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Science, Technology and Innovation in India since Independence

Ganeswar Sahoo*

India has witnessed a significant change in its science and technology infrastructures since independence. Today India is considered a knowledge superpower with humungous growth in science, technology and its contribution in innovation to the world. The papers is about the study of innovation in pre and post independent India and to what extent India's science and technology infrastructures touches a new height today. This paper studies brief history of science, technology and patent to understand the position of India before Independence from Britain. Methodologically, the paper adopts a qualitative study compiling data on key innovation indicators – such as input measure (Workforce and Educational Infrastructures and Science and Technology Infrastructures) and output measure (R & D and Patents) of innovation. Besides contribution to the existing literatures, the paper found India's R & D initiative still faces major challenges. India's policy on tax incentives is centralized to few sectoral benefits that the innovation is limited and recommends a policy change.

Keyword: Science, Technology, Innovation, India, BRICS, Patent and R & D

Introduction

India has been a land of history and heritage of both invention and innovation. The history of science and technology in the Indian subcontinent is as old as the prehistoric period (5500 BC), and is believed to be continued through the Indus Valley Civilization (Kenoyer, 2006). India's innovation is well inhered from the iron works in the Vedic period of India (composed roughly between begins1700 – 1100 BCE and ends 500 -150 BCE) (Witzel, 2003). Tewari (2003) found that the period of iron melting, iron artefacts and the practice iron technology could be calibrated and believed the early 13th century BCE by the Indus Valley Civilizations in the Indian subcontinent.

The world has been witnessing the valuable contributions of India in the field of science and technology. Whether it is number zero or mathematical formulas, history has recorded India's scientific tradition from the ancient era. The conceptualization of squares, rectangles, circles, triangles, fractions, the ability to express the number ten to the twelfth power, algebraic formulas, and astronomy had even more ancient origins in Vedic literature, some of which was compiled as early as 1500 B.C.The concepts of astronomy, metaphysics, and perennial movement are all embodied in the Rig Veda (seedas and Polytheism, ch. 3). Technological discoveries have been made relating to pharmacology, brain surgery, medicine, artificial colors and glazes, metallurgy, recrystallization, chemistry, the decimal system, geometry, astronomy, and language and linguistics (systematic linguistic analysis having originated in India with Panini's fourth-century B.C. Sanskrit grammar, the Ashtadhyayi). These discoveries have led to practical applications in brick and pottery making, metal casting, distillation, surveying, town planning, hydraulics, the development of a lunar calendar, and the means of recording these discoveries as early as the era of Harappan culture (Harappan Culture, ch. 1).

The Mughals, an imperial power in the Indian subcontinent from about 1526 to 1757, had developed and contributed many techniques that included "the technology of textile production, hydraulic engineering, water-powered devices, medicine, and other innovations, as well as mathematics and other theoretical sciences" (US Library of Congress). India has also produced many talents in the world of science and technology inventions. One of the most famous scientists is C. V. Raman who credited for the Raman Effect for which he was awarded Nobel Prize in physics in 1928. Dr. Homi Jehangir Bhabha, an eminent physicist, who is known for his enormous contributions to the fields of positron theory, cosmic rays, and muon physics at the University of Cambridge in Britain. Other eminent scientists include Sir Jagadish Chandra (J.C.) Bose, a Cambridge-educated physicist "who discovered the application of electromagnetic waves to wireless telegraphy in 1895 and then went on to a second notable career in biophysical research" (see Country studies; US Library of Congress). Recently the Higgs -Boson was named after him. So, India has always been a well-respected place in science and technology.

* *University of Trento, Italy; Email: sahoog@gmail.com*

Innovation in India:

India has witnessed a tangible change in Innovation post –Independence. As the output measure, R & D and Patents are known as the key output indicators of innovation growth. Table 1 (innovation indicators as the measurement of innovation) shows the progress and innovation - structures of India. As measurement method, social scientist and innovators used various indicators as growth of innovation which can be easily categorized in to three segments (Table 2).

In the post-independence era (1947 onwards), India realized that science and technology were the key elements of economic growth. The then first prime minister of India Pandit Jawahar Lal Nehru declared "It is science alone that can solve the problems of hunger and poverty, of insanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources running to waste, or a rich country inhabited by starving people. Who indeed could afford to ignore science today? At every turn we have to seek its aid. The future belongs to science and those who make friends with science".Prioritizing science as key to growth and success, India's first national laboratory 'Council of Scientific and Industrial Research (CSIR)' was set up in the 1950's and now consists of a network of 40 laboratories, and is considered as the central to innovation progress in India. Keeping on the skilled

Table 1: Exponential Growth of Innovation Indicators

Decades	50s and 60s	70s	80s	90s
Main Indicators used	R & D	R & D	R & D	R & D
		Patents	Patents	Patents
		Technological Balance Of Pay ments	Technological Balance Of Payments	Technological Balance Of Payments
			High tech Products and sectors	High tech Products and sectors
			Bibliometrics	Bibliometrics
			Human Resources	Human Resources
			Innovation surveys	Innovation surveys
				Innovations mentioned In technical literatures
				Survey of Production Technology
				Intangible Investment
				Productivity

