supplies.[21]

The biotechnology sector is set to provide the next wave of opportunities in India. In recognition of its huge potential, some analysts have compared the Indian biotechnology sector to a baby elephant which means that, when it matures, it will occupy much of India's economic space.

India's Ranking as a Knowledge-Based Economy

Looking at these industries, one can safely conclude that India has made significant progress in its knowledge-based sectors. But how does India compare with other knowledge-based economies such as Ireland and Israel, or emerging knowledge-based economies like China? I must confess that the data is rather limited for some variables but I shall try to present an overview based on available data.

According to the World Bank's Knowledge Economy Index (KEI)[22] that takes into account the conduciveness of an economy's environment for knowledge to be used effectively for economic development, India ranked 101st out of 140 countries in 2007.[23] Ireland, Israel and China ranked 14th, 22nd and 75th respectively. The same source showed that, while China and other emerging economies have improved their position significantly, in terms of innovation, education and ICT, India's ranking remained the same in 2007 when compared to the 1995 figures. I have some doubts on the reliability of this figure. But it is possible that India lags behind the other countries in terms of R&D and education. India's position, in terms of the publication of technical journal articles, patent granted by the United States Patent and Trademark Office, gross tertiary enrolments, computer usage per thousand population, internet users per thousand people, and the number of telephone per thousand people, is still low when compared to other knowledge-based economies.

According to the Switzerland-based IMD World Competitiveness yearbook 2007,[24] India is the 27th most-competitive economy out of 55 countries in the survey based on economic performance, government efficiency, business efficiency and infrastructure. It also showed that R&D expenditure in India (as percentage of GDP) declined in recent years. In 1998, India's R&D expenditure was 0.81 percent of its GDP but declined to 0.61 percent in 2005. China's R&D expenditure increased from 0.65 percent (US$6,656.52) in 1998 to 1.33 percent (US$36,910.23) of its GDP in 2005. The same source also reported that, in 2005, Singapore R&D expenditure was US$2,752.74 equivalent to 2.36 percent of the country's GDP. Israel's R&D expenditure was 4.53 percent (US$6,440.31) of its GDP in 2006. In 2005, India's per capita R&D expenditure was US$4.41, whereas, China's and South Korea's per capita R&D expenditure were US$22.87 and US$1,537.57 respectively. The OECD Fact Book 2007 also painted a similar picture of India's expenditure in R&D.

However, in terms of availability of information technology skills, development and application of technology, the IMD World Competitiveness Center states that India ranks favourably vis-à-vis Israel and China, among others. The same source reports that science education in the Indian schools is being sufficiently emphasised when compared to Israel and China (See Table 1). In some areas, India is ahead of its peers. For instance, as mentioned earlier, in the pharmaceutical sector, India has the largest number of FDA-approved plants after the United States.

India's Strategic Advantages

The available data does not rank India as impressively as some of the other knowledge-based economies in the world. This is perhaps understandable, given that India's liberalisation efforts, when compared to other knowledge-based economies, are a recent phenomenon. However, India has several key advantages which could work in its favour in the "knowledge-based economy" game. These are:-

a) Young population – India enjoys the advantage of having a young population. In 2004, the proportion of population below 15 years of age was 32.5 percent in India, compared to 22 percent for China. It is estimated that, in 2020, an average person will only be 29 years old in India, compared to 37 years in China, 45 years in Western Europe, and 48 years in Japan. Therefore, it is argued, India possesses the potential to benefit from the 'demographic dividend' many long years into the future. However, India will only be able to reap the benefits of its young populace if it is able to provide the education and skills needed to meet the demands of its high-technology industries.

