ERAWATCH COUNTRY REPORTS 2011: India

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Executive Summary

India with 1.2 billion people is the second most populated country in the world and come to be recognised as the world's largest democracy. India is divided into six major zones: East India, West India, North India, South India, Northeast India and Central India. It is the 7th largest country in the world and in recent times has been characterised as an emerging economy member of new group called BRICs (Brazil, Russia, India, China). After witnessing economic growth rate at an average of 8.8% for the five years (2003-2004 to2007-2008), India's growth rate declined to an average of 7.6% during 2009 and 2012. India's R&D as proportion of GDP increased from 0.81% in 2002 to 1% during 2007-08. India is currently spending close to 1% of GDP for R&D as a whole.

Over the last five years since 2007, S&T cooperation between EU and India have progressed by building partnerships in various big science and high technology projects as part of FP7. Reiterating the growing cooperation, a Joint Declaration on Research and Innovation Cooperation was issued in New Delhi on 12 February 2012. Since 2007, 60 million EUR was jointly funded for research and innovation. A further expansion was pledged after the end of 2012. EU committed 8.1 billion EUR investment in research and innovation in 2012. India has the equal opportunities to take part in this investment for bidding projects as any other country in EU and North America.

One of the major problems for an economy of the size of India is relatively low investment in GERD compared to other BRICs economies. However, the business enterprise sector in the last decade increased its share from 22% to nearly 30% of GERD in 2011 and both the public and private investments in R&D have kept pace with the growth of the economy which nearly doubled (in terms of GDP) during the decade. In the last two years the international economic crises has had some impact on the private R&D investment. The government has committed to increase the investment from 1% now to 2% of GDP in R&D by the 12th Plan (2012-2017).

Among the various measures adopted as a part of the policy mix, the encouragement in the form of public –private partnerships PPP and incentives given to private indigenous firms has led to increase in the BERD investments in the national R&D. Various innovation schemes introduced in the last five years have yielded some results in the commercialisation of small car (Nano) and a couple of vaccines.

The main barrier for private R&D investment, particularly, through Foreign Direct Investment route has been the slowdown of liberal economic reforms in mining, aviation, insurance, banking and defence and strategic sectors of economy.

No major policy thrusts have been reported to promote linkages between research, education and innovation in the last two years. The Department of Science and Technology, Department of Scientific and Industrial Research and the Department of Biotechnology (DBT) have some four to five innovation policy measures to promote innovation in the mode of knowledge triangle.

Among the three Departments, DBTs Small Business Innovation Research Initiative (SBIRI) has become quite pro-active in promoting research and innovation links between science agencies, higher educational institutions and business enterprises. The social and rural industry sector witnessed some policy initiatives towards inclusive development, which are likely to create a demand for inclusive innovation. Here again, public procurement in health, food security and employment guarantee schemes are likely to create demand for grass root and organisational innovations.

Knowledge Triangle

	Recent policy changes	Assessment of strengths and weaknesses
Research policy	National Chemical Policy (draft) 2012 National Telecom Policy 2012 Constitution of a new basic research funding body in DST (National Science and Engineering Research Board) Steering Committee on S&T for the 12th Plan (2012-2017) Open Source Drug Discovery programme (CSIR)	- A paradigm shift in the approach to S&T sector, which moves away from input oriented and driven model followed so far to an output directed trajectory. This would call for creation of an innovation ecosystem most suited for this transition and which will enable the S&T sector to realise the set of developmental objectives for the country. - India is yet to attain the committed target of 2% GDP expenditure on R&D. - Low level of HERD of 7% of GERD and GER of 13.
Innovation policy	-Draft National Innovation Act (2008) under discussion in 2012 -Creation of Medical Innovation Fund -University Innovation Clusters -State Innovation Clusters -Sectoral Innovation Clusters -National Rural Health Mission -India Inclusive Innovation Fund	- Shit to diffusion end of the R&D spectrum -Major boost and turn to innovation in the national science and technology policy discourse -Major turn to inclusive innovation - Underdevelopment of venture and risk capital - Slow implementation of innovation fund
Education policy	-Foreign Universities Bill -Meta University[1] announced by education ministry - PPP models in higher education and research -Promotion of IPR in universities - Promotion of university-industry relations	-Major boost to higher education and research envisaged in the 12th Plan (2012-2017) - Skill and training given high importance in education - Slow implementation of reforms in higher education - Slow implementation of IPR in universities as bill is still pending in the Parliament - Low level of HERD as proportion of GERD
Other policies	-public procurement in infrastructure, e-governance, housing, health, defence is expected to increase demand for innovative products - inclusive and social development policies leading to grass root innovation	- New demand created for research and innovation (both high technology and grass root innovations) and technological inputs across various social and infrastructure sectors of economy - Linkages between public procurement and R&D institutions and universities very weak

[1] A group of universities located in close proximity in a region will interact and collaborate in higher education and research. Students will be able to offer courses and from a basked of courses available in the group of university cluster characterised as 'meta-university'.

Assessment of the national policies/measures

	Objectives	Main national policy changes over the last year	Assessment of strengths and weaknesses
1	Labour market for researchers	- Initiatives for expansion of higher education - Public –Private partnerships in higher and technical education - Expansion of private sector in higher education	- Good move to enhance national Gross Enrolment Ratio - Slow in policies which implement expansion of higher education by government - PPP mode implemented and impacting the national scene through expansion of private sector role in higher education
2	Research infrastructures	- Initiatives to strengthen the research and innovation eco systems - Initiatives to increase research intensity in universities	-Inadequate mechanisms to implement the initiatives -Slow to allocate required funds
3	Strengthening research institutions	- Policies to enhance the quality and better training to suit industrial demand - Initiatives for assessing/grading universities and colleges	- National assessment mechanism (NACC) revamped and implemented - Publications in quality peer reviewed journals essential for career advancement - Lack of national level quality indicators
4	Knowledge transfer	- Policies for innovation clusters in universities, R&D institutions and States	- Good move to commercialise indigenous R&D and know-how from publicly funded labs - Slow implementation with inappropriate funding
5	International R&D cooperation with EU member states and bilateral cooperation with individual member countries	-New and pro-active initiatives to enhance cooperation with EU	- Greater access to Indian researchers and institutions to take part in FP7 projects - Lacks awareness among various R&D institutes and universities about EU-India
6	International R&D cooperation with non-EU countries	- New initiatives with Australia, USA and South East and East Asian countries	- Joint S&T programmes with USA and Australia implemented -India will benefit in renewable energy and agriculture with USA which will promote joint R&D projects - Joint R&D project with Australia under India-Australia Strategic Research Fund in biotechnology and renewable energy technologies -Dissemination of information is not rapid

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1 INTRODUCTION

The main objective of the ERAWATCH International Analytical Country Reports 2011 is to characterise and assess the evolution of the national policy mixes of the 21 countries with which the EU has a Science and Technology Agreement. The reports focus on initiatives comparable to the ERA blocks (labour market for researchers; research infrastructures; strengthening research institutions; knowledge transfer; international cooperation). They include an analysis of national R&D investment targets, the efficiency and effectiveness of national policies and investments in R&D, the articulation between research, education and innovation as well as implementation and governance issues. Particular emphasis is given to international research cooperation in each country.

2 PERFORMANCE OF THE NATIONAL RESEARCH AND INNOVATION SYSTEM AND ASSESSMENT OF RECENT POLICY CHANGES

2.1 MAIN POLICY OBJECTIVES / PRIORITIES, SOCIAL AND GLOBAL CHALLENGES

The overarching body, which plays an important role in the articulation of the country's policy objectives, priorities and challenges of innovation system, is the Planning Commission (PC). The PC constituted a Steering Committee for Science and Technology for the XIIth Plan (2012-2017). It's most recent report underlined the main policy objectives and priorities as follows:

- The most important role of science and technology for the country is to provide better quality of life and opportunities to every citizen. The aim is to enhance and scale up mechanisms and policies in this regard. The new plan objective envisages the expansion of scope of science and technology to areas that have remained uncovered so far;
- To aim at scaling up to new heights in achievements and putting the country in the forefront of the globalised world;
- A paradigm shift in the approach to S&T sector, which moves away from input oriented model followed so far to an output, directed trajectory. This would call for the creation of an innovation ecosystem most suited for this transition and which will enable the S&T sector to realise the set of the national developmental objectives;
- To strengthen mechanisms and policy strategies towards building greater self reliant national technological capability, particularly in the strategic sectors of S&T;
- Special focus to be laid on the development of high technology materials, high end electronics, probing diagnostic and characterisation equipment, variety of software and codes which fall under dual use technology which is not easy to access from the world markets and which are vital for the strategic interests of the country;
- To also stress goal oriented research to cover all aspects of development in agriculture, education, health care, food, energy, water, minerals etc;
- To enhance national and global competitiveness through technological capabilities. To develop new mechanisms to trigger R&D outputs for commercialisation and development of marketable products and services in the public and private sector;
- To increase several incentives and policy interventions which will grant loans, equity and incentives for undertaking R&D in the private sector for commercialising indigenous technology. Together with custom duty exemption mechanisms the objective is to also promote angel investments and venture capital to the business sector;
- A special focus on education, which is vital for a young country. A major leap in the higher education to attain a Gross Enrolment Ratio of 20% in the coming decade. To stress policies and mechanisms which forge new public – private partnerships in expanding higher education and research.

- To build a vibrant landscape with effective mechanisms to forge partnerships between R&D institutions, universities, industry/society, which will also help the country to move closer to attaining a 'knowledge society'.

2.2 STRUCTURE OF THE NATIONAL RESEARCH AND INNOVATION SYSTEM AND ITS GOVERNANCE

The Republic of India comprises of 28 states and seven union territories. India is the second most populated country in the world and come to be recognised as the world's largest democracy. India is divided into six major zones: East India, West India, North India, South India, Northeast India and Central India. It is 7th largest country in the world and in recent times has been characterised as the emerging economy.

After witnessing economic growth rate at an average of 8.8% for five years (2003-2004 to2007-2008) India's growth rate declined to an average of 7.6% during 2009 to 2012. India is currently spending close to 1% of GDP for R&D as a whole. India's national aggregate gross expenditure on research and development (GERD) is about 6863 billion Euros in 2009.[2] A dominant proportion of GERD, around 68%, is met by the government sources and 30% from the business enterprise sector.[3] In absolute terms, Indian GERD witnessed substantial increase of 60% from 3600 in 2004-05 to 5968 million Euros in 2007-08.[4] As proportion of GDP, it witnessed an increase from 0.8% of GDP in 1992-93 to 1.13% in 2003-05.[5] However, it registered a marginal decrease to 1% in the period 2008 as estimated by various sources.[6] Encourage by relatively high GDP growth rates, the leadership of the country, in January 2011, reiterated their commitment to increase India's R&D budget to 2% of GDP during Indian Science Congress Sessions.[7] In PPP terms it works out to be about 24.98 billion Euros in 2009. India ranks higher as compared to countries such as Brazil, Mexico, and South Africa but is behind China which spent 105.8billion Euro in R&D in PPP terms in 2010, after United States at almost 300 billion Euros in 2009.[8]

In the last decade India's international cooperation in science and technology has witnessed a renewed and pro-active moves with USA, Europe, particularly EU and East and South East Asia. While India focused its relations with USA and EU, the new region which became a focus of attention is East and SE Asia. This is part of the 'Look East' policy initiated by the Manmohan Singh government in the last few years.

Main actors and institutions in research governance

Under the overall administrative and executive control of the Prime Minister's Office (PMO), the structure of S&T system operates in a coordinated and consultative mode.

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[2] According to sources in Department of Science and Technology, Government of India, budget information from the Ministry of Finance and other budget papers, India's GERD for 2009-10 works out to be Rupees 453333 million. One Indian Rupee is equal to 60.5 Euros as accessed on 15 Janaury 2011.

[3] It may be noted that the figures being quoted are from the R&D statistics given by the Department of Science and Technology (DST). However, the DST figures grossly under estimate the foreign R&D inflow that has come into India during the period ending 2006-08.

[4] Kindly note that the figures for 2007-08 are estimated by the Department of Science and Technology, New Delhi as per the rate given in the above reference

[5] See UNESCO Science Report 2005, Paris: UNESCO, Chapter on South Asia.

[6] See Presidential Address by Dr T.Ramasami, Secretary, Department of Science and Technology, to the 96th Indian Science Congress held at Chennai, Tamil Nadu during 3 and 7 Janauary 2011.

[7] Prime Minister's address at the 96th Indian Science Congress held at North Eastern Hill University, Shillong, Mehalaya during 3-7, January 2009.