Source: Mani, Sunil (2009); Centre for Development Studies, India

Table 2: Indicators of Innovation Activities

Input Indicators	Output Indicators	Other Indicators
Educations and HRD expenditures	Bibliometric data	Technology Balance of Payments
		Technolgy Content Exports
R & D Expenditures	Patents	Total Factor Productivity

workforce to be produced, some of the world class educational institutes such as Indian Institute of Science (IISc, Bangalore was founded much earlier in 1909 by J. N. Tata in the British India and University Grant Commission (UGC) granted status as deemed university on 12th May 1958), Indian Institute of Technology (1951, to create and train elite scientists and engineers), Indian Institute of Management (first IIM Calcutta estd. 1961 to create and train professionals for business and entrepreneurship), Institute of Mathematical Science (estd. 1962 for fundamental research in frontier disciplines of the mathematics and physical sciences), Indira Gandhi Centre for Atomic Research (estd. 1971 previously known as The Reactor Research Centre under the Department of Atomic Energy), Indian Institute of Information Technology (first IIIT Allahbad estd 1999 and recognised as deemed university in 2000, to fill the gap of skills required by Indian IT firm and foreign MNCs), National Institute of Technology (NIT: 2002, to create greater capacity of elite science and technology professionals), and Homi Bhabha National Institute (HBNI: estd. 2005 a premier research institutes for atomic research and development) were established. It is worth to be noted here that some well-known much earlier institutions such as University of Calcutta (estd 24th Jan. 1857), University of Mumbai (estd. 18th July 1857, known as University of Bombay until 1996) and University of Madras (estd 5th Sep. 1857 by Legislative Council of India), were established which are even today considered as the premier educational institutions in the country (Source: University Grant Commission).

Workforce and educational infrastructures

India produces thousands of young bright scholars every year. Today, India is often considered as the knowledge superpower with 639 universities, 39 institutes of national importance, and 29 autonomous higher institutes. The number of Universities/ University-level institutions has increased 18 times from 27 in 1950 to 504 in 2009.The number of colleges has also registered manifold increase with just 578 in 1950 growing to be more than 30,000 in 2011 (Source: Ministry of HRD, Govt. of India). This increase in education and educational infrastructures shows a positive policy impact of the innovations.

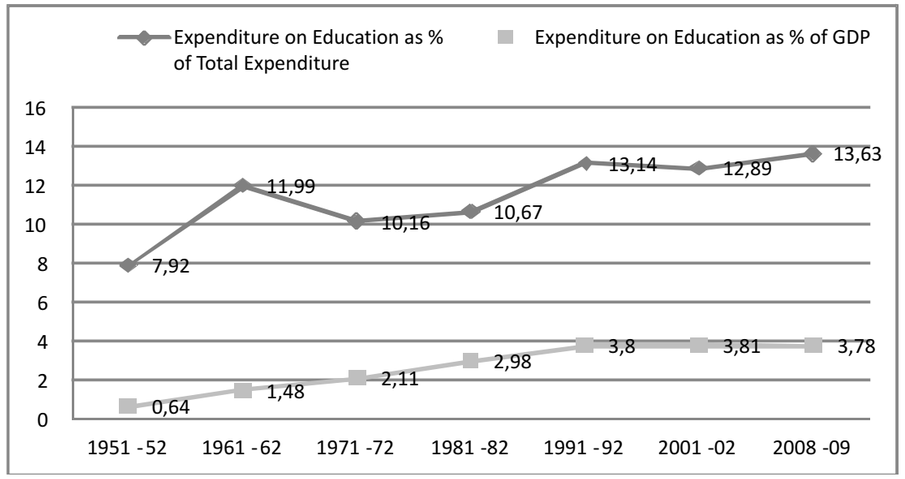
India ranks eleventh in the world in its number of active scientific and technical personnel. Including medical personnel, they were estimated at around 188,000 in 1950, 450,000 in 1960, 1.2 million in 1970, 1.8 million in 1980, and 3.8 million in 1990. India's universities, university-level institutions, and colleges have produced more than 200,000 science and technology graduates per year since 1985. Doctorates are awarded each year to about 3,000 people in science, between 500 and 600 in engineering, around 800 in agricultural sciences, and close to 6,000 in medicine. However, in 1990 India had the lowest number of scientific and engineering personnel (3.3) per 10,000 persons in the national labor force of the major Asian nations. For example, Japan, had nearly seventy-five per 10,000 persons , South Korea had more than thirty-seven per 10,000, and China had 5.6 per 10,000 (see "India – Science and technology"; US Library of Congress).

Table 3: Growth of Recognized Institutions

Sl. No.	Types of Institutions	1950 - 51	1970 - 71	1990 - 91	2010 - 11
1	Central Universities	27	82	184	43
2	State Universities				256
3	State Private Universities				80
4	Institution established through state legislation				5
5	Institution deemed to be universities				130
6	Colleges for general education	370	2285	4862	33023
7	Colleges for professional education	208	992	886	
	Total Institutions of Higher Education	**605**	**3359**	**5932**	**33537**

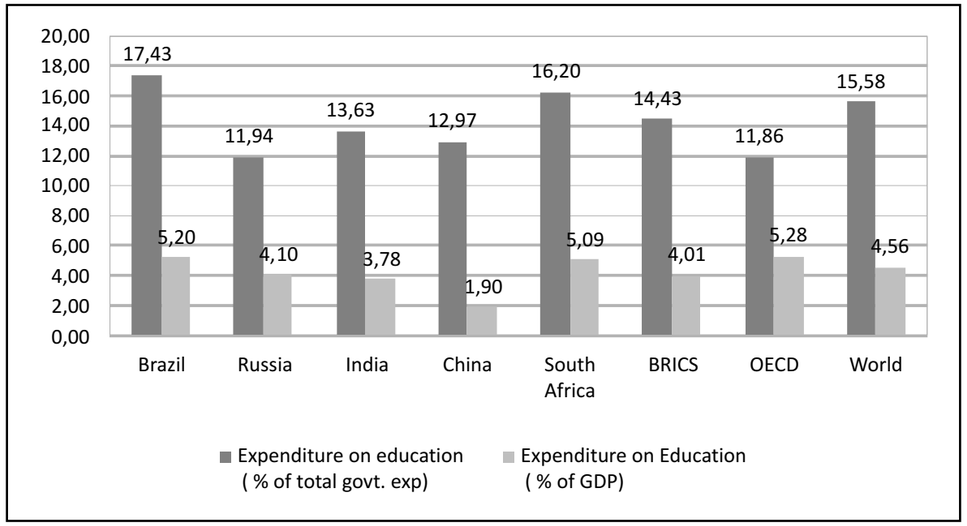
Notes: Data includes agricultural, veterinary, medical, architecture, engineering/technical, open universities and other colleges. Source: University Grant Commission (data 2010-11), Ministry of HRD (data 1950-91), Govt. of India