As will be discussed later, the education sector is a key challenge in India's push to becoming a knowledge-based economy.

b) Critical mass of English-speaking workers – In 2001, India's English speaking population was estimated to between 30 and 50 million, which is almost as large as the population of a medium-sized country.[25] At present, it is estimated to beyond 70 million. Such linguistic skills are important to allow Indians to connect with the rest of the world and to benefit from the opportunities in the global market place. Singapore opted for English as the main language for two reasons. Firstly, it provided a level playing field for the different races to compete in. Secondly, it enabled the nation to plug directly into the science and technology sector without going through a translation. India must use the English language for the same purpose.

c) Large and fast growing domestic market – Its relative domestic market size makes it one of the world's largest. This is true regardless of the conversion factor one chooses to use. Using the new conversion factor, India's GDP at PPP is estimated at US$3.19 trillion, making it the fifth largest economy in the world. At the nominal exchange rate (which means the value of a country's currency in relation to other currencies without adjustment for the inflation rate), India's GDP is projected be US$1.16 trillion in 2007-08. India's per capita GDP at market prices (constant 1999-2000 prices) grew by at an average rate of 7.2 percent per annum during the last five years (2003-04 to 2007-08). At this rate, India's average income would double in a decade. The growth rate of per capita consumption has also accelerated during the last five years to 5.1 percent as against the average growth rate of 2.6 percent in the 1990s.[26]

d) Large and impressive diaspora – The Indian diaspora allows for invaluable knowledge linkages and networks globally. At the same time, the highly influential diaspora of Indian professionals and entrepreneurs have been instrumental in bringing high technology investments to Bangalore, Hyderabad and other Indian cities. The decision by the Indian government to allow for dual citizenship has provided further impetus to the diaspora to continue to stay rooted to India. India currently holds non-resident Indian (NRI) investments worth US$35 billion, with annual accretion of US$2-3 billion.[27] Remittances form nearly three percent of India's GDP and have almost doubled over the last five years. The World Bank estimates have placed India as the largest recipient of remittances in the world and have predicted that India would receive more than US$200 billion remittances over the next five years.[28]

e) Emerging financial sector – In recent years, India has attained macroeconomic stability and has made significant strides in institutional developments, including having a well-functioning financial sector. Currently, the Indian financial sector is more efficient at capital allocation than many other Asian countries. Small and medium enterprises account for 45 percent of banks' business loans in India, compared to 26 percent in China.[29] India continues to attract foreign investments and presence in its banking sector due to its sheer potential alone. The total asset size of the Indian banking sector was US$270 billion in 2006 while total deposits amounted to US$220 billion. Revenues of the banking sector have grown at six percent (compound annual growth rate) in recent years to reach US$15 billion in 2006. This has resulted in commercial banks no longer simply catering to short- and medium-term financing requirements, but also joining national-level and state-level financial institutions to provide project financing.[30]

The deregulation of the banking industry has contributed to improved capital access as it has increased the presence of foreign banks in India. In accordance with the first phase of this deregulation, between March 2005 and March 2009, foreign banks may establish a presence by way of setting up a wholly-owned subsidiary (WOS) or conversion of existing branches into a WOS. This has prompted some of the world's largest banks such as Citibank, ABN AMRO, HSBC, DBS and Standard Chartered Bank, among others, to have a significant presence in India.

Key Challenges

Whilst India enjoys significant advantages, it also faces several challenges which may impede or hinder it from becoming a knowledge superpower. I shall highlight the key challenges.

Education

India's premier technical institutions, namely, the Indian Institutes of Technology (IITs) and the Indian Institutes of Management (IIM) have been the source of entrepreneurship in recent years. India has emerged as an important player in the world-wide ICT revolution on the basis of the substantial number of skilled professionals in software and hardware. Over the decades of planned development, India has built a fairly extensive system of higher education. This existing system is of varying quality. In March 2005, there were 343 institutes of higher education and 16,000 colleges. The total enrolment in higher education is estimated to be 9.3 million.

However, India's system of higher education suffers from several limitations.[31] Firstly, the gross enrolment ratio in higher education is less than nine percent in India, compared to 15 percent in China and more than 20 percent in many developing countries such as Mexico, Malaysia, Thailand, Chile and Brazil. In the case of IT, enrolment is 40 to 50 percent more in developed countries.[32] Secondly, the enrolment ratios vary across Indian states, with the southern and western states faring better than their eastern counterparts. Furthermore, the share of students enrolled in science was less than 20 percent in 2002-03 while the share of student enrolment in medicine and engineering/technology accounted for less than 12 percent of total student enrolment.