[8] Source: **Battelle, *R&D Magazine*, See:** *http://www.rdmag.com/Featured-Articles/2009/12/Policy-And-Industry-Global-Funding-Report-Emerging-Economies-Drive-Global-R-D-Growth/* (accessed 15 January 2011)

The top level research policy formulation, planning, coordination and advisory role in S&T from a long term perspective (generally keeping five years plans in view) is carried out by three major actors: (i) The Planning Commission; (ii) the Ministry of Science and Technology including the Department of Science and Technology; and (iii) the Principal Scientific Advisor, the Science Advisory Council to the Prime Minister. In 2010-11 the Prime Minister's Office also set up a National Innovation Council with the advisory role.

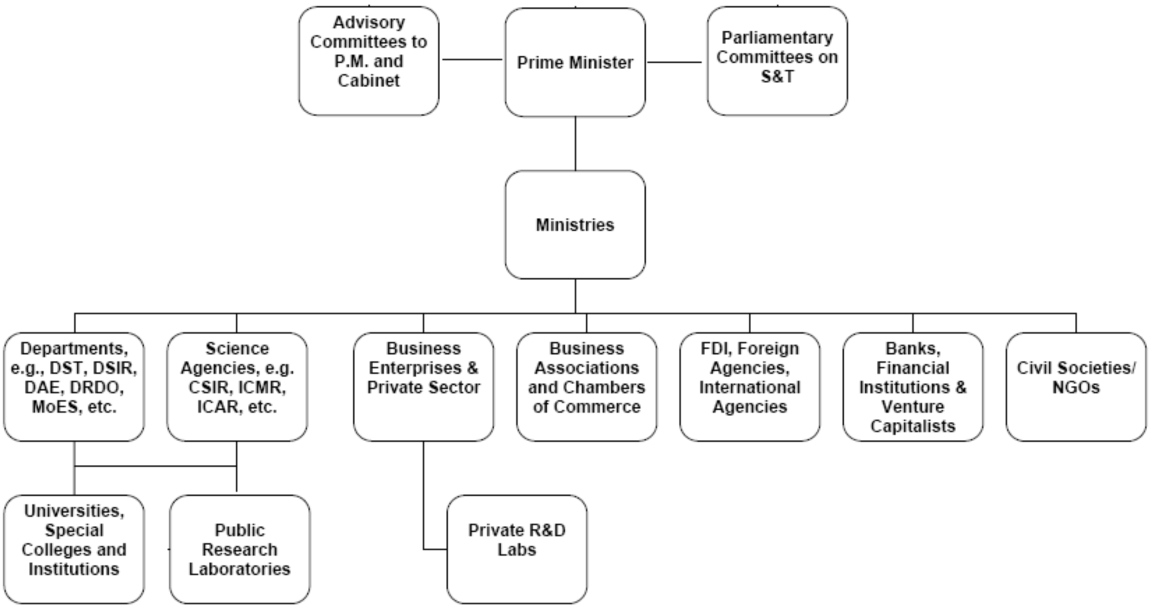

Figure 1: Overview of the India's research system governance structure

The PMO and the Planning Commission represent the top most bodies in the governance structure of India's research system. The Second level comprises of Ministries in various S&T sectors, industry, finance, economy etc. At this level as the Fig 1 shows, there are Departments such as DST, Department of Atomic Energy, Department of Biotechnology etc., and science agencies such as CSIR, ICMR, ICAR. Under the Ministry of S&T, whilst the Departments such as DST controls and distributes R&D funds in almost all areas of research, science agencies such CSIR which houses 38 national laboratories are devoted to broad areas such as industrial research (CSIR), agriculture research (ICAR), medical research (ICMR) etc.

The sector of education consisting of primary, middle and higher education is governed by Ministry of Human Resource Development (MHRD). The higher education is governed by mainly four councils, namely, All India Council for Technical Education including management; Medical Council, University Grants Commission which governs all public and private universities; and a body which governs social science research and vocational education and training.

The institutional role of regions in research governance

The term regions in India mainly refer to different federal states. Much of the research governance in the states is carried out by the state S&T councils created in most of the 28 states in India. Each state government has institutionalised a ministry of science, technology and education. In some states the S&T ministry is separated from the education portfolio. Much of the R&D is organised under these ministries and coordinated and governed by the State S&T councils appointed by the state governments. The states, which have become pro-active in aiding and complimenting the research and innovation policies of central government, are Karnataka, Delhi, Maharastra, Andhra Pradesh, Punjab, Haryana, Kerala, Gujrat and Tamil Nadu. It is for this reason that state capitals in these states have evolved as India's major knowledge and innovation hubs. The notable ones are Bangalore, Hyderabad, Mumbai, Pune, Chandigarh, National Capital Region of Delhi and Chennai.

Whereas in 2005-06, 57% of the GERD was met by the Central Government, 8% of GERD was contributed by the State Governments. Hence, the proportion of R&D effort funded and undertaken by States in India is relatively marginal compared to that of the Central Government. From an overall perspective of the spread of the science, technology and innovation system in India, it may be said that a dominant proportion of GERD is concentrated in the major cities such as Delhi, Bangalore, Chennai, Hyderabad, Mumbai, Pune, Calcutta, Ahmedabad, Thiruvananthapuram, Lucknow and Chandigarh. Even here, a dominant proportion of R&D expenditure by each of these states is met by the Central Government GERD budget.

Main research performer groups

The national innovation system is mainly constituted by a) public research system; b) private business enterprise and transnational corporations- TNCs (Indian and foreign); c) higher educational institutions (universities and colleges); and d) NGOs and civil society organisations.

a) *Public Research System (PRS)*: This comprises national laboratories under a dozen science and technology agencies from space, atomic energy, agriculture, industrial research etc, and in-house R&D laboratories in large public sector enterprises in steel, fertilisers, railways, power, transport and aviation, chemicals, petroleum and energy etc. PRS is India's main actor of NSI as it accounts for 68% of GERD. The dominance of PRS in India contrasts with East Asian economies such as Korea and Japan where over 75% of GERD comes from private sources. The role of State governments to GERD is quite marginal and State Science and Technology Councils created in almost all 28 States are just beginning to become proactive in assessing their strengths and weaknesses.
b) *Private Business Enterprises and TNCs*: This is the second major actor of Indian innovation system, which accounts for 30% of GERD. In the recent years business enterprise sector assumed considerable importance with the global competitive edge in pharmaceuticals, automotive, software, telecommunications and biotechnology. Whereas the international economic crises created ripples in the US and European markets and industry in so far as the auto and IT sectors are concerned, a more optimistic market scenario emerged in the Indian case. In the midst of crises, Tata launched the world's cheapest indigenous small car, Nano. The other sector, which witnessed robust growth and expansion, is the telecommunications sector. The Indian telecom market is one of the fastest growing markets in the world in 2011-12. There are 850 million mobile subscribers in India, second only to China.
c) *Higher educational institutions (HEIs)*: With over 447 universities with 25000 affiliated colleges, much of the recent dynamism witnessed in the knowledge based and high technology sectors of Indian economy is the result of human resources, skills and the vast institutional base already created in the higher educational sector. In an effort to sustain this dynamism the government has

increased the higher education budget by three times in 2009-10. However, R&D in HEIs in India is a weak link in India's NSI which accounts for mere 14% of R&D personnel compared to 55% of total R&D personnel of the country in PRS. The structure of HEIs is quite diverse and varied when we look into quality of institutions. The most eminent and well recognised HEIs are 20 Indian Institutes of Technology, 6 Indian Institutes of Management, 12 Institutions of National Importance such as the Indian Institute of Science and Tata Institute of Fundamental Research and about 20 Central Universities. Together with these institutions a tiny proportion of 5% of state level universities may be considered as India's high-ranking research based HEIs. By all means, a bulk of nearly 70 to 75% of HEIs are pre-dominantly teaching universities and colleges which are yet to achieve the Humboldtian goal of teaching and research based institutions.

d) Non-governmental research institutions aided by both public and private sources: This sector plays a very important role representing the civil society. This sector in the last few years begun to undertake substantial policy oriented research relating to science and technology issues. The sector has also come to influence policy decision-making in the country. They are involved in environment, ecology, energy, rural development, women and gender, grass root innovations and small technologies research including cottage and micro enterprises.

India's science, technology and innovation system has evolved over a long period of time. It may be said that this is the most stable and growing innovation systems among the emerging economies. Even though it is dominated by public research system, the business enterprise sector is the fastest growing domains of GERD in 2011-2012. The weakest link of the innovation system is the low proportion of GERD devoted to universities and HEIs.

2.3 RESOURCE MOBILISATION

2.3.1 Financial resource provision for research activities (national and regional mechanisms)

- **Progress towards R&D investment targets**: India's GERD as proportion of GDP progressed gradually from 0.69% in 1995-96 to 0.81% in 1999-2000; to 0.88% in 2006 to 1% in 2008. In absolute terms the money allocated to GERD witnessed a good deal of increase as India's GDP increased 1.4 times from 293 $ billion in 1988 to 416$ billions in 1998. In the next ten years, the GDP increased by 2.82 times to 1.176 $ trillion in 2007-08.[9] It may be pointed out that much of the public investments in R&D in the last decade and a half were prioritised from the perspective of strengthening the public R&D system including national labs and universities. Here again, the university sector was quite marginalised in terms of R&D in higher education. It is only the last five years from 2005 that the business enterprise R&D or private R&D component of GERD come to play a significant part which now constitutes about 30% of GERD.
- **Provisions for R&D activities**: India does not have a systematic multi-annual RDI strategy; such provisions are generally spelt out in the yearly budget speech of the government in March. It does focus on a limited number of priorities. For instance in the years 2009 to 2011 budget speeches focused

[9] *India Development Report* (2011) New Delhi: Oxford University Press, 2011, p27.

on inclusive development which included a number of social sector projects such as employment generation, urban renewal missions, health and infrastructure development. In each of these there was technology and R&D component but implicit in its various forms in the process of public procurement. The focus on social sector was aimed at reducing the poverty while keeping the economic growth. The financial crises of 2008 did not have any ripples in the Indian context.

There are a number of main funding instruments as follows:
Science and Engineering Research Council of (DST) funds national basic research programmes. There is a move to convert this as National Science and Engineering Research Board.
Innovation in Science Pursuit for Inspired Research (INSPIRE): A Second major recent initiative by the government has been the launching through DST which provides scholarships to attract talents to science. It is for forging vertical links between different stages in the pursuit of a career in science.
Promotion of University Research and Scientific Excellence (PURSE): In an effort to strengthen the scientific research base in universities and further encourage performing universities, the government announced the PURSE scheme which grants 100 million INR or 1.55 million EUR to universities over their normal budget for 3 years ending 2012.
Biotechnology Industry partnership Programme (BIPP): The Department of Biotechnology has launched a public-private partnership BIPP programme for high risk discovery and innovation and accelerated technology development especially for futuristic technologies.

Regional support schemes in the Indian context point towards federal states. They play a relatively marginal role in R&D as in 2007-08, 57% of the GERD was met by the Central Government; the State Governments contributed 9% of GERD. In terms of international aid programmes, they constitute less than 0.5% of GERD, which is again marginal. Here the main institution is USAID, which mainly focuses on research in agriculture and health related areas.

In terms of funding sources of R&D programmes, much of India's funding is channelled through institutional or block funding and only a small proportion is given to competitive funding by the SERC which is the main basic research funding body of DST. Subsidies and tax incentives share equal importance. The former is mainly manifested in the form of soft loans and tax holidays such as given occasionally to software firms.

The most important policy change, which is likely to come into force in the 12th, Plan (2012-2017) is the funding pattern of research which focuses on output and diffusion end of R&D spectrum compared to the existing input side.

In the 12th Plan the focus and special policy emphasis given to social and infrastructure sectors of economy which are closely linked to employment generation and reduction of poverty can be considered as an important strategy of the government for building science-society relationship.

In terms of main societal challenges, the financial resources in research will be devoted to climate change and renewable energy technologies; building high technology material and ICT related sciences for national security; and the management of transition from agriculture based economy. The last relates to grass root innovations for employment opportunities for people coming out of agriculture based economy.

2.3.2 Providing qualified human resources

National Context

The four layers for generating qualified human resources in India consists of a) UGC which has more than 447 universities and 25000 affiliated colleges (operating in under graduation and post graduation) and accredits private universities and deemed universities; b) All Councils of Technical Education which control the technical, business management and other educational institutions such as hotel management etc.; c) Medical education which is controlled by the Medical Council of India (MCI); and d) Vocational training through 5000 Industrial Training Institutes (ITI) under the Directorate of Employment and Training in the Ministry of Labour, Employment and Training, Government of India. India's current Gross Enrolment Ratio in higher education is around 13 for the age group 18 to 25 years.

The decade 2000 to 2010 witnessed doubling of enrolments in the higher education in India from 8.399 million in 2000 to 16.975 million students in 2010 according University Grants Commission of India.[10] This figure is however quite low compared to India's 1.2 billion population. As per the statistics available on HRST from DST for the year 2005, about 392000 personnel were employed in the R&D sector which works out to be around 137 per million population according Unesco Science Report 2010.[11] Out of this graduates (30%), post graduates (38%), Ph.D (18%), diploma (8%) and others 6%. It is rather difficulty to speculate on the proportion of HRST population in the age group 25-65.