Figure 1: India's Public Expenditure on Education



Note: 2008-09 data provisional, Source: Ministry of HRD, Govt. of India

Figure 2: Public Expenditures on Education in the year 2008



Note: China data refers to year1999, India data refers to FY 2008- 09 provisional; Indian Financial Year (FY) starts on 1st April and ends on 31st March every year
Source: World Bank; Ministry of HRD, Govt. of India (only for India data);

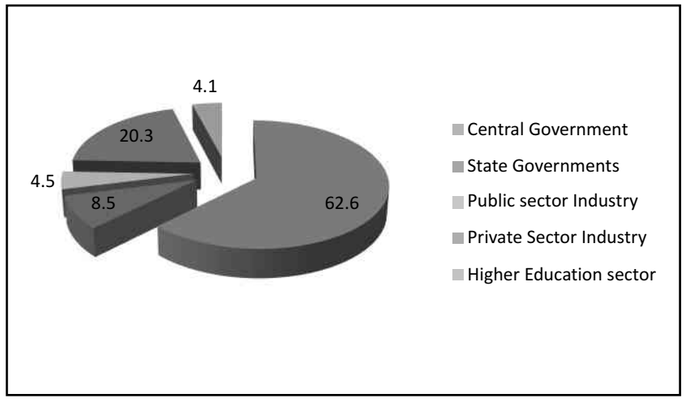
On the other side, figure 2 showed a comparative study of India's public expenditures on education with BRICS countries, OECD and the world. India spent a low per cent age of GDP, i.e., 3.78% of GDP just above China (1.9%), while OECD average expenditure on education accounts as 5.52%, whereas BRICS average and the world average are 4.15% and 4.56% respectively. When we compare the educational expenditures as percentage total government expenditures, India (13.63%) is above Russia (11.94%), China (12.97%) and OECD average (11.53%), but India spends a lower portion of total governmental expenditures on education in comparison to Brazil (16.82%), South Africa (19.2%), BRICS (14.91) and the World average (15.58%). Ghosh (2011) studied that India's public spending on education to GDP is less than a quarter of the equivalent ratio in Cuba, but even well below the expenditures of other developing countries such as Kenya, Malawi and Ethiopia. On quality of education, she inspected that "institutions in backward areas and in educationally backward States tend to be both underfunded and of poorer quality than institutions in metros or in more educationally developed States".

On the other hand, comparing the number the researchers with other countries, India witnesses a comparably lower number researchers. India has 140 researchers per thousand populations whereas the same for Sweden, Japan, Denmark and U.S.A. was 6139, 5546, 5277 and 4651 respectively. However, in terms of total researchers, USA tops the list with 1.39 million researchers followed by China and Japan with 1.215 million and 0.71 million researchers respectively (Ministry of HRD, R & D report). So, this data shows India is far behind. So,right policies and resources should be implemented to tackle the global competition scenario.

Science and Technology Infrastructures

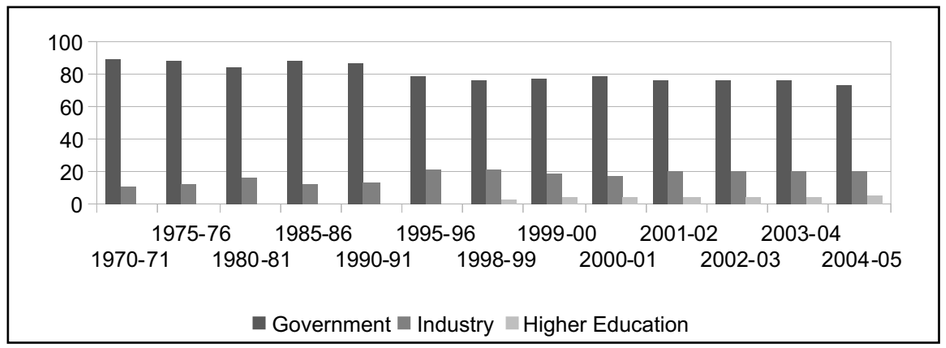
At the time of Independence, India's science and technology infrastructures were neither strong nor organized, and India was a technology dependent country, particularly, to the developed world.The post-independence era, India valued science and technology infrastructures as base of its growth and development. Scientific research and technological developments have received substantial political support and governmental funding. India initiated policies to promote and develop its technological base, moreover to be a technology independent country. India started five- year plan, which are based on fulfilling short term needs while aiming to provide the institutional base needed to achieve long-term goals. In 1951-56 by its first Prime Minister Jawaharlal Nehru, India had given prioritizing to science and technology such as transport and communications (24%), industry (8.4%), irrigation and energy (27.2%) etc. In 2nd five year plan (1956-61), it focused on heavy industry such as power and irrigation. During this period, the Atomic energy commission was formed in 1958 and Tata Institute of Fundamental Research was established (see GOI web on S & T).