In the case of youth literacy, India lags substantially behind all the other BRIC (Brazil, Russia, India, and China) countries. India's achievements are well below the average of all developing countries (See Table 2). In India, 93.4 percent of all elementary-school-age children (6-14 year olds) were enrolled in school in 2006. Enrolment, however, is only the first step. A child must complete eight years of basic schooling. However, based on the Planning Commission Report of 2006, the drop-out rate in primary schools for the country as a whole was around 31 percent in 2003-04 and it was much higher in many states. The picture is not very rosy for secondary education, with gross enrolment ratio in 2003-04 estimated to be only 39 percent.

The problem in the education sector is further compounded the lack of proper teaching facilities and best-practices, especially in the rural areas. According to the Third International Mathematics and Science study, 9^{th} and 11^{th} grade students in India scored way below the international average.[33] Some of the causes identified by education experts are a high teacher to pupil ratio, at 1:42 in some states and as high as 1:83 in others. There are also no standard teacher training processes in place, and accountability and benchmarking are almost absent. The outdated rote learning is also in practice, without sufficient conceptual understanding.[34]

Another challenge for the education sector is bridging the digital divide in the country. If India aspires to be a knowledge-based economy, it will have to ensure that most, if not all, of its people are equipped, prepared and ready to contribute to its development in this regard. At the moment, there is an urgent need to ensure affordable access to locally-relevant IT applications at a broad level. As it stands, less than two percent of the population in India owns a computer, only two percent of all schools have computers and about six percent of the total population is internet users.[35]

A key development in the Indian education sector in recent times is the emergence of private schools. The Planning Commission reported in 2006 that private aided and unaided schools accounted for 58 percent of the total number of secondary schools and 25 percent of the student population. The proportion of private schools has certainly gone up in recent years. However, these schools have largely benefitted the relatively better-off sections of the Indian society. India needs to reduce this growing inequality in educational opportunity through state intervention and public investment in education.

The Indian government has been taking steps to address the challenges of the education sector. The annual budget allocation for education has been increasing over the years. The government allocation for education grew from Rs.18,337 crore in FY2005-06 to Rs.28,674 crore in FY2007-08. This accounted for three percent and four percent of the budget in FY2005-06 and FY2007-08 respectively. Expenditure on education will increase by 20 percent over FY2007-08 to Rs.34,400 crore in FY2008-09, accounting for 4.5 percent of the budget.[36]

Also, in the Budget of 2008, the Indian Finance Minister announced the establishment of three Indian Institutes of Science Education and Research (IISERs) at Mohali, Pune and Kolkata while an IIT has started operations at Kanchipuram. At the same time, the government will to set up 16 central universities in each of the hitherto uncovered states; three IITs in Andhra Pradesh, Bihar and Rajasthan; two IISERs at Bhopal and Tiruvananthapuram; and two Schools of Planning and Architecture at Bhopal and Vijayawada. It provided Rs.5 crore grant to Deccan College, Postgraduate and Research Institute, Pune while Rs.85 crore has been allocated for Innovation in Science Pursuit for Inspired Research which will include scholarships for young learners (10-17 years), scholarships for continuing science education (17-22 years) and opportunities for research careers (22-32 years). Also, Rs.100 crore has provided for establishing the National Knowledge Network.

Over-regulated and Cumbersome Bureaucracy

India has more than 17 million state and federal government employees. "About 20,000-odd federal officers control the collection and disbursement of over US$71 billion federal revenue every year".[37] Transparency International, a global watchdog body on corruption, ranked India 72nd out of the 179 countries in its corruption perception index in 2007, One recent study by the Center for Media Studies, New Delhi, on corruption in urban services revealed that "nearly half of those who avail the services of the most frequently-visited public departments of the government in the country have had first hand experience of greasing palms at least once."[38]

At the same time, the "Inspector Regime" or "Licence Raj" has its inherent problems and, unfortunately, India has not done away with the old structures. A World Bank report ranks India 120th out of 178 countries in ease of doing business in 2006. The time to obtain a business licence in India ranges from 35 days in the financial hub, Mumbai, to 522 days in the eastern city of Ranchi. In contrast, a start-up takes five days in Singapore, and 17 days in the countries of the Organisation for Economic Co-operation and Development.[39]