Articulation of education policies within the Knowledge triangle

Even though India is producing about 17 million students in the higher education every year from 2010, the question of employability of these students has come into sharp focus in recent years. India is now finding various policy mechanisms to increase the potential of employability of students coming out of higher education. Most of the public sector enterprises in the government sector run internships and on-the job training programmes. Various reports from the business enterprise sector indicate that given the lack of appropriate skills from graduating students, they have also initiated on the job training programmes particularly in the software sector. The policies on higher education have not helped the expansion of technology, management and engineering demands of human resources in the government sector of higher education. In the last decade, the policies have encouraged public – private participation in higher technical and medical education to meet the demands of private sector.

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[10] The figure is from the Steering Committee Report on higher education given by UGC, New Delhi, 2012.

[11] See UNESCO Science Report 2010, Paris, P373.

Main social challenges

The current policies are meeting the demands of science, maths, engineering and medicine but there is a concern of trend of students moving away from science and maths towards commerce, economics and management subjects. Notwithstanding this situation, the production of human resources is meeting the demands of industry and the market. Higher education policies in 2012 are going through a process of reform and perspective planning for the 12th Plan period. Here, the policies aim at increasing the quality standards of higher education and creativity. Much of the existing higher education and its mode of teaching lack entrepreneurship training. This aspect is given a good deal importance in the 12th Plan perspectives as suggested by the Steering Committee Reports of the Planning Commission.

2.3.3 Evolution towards the national R&D&I targets

This section aims to capture the main dimensions of the policy mix with an emphasis on private R&D investment. As already mentioned in the Section 2.2, the government is committed to increase the R&D/GDP ratio from the current 1% to about 2% in the coming five years. Even though the GERD is dominated by government sources, policies encouraged the investment of business and private industrial sectors of Indian economy in the recent years.

Evolution of BERD

In 1990-91 BERD accounted for 13.8% of GERD and increased to 20.3% in 2001-02; 23% in 2006; it further increased to 30% in 2008-09. The Steering Committee Report of the Planning Commission for 12th Plan and the 2011 Report of the National Innovation Council (advisory body to the Prime Minister), have underlined the importance to increase the proportion of BERD to GERD.

Policy Mixes towards increased private R&D investment

Much of the policy discourse to enhance the BERD is now centred on the perspective of public-private partnerships (PPP) in research and innovation. There are various incentives and research and innovation policy measures introduced by the DST in the last five years to encourage BERD and PPP (See Inno-Policy TrendChart – Innovation Policy Report on India 2009).

In February 2010 the government increased the tax incentives given to enterprises. It enhanced the tax deduction of R&D expenditure by firms and business enterprises from 150% to 200% to boost research intensity of firms and increase the proportion of private sector in GERD.

Among the policy mixes, much attention is given in recent years to encourage and stimulate greater R&D investments by large indigenous firms and companies under Tata Group, Mahindra Group, Reliance, Birla, Suzlon, Infosys, Satyam, Reddy Labs, Biocon among others. Various incentives by the DST and other ministries in tax concessions and other policy measures led to encourage PPP in R&D and innovation. This has resulted in the development and marketing of products such as Nano car, drugs and vaccines, renewable energy technologies etc. The decade of 2000 to 2010 has witnessed a major change in the increase of investment of private indigenous firms in the national R&D basket.

Secondly, India has attracted more than 250 FORTUNE-500 global and foreign firms to invest in FDI in R&D via opening up of R&D labs and units. The decade 2000 to 2010 witnessed FDI R&D in ICT and BT to the extent of 12.5 US $ billion. In other words, the policies to encourage internationalisation and globalisation of R&D have gained a good deal of momentum in the last few years. Another important policy mechanism, which led to inflow of FDI R&D, is the development of Software Technology Parks and expansion of higher educational institutions in Bangalore, Hyderabad, Pune, Delhi and Chandigarh metropolitan regions.

There are some 3 to 4 well-targeted research and innovation schemes launched by DST and Department of Biotechnology to encourage PPP in R&D and innovation. Even though these schemes are by and large restricted to Indian firms and institutions, there are other national strategies aimed to attract and encourage FDI R&D. These specifically relate to strengthening the research and innovation eco-systems in the major cities identified above. India, as is the case with China, has been quite successful in attracting FDI R&D in ICT and other new technologies due to availability of highly skilled human resources and emerging knowledge hubs.

In the Public Research System, specific schemes of DBT such as Biotechnology Industry Partnership Programme, Small Business Innovation Research Initiative; CSIR's The New Millennium Indian Technology Leadership Initiative; and DSIRs Technopreneur Promotion Programme and Technology Development and Promotion Programmes are concerned with the creation of new firms. All the Indian Institutes of Technology and Institute of Science have established incubation centres which aim at the creation of new firms.

Innovation-oriented procurement policies

In the last five years or so three major sectors of economy have been the major sources of innovation-oriented procurement policies. The first is the strategic sectors relating to defence related purchases in electronics, automobiles, ancillaries for various kinds of guns and armaments. Whilst conventionally the Defence Research and Development Organisation (DRDO) under the defence ministry has been the direct beneficiary of this sector of innovation, the last five years has witnessed the opening up of private Indian and foreign firms for offering or bidding for contracts.

The second sector that assumes significance is the ICT including telecommunications. The demand and needs of various Central and State governments in e-governance programmes are directly related to innovation-oriented procurement. By and large this sector is dominated by both Indian and foreign firms.

The third sector that has assumed enormous significance in the last three years is the social sector where various government ministries and departments have initiated and implemented five major programmes involving multibillion Euros as follows:

- National Rural Employment Guarantee Scheme (NREGS) – EUR 5631 million for 2009-10

- *Bharat Nirman* involving six schemes for improving quality of life, transportation and bridging the gap between rural and urban – EUR 2746 million in 2009-10
- *Indira Awaas Yojana*: a national housing scheme for poor – EUR 127 million in 2009-10
- *Pradhan Mantri Gram Yojana*: for integrated development for reduction of poverty and infrastructure in 1000 villages as pilot project – 14.5 million EUR in 2009-10
- Urban Renewal Mission: building urban infrastructure – 1862 million EUR in 2009-10
- National Rural Health Mission: 2041 million EUR in 2009-10.

Among these programmes, NRGES , Urban Renewal Mission and National Rural Health Mission are considered as quite promising and relatively successful as in various regions of the country they have yielded results according to the National Advisory Council of the ruling Congress Party. On the other hand, the *Bharat Nirman* and *Pradhan Mantri Gram Yojana* which are linked to improving the lives of people in rural areas are yet to demonstrate their effectiveness. Given the large rural population of nearly 500 to 550 million people, the impact of such policies in specific regions pales into insignificance.

Other policies that effect R&D investment

The Small Business Innovation Research Initiative (SBIRI) launched by the Department of Biotechnology has the focus on small business enterprises along with forging and promoting public-private partnership (PPP). Pharmaceutical, biomedical, automobile and ICT including telecommunications have witnessed a good deal of policy focus in PPP mode in the last two years.

Much of the venture capital type of funding executed by the Ministry of Science and Technology units take the form of loans for commercialisation of inventions and technologies. Such funding is mainly directed to the pharma and biomedical sectors. Indirect funding measures are confined to ICT software sector, which is mainly concentrated in the Software Technology Parks of India (STPI). There are over 45 STPIs, which account for 80% of 70 Billion Euros of software exports from India in the year 2011-2012. The indirect funding here concerns infrastructure building and providing high-speed connectivity. Public innovation policies have been relatively successful in the commercialisation of research in so far as the SMEs are concerned and particularly the ICT software sector.

2.4 KNOWLEDGE DEMAND

Business driven knowledge demand

The main drivers of R&D in India are defence and strategic affairs; chemicals and pharmaceuticals; ICT and telecommunications; automotive and ancillary industries; biotechnology; space and aerospace industries; infrastructure including housing, buildings, roads and bridges; food processing; primary industries including mining and agriculture; health; machine tools etc.

In so far as the business driven knowledge demand and FDI is concerned one may single out few sectors, namely, ICT and telecommunications, biotechnology, pharmaceuticals, automotive and infrastructure related industries. All these sectors are the sectors, which can be characterised as business driven in terms of their knowledge demands, are concerned. As already pointed out above, India has attracted more than 250 FORTUNE-500 global and foreign firms to invest in FDI in R&D via opening up of R&D labs and units. In all there are 470 foreign firms with 670 R&D centres. The decade 2000 to 2010 witnessed FDI R&D in ICT and BT to the extent of 12.5 US $ billion. With the possible exception of infrastructure industries, both Indian and foreign business enterprises operate R&D centres in the country. Much of India's public policies regulate and govern these sectors. As already mentioned ICT, telecommunications, biotechnology and pharmaceutical R&D units are located in the knowledge hubs and Software Technology Parks (STPs) such as Bangalore, Hyderabad, Pune etc. There are some 41 STPs in India.

2.5 KNOWLEDGE PRODUCTION

2.5.1 Quality and excellence of knowledge production

Indian publications nearly doubled in about two last decades between 1990s and 2008 (see Table in section 3.3.1). Much of the scientific publications come out from HEIs and PRIs as shown in the table. Business enterprises only contribute marginally to the extent of 3% of the total in 2007-08. Indian universities and colleges accounted for mere 7% in 2008 of GERD. In contrast, the business enterprise sector accounted for 30% and public research institutions sector accounted for around 62% of GERD during 2006-08. Despite a very low level of GERD devoted to HEIs, the sector accounted for nearly 52% of total science output, that is 22,945 publications measured by SCI extended database in 2007.

As per the statistics available on HRST from DST for the year 2005, about 392000 personnel were employed in the R&D sector. Out of this graduates (30%), post graduates (38%), Ph.D (18%), diploma (8%) and others 6%. It is rather difficulty to speculate on the proportion of HRST population in the age group 25-65 yrs. As per detailed break up available from the UGC, nearly a third of total 11.5 million students in higher education, that is 30%, are from science and engineering; 45% from Arts and social sciences; and 23.5% from commerce, management and law faculties in 2006.

According to the SCOPUS database, Indian institutions published 41126 papers in all areas of science and technology. Whilst public research institutions account for 44%, HEIs account for 52% of total publications. The business enterprise sector is a minor actor with just 3% of total publications. Even though Indian HEIs account for mere 4-5% of GERD they account for half of the national scientific output.

A total of 9,622 patents are granted to the innovators with Indian address from 1990-2011. Among the 9,622 patents granted to Indian innovators till 2011, there are about 6,580 patents (about 70%) which were granted to foreign entities by the USPTO from their R&D work undertaken in India during the period from 1990-2011. The patents cover a wide range of technological areas. The period from 2000-2011 reveals a technological shift in the types of firms involved and the types of patents that were granted. Pharmaceutical, chemical and consumer goods firms were predominantly involved in patenting activity before 1995, whereas from 1995 onwards ICT firms were more involved in this process. This has strong correlation with the foreign R&D units that are opening in India over the period. It may be noted that patenting in software is only a recent trend. Much of the R&D work carried out in India in software, though of high quality, is of contractual nature feeding into parent companies. The established practice of the software firms was to obtain 'protection' through copyrights.

2.5.2 Policy aiming at improving the quality and excellence of knowledge production

Policies aimed at improving the quality and excellence of knowledge production is to be understood in a heterogeneous perspective in the Indian context. This is because higher educational institutions are divided into – central universities, state universities, private and aided universities and colleges affiliated to various universities. Quality and excellence in knowledge production here is by and large applicable to 25% of the universities mostly central universities and institutions of repute such as the Indian Institutes of Technology (IITs) (we have some 20 institutes), Indian Institutes of Management; Indian Institute of Science (IISc), Bangalore; and National Institutes of Science, Education and Research. The rest of Universities about 75% are mostly teaching based universities and colleges. Research is undertaken but it is not the mainstream activity. In the former, which are both teaching and research based institutions, there is effective monitoring and reviews making use of output indicators and often-international benchmarks are used as in IITs and IISc. It may be pointed out that international benchmarks such as issued from Time Higher Education, UK, or the Shanghai Jiao Tong University rankings to rank Indian universities are not uniformly followed.

The UGC has its own benchmarks for ranking via its National Assessment and Accreditation Council (NACC). This is the main body under the UGC which has come to play a pro-active role in the last couple of years for monitoring the quality standards of HEIs institutions. The UGC in the last two years has linked its research funding to research contribution and quality of research. Whereas the quality standards across all universities are set and measured by NACC, the UGC uses these measures to allocate special research funding under the scheme called 'universities with potential excellence' (UPOE). During 2009 and 2011, some 20 universities were selected under UPOE scheme.