Figure 3. Share of R & D expenditures in 2002 (per cent age)



Source: R & D Statistics report; Dept. of Science and Technology

Figure 4. Sectoral performance of GERD* in India, 1970-71 through 2004-05 (% of shares)



Source: Mani, Sunil (2010); Appendix Table No. 1
**GERD: Gross Domestic Expenditure on Research & Development*

The Government of India established the Ministry of Science and Technology in 1971 to formulate science and technology policies and implement, identify, and promote "frontline" research throughout the science and technology infrastructure (Planning Commission). By the 1980s India had already developed science and technology establishments. Advanced scientific and technology infrastructures had developed over the years.

Research as an input indicator measures resource, both financial and human capital, devoted during the period of the program. In concerned to the resources allocation, central government contributed a major share (75.7 %), whereas state government contributed 9.3 per cent and private sector contribution was15% in 1992. In year 2002 the share of R & D expenditures by the central government had reduced to 62.6% due to participation of other entities.

India demonstrated a sharp change in expenditure on R & D during the period of 1970 to 2005. Figure 4 shows India's performance on Gross Domestic Expenditure on Research & Development (GERD). The figure shows the governmental investment is constant but industry participation has increased. Undoubtedly it was a green sign for the developing India as it witnessed a growing privatization of Industrial R & D and the share of the industry in performance of R & D has doubled during that period. Higher education sector contributed to the sectoral performance from 1998-99.

Table 4. Industry wide distribution of Industrial R & D

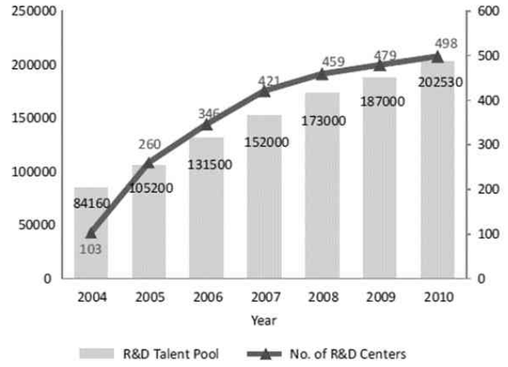
Industry	Share
Metallurgical Industry	4.21
Fuels	6.12
Electricals and Electronic Equipments	8.94
Telecommunications	3.75
Transportations	15.16
Industrial Machinery	1.84
Agricultural Machinery	1.33
Chemicals (other than Fertilisers)	8.35
Drugs& Pharmaceuticals	19.3
Defence Industries	8.32
Information Technology	4.69
Biotechnology	1.59
Misc. Mechanical Engg.	1.22
Miscellaneous Industries	15.18
Total	**100**

Cumulative shares in per cent 1998-99 through 2002-03
Source: Mani, Sunil (2010)

India's industry wide distribution of R & D was purely meant for the high tech, chemical and defence industries during the period of 1998-99 through 2002-03 which accounted 75.09% of total R & D (Table 4). The measure eight industries such as Metallurgical, automotive, electrical and electronics equipment, transportations, chemicals, drugs and pharmaceuticals, defence IT were having a bigger share of R & D expenditures. Drugs and Pharmaceuticals alone spent 19.3% R & D crediting as biggest R & D expenditure followed the Transportation accounted 15.16% claimed the second highest R & D expenditure during that period. It's clear that India's R & D expenditures were meant for strengthening the physical infrastructures as well as superior innovations in the drugs, chemicals, electronics and defence. Mani (2009) points out that India's national system of innovation is dominated by the sectoral system of innovation of the pharmaceutical industry and automotive industry. He further experiences that the auto parts subsector has rather high export intensity of nearly 20% which means there has been a continuous investment on technology in subsector to meet the technological requirements of foreign buyers.

The figure 5 shows that there has been a curve of growth both in R & D centres and R & D talent pools in India since 2004 to 2010. The CAGR is estimated 30% in R & D centres and 15.7% in R & D talent pools over the period. Many research findings pointed out that most of quality R & D is being done by MNCs

Figure 5: Trends in Growth of R & D Centres and R & D Talent Pools in India

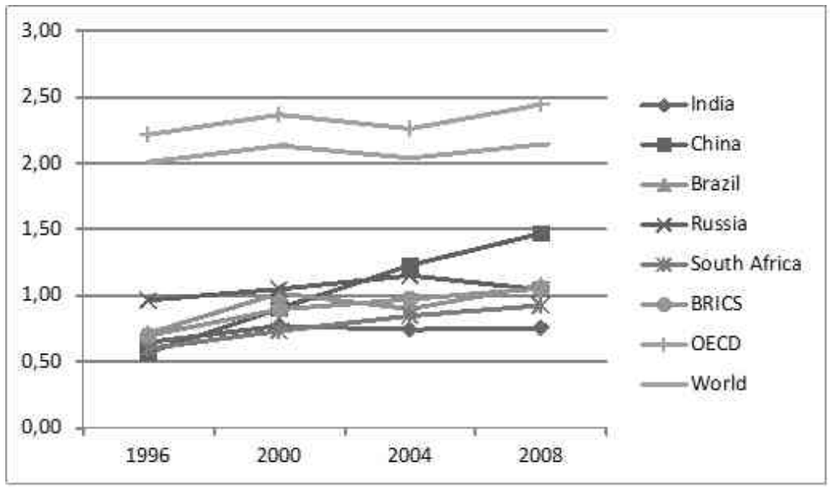


Source: Battelle India, India R & D 2011, FICCI, pp.5

that work in India for their internal benefits and other fundamental researches are carried out by the academics. Also, most of researches done by public sectors lack market values as compared to the R& D being carried out by profit oriented private sector that focuses on cutting-edge R & D activities that creates innovation at a globalized way. So, the research spillover is limited within certain boundaries and the research benefits are still not fully exploited by the all sections of the knowledge societies which cause "externality loss" or "efficiency loss". This is considered a measure issue why India still lags behind many developing and developed countries.