In sectors where 100 per cent foreign ownership is allowed under the "automatic route", NRI Overseas Corporate Bodies (OCBs) have to get the Foreign Investment Promotion Board's permission to purchase even one share in an Indian company. And it takes a minimum of four to five weeks to get the approval of the Reserve Bank of India (RBI). The whole process for approval for a normal case for NRI OCBs can take between three to four months. In the interim period, the market conditions could change. It is estimated that investors setting up shop in India require up to 70 different approvals. The World Bank estimates that there are 47 national laws and 157 state regulations governing employment in India.[40]

Infrastructure Development

This is an often-spoken subject in many forums. To develop a knowledge-based economy, the role of ICT, education and scientific infrastructure are necessary. However, equally critical is the need for supporting physical infrastructure such as railways, roads, ports, telecommunications and energy. A good infrastructure does not only enhance an economy's productivity, it is also a crucial determinant in attracting investments into the country.

India needs to develop of its infrastructure. It remains one of the lowest per capita energy consuming countries, only ahead of the African countries. Only half of the total households have access to electricity. The IMD World Competitiveness Online database shows that, based on survey data, India graded poorly in terms of the distribution infrastructure of goods and services, the maintenance and development of infrastructure and energy infrastructure, among others (See Table 1).

On education, scientific and technological infrastructure, India needs improvement in terms of R&D expenditure, enforcement of intellectual property rights, the number of computer and Internet users, and knowledge transfer between universities and companies, inter alia.

Role of Government in R&D

The state has an important role in transforming the economy from a traditional to a knowledge-based one, as the private sector may not always invest in areas like education, infrastructure and R&D, if there a mismatch between the firm's revenue and cost. In this context, Nobel Laureate Economist Joseph Stiglitz's view is worth mentioning. Citing knowledge as a public good, Stiglitz expressed the view that the state must play some role in the provision of such goods.[41] Otherwise they will be undersupplied. To him, governments have pursued two different strategies in addressing the concern. The first is to increase the degree of appropriability of the return to knowledge by issuing patents and copyright protection. The second strategy for dealing with the appropriability problem entails direct government support. These two sets of issues are highly linked with an economy's basic, scientific and information technology infrastructure.

Cross-border cooperation in R&D is another way to enhance a country's scientific research. Countries in consideration can share their expertise based on comparative advantages. India has such an agreement with Israel, known as India-Israel Cooperation in Science and Technology. It could explore more of such collaborations, especially with countries which have made great strides in knowledge-based industries. In such instances, the government needs to take the lead.

Sharing the Singapore Experience

Before I conclude, I would like to share the experiences of Singapore in its push towards becoming a knowledge-based economy. One may argue that there is really no comparison between the two countries, given the size and complexities in India. However, I believe that we can draw some lessons from the tiny island state which could be useful and relevant to India.

Firstly, the Singapore government takes the lead to promote sustained innovation as a driver of Singapore's economy. In this regard, it aims to increase R&D in three key areas. Based on their growth trajectory in Asia, the Singapore government anticipates biomedical science, environment and water technology, and media industries to be key economic drivers in the future. Intensive R&D will, thus, help these industries achieve their potential. Singapore's aggressive R&D pursuit includes a government commitment to increase research investment in these areas to three percent of its GDP by 2010 from the current 2.1 percent. This will increase Singapore's overall research expenditure by three-fold from the current US$6.1 billion to reach US$19 billion in 2010.[42]

Each of these growth sectors contributes to the development of a knowledge-based Singapore. An extensive and reliable ICT infrastructure supports knowledge building in the country. In this regard, the info-communication authorities in Singapore have been instrumental in developing the Intelligent Nation 2015 masterplan.[43] This plan was hatched after a year-long consultation with the public and private sectors to develop Singapore as an intelligent nation. The main objective of this masterplan is to establish an info-communication infrastructure that will create the information superhighway to support the future generations of knowledge-based Singapore. This proposed infrastructure would consist of a wired and wireless network that would ensure the entire country is connected at home and everywhere.

Human capital is arguably the most valuable asset that India has. It is this strength that possesses the potential of propelling India into a knowledge-based economy if carefully nurtured.[44] Singapore, like India, also depends heavily on its human capital to facilitate this transition. Without any other resource, Singapore has relied heavily on human capital to drive its growth and, in doing so, has built up a resource base that is resilient enough to withstand shocks and flexible enough to meet the demands of globalisation.