In the public research institutes which are under the science agencies such as Council of Scientific and Industrial Research (CSIR), atomic energy, space research etc, and other national labs under Central and State government departments –there is a diversity of evaluation standards followed in so far as the recruitment of R&D professionals are concerned as there are engineers, scientists, technicians, managers and other professionals. In so far as the scientists whose primary aim is to undertake research, their R&D output or knowledge is evaluated by peer oriented international benchmarks. More than patents, publications assume considerable significance in the Indian R&D labs and universities.

National funding for basic research administered by SERC of DST is allocated through internationally recognised peer evaluation processes.

2.6 KNOWLEDGE CIRCULATION

2.6.1 Knowledge circulation between the universities, PROs and business sectors

Historically speaking, most leading universities in India have been performing the roles of teaching and research so as to make an impact on the society and economy. Traditionally consultancy and sponsored research between industry and university or PROs was prevalent. However the feature of coupling teaching/research with innovation and at the same time forging university – industry relations (UIR) including with PROs with various actors and agencies in the respective national systems of innovation has come into sharp focus in the last decade in India. Knowledge circulation and the policies, which promote three or two way interaction in UIR, can be explored from three levels.

At the national and centralised level involving the Department of Science and Technology and the Department of Scientific and Industrial Research, various innovation policy measures and instruments are initiated. For instance, DSIR has initiated several research programmes[12] to forge science and industry links. Two notable programs under DST are Home Grown Technologies and Technology Development Board programme. Home-grown Technologies: This programme is administered through the Technology Information and Forecasting and Assessment Council (TIFAC) under DST. Projects are supported to commercialise Indian processes and technologies with loans at low interest rates compared to market and equity participation. Similarly, DST also administers the programme through the Technology Development Board. All these programmes demand partners in universities and business enterprises.

At the science agency level for example in departments concerned with industrial research, biotechnology, electronics, ICT, atomic energy, space, defence, industrial research, agricultural research etc various programmes and schemes are initiated to forge the knowledge circulation. The notable scheme from the Department of Biotechnology is the small business innovation research scheme (SBIR). Similarly CSIR has initiated some schemes which promote knowledge circulation. The New Millennium Indian Technology Leadership Initiative, the creation of CSIR academy has the objective to enhance its links and collaboration between universities and CSIR. Since CSIR is under the Department of Scientific and Industrial Research, there are research schemes which specify collaboration with universities.

In the recent years there has been a growing interaction between the Indian Institutes of Technology (IITs) and the industry at the Laboratory level. This has manifested

[12] Some of these are: Industrial R&D Promotion Programme; Technology Development and Innovation Programme; Technology Development and Demonstration Programme; Technopreneur Promotion Programme; Technology Management Programme; International Technology Transfer Programme; International Technology Transfer Programme; and Technology Development & Utilization Programme for Women.

itself in different forms. For instance, Tata Consultancy Services (TCS) and the Indian Institute of Technology (IIT), Chennai, launched an Academic Centre of Excellence and a user-oriented M.Tech. programme in Computational Engineering. The establishment of incubation units at IIT Delhi (TBIU), IIT Bombay (SINE), IIT Kanpur (SIIC) and IIT Kharagpur (TIETS) are relatively recent developments in aiding knowledge transfer and circulation. Incubation and enterprise creation or what is known as spin-offs has come into prominence and sharp focus in the IITs via incubation units.

The impact of globalisation or globalisation of innovation via foreign multinational corporations has led to the emergence of 'new' knowledge R&D centres now extended to the Indian cities. Universities and colleges and other knowledge institutions have become important sources of skills, knowledge and innovation activities and they have the additional task of tapping into, or networking with, this globally dispersed knowledge networks and institutional sites. From a macro S&T studies perspective, HEIs have come to play an important part in India's high technology related knowledge and innovation clusters (KICs) in major cities as noted earlier. From the perspective of UIR, the emergence of KICs in half dozen Indian cities such as Bangalore can be seen as a major development. More than 250 multinational corporations such as IBM, GE, Microsoft, Intel and others have established R&D labs and centres in the cities.

2.7 OVERALL ASSESSMENT

The S&T Steering Committee of the Planning Commission has set a goal of attaining 2% of GDP in R&D by the end of the XIIth Plan (2012-2017). The Plan document seeks a paradigm change in the orientation of science and technology policies from an input oriented policy mechanisms to focus on the demand and diffusion end of the spectrum. Two major shifts in the mode of funding research and innovation can be seen in the last one year. The government has given a renewed policy focus to solicit the participation of business enterprise sector through PPP in almost all sectors of the economy including the social and S&T sectors. Closely related to this is the policy focus on attracting the FDI in R&D by creating enabling research eco-system. Currently there are more than 470 foreign MNCs (250 are FORTUNE-500 global firms) which have opened up R&D centres in India. Secondly, there is a move towards project based and mission mode funding compared to the existing focus on institutional funding. The basic research wing of DST, (Science and Engineering Research Council) has already turned to fund research on project mode funding based on competitive bidding and peer evaluation. All new areas of research and innovation such as nano S&T, climate change, renewable energy and others sectors have joined the space and atomic energy programmes to shift towards mission mode of funding. These mission-oriented projects have large goals or mission to be achieved in specific time boundaries.

India is among the top S&T producers in the world but lagging behind China. However, the quality of research output compared to China fares better in terms of journal citations and other quantitative measures. The NACC, which is the national body responsible for assessing the quality of university and colleges output, is given a renewed policy thrust by the government. NACC expert and peer review teams assess and evaluate universities and colleges periodically to grade and rank these institutions.

One of the major constraints in knowledge circulation, particularly with regard to flow of knowledge between research and industry comes from the side of the universities. Indian universities are yet to join the emerging paradigm and strategies of innovation involving 'Triple Helix' or university-industry-government relations. By and large universities operate in traditional mode of consultancy and sponsorship. With the exception of IITs and IIMs, universities are yet to accept the culture of innovation as an important domain of their objective along with teaching and research.

3 National policies for R&D&I

3.1 LABOUR MARKET FOR RESEARCHERS

3.1.1 Stocks of researchers

India with a population over 1.1 billion people is generally seen to have a big demographic dividend as India will have over 50% of population under the age of 25-29 even by 2030 and beyond. However, HRST as share of total population is staggeringly low. While Australia, North America and most parts of Western Europe are endowed with average 3500 -4000 per million researchers during 2004-06, Indian figure stands around 137-140 for the same period. Several SE Asian nations such as Malaysia and Singapore come under the category of 301 to 1000 researchers.

As per the statistics available on HRST from DST for the year 2005[13], about 392000 personnel were employed in the R&D sector. This figure is estimated to have increased to over half a million in 2010. Their breakdown is: graduates (30%), post graduates (38%), Ph.D (18%), diploma (8%) and others 6%. In addition to this, there are some 3.2 million professionals employed in the ICT software and related services in 2009. It is rather difficulty to speculate on the proportion of HRST population in the age group 25-65 yrs. As per detailed break up available from the UGC, nearly a third of total 11.5 million students in higher education, that is 30%, are from science and engineering; 45% from Arts and social sciences; and 23.5% from commerce, management and law faculties in 2006.

In terms of HRST there is no real crisis of demand – supply in the Indian context. India was worried about brain drain in the 1970s and 1980s but this is not a major issue of concern currently. What is however an issue is internal brain drain specifically for engineering graduates. Trend among the best of engineers is to migrate to management positions rather than getting into production engineering. Another issue of engineering, which has come into sharp policy discussion, is about the low level of Ph.Ds in engineering. India in 2012 is producing hardly 1058 Ph.Ds in engineering, which is low, compared to China and other countries. According to statistics available from the DST, in 2005-06, India produced 18730 Ph.Ds in all sciences and engineering. Analysis of data reveals that 45% of this number is from S&T faculties and the rest from non-S&T faculties, which again is a low figure compared to 13.5 million in higher education as a whole.

3.1.2 Providing attractive employment and working conditions

- The situation of employment conditions in India has been quite stable as far as the permanent positions are concerned. In various R&D institutions and universities, the majority of professionals are recruited on a permanent basis. Contract researchers and professionals are not very popular with Indian institutions. However, the situation is not the same in business enterprises' R&D units.

[13] This is the most recent data available, DST is yet to come out with new Report (Sep 2012)

- The salaries of researchers in public R&D institutes and universities are more or less at par. However, the salary packages between private and public universities vary. The former, particularly private business and management institutes offer two to three times more than public institutions. However, Indian salaries in R&D institutions and universities are quite low compared to their counterparts in East Asian OECD countries. During the last decade, the salaries of professionals in R&D and universities have increased by 2.5 times and hence they are seen to offer quite a stable and attractive career prospects. The salaries of professionals in R&D institutions and universities are comparable with those of doctors, civil servants and other professionals employed in the public research system. However, doctors in private hospitals earn more than two or even three times their counterparts in public research institutions. It is difficult to compare with business community which ranges from petty, small, medium and large businesses. However, the social security and pensionary benefits for professionals in public research system is quite good and gives them more security compared to professionals in private institutional system.

- It is not possible for R&D institutes in government and universities to determine their own salary levels for researchers. There are norms, which govern and offer somewhat comparable salary levels in both organisational contexts. There is hence no flexibility in offering salary levels in different public research systems. The mobility between R&D institutions in government and universities are not quite common. There are various hurdles, which prevent mobility. Salary packages do not matter here, as they are comparable. Placements for children in schools, housing facilities and habitat reasons prevent mobility of Indian researchers in the public research systems. However, there is some mobility within the university sector. The mobility is always from a less-known university to well known and prestigious universities within the country.
- Indian R&D institutions and universities have a clear advantage over corporate R&D jobs in so far as vacation, parental leave, maternity leave, education leave and other opportunities are concerned. Working conditions are quite favourable for women, which offer various breaks and facilitate their career stability. Younger and senior professionals find themselves confronted with various opportunities (sabbatical for instance) for temporary mobility to take up post-doctoral positions and training visits both in the country and abroad while retaining their positions.
- Brain drain is no more a major concern in India as it used to be in the 1980s. There are various policies, which are aimed at brain-gain and brain circulation. The DBT and DST have two main schemes (Ramalingaswamy Re-entry Fellowships and Energy Biosciences Overseas Fellowships) which are directed to attract talented and outstanding researchers of Indian origin or Non Resident Indians back to the country. There is some evidence to suggest that the last decade witnessed return migration of software professionals from the USA, mainly to initiate firms and businesses. The software companies association (NASSCOM) in New Delhi has announced that there are some 500 firms established by these Indian return migrants (brain gain) in cities such as Bangalore, Hyderabad, Delhi and Pune.

3.1.3 Open recruitment and portability of grants

In India academic staff working in universities and scientists working in science agencies and national labs is not deemed as civil servants. Researchers in national labs under science agencies and government labs are considered as employees under government. Academic faculty in universities are considered as professionals in semi-autonomous organisations. In any case all these professionals are governed by civil service norms with pensions and other benefits such as medical and health cover in government hospitals, government subsidised housing and subsidies on children's educational fees.

While foreign nationals can work as visiting faculty or researchers in Indian institutions, they will have to go through an official process of the Home Ministry and Foreign Ministry before invitations are rolled out. Prior permission of the government is required to hire foreign professionals in government labs. These conditions are a bit more liberal in the university sector. Business enterprises in the private sector can hire foreign professionals with minor reporting procedures. On the whole India is open to non-nationals and there is nothing which prevents these other nationals to work and associate with research institutions in India. There is no systematic data available but given the domination of US and European firms operating in India, non-nationals are mostly from these regions of the world.

There is no discrimination between national and non-national professionals in so far as the norms governing their recruitment. In both cases the same peer review, competitive procedures and standards of excellence are applied in recruitment.

The University Grants Commission, Medical Council and the department responsible for technical degrees have a list of institutions and universities, which are recognised by Indian government. Most well-known and reputed universities in various countries are recognised by these bodies.

International advertising of research vacancies has come to assume considerable significance in the last decade, particularly in the top-notch universities and institutions of national repute in India.

Research grants allocated to professionals in India are not generally portable and they will have to be implemented and spent in the country. However, depending on the grants, professionals are allowed to undertake field research and sabbatical leave for short and long periods to work in foreign locations.

3.1.4 Enhancing the training, skills and experience of researchers

Most universities and post-graduate colleges offer accredited Ph.D programmes. However, post-doctoral positions are offered only by leading universities and institutes of eminence.

Given the British colonial background English is widely used in bureaucracy and teaching at all levels of education in India. While English is the main language in teaching and research in most of the central and state government labs and central universities, the state universities and colleges have the autonomy to teach and research in their own state based languages.

Universities and science agencies have considerable autonomy to enter into memorandum of understanding with foreign based institutions for joint research programmes, teaching and combined degrees. There are no specific policies aiding internationally mobile researchers compared with national or local professionals. Standards of excellence, professional recognition and peer evaluation are applied across all professionals irrespective of their nationality or colour or caste. However, there are certain affirmative policies to aid professionals or neophytes from socially and economically disadvantaged Indian communities. These policies are however restricted to about 50% of total vacancies. Such policies in most cases apply only to entry level but not at a later stage.