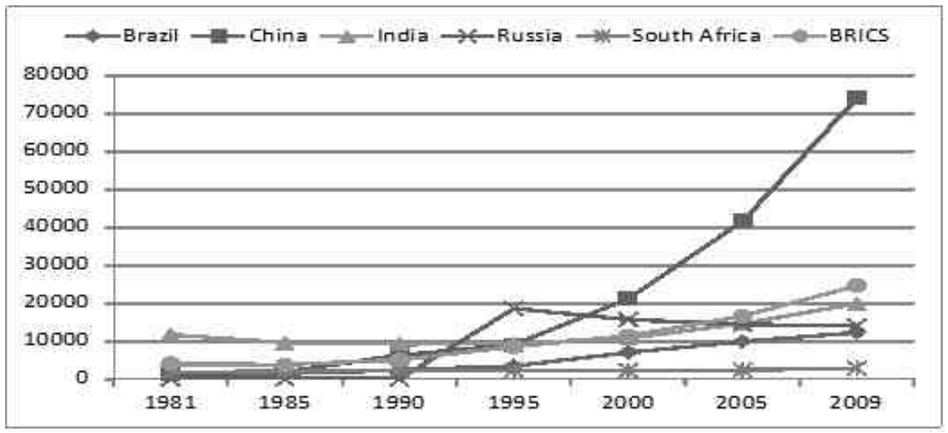
The figure 6 gives a clear picture of India's R & D expenditures in comparison to BRICS, OECD and the world average. While the world average spending on R & D is around 2.1% and OECD average from 2.2 to 2.4 per cent, India spends as low as 0.64% to 0.76%. All the BRICS economies spend more on R & D by the year 2008. China being a measure economy spends around 1.469% but India still spends less than 1% which urges a policy intervention and political willingness.

Figure 6: R & D expenditure as % of GDP



**India 2008 data from the year 2007, South Africa 1996 data from 1997 and data 2000 from 2001*
Source: World Ban

Figure 7: Scientific and Technical Journal Articles



Source: World Bank

As an innovation indicator, scientific journals show how a country is using its talents and resources in generating ideas and pre-innovative capabilities. In contribution to the scientific and technical journal articles, India topped among BRICS countries from the year 1982 to 1995 and also India was quite above the BRICS average during that period, but in 1995 Russia became the top contributor among the BRICS countries. The World Bank statistics shows that India has contribution lower than the BRICS average from the year 2000 to 2009.

Patenting Trends in India:

Indian patent system has a long history back to the First Patent Act VI of 1856 in the British India which was based on the British Patent Law of 1852. The main objective of the patent act was to encourage inventions of new and useful manufactures and to induce inventors to disclose secret of their inventions. India's patent laws and policies were made in the United Kingdom in the Pre-Independent India. In 1911, The Indian Patents and Design Act of 1911 was enacted by the British Government of India and was replaced all the previous act concerning all types of Intellectual property in British India, including patents, copyrights, industrial designs and trademarks. However, after Independence from the British, following the decades of criticism that it offered insufficient protection to the inventor, India reviewed and replaced completely the Patent Act 1911 by a separate patent act called Indian Patent Act 1970 and with further amendment in 2002.

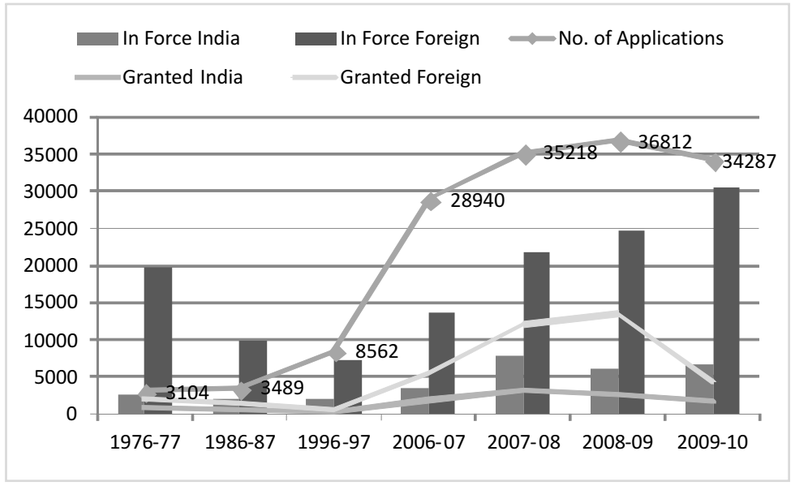
The Indian Patents and Designs Act 1911 that was legislated during the British government, was believed to be poorly protecting the inventions. Following complains and dissatisfaction from the Indian inventors, the government of India legislated new policy on patents known as The Indian Patent Act 1970 which came into force on 20th April 1972. This patent act 1970 changed the structure of patenting that resulted a move away from product patents to process patents which had a major impact on Indian drugs and pharmaceuticals industry (Dhar & Gopal Kumar, 2011).

Patent Applications as output indicator of innovation show how the innovation is being utilized through the provision of goods and services. During the period of 1976 to 2009, India achieved tremendously in patent applications which provide India's innovation capabilities at a wider perspective. From the graph 9, it is clear that India suffered a downside in the patent race domestically during the period 1986 to 1996, but then it marked an enormous growth. The graph 9 shows foreign patents are in a dominant position throughout the period. The total number of patent applications filed during the period 2009-10 was 34287 compared to 36812 in the previous year resulting a decrease of about 6.86%. The number patent application filed by Indian in 2009-10 was 7044 which is estimated an increase of 12.54% over the previous year where 6161 patent applications were filed.