Education has been a fundamental component of this process. Singapore has ensured that it provides the primary English, Mathematical and Science foundations needed to survive in this competitive environment.[45] However, this is insufficient for the society to transcend into an effective knowledge society and cope with the demands of a global workforce. The Singapore government introduced vocational education early on in its development history. This has helped to provide the talent needed for a skills-based section of the workforce. Further, by tapping on alternate talents than strict academic education, Singapore has ensured that every spectrum of the society contributes positively to the overall knowledge attainment. In this regard, Institutes of Technical Education and polytechnics plug this gap for a technically- sound workforce.

Conclusion

The growth of a knowledge-economy is highly dependant on a robust policy environment. Countries aspiring to be knowledge-based economies must ensure a stable political and economic environment so that foreign direct investment and foreign expertise come in with their capital and other intangible assets. At the same time, local companies and talents will find it conducive to apply their knowledge and flourish in India.

In conclusion, India has progressed well since it initiated its liberalisation drive in the early 1990s. It has emerged to become an important global economic power and it will continue to witness good growth. Its key knowledge-based industries have also moved out of its borders to compete and collaborate with some of the best around the world. However, I would add that India faces several key challenges. These are, by no means, small but, at the same time, they are not insurmountable. They can be overcome but this would require a direct and more proactive approach from the Indian government and the large Indian conglomerates.

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Table 1: Comparisons: Israel, India and China in the K-economy

	Israel	India	China
Education			
University education meets the needs of a competitive economy (score 0-10), 2007 data	7.33	6.07	4.98
Knowledge transfer between universities and companies (score 0-10), 2007 data	8.62	4.70	3.98
Scientific Infrastructure			
Total Expenditure on R&D (% of GDP), 2005 data	4.53	0.61	1.41
Total Expenditure on R&D per capita (US$ per capita), 2005 data	905.81	4.41	28.08
Basic Research (score 0-10), 2007 data	7.08	5.30	6.56
Science in school sufficiently emphasised (score 0-10), 2007 data	5.33	6.63	5.98
Youth interest in science (score 0-10), 2007 data	6.10	6.73	5.94
No. of patents granted to residents , 2004 data	N.A	695	11798
No of patents securing abroad, 2005 data	1633	710	716
Intellectual property rights are adequately enforced (score 0-10), 2007 data	6.79	5.29	5.40
Technological Infrastructure			
Communication technology meets business requirements, 2007 data	9.08	7.63	7.67
No. of computers per 1,000 people, 2006 data	606.72	19.18	56.04
No. of Internet users per 1,000 people, 2006 data	637.67	61.70	103.59
Information technology skills (score 0-10), 2007 data	9.28	8.75	5.81
Technological cooperation between companies, (score 0-10), 2007 data	7.79	6.03	5.08
Development and application of technology, (score 0-10), 2007 data	8.05	6.57	6.44
Funding for technological development, (score 0-10), 2007 data	7.74	6.37	4.12
High-tech exports (% of manufactured exports), 2004 data	18.82	4.88	29.81
Basic Infrastructure			
The distribution infrastructure of goods and services (score 0-10), 2007 data	6.65	4.77	6.58
Maintenance and development of infrastructure (score 0-10), 2007 data	5.59	3.37	6.17
Quality of air transportation	6.67	6.83	7.38
Energy infrastructure (score 0-10), 2007 data	6.05	2.92	5.48
Energy intensity (Commercial energy consumed for each dollar of GDP in kilojoules)	7,094.46	22,144.92	27,314.09
Productivity & Efficiency			
Overall productivity, GDP per person employed, US$, 2006 data	73108.87	9462.01	12772.32
Productivity in services, GDP per person employed in services, 2006 data	71105.44	20257.29	14795.88
Productivity of companies is sufficiently supported by global strategies, (score 0-10), 2007 data	6.15	5.73	5.38

Source: *IMD World Competitiveness Yearbook*, various years

Table 2: Youth Literacy Rates (15-24 year olds): Latest available between 2000-04

Country	Total	Male	Female
India	76.4	84.2	67.7
China	98.9	99.2	98.5
Brazil	96.8	95.8	97.9
Russian Federation	99.7	99.7.	99.8
World	87.3	90.5	84.1
Developing Countries	84.8	88.6	80.9

Source: Extracted from Table 1 in Kingdom (2007)

Endnotes

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