Realising the demographic dividend, the government formulated a National Skills Policy in 2009 which led to the establishment of the National Council on Skill Development in 2010. The government has the target of imparting skills and training in various sectors of economy to over 500 million people by 2022. Under the Deputy Chairman of the planning Commission, National Skill Development Coordination Board was set up to coordinate with various agencies and ministries. PPP model is given a good deal of importance in these policy measures relating to training and skills.

Some the programmes and schemes from various Ministries are as follows:

From the Ministry of Human Resource Development

- Vocationalisation of Secondary Education by covering 6800 schools by 2012. The target group here is students who have passed 10th class and the duration is of two years;
- National Promotion of Technhology Enhanced Learning launched in 2003. This is meant for engineering and science under graduate. This is a web based distance learning scheme which is designed and course material prepared by IITs and other leading engineering colleges;
- National Programme on Earthquake Engineering Education. This is meant for faculty development for short term training programmes in disaster management and engineering colleges;

From the Ministry of Rural Development, Urban Development and other Ministries:

- Swarnajayanti Gram Swarozgar Yojana directed at poor sections of the population under poverty line. The programme aims at skills training through the Rural Development and Self Employment Training Institutes set up by the government;
- Food processing training centres through CSIR's food research lab;
- 478 multipurpose health worker training schools for women set up 2010-2011
- Quality measures for ICT training institutions by the ministry of information and communication technology. It is known as Department of Electronics and Accreditation of Computer Classes (Doeacc). This is an independent organisation under the ministry to ensure training quality in ICT ;
- 51Training centres in 35 different programmes in the micro, small and medium enterprises; and

- Integrated skill development scheme for textiles and apparel sector launched in 2010. Under this, skills for manufacturing apparels through research and training are given via 18 nodal institutional centres in the country.

3.2 RESEARCH INFRASTRUCTURES

Research infrastructures (RI) are a key instrument in the creation of new knowledge and, by implication, innovation, in bringing together a wide diversity of stakeholders, helping to create a new research environment in which researchers have shared access to scientific facilities.

There are a wide variety of scenarios to explore the feature of RI in Indian institutions and universities. Establishing research infrastructures has gone through a long historical process in India in the last 60 years after independence. About 20 years back, research infrastructure was an issue of concern to most universities and research establishments. As it has improved over the years it is no more a big concern for various research establishments and universities for undertaking nationally and locally relevant research. DST and the Ministry of Human Resource Development have several research schemes and policies to aid in building centres of excellence and advance research in various institutions.

However, when it comes to benchmarking with world-class research facilities, there is diversity of research and higher educational settings. India has several institutional settings with world-class research facilities. For instance, in space and astronomy research, atomic energy, missile and material sciences and research, ICT and telecommunications, pharmaceuticals and chemical research, mathematics and supercomputing there are several institutions and national research agencies, which can be easily characterised and considered as world class. For example, India could not build and launch satellites from its soil without attaining world-class research standards in research facilities. IITs, IISc, Tata Institute of Fundamental Research, Indian Institutes of Management and over 15% of 447 universities have built world class RI.

India has no international cooperation projects or programmes at building RI but there are several projects on international cooperation between Indian world-class research institutions and EU, USA and UK based institutions.

3.3 STRENGTHENING RESEARCH INSTITUTIONS

3.3.1 Quality of National Higher Education System

Size and rough composition of the HE[14]

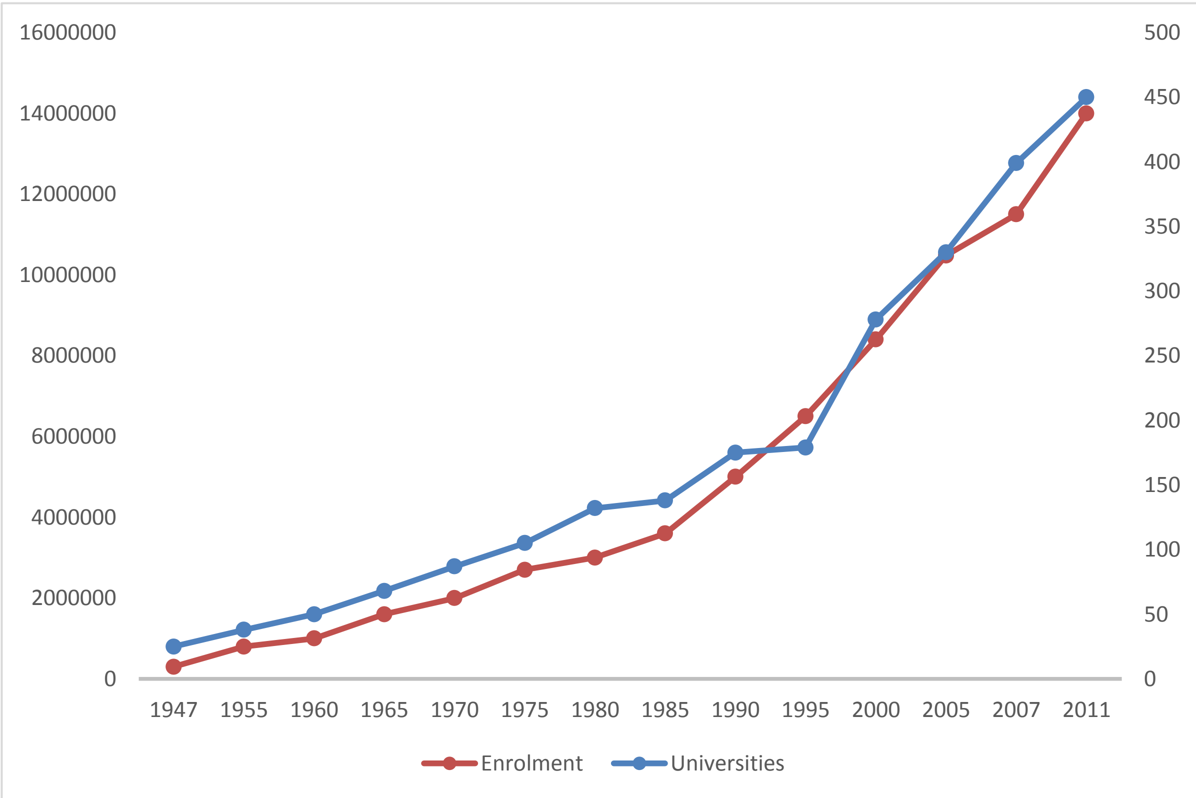
First three Indian universities were established in 1857 in the three Presidencies (Madras, Calcutta and Bombay). By independence, there were around 30 universities and some two hundred colleges affiliated to these universities. Currently India has some 447 universities and 25000 colleges affiliated to respective universities. The

[14] Material in this section of 3.3 is also drawn from Krishna (2012)

figure below shows the growth of universities and enrolment of students in higher education. The growth of higher education in independent India can be conceptualised in terms of three phases: 1940s to 1980; 1980 to 1990; and the era of liberalisation after 1991. Right from the beginning, government support to higher education under the leadership of India's first Prime Minister J.N. Nehru assigned top priority to develop higher education with public support. Though there were initiatives from the private sector such as from Tata's in building Indian Institute of Science, Bangalore and Tata Institute of Fundamental Research, Bombay and Birla's in building Birla Institute of Technological Sciences, Pilani, the public support played an important part and continues to do so. Private institutions account for 50% of the total medical seats and 80% of the engineering seats available in students in India.

The University Grants Commission operating under the Ministry of Human Research Development governs the university system in India. Similarly, the ministry oversees technical and medical councils, which in turn govern the respective domains in higher education. The education in India is a State subject and hence the State governments enjoy considerable autonomy to shape the growth of higher education in their respective states. Whilst universities and colleges in China account for around 10% of GERD in 2005-06, Indian universities and colleges accounted for mere 7% in 2008.

Figure: Growth of universities in India and Enrolment 1947-2011



In the last two and a half decades the higher education enrolments increased over almost 3.5 fold to a total of 11.5 million in 2007. As depicted in the figure, the enrolment in 2011 is around 14 million students. Out of the 11.5 million enrolment

(2007 figure), for which some break up is available, about 60% are male and 40% women students. However, India lags behind other developed and developing countries in Gross Enrolment Ratio (GER). For instance, GER's for USA, Australia and UK are 82, 72 and 60 respectively. On the other hand GER for India is 11 compared to 29 in Malaysia and 19 in China for 2004 (Duraisamy 2007).[15] The figure below shows the discipline wise enrolment of students in HEIs.

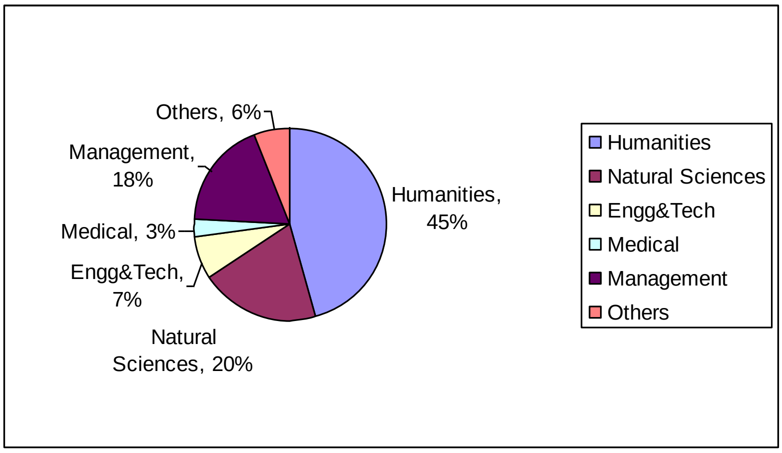


Fig: Discipline wise enrolement of students in HEIs 2007-08

From the perspective of governing and setting up of HEIs, seven different types can be seen in operation in the Indian context[16] :
a) Public universities or institutions which are promoted and set up by the central government;
b) Universities set up by the state governments;
c) Private universities or institutions set up and funded by private sources;
d) Government dependent private institutions which are set up by private sources but are aided to some extent by the government;
e) Among c and d there are universities which are given the title of 'deemed university'. They are qualified to be considered as universities although their legal status is not that of a university;
f) Institutions of national importance and those which are set up state legislatures; and
g) University affiliated colleges which offer under graduate and graduate courses. These are also given the title of deemed universities. Deemed and private universities relatively enjoy greater autonomy compared to public universities and those of aided universities. The Table shows the growth of different types of HEIs during 2002 and 2007

Table: Growth of Different Types of universities and HEIs

University level institutions	2002	2007	2011
State universities	178	232	250
Deemed universities	52	114	140
Central universities	18	24	25
Private universities	-	11	34

[15] Duraisamy P-(2007) Enrolment Projections for Inclusive Higher Education in the 11th Five Year Plan, Study sponsored by UGC

[16] The UGC is the apex body which regulates the universities as a whole. However, HEIs in engineering, management and other professional areas are regulated by AICTE and medical institutions are regulated by Medical Council of India.

Institutes of national importance	12	13	13
Institutes set up by state legislature	5	5	5
Total no. of all universities	**265**	**399**	467**
Colleges affiliated to various universities	16885*	18064	25951

*Figure for 2003-04; ** some institutions are notified

During 2000 and 2006 as the Table below shows, whilst the enrolments increased between 309000 (9%) and 376000 (12%) in government and government aided private institutions respectively; the enrolments in private unaided institutions increased almost four fold to 1.397 million (76%). Much of this expansion is witnessed in professional disciplines, particularly engineering and medicine. As the Table shows, engineering, medicine and management subjects take a lead in the private sector expansion to the extent of 80% compared to 20% in the public institutions for the data available for the period between 1999 and 2007.

Table: Higher Education Enrolments in public and private Institutions (Figures in 000)

Type of Institutions	2000-01	2005-06	Growth (%) in 2000 to 2006
Government	3443	3752	309 (9)
Private Aided by Government	3134	3510	376 (12)
Private Unaided	1822	3219	1397 (76)

Studies and surveys undertaken by Gupta and Dhawan (2006, 2009) shows that only 18 to 20% can be classified as research based universities which have a publication intensity on an average of over 120 papers per year over a period of a decade. The rest of the universities, though involved in research, focus more on teaching. India is yet to achieve the Humboltdian of increasing the research intensity in HEIs.

According to database on the level of enrolments, the data for the typical year of 2003 reveals that 83% of the enrolments are graduate students and the rest post graduation and Ph.D. If we take 1992-93 as base year, the total number of Ph.D's in science and engineering and non science disciplines witnessed almost twofold increase from about 8800 in 1992-93 to 17898 in 2004-05 for which data is available from UGC. Whilst the science Ph.Ds grew around 150%, the engineering Ph.D's increased by 300% during this decade. Similar extrapolations can be assumed for the current period.