Table 5: Brief History of Indian Patent System

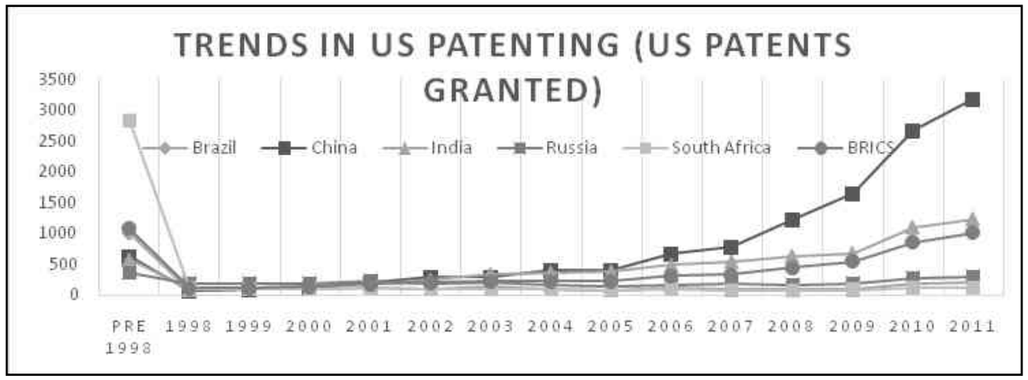
Year	Changes in Patent Policy
1856	The Act VI of 1856 on protection of inventions based on the British patent law of 1852. Certain exclusive privileges granted to inventors of new manufacturers for a period of 14 years.
1859	The Act modified as Act XV; patent monopolies called exclusive privileges (making. Selling and using inventions in India and authorizing others to do so for 14 years from date of filing specification).
1872	The Patents & Designs Protection Act.
1883	The Protection of Inventions Act.
1888	Consol idated as the Inventions & Designs Act.
1911	The Indian Patents & Designs Act.
1972	The Patents Act (act 39 of 1970) came into force on 20th April, 1972
1999	On 26 th March, 1999 patents (amendment) act, (1999) came into force from 1st January, 1995
2002	The Patents (amendment) Act 2002 came into force from 20th May, 2003
2005	The Patents (amendment) Act 2005 effective from 1st January, 2005

Figure 8: Patents Applications, Granted and In-Force in India



Source: Controller General of Patents, Design and Trade Marks, Govt. of India

Figure 9: Trends in US Patenting of Indian Inventors,



1998 -2011 (utility patents granted)
Source: USPTO

Statistics further says that the compounding annual growth in patent grants during period 1976-77 to 2009-10 for India and foreign were 1.9% and 2.5% respectively, while compounding annual growth for patent in-force for the same period of India and foreign were 2.78% and 1.33% respectively. The statistical figure between 1999-2000 and 2009-2010 gives evidence that the compounding growth rate in Indian patent application was 8.15% whereas the foreign application was 12.15%.

Patent as recognition of the importance of human intellect plays a significant role in this techno-scientific age. It has been widely accepted the exploitation of resources beyond geopolitical boundaries and has seen as symbol of progress of a country's innovativeness at the global stage. We also agree that the maximum protection of IP can help the country to maintain a continuous growth to the sustainable developments. So, patents which measure the country's ability in R & D and innovation identify whether the research activities are clusters or scattered.

The growing economic activity and patents reforms pushed a significant change in India's patenting landscape. With rapid technological development and innovation, India has witnessed a measure economic growth in recent years. India's IT sector which has contributed a measure portion to its economy is believed to be a major factor for the overall growth scenario. India with its administrative measures and various policy reforms has strengthened its IP infrastructures which lead the country a tremendous success of IP through licensing, commercialization and enforcement.

There is a similar result in European patents. The table 8 states that India is in 2nd place after China in patent grants. The CAGR of India was 23% where as China topped the list with 39% and the BRICS average was 21%. When we study about the patent application, China has a humongous growth in patent applications, more than 10 times of Indian patent applications in 2011 alone, but China has an extremely poor success rate in patents grant. While India had 10% the ratio of patents granted to total number of applications, China poorly managed to 3% patent grants of total applications 61664 during the period 2002 to 2012.

Figure 10 shows India is above BRICS average in US patents granted. China tops the list among the BRICS nations.

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Japan Patent Office statistics says Chinese topped the BRICS country both in patent filings and grants, but had a low grant ratio in comparison with the Indian counterpart. Amid an intensifying global competition, India among the BRICS countries shows a continuous progress in patenting that measures country's technology progress. This ameliorative effect provides a signal that India's technology amenities are in better stage than ever.

Furthermore, the relationship between patents and R & D expenditures shows the coherence of rich and poor countries and the patent race. Patent as a measure of country's technological change shows a varying result of R & D expenditure and patent filings.

Table 7: Patents Applications and Issued by Japan Patent Office in 2010

Country	Applications			Grants			Grants ratio
	Direct	PCT	Total	Direct	PCT	Total	
Brazil	11	71	82	2	20	22	27%
China	424	639	1063	92	163	255	24%
India	21	141	162	10	82	92	57%
Russia	5	35	40	0	17	17	43%
South Africa	4	47	51	1	29	30	59%

Source: JPO 2012

Table 8: Number of resident patent filings per $ million R & D expenditures

Country	2001	2002	2003	2004	2005	2006	2007	2008
Australia	0.51	0.47	0.44	0.43	0.39	0.38	0.31	0.29
Canada	0.34	0.30	0.32	0.42	0.40	0 .43	0.38	0.39
China	1.65	1.90	2.18	2.13	2.36	2.52	2.57	2.79
Denmark	0.63	0.65	0.60	0.61	0.56	0.50	0.54	0.48
France	0.58	0.56	0.54	0.59	0.58	0.60	0.58	0.57
Germany	1.15	1.09	1.09	1.09	1.09	1.08	1.01	1.01
India	0.95	0 .99	1.22	1.16	1.10	0.95	0.93	0.83
Russia	2.65	2.16	2.06	1.75	1.86	2.26	2.10	1.94
UK	1.04	0.99	0.97	0.92	0.88	0.84	0.80	0.71
USA	0.79	0.83	0.90	0.89	0.97	0.98	1.01	0.91

Source: WIPO statistics database and World Bank (World Development Indicators); Dec 2011
Note: R & D expenditures in million US $ are in billions of US $, based on 2005 purchasing power parities and lagged by one year to derive the resident patent filings to R & D ratio.