Mission of HEIs

Historically speaking, most leading universities in India have been performing the roles of teaching and research so as to make an impact on the society and economy. As noted earlier, India is yet to fully achieve the objective of Humboltian goal of increasing the research intensity in HEIs. Whilst about 20% of 447 universities can be considered as teaching and research based, the rest can be taken mainly as teaching universities. Even though the latter do undertake research, it is a marginal or non-mainstream activity. However the feature of coupling teaching/research with innovation and at the same time forging university – industry relations (UIR) with various actors and agencies in the respective national systems of innovation has come into sharp focus in the last decade. Here again the third mission of innovation and creation of wealth is mainly relevant to 20% of Indian universities. Most of these are 'elite universities' including the IITs and IIMs.

HEIs have come to play an important part in India's high technology related knowledge and innovation clusters (KICs) in major cities as shown in Table below. From the perspective of UIR, the emergence of KICs in half dozen Indian cities such as Bangalore can be seen as a major development. More than 250 multinational corporations such as IBM, GE, Microsoft, Intel and others have established R&D labs and centers in the cities shown in Table below. These foreign R&D centers basically take advantage of the location and supply of highly skilled science and engineering graduates.

Table: India's Emerging Knowledge Innovation Clusters

Indian Cities/ States	**KICs & Relevant Business Enterprises**	**Global Foreign R&D Centers/ Laboratories in the main city**	**Public + Private Indian R&D Laboratories in the State**	**Universities + Colleges in the State**	**Institutes imparting engineering + and medical education**	**Publications 1996-2006 (SOPUS) from the State (10 years) (% of total)**	**Enrolments in universities and colleges in the State**
Bangalore (Karnataka)	ICT software, Aerospace and biomedical	45	107+38	16+1970	180+420	35000 (11.6%)	708195
Chennai (Tamil Nadu)	Automotive and ICT software	7	138+42	17+1244	270+200	48000 (16%)	841755
Pune and Mumbai (Maharastra)	Automotive, ICT software, chemical/pharma and bollywood	22	176+105	20+2487	185+330	46000 (15.3%)	1506702
Delhi, Noida and Gurgoan (NCR)	ICT software, biomedical, Automotive	24	93+40	5+ 285	85+ 25	45000 (15%)	636093
Hyderabad (Andhra Pradesh)	ICT software and biomedical	9	126+36	16+2131	275+225	21000 (7%)	911709
Calcutta (West Bengal)	ICT software/ biomedical	3	89+31	16+565	60+75	22000 (7.3%)	721762

Krishna (2012): Universities in India's National System of Innovation – An Overview, Asian Journal of Innovation and Policy, May 2012.

Research Performance

Despite a very low level of 7% of GERD devoted to HEIs, the sector accounted for nearly two third's of total S&T output measured in terms of peer reviewed publications in SCI Extended version data base during 1985-86, 1994-95 and 2001-02.[17] (see Table below). Between 1980s and 2007, even though the proportion of HEIs contribution in the national output has come down from 69% in 1985-86 to around 52% in 2007, the HEI sector accounted for over half of national output.

Table: Publication Output of HEIs, PRIs and Business Enterprises 1980s – 2007

	HEIs*	PRI**	Business	Others	Total

[17] Whilst universities and colleges accounted for 46%, institutes of national importance (which are also counted as deemed universities) accounted for 20%

			Enterprises***		
1985-86 (SCIE)	16,085 (69%)	6,569 (28%)	411 (1.7%)	235 (1%)	23,300
1994-95 (SCIE)	17,302 (62%)	9,218 (33%)	496 (1.8%)	562 (2%)	27,578
2001-02 (SCIE)	23,578 (60%)	13,329 (34%)	708 (1.8%)	1,237 (3%)	38,852
2007-08 (Scopus)	22,945 (52%)	19,415 (44%)	1,325 (3%)	441 (1%)	44,126

* Universities and Institutions of national importance; ** Public Research Institutes; **** mainly private

Krishna (2012): Universities in India's National System of Innovation – An Overview, Asian Journal of Innovation and Policy, May 2012.

According to Government of India patent office, 36,812 patent applications have been filed during 2008-2009. During this year about 16,061 patents granted from Indian patent office out of which 2,541 patents granted to Indian applicants and rest to foreign national. The number is about 5 percent more than the previous year. (Annual report 2008-09, Government of India, Patent Office). According to data available with the DST, whilst the EU-27 registers nearly 13 patents per million in 2009, for the same year Russia registered 0.23; India 0.10 and China 0.14.

It may be pointed out that international benchmarks such as issued from Time Higher Education, UK, or the Shanghai Jiao Tong University rankings to rank Indian universities are not uniformly followed. The UGC has its own benchmarks for ranking via its National Assessment and Accreditation Council (NACC). During the last six years IITs in India were ranked in the third position after US and UK engineering institutions in the THE rankings of UK.

The UGC has its own benchmarks for ranking via its National Assessment and Accreditation Council (NACC). It is an autonomous institution of the University Grants Commission set up to assess and provide accreditations for higher educational institutions in the country. Lately in India there has been an increase in mushrooming of various educational institutions with sub standard facilities in terms of competence of personnel and infrastructure thus spoiling the intent of education. The criteria of assessing the HEIs by NACC are as follows:

- The preparation and submission of a self-study report by the unit of assessment;
- The on-site visit of the peer team for validation of the self-study to report and recommend;
- The final decision by the Executive Committee of the NAAC.

UGC from 2011 is using NACC reports of assessment of colleges and universities both for funding research via its scheme on Universities for Potential of Excellence and colleges.

3.3.2 Academic autonomy

Autonomy

Autonomy in the HEIs can be conceptualised in terms of political, academic and financial and management autonomy. The feature of autonomy of HEIs varies depending on the type of university (public and central or state; private and partly aided etc). Broadly three types of universities matter when we explore the question of autonomy. The central universities, IITs, IIMs and institutes of national importance enjoy considerable autonomy. Even though the education related ministries control the budget and govern these institutions through various policies, this segment of HEIs command considerable autonomy in establishing certain standards of teaching, quality measures adopted to evaluate staff and in the introduction of certain measures to recruit students. The same cannot be said about the state universities.

Since education is a State subject of the constitution and State governments fund universities the government interference in the affairs of HEIs in the state has come into sharp discussion over the last few years. The main problem in the management state universities is the arrangement of appointing Vice Chancellors by the State Governors – political representative. Even though Governors have their own consultative mechanism, often peer review and excellence or quality based research indicators are ignored in the appointments of Vice Chancellors by the State. This has created a problem to develop quality measures of evaluation down the line in various state level universities. Since Vice Chancellors become political appointees in one form or another, there are various instances in the Indian universities where political interference influences the faculty recruitment.

Governance

A typical Indian university is governed at three levels, namely a) the executive body at the highest level; b) the academic senate or academic council or sometimes an academic court joined along with the senate; and c) School or Faculty level (social sciences or life sciences or international relations etc) councils or boards of studies. Whilst at a) and b) there are external members representing society, industry (only at the executive committee level) and sometimes political party members, at c) which looks after the academic matters of the university is represented by the faculty of the university based on seniority.

Rectors and Deans are not generally hired on open tender or interview process. The V.Cs or Presidents of universities have the power and influence to appoint these positions from within the university. The V.Cs in Central Universities, IITs, IIMs are selected on the basis of peer consultative process mediated through the education ministries, the V.Cs in State universities are appointed by State level Governors.

For the day-to-day affairs of the institution, a typical university again has three levels, namely a) Vice Chancellor or Director or President of the university; b) Rector or Rectors who assist the V.C; and c) Dean at the school or faculty level.

3.3.3 Academic funding

The decade (2000 to 2010) witnessed an unprecedented public investment in education in India. The public expenditure on education by the government increased from 2.2% in 2002 to 5% of government expenditure in 2009. Against the global average of 4.2% of GDP on education, India spends 3.80% of GDP. However, the proportion in higher education is much to the extent of 0.70% of GDP in 2009. Allocation for higher and technical education during the 11th Plan (2007-2012) has been raised by eight times to 8490.43 million from 960 million INR in the 10th Plan (2002-2007). Despite these increases, the proportion of R&D in higher education of GERD is very low (7%) compared to public research system (outside the sector) 58% of GERD.

The HEIs are generally given a block or institutional funding from the ministry, which is over 90 to 95% of their total funding. The HEIs compete for project based funding from various other sources of government and DST, DBT etc. It may be noted that block funding is not allocated on the basis of research output but on the basis of enrolments in graduate, post-graduate and Ph.Ds. The HEIs command a good deal of autonomy to allocate their research resources by deriving their institution-based priorities.

3.4 KNOWLEDGE TRANSFER

3.4.1 Intellectual Property (IP) Policies

So far Indian HEIs and public research labs are not governed by uniform IP policies such as the Bayh-Dole Act of USA. It is only in 2008 that the government introduced an Indian version of the Bayh-Dole Act called, '**The Protection and Utilisation of Public Funded Intellectual Property Bill 2008'** The Bill gives right of ownership to public research institutions and universities for R&D output leading to intellectual property and authorises these institutions to institute technology transfer and innovation units for R&D commercialisation. Researcher(s) who created intellectual property; the research group or department involved and the funder are entitled for one third each of the rents and royalties generated out of the intellectual property commercialisation under this Bill. Scientists and faculty will be allowed to set up Centres for entrepreneurship and innovation from the intellectual property developed. This bill is still pending in one of the houses of Parliament and is likely to come into effect before the end of 2012. Indian HEIs are encouraged to publish their research results in the peer reviewed open domain journals. Even Ph.D students are from 2012 expected to publish at least one research paper by the time their Ph.D is declared.

Most research based universities and public research institutions have established IP units, which govern IP rights of staff and students. These units in individual institutions come into picture during the negotiations with industry for transfer of IP .

Various HEIs and public research institutions have created incentive measures for the distribution of rents generated from IP. The most commonly prevalent ratio of distribution of rents indicates that the group or individual inventor gets over 65% and the institution gets 35%. Somewhat similar distribution operates for consultancy projects. These IP units deal with any conflicts arising out of IP and technology transfer and wherever such units do not exist they deal either by the Vice Chancellor or the Director of the Institution.

Knowledge Transfer Offices (KTOs) are established mainly in IITs, IIMs and some leading universities. These KTOs are managed by institutional faculty members and hire IP consultancy services. Converting patents and technologies into commercial products or services involve a good deal of investment. There are various innovation schemes from DST, DBT and other science departments which fund commercialisation of publicly funded research outputs. There is also a nodal agency called National Research Development Corporation (NRDC) specifically created to act as an innovation agency for public funded research. However, HEIs rely more on DST and DBT based innovation schemes to commercialise their research outputs.

3.4.2 Other policy measures aiming to promote public-private knowledge transfer

Governments and institutions have been very active in creating measures, schemes, initiatives, programmes, laws, technology transfer office etc. to foster the creation of university spin offs.

Spinoffs

As noted earlier, the culture of innovation is not evenly spread in the Indian university system. The concept of innovation and commercialisation of research in the university system including IITs, IIMs and other institutions of eminence such as IISc has become popular only in the last decade. There are a number of innovation research schemes from the DST, DSIR and DBT, which promote commercialisation of technology developed in Indian public research institutes and universities. Such policies are mainly relevant for IITs, IIMs, IISc and some universities. While sponsored and consultancy modes of technology transfer are still popular in these institutions, spinoffs and incubation are well established in the case of IITs and IISc. While IITs at Kanpur, Delhi and Bombay have adopted the conventional approach of creating formal incubation units, the spin-offs at IIT Kharagpur and IIT Madras have been created without the formal incubation setup. The Telecommunication and Computer Networking (TeNeT) group at IIT Madras comprises of faculty members from electrical and computer faculties who came together about 16 years back in 1994. Similarly there is Technology Incubation and Entrepreneurship Training Society (TIETS) and a technology transfer group (TTG) at IIT Kharagpur which are student's initiative under the auspices of sponsored research and industrial consultancy (SRIC), IIT Kharagpur. The TTG has been founded recently in 2007 and has the dean of SRIC, and few faculty members as advisors. The five IITs in the last five years have shown significant growth in promoting incubation units thus becoming an integral part of the support system for the growth of knowledge based entrepreneurship particularly in the SME sectors. The total number of spin-off firms from all the five IITs since 1994 up to June 2008 is 83. More than 50% of these spin-offs are reported to be successful in 2009-10.

Inter-sectoral mobility

Mobility within and between public research institutes (such as CSIR and other government labs) and universities are formally possible, there is very little mobility of research personnel in actual practice. Even though the administrative framework does not discourage, the social and other conditions do not help the process of mobility. Problems surrounding housing and finding appropriate schools for children are the two major factors which prevent researchers to move from one place to another. More over couples working in the same towns are unlikely to seek transfers to other institutions without any compelling reasons. There is mobility between public and private institutional set-ups but these movements entail leaving the public institution.