India can be compared with the US in terms of number of resident patent filings per million $ R & D expenditure. Statistics gives evidence that 0.95 number of patent filings for million $ expenditures in India, while US has 0.79. Other developed countries such as U. K., Denmark, Australia, Canada etc. have even lower number of patents filings. Though Russia and China are ahead of other countries, but questions are raised about the quality of patents and its contributions to the technological growth and innovation. Study of technology-wide patents grant is important as it gives a coherence study of R & D effect.

Studying the sectoral patents grants, table 11 states that most patents were granted to chemicals, mechanicals and drugs, and other industries such as food, electrical, machinery parts were given little importance. It is the coherence effect that most R & Ds have been done to the respective sectors where patent applications are comparably high.

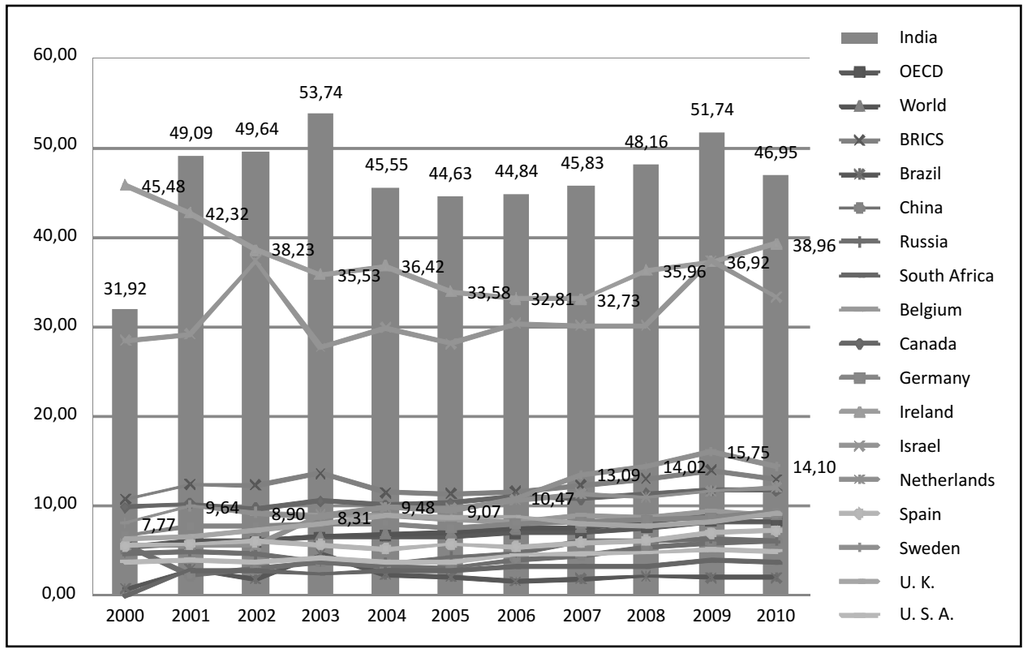
India achieved tremendous success in IT service exports and became the largest exporter of ICT services in the world. The figure 10 gives a clear image of India and its position in the world. India has been continuously on top in ICT service exports since 2001. It's undoubtedly well-defined that India

Table 9: Technology-wide distribution of patents granted in India, 1999-2000 to 2006-07

Year	1	2	3	4	5	6	7	8	Total	1+2+7
	Chemical	Drug	Food	Electrical	Mechnical	Computer/ Electronics	Bio - Technology	General		
1999-2000	516	307	250	147	569			92	1881	823
2000-01	353	276	72	142	254			221	1318	629
2001-02	483	320	36	139	311			302	1591	803
2002-03	399	312	67	118	228			255	1379	711
2003-04	609	419	110	396	539			401	2474	1028
2004-05	573	192	67	245	414	71	71	278	1911	836
2005-06	1140	457	110	451	1448	136	51	497	4290	1648
2006-07	1989	798	244	787	2526	237	89	869	7539	2876

Source: Mani (2011, p.50)

Figure 10: ICT Service Exports (% of service exports, BoP)



Source: World Bank Statistics 2011

has been incessantly growing its position at the international market as an IT global leader. India's vast population is considered as a boon to the nation and its English language is often recognized as an incentive for this achievement.

The skilled IT workers of India who are able to exporting the world's half of the IT services are to be believed a major contribution to its 1.8 trillion (GDP nominal) economy. In the last two decades, the Indian IT/ITES industry has contributed significantly to the Indian economy in terms of GDP, foreign exchange earnings and employment generation. A joint study report by the National Association of Software and Service Companies (NASSCOM) and the global consultancy firm Deloitte says the IT Contribution to the Indian GDP has been steadily increasing from a share of 1.2% in financial year 1998 to 5.2% in the financial year 2007. In studying the forex reserve, the report says export earnings in the financial year 2008 stood at approximately US $ 40 billion with a growth of 36%. On employment generation, the study further states the direct employment in the sector is expected to be 2.0 million by end of FY08, growing at a CAGR of 26% in the last decade, making it the largest employer in the organized private sector of the country. India, with 53.7% of services sector contributions to total GDP and 523.5 million work forces, is expecting to fuel the growth in the smartphones, e-commerce 2.0, banking and telecom (Business Map of India & Deloitte, 2012).

Concluding Remarks and Policy Implications

The study shows how India's long exertion to be a successful innovative nation in the world. The country, since the Independence from the Britain, has successfully managed its manpower, both tangible and intangible resources to compete in the global stage. The multi-fold growth in physical and e-infrastructures and with its vast population, India is still contending severely to shape its image at a wider perspective. But, India has still to go a long way for enabling innovation of global dimension and it has to purse a more innovative and collaborative research environment with a strong scientific workforce which is essential to positioning it as a global innovation leader in the world.

The input indicators of innovation activities are education expenditures and R & D expenditures, Education, considered being a major turning point with its integrated effort in managing its huge population, have shown a positive growth. Though there have been a manifold growth in educational institutions but very few institutions are considered to be in elite institutions, so quality has been a major concern so far. India still lacks a proper funding base to channelize its resources. India's expenditure in term of GDP both on R & D and education is very low compared to most developing and developed economies. India's R & D initiative still faces major challenges. India still lacks proper collaboration to channelize its R & D which has a coherence relationship with patent. Lack of proper regulatory framework can cause a randomized and disintegrated environment that will automatically provide less or no incentives in term of encouragement and curiosity for research and innovation. The technology gap between education and industry could cause labor shortage necessary for high skilled scientific research which in turn the R & D will lose its capability to channelize its research, which is, why India still sees an insufficient resource base. India's R & D industry needs a strong collaboration with the west in order to exploit their high technology for better research outcomes. On the other hand, regulatory framework lacks policies for sound collaboration among industry, government and academic institution which focuses on disintegrated research and in collaborative benefits.

Research shows that there have been growth in innovation outputs in the Indian industry since the Independence but the growth is unequally distributed among the sectors. Most innovation outputs are restricted to pharmaceutical industries. Whereas automobiles, food, biotech, computer and electrical industries have been considerably ignored or not given due attention which has a lower contribution to GDP, employment and foreign exports as well. Considering the R & D tax incentives, pharmaceutical industry has been receiving a comparable bigger share In studying of technology wide patent grants, most patents were granted to chemicals, mechanicals and drugs, and other industries are given little importance and it is the coherence effect that most R & Ds have been done to the respective sectors where patent applications are comparably high.

Concluding the innovation since the post-independence India, India has achieved milestones but research still needs clarifications on certain policy. India's policy on tax incentives is centralized to few sectoral benefits that the innovation has been limited. Policy still needs to clarify why Indian

government is giving less important to electronics including computer sectors and communication equipment industries. Policy and data do not tell anything why the public expenditure on education remains comparable lower. Finally, how India is initiating policy measures for industry participation in R & D to exploit the resources effectively, perhaps, literatures also became silent on these issues.

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New Paradigm in Higher Education in India : Edupreneurship

Vivek Tharaney* **Dr. Deepika Upadhyaya****

With liberalization in Indian economy, a large number of private enterprises in service sector including in education have come up. 15 to 20 fold growth in school level & higher level education (management & other technical education) in India during last 20 years is a sure sign of phenomenal increase in number of students enrolled in schools & professional colleges in India. This could be possible only through entrepreneurial zeal of socially- conscious individuals and groups. From around 100 Management Institutes / Departments of Management Education in Indian Universities in 1991-92, the number increased 10-fold to nearly 1000 management institutions in the country in 10 years' period i.e up to 2001-02. During next 10 years, the number has shot up to approx. 4,000 management institutes by 2011-12. This tremendous growth became possible due to Government facilitated liberalisation process through the entry of private entrepreneurs in technical education including management area. Today nearly 80 percentof such institutes are run by entrepreneurs in private sector.

Key words: Paradigm change, Edupreneurship, Higher Technical Education , Perception

Our country now stands on threshold of global market economy. Globalisation has a multi-dimensional impact on the system of education. It promotes new tools & techniques in this area like e-learning, flexible learning, Distance Education programmes and overseas training. Whether education can prepare citizens to face the new challenges will depend upon quality of management education which the system generates. In the fast pace of globalization, India has to develop its education system to respond to the challenges arising out of the rapid changing environmental factors including global competition to cater to the developmental needs competitively and strategically.

Various factors demand consideration for achieving overall high quality of education. A large part of our country's population today is young in late-teens or early-twenties. Its implications are that within next 5-10 years they would be entering job market. We need to create around 1.5 crore jobs per year in the next decade. This was stated by Dr. S. Ramadorai, Advisor to the Prime Minister in the National Council of Council on skill development, Govt. of India (Employment"Employment Newspaper", 4-10 May 2013). According to him 'job creation has to move closer to smaller towns and rural areas'This can be achieved only when quality education is available in various parts of the country.

Majority of graduates today are from generic disciplines in education. They are not capable of handling knowledge economy related work. Therefore improving quality of education is need the hour. Governmental efforts, though with good intentions, are not sufficient. It is a known fact that state of affairs in government schools and colleges is not something to be happy about. So there is something lacking in this set up. Can entry of private entrepreneurs in this domain fill this gap?

Other factor that merits consideration is that there shall be large increase in demand for graduates in India and abroad because of growth in Indian economy, increasing share of services and globalization of workforce. Hence need for large capacity expansion in Indian Higher education. Government has limited capacity to fund this expansion. So in country's interest it is required that edupreneurs are encouraged to set up good academic institutions in the country.

* *Senior Faculty, Footwear Design & Development Institute (Ministry of Commerce & Industry, GOI , Delhi), Near National Law University, Mandoor, Jodhpur (Rajasthan). Email: vivektharaney74@gmail.com*

** *Assistant Professor, FMS, MDS University, Ajmer (Rajasthan). Email: deepikaupadhyaya@gmail.com*