Promoting research institutions - SME interactions

There are cluster development policies directed at SMEs but the interaction between research institutions and SMEs or local regional industries or sectors of economy are relevant in the ICT software and biotechnology sectors only. In section 3.3.1 there is more information on the Mission of HEIs, where the example of knowledge innovation clusters in Bangalore, Chennai, Pune, Hyderabad etc are given.

Involvement of private sector in the governance bodies of HEIs and PROs

The involvement of business enterprise sector in the governance of HEIs and PROs has acquired considerable importance in the last decade. The leading Indian business enterprise houses are represented through their founders or CEOs in the leading universities and PROs. For instance, Mr Ratan Tata (Tata Group), Mr Mukesh Ambani (of Reliance Industries), N.R.Narayanmurthy (INFOSYS), Keshub Mahindra (Mahindra Group) – to take only few names prominently figure in the governing bodies of various PROs and universities.

Regional Development policy

Regional policies, which serve as good examples for understanding the instruments and their impact, are in ICT software and biotechnology. States such as Karnataka (where India's version of Silicon Valley – Bangalore is located), Andhra Pradesh, Maharastra, Delhi, Haryana and Tamil Nadu have initiated State related Information Technology and biotechnology policies and have implemented to promote these sectors. For instance, one can find IT software clusters in all these States. Bangalore and Hyderabad are also known for 'bio-valleys', which have resulted from the regional policies. India's major biotechnology firms such as Reddy Labs and Biocon are located in these states.

3.5 ASSESSMENT

In absolute terms Indian stock of S&T human resources compares quite well with that of other leading countries but India falls behind to a low level in terms of HRST measured for per million populations. There is a very long distance that India has to cover in terms of increasing the HRST compared to leading countries of the EU and North America. Indian universities witnessed considerable growth of HEIs in the last decade attaining the Gross Enrolment Ratio of 13 in 2011. The aim is to attain 18 to 20 in the coming decade. One can say that India does not suffer from shortages in the labour market for researchers but certainly does suffer from the quality and skills required by the industry. Most business enterprises have begun to run in-house based internships and have also entered into collaboration with IITs and other institutions in science and engineering for sponsoring skill and training programmes for emerging technologies.

Training human resources in highly skilled areas of S&T including medicine and management has raised some issues in the last couple of years. Business enterprise sector has immensely contributed to meet the human resource demands in technical, engineering, management and medical sciences in the last decade. This is likely to expand through PPPs. Leading business houses such as in ICT, telecommunications, auto and engineering have entered into training and internship based programmes with IITs and other leading universities.

Relatively low level of about 1% of GDP for R&D for a growing economy such as India is quite low and this has a cascading effect on the building and strengthening of infrastructure in public research institutes and the research intensity of universities. The XIIth Plan has given special focus to building an appropriate research eco-system and infrastructure in the current plan period ending 2017. The DST has increased its research funding related to building infrastructure in universities and public research labs.

Even though universities claim hardly 7% of GERD funding for research, it contributes over 50% of national science output measured in terms of SCI extended database. One of the weak links in the Indian national innovation system is the low research intensity of universities. Out of 450 universities, it can be said that nearly 75% of universities remain predominantly as teaching universities. The XIIth Plan on the recommendations of the National Innovation Council has committed to increase the HERD proportion of GERD by the end of the plan period.

Public and university research settings offer good working conditions. There is no culture of 'hire and fire' and penalties for not producing in research in universities and R&D institutions. This culture is changing but there is considerable resistance to bring in quality measures for evaluation in particular in the universities. The arrangement of contract researchers and faculty has just begun to be introduced in some Central Universities, IITs and IIMs.

With the exception of IITs and IIMs, universities as whole are yet to accept the culture of innovation as an important domain of their objective along with teaching and research. Incubation and technology transfer offices have been established in IITs and IIMs but this culture has not attracted the universities. However, most research based universities have established small IP units which mediate the knowledge creation, patenting and transfer of knowledge. A national law on IPR, which binds all public institutions, including universities is already framed but waiting to get approval from the Parliament.

The major problem of research and academic autonomy in the national innovation system is in the case of State universities. There is a good deal of political interference in the academic affairs of State universities. The Vice Chancellors and heads of state-based HEIs are appointed by Governors who are representatives of the ruling political parties at the Centre. Similarly, the caste, ethnic and other factors which come into play in the governance of universities have an impact on the quality of teaching and establishing high standards of learning in the state universities.

4 International R&D&I Cooperation

4.1 MAIN FEATURES OF INTERNATIONAL COOPERATION POLICY

The main objectives underlying India's international S&T cooperation are:

- Promotion of interaction and building partnerships in S&T for mutual benefit and advancement of knowledge;
- Build partnerships and cooperation agreements both with government science agencies, academia and business enterprises;
- Establishing joint projects, programmes and research centres of excellence for working on national and international challenges;
- Promote cooperation through exchange of researchers, information on S&T and training programmes through bi-lateral, multilateral or regional framework;
- Support Indian researchers and scientists to get access to major research facilities abroad; and
- Support workshops, meetings and seminars on national and international issues relating to science, technology and innovation.

4.2 NATIONAL PARTICIPATION IN INTERGOVERNMENTAL ORGANISATIONS AND SCHEMES

Involvement in Multi-lateral S&T Fora

India has involved in various multi-lateral S&T fora at UNESCO, UNDP, BIMST-EC; Indian Ocean Rim – EC; Third World Academy of Sciences etc. India is also taking part in ASEAN; Asia Pacific Economic Forum; UNFCC; Asia Pacific Climate Change Council etc.

India is not a formal member of any inter-governmental research infrastructures body. However, India has entered into various bi-lateral S&T cooperation programmes where development of S&T infrastructure is one of the elements.

4.3 COOPERATION WITH THE EU

4.3.1 Participation in EU Framework Programmes

In continuation of cooperation activities between EU-India on Climate Change mitigation, clean energy (clean coal technology, nuclear energy) energy efficiency and renewable energy (in particular solar energy), computational materials, food and nutrition research and water technologies, a Joint Declaration on Research and Innovation Cooperation was issued in New Delhi on 12 February 2012. This followed the successful cooperation since 2007 in the above areas for which 60 million EUR was jointly funded by India and EU. A further expansion was pledged after the end of 2012. EU committed an 8.1 billion EUR investment in research and innovation in 2012. The close cooperation between EU-India is revealed as India has the equal opportunities to take part in this investment for bidding projects as any other country in EU states and North America.

India has become the fourth largest international partner for the EU under the 7th (2007-2013) EU Framework Programme for Science and Technological development (FP7). Indian organisations are participating in research projects in various technological areas of which health, environment, food agriculture biotechnologies and ICT are the most prominent. India has become a full partner in the International Thermonuclear Experimental Reactor (ITER) nuclear fusion project.

The EU is India's largest trading partner accounting for approximately € 69 billion in trade in goods and services in 2009. The EU accounted for 21% of India's total exports and 14% of India's total imports. On the other hand, India accounts for 2.5% of EU's total exports and 2.1% of the EU's total imports. The EU has been the biggest investor in India with a cumulative volume of about € 20.0 billion since 2000. Tables below furnish some details on India's participation in FP 7 Projects.

Table: India participations in FP7

		All submitted		Mainlisted			Success Rate: applicants in mainlisted proposal/ applicants in all submitted proposals - applicants from India
Proposal SP Description2	Proposal Program	Number of Proposals	Number of Applicants	Number of Proposals	Number of Applicants	Total budget of the successful proposals	
Not_Available	N/A	1	1				
SP1-Cooperation	ENERGY	47	97	7	10	36,717,233	10.31%
SP1-Cooperation	ENV	105	210	17	35	75,202,085	16.67%
SP1-Cooperation	GA	2	8				
SP1-Cooperation	HEALTH	138	227	33	57	161,625,194	25.11%
SP1-Cooperation	ICT	145	208	19	29	58,933,492	13.94%
SP1-Cooperation	KBBE	96	148	26	41	69,282,541	27.70%
SP1-Cooperation	NMP	29	54	6	12	31,590,267	22.22%
SP1-Cooperation	SEC	6	7	1	1	5,980,704	14.29%
SP1-Cooperation	SPA	11	13	3	3	8,727,353	23.08%
SP1-Cooperation	SSH	107	158	8	13	27,659,839	8.23%
SP1-Cooperation	TPT	31	44	8	12	21,592,990	27.27%
SP2-Ideas	ERC	7	7				
SP3-People	PEOPLE	227	256	59	76	15,665,745	29.69%
SP4-Capacities	INCO	16	31	5	11	7,231,924	35.48%
SP4-Capacities	INFRA	20	53	7	20	13,164,223	37.74%
SP4-Capacities	REGIONS	3	3				

SP4-Capacities	SiS	26	29	8	9	12,338,235	31.03%
SP4-Capacities	SME	8	8				
SP5-Euratom	Fission	2	2				
	Sum:	**1,027**	**1,564**	**207**	**329**	**545,711,824**	**21.04%**

Programmes of Participation

a). India is member of European Union's **International Thermonuclear Experimental Reactor** (ITER) nuclear fusion energy project.

b). India recently joined the satellite based navigation system, **Galileo Project** (European version of USA's Global Positioning System) and participation member of Framework Programmes FP7 for 2007-12.

c) India and the European Union also decided to embark on joint scientific projects, including those in strategic fields, after holding their first ministerial science conference in the Indian capital, New Delhi, on 10 February 2007. India also signed a pact with the EU to participate in the proposed **Facility-for-Antiproton-and-Ion-Research (FAIR)** project aimed at understanding the tiniest particles in the universe.
d) Indian S&T international cooperation has the budget of over 48 million Euros.[18] Much of this budget is being spent on the EU related programme in S&T.

e) **Euro-India ICT Co-operation Initiative (EuroIndia)**: This is a 24-month EC-funded project aimed at addressing strategic goals to identify and sustain EU and Indian Research & Technology Development (RTD) potential. Key objectives include mapping of ICT research and innovation activities across India and survey the Indian ICT R&D players, which will be supported by Information Days and Technology Brainstorming events across India. These activities and events will foster networking between a spectrum of stakeholders from the ICT communities to identify mutual areas of interest and facilitate co-operation and joint research projects. EuroIndia also aims to support, enrich and strengthen the annual Policy Dialogue between the European Commission and India by bringing across the views of the ICT research communities from India and the European Union into this process and also by helping in the translation of the policy recommendations and joint action agenda into concrete cooperation projects.[19] India is also participating in the FP 7 ICT programmes.

f) Another important area in which EU and India have entered into S&T cooperation agreement is on **Nano technology** for developing new materials. EC Director General, Mr Jose M. S. Rodriguez in 2007 and Indian government under this above agreement committed an investment of 5 million Euros by each party. The projects have commenced in 2008 and continuing in 2011.

[18] ibid see also the article by R. Ramachandran
[19] See http://www.ercim.org/content/view/139/60/

g) Apart from Nuclear technology for which India and EU countries are entering into strategic partnerships, the Joint Work Programme of EU-India on **Energy, Clean Development and Climate Change** meeting in Marseille on 29 September 2008 has led to strategic partnerships in this area. A Joint EU-India Call for Proposals on Solar Energy Research was launched in 2009 with € 5 million contributions from each side. The programme continues in 2012.

Other EU developments

India now is also a partner in the European Union based Facility for Antiproton and Ion Research (FAIR) project contributing (28 million Euros) 35 million US$. Apart from S&T cooperation, EC's cooperation with India for 2007-13 has given a special focus on helping India meet Millennium Development Goals (MDGs) in the social sector and pro-poor sector reforms. This initiative of 6th EU-India Summit of September 2005 is continued well into 2007-08 with additional focus on higher education cooperation between leading EU universities and Indian universities. The focus on social sector is well reflected in India's XIIth Plan 2012-17.

Table: India Contract type of the FP7 projects with country's participation

Proposal Funding Scheme Description	Total proposals submitted	mainlisted
Collaborative project	594	96
Combination of CP & CSA	8	1
Coordination and support action	179	49
Network of Excellence	2	2
Proof of Concept	1	
Research for the benefit of specific groups	9	
Support for frontier research (ERC)	7	
Support for training and career development of researchers (Marie Curie)	227	59
Sum:	**1.027**	**207**

4.3.2 Bi- and multilateral agreements with EU countries

India has signed international cooperation in S&T with 45 countries around the world (see *http://www.dst.gov.in/scientific-programme/International-s-tcoop.htm*). Various international cooperation agreements address societal and global challenges. Some notable areas are: USA in agriculture, climate change and energy; France in energy, telemedicine and nuclear technology; Russia in energy, nuclear, space and material sciences; EU countries in climate change, energy, advance materials, ICT etc; Germany in renewable energy, power and instrumentation; and UK in biomedical, climate change and health.

The most relevant agreements are:

- Joint Action Plan agreed in 2008 is expanded to include sustainable development, research and technology with UK
- India and UK entered into collaborative defence R&D pact towards end of 2011 between India's Defence Research and Development Organisation which has over 35 labs and UK's Defence Science and Technology Laboratory.
- India and Belgium entered into R&D and innovation cooperation in 2011 for nano technology, renewable energy, biopharma and aerospace sectors.
- India and France have entered into bi-lateral space cooperation between ISRO (India) and CNES (France) to explore earth science systems and climate change.
- India and France in January 2012 signed bi-lateral agreement to enhance R&D cooperation in water, life sciences, biotechnology, nano, ICT and innovation.
- India and France are joint partners with funding to pursue advanced research through joint laboratories in formal methods; solid state chemistry; catalysis and environmental chemistry; sustainable chemistry and interfaces; nuclear sciences; ground water; medical research in immunology; and neurosciences.

4.4 COOPERATION WITH NON EU COUNTRIES OR REGIONS

4.4.1 Main Countries

India has S&T cooperation with USA, Canada, Russia, China, Australia, South Korea, Japan, Singapore and other South East Asian and East Asian countries. Even though India had collaborations with a number of these countries, Indo – US cooperation in S&T has acquired renewed thrust on both sides in the last decade.

Indo-US forum on S&T (IUSSTF) has come into existence in 2000. It is a government supported body on both sides and governed by two Co-Chairs from India and the US. The governing body has eight members each from India and US representing leading science administrators, professionals and business enterprises. Indo-US bilateral collaborations in science, technology, engineering and biomedical research through substantive interaction among government, academia and industry has progressed in the last decade. As a grant making organisation, the principle objective of IUSSTF is to provide opportunities, to exchange ideas, information, skills and technologies, and to collaborate on scientific and technological endeavours of mutual interest that can translate the power of science for the benefit of mankind at large. Some of the important flagship programmes being undertaken under IUSSTF are: Intelligent transport system; engineering at the interface of science; technology enablers for advances in aerospace materials; and engineering large infrastructure for disaster and hazards. Indo- US cooperation in S&T in many ways is also closely linked to cooperation in nuclear technology following Indo-US nuclear deal.

Recently India and Australia have launched Indo-Australian Strategic Research Fund with 50 million US $ from each side. The main areas of cooperation range from climate change, renewable energy, biomedical and ICT.

India has close relations with its immediate neighbours in S&T under the South Asian Association for Regional Cooperation (SAARC) and ASEAN countries. The SAARC S&T forum has identified a number of programmes in biotechnology, ICT, agriculture and industrial research. India is a member of BRICS where Brazil and South Africa are also involved. Among the African countries, Egypt, South Africa, Zambia among other countries.

4.4.2 Main instruments

The main modalities to initiate and implement international cooperation are through the periodic meetings of Heads of State, meetings of ministerial colleagues and special invitations for trade, technology and business. The main instruments for implementing cooperation in S&T are generally the joint working groups, task forces, agreements and MOUs. In the last five years India has established joint laboratories with Germany and France; and joint programmes with USA, UK, Belgium, Sweden, Australia and several other countries. Indo- US Forum in Science and Technology is a good example here. Joint laboratories and joint R&D programmes have been very effective in achieving the objectives in R&D cooperation. The nodal agency for international cooperation in S&T is DST which has cooperation with some 40 countries of the world.
http://www.dst.gov.in/scientific-programme/International-s-tcoop.htm

Some bilateral agreements and initiatives are as follows:

Bilateral Research Projects

- Argentina: 15 joint R&D projects are supported.
- Australia: Under the "Targeted Allocation Category" of the India and Australia Strategic Research Fund Program involving a$ 20 million per year from 2010. Twelve Indo-Australian Projects have been approved. Under the "Competitive Category" since 2010. Seven Indo-Australian research projects have been supported in the areas of agricultural research, astronomy and astrophysics, microelectronic devices & materials, nanotechnology, renewable energy and marine sciences.

- Brazil: 12 joint projects, 7 exploratory visits, one joint workshop in the area of Molecular Physics

- Indo-Russian Technology Centre with 1 million $ per year from Indian government from 2008-09

- India –Israel initiative for R&D with 1 million $ per year from Indian side from 2008-09

4.5 OPENING UP OF NATIONAL R&D PROGRAMMES

There are no specific policies announced or initiated so far for opening up national research programmes to foreign researchers or teams. At the same time there are no specific policies or mechanisms currently in place, which hinder such inflow of foreigners, except in strategic research sectors. Given that Indian professionals are paid relatively lower salaries compared to their counterparts in Western Europe or North America, this issue has not come into any policy discourse as yet. The only way the research programmes become open to foreign scientists or researchers is through bi-lateral or multilateral S&T programmes or projects. Even here, a specific provision has to be made in the TOR of the joint projects. A second channel that is available to foreign scientists and researchers to work in India is through availing visiting positions in R&D labs and universities. However, the R&D units or laboratories run by TNCs or foreign multinationals in India are open to hire researchers irrespective of their nationality or gender.

4.6 RESEARCHER MOBILITY

4.6.1 Mobility schemes for researchers from abroad

There are some specific schemes to attract researchers from abroad, which are mainly administered through CSIR, DST, DBT and other science agencies. The UGC has a number of postdoctoral scholarships for Indian professionals who wish to come back and work in Indian institutions. The DST and DBT from time to time offer special visiting position fellowships ranging from 6 months to 3 years for Indian professionals abroad. In various science agencies and universities the return migration of scientists and researchers has contributed to the process of professionalisation in one form or other. The front ranking research groups in biotechnology, ICT and telecommunications in IITs, CSIR and various universities have benefitted from return migration of professionals.

In 2004 the Ministry of overseas Indian affairs was created to look into various matters concerning Indian diaspora. The ministry has several programmes and schemes to facilitate Indian professionals coming back to India. The ministry created various platforms and mechanism to facilitate returnees. It has created Overseas Indian Facilitation Centres abroad and other offices as part of the Indian Embassies, which mediate and promote various schemes in collaboration with various science agencies.

It may be pointed out that over the last few years, Indian professionals have returned back home on their own due to economic growth and emergence of ICT software and services sector in major cities such as Bangalore, Chennai, Hyderabad, Pune and Delhi. NASSCOM report reveals that over 500 firms in ICT software in these cities are the direct spin-off of return migration.

4.6.2 Mobility schemes for national researches

There are some formal mobility schemes for national researchers which have come into existence in the last few years but they are not sufficient and adequate to cater to the demands of large science and technology community. In the last couple of years, the government is encouraging mobility through offering long term educational loans via public banks for students going abroad.

- BOYSCAST –Better Opportunities for Young Scientists in Chosen Areas of Science and Technology from DST for scientists below age of 35 for 3 months to 12 months to spend time in the leading laboratories of the world (see annual report - http://www.dst.gov.in/about_us/ar10-11/default.htm)

- DBT in collaboration with US established Indo-US Career Transition Award Progamme which enables researchers to spend 3-12 months in the leading US University and public laboratories.
  http://dbtindia.nic.in/uniquepage.asp?id_pk=20#

- DBT has instituted scholarships in collaboration with Third World Academy of Sciences (TWAS) for mobility of research personnel under South-South

Cooperation in the field of biotechnology. (http://dbtindia.nic.in/uniquepage.asp?id_pk=20#)

- Leading science agencies such CSIR, ICMR, ICAR etc have all instituted collaborative agreements with several countries and science agencies abroad which enable researchers to spend 3-12 months under various exchange schemes.

- UGC and most Central Universities, IITs, IIMs and other Institutions have also instituted exchange schemes with various countries and universities abroad.

5 CONCLUSIONS

India is passing through a critical phase confronted by societal and economic challenges to boost economic growth, generate wealth through knowledge and reduce poverty in the 12th Plan period (2012-2017). The entire social and economic effort is directed to put the country on fast and high economic growth trajectory of 8 to 8.5% per annum in the coming five years. The government has appointed a Steering Committee with some 12 groups in various sectors of economy to design and put into action the 12th Plan. The S&T Steering Committee of the Planning Commission, which is the nodal agency and which gives direction to various sectors, has set an ambitious goal. The aim is to attain 2% of GDP for national R&D and seek paradigm change in the orientation of science and technology policies from an input oriented policy mechanisms to focus on demand and diffusion end of the spectrum.

The Draft National Innovation Act 2008 is still under discussion at the public domain. The policy discourse on this is in line with the new realisation that innovation is the main engine of growth and national competitiveness in the 21st Century is likely to be determined by the research and innovation base. The President of India officially declared the decade beginning 2010 as the 'Decade of Innovation'. At the same time there is a strong realisation that much of the innovation in high and new technology sectors is based on commanding new capacities in scientific research and frontiers of knowledge. The 12th Plan Steering Committee on S&T has a special policy focus to strengthen India's basic research base.

Indian R&D efforts and institutional initiatives in the area of agriculture security and in boosting agriculture productivity have fallen short of national expectations. The last few years witnessed relatively low to modest growth in agriculture production. The national innovation agriculture project has not contributed in boosting agriculture productivity for several important staple grains. The government initiatives towards accomplishing Second Green Revolution is yet make any major impact.

Two major shifts in the mode of funding research and innovation have come about in the last one-year. The first is to do with the policy focus on PPP in a range of sectors from defence, strategic, social, economic to infrastructure. Closely related to this is the drive towards liberal economic policies to attract foreign investment and also allow greater equity in Indian firms. FDI in R&D is another important component of the 2nd generation economic reforms, which have just begun to be introduced in 2012. Secondly, there is a change in the funding of research and innovation from institutional mode to project and mission mode funding. However, the demand side of innovation measures and policies administered by Department of Science and Technology and Department of Scientific and Industrial Research lack adequate financial resources. Most of the innovation policy measures operate at sub-critical level with low level of funding.

The social sector and inclusive development policies have created a good deal of demand for R&D and technological innovation, particularly in grass-root innovations. However, mechanisms to link and connect the needs and demands of rural sector with the formal public research and universities are slow to evolve and lagging behind. The other main problem of innovation governance has to do with the relative absence of links between knowledge institutions and rural industries and the informal sector of the economy in the bulk of 600 000 villages where 65% of Indian population live.

India has been able to attract a good deal of FDI in R&D in the last few years and currently over 471 foreign firms have opened up R&D centres. The last decade witnessed over 30 billion EUR investments in India. India in 12th Plan is set to sustain this momentum by strengthening the research infrastructure and innovation ecosystem.

India is a young country where nearly 50% of its 1.2 billion people are under the age of 35 and the situation is likely to persist for the coming two decades. The research and innovation policies via National Innovation Council and National Skill Development Council are put in place to take advantage of the demographic dividend. The main problem however seems to be slow implementation of policies which filter down to institutions operating in skills, education and innovation networks. Given the lack of adequate institutional arrangement for imparting skills required in the industrial sector, the business enterprises in most leading sectors have initiated various measures to train neophytes through in-house internships leading to employment. This is happening across ICT and telecommunication sectors of economy.

With low intensity of R&D in the university sector, the challenge of attaining Humboldtian goal still remains. The government has committed to increase the research intensity in the university sector during the 12th Plan period (2012-2017). The additional challenge that India faces is to increase the GER from its 13 to 20 in the coming decade.

The question of research and academic autonomy in the case of state universities has raised several problems in the HEIs sector. At least one government appointed committee has called for delinking political interference with the state universities. A particular demand has been made to adopt the same academic consultative and peer system of appointing university heads and Vice Chancellors in the state universities as followed in the Central universities.

There is a low level of mobility of professionals between universities and public research institutions. This feature has not yet attracted the policy attention of decision makers in science, technology and higher education. Indian universities are yet to wake up to the emerging paradigm and strategies of innovation involving 'Triple Helix' or university-industry-government relations. By and large universities operate in a traditional mode of consultancy and sponsorship to impact industry. A Bill on IPR which binds all universities to harmonise their IPR policies and adopt institutional measures to promote innovation is still pending in the Parliament for ratification. Once this bill is approved, all universities will wake up to introduce policies, which promote innovation. With the exception of IITs and IIMs, universities are yet to accept the culture of innovation as an important domain of their objective along with teaching and research.

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7 List of Abbreviations

ACRI	Austrian Cooperative Research Institutes (Vereinigung der kooperativen Forschungsinstitute)
ARC	Austrian Research Centers
CSIR	Council of Scientific and Industrial Research
DST	Department of Science and Technology
ERP Fund	European Recovery Programme Fund
FP	European Framework Programme for Research and Technology Development
HEI	Higher education institutions
HES	Higher education sector
MOU	Memorandum of Understanding
NACC	National Assessment and Accreditation Council
PRO	Public Research Organisations
PC	Planning Commission
PRS	Public Research System
R&D	Research and development
SF	Structural Funds
S&T	Science and technology
TNCs	Transnational Corporations
UGC	University Grants Commission
USAID	United States Aid for International Development