ERAWATCH COUNTRY REPORTS 2010: India

ERAWATCH Network – Jawaharlal Nehru University

Dr V. V.Krishna

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Executive Summary

The Republic of India comprises of 28 states and seven union territories. India is the second most populated country in the world with 1.2 billion people according to recent census data. India has 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 a leading economy in Asia after Japan and China. In the last four years, India has emerged as an important member in the BRICS and G20 influencing the decision-making systems in world finance, trade and climate change related domains and regimes.

After witnessing economic growth rate at an average of 8.8% for five years (2003-2004 to 2007-2008) India's growth rate decelerated to 6.7% in 2008-2009. India's GDP growth rate for 2009-2010 and 2010-2011 registered 8% and 8.6% respectively. India's is the fourth largest economy in the world on PPP terms and India's per capita income is US $3,176 or 2243 Euros (PPP)[1]. The service sector is the largest contributor to GDP accounting for 57.8%, while the industry and agriculture accounted for 28% and 14.2% respectively in 2010-2011. A dominant proportion of GERD, around 68%, is met by the government sources and 30% from the business enterprise sector. In absolute terms, Indian GERD witnessed substantial increase of 60% from EUR €3.6m in 2004-2005 to EUR €5,968 m in 2007-2008. As proportion of GDP, it witnessed an increase from 0.8% of GDP in 1992-1993 to 1.13% in 2003-2005. However, it registered a marginal decrease to 1% for the period 2007-2008. The government is committed to increase R&D spending to 2% of GDP in the coming five years.[2]

Compared to EU's average of above 2.2% GERD/GDP, India's figure is less than half. However, the most remarkable growth in R&D intensity has been from the business enterprise sector, which has witnessed a substantial increase from 18% in 2003 to nearly 30% of GERD in 2010. The economic crisis of 2008-2009 did not have any major impact on GERD. Rather the governmental efforts were directed toward stimulus packages and poverty reduction programmes of the social sector to increase the buying capacity of poor people.

One of the major problems for the economy is the size of India, compared to other emerging nations, and in the international context, the problem is the very low level of gross expenditure on R&D. From the perspective of overall budgetary provisions, the major challenge is to implement the research policy commitments of spending 2% of GDP on R&D, up from the current level of 1%, and nearly 6% of GDP on education, up from the current level of around 4.4%.

Universities accounted for over 52.2% of India's total of 28 603 Science Citation Index (SCI) based publications in 2005, which makes the sector a very important actor of the innovation system. However, 4 to 5% of GERD expenditure on research in higher educational institutions) is very low compared to the figures of 20-28% reported in the OECD and leading Asian economies such as China, Japan and Singapore.

The major problem faced by the Indian research system is the inadequacy of contribution from the business enterprise sector which is just quarter of GERD. Though it has increased in the last five years it still falls short of the growing demands of emerging Indian economy, which has the goal of achieving a high rank in the world leadership of science and innovation.[3]

The main barriers for attaining higher proportion of BERD are twofold. The first is the heavy dependence of business enterprise on the proven foreign technology; and secondly, the business enterprise is nervous about the risk element. Underdevelopment of venture capital further adds to the barrier of business enterprises increasing their share in GERD.

[1] All conversions accessed on 8 August 2011
[2] See India Country Report http://www.proinno-europe.eu/trendchart/annual-country-reports
[3] See the Vision document, *India as Global Leader in Science*, Science Advisory Council Report submitted to the Prime Minister of India, 2010, http://www.dst.gov.in/

The government has initiated a number of initiatives in the last few years. Such policy measures and instruments have not only begun to attract private business enterprise investments in R&D but have roped these actors into public – private partnerships. The indigenous production of the electric car, Reva and Indica by Tatas, and the indigenous hepatitis B vaccine production, among other examples draw attention to such developments. Some other initiatives have led to improving the research infrastructure and strengthening the research eco-system in and around 'knowledge hubs' located in Bangalore, Hyderabad, Delhi, Mumbai-Pune corridor and Chennai.

The research and innovation policy discourse and action oriented programmes in the current Five Year Plan period (2007-2012) exemplify various efforts to strengthen and link actors in the knowledge triangle.

Knowledge Triangle

Knowledge Triangle	Recent policy changes	Assessment of strengths and weaknesses
Research policy	• National Science and Engineering Research Board (NSERB) for funding basic research • Innovation in Science Pursuit for Inspired Research (INSPIRE) for attracting young talents in science and technology • Nano Mission to build capacity in PROs toward global leadership • National Action Plan on Climate Change to promote 8 national missions	• Expanding basic research base in national innovation system • Underdevelopment of research – industry linkages • R&D budget thinly spread over many projects
Innovation policy	• Biotechnology Industry partnership Programme (BIPP) to promote public – private partnership and global competitiveness in bio innovation. • The New Millennium Indian Technology Leadership Initiative (NMITLI) for technological leadership in some niche areas. • Establishment of National Innovation Council to strengthen the national innovation system and forge links between different actors.	• Focus on SMEs and good response from biotech industry • Poor university-industry relations • Underdevelopment of Venture Capital institutions
Education policy	• The Protection and Utilisation of Publicly Funded Intellectual Property Bill, 2008 • Encouraging and Development of Commercialisation of Inventions and Innovations - A New Impetus.	• Resistance from universities to focus on innovation and patenting over publications • Lack of adequate incentives and fringe benefits to researchers to encourage mobility between different research and academic institutions. • Lack of teachers and slow expansion of educational institutions to train teachers to implement

	• Right to education Bill	
Other policies	• India's Look East Policy • Policies on inclusive development	• Enhancing South – South Cooperation • India signed free trade agreements with ASEAN, Australia and SAARC countries • Creating employment opportunities in rural areas • Inadequate budget for inclusive development

European Research Area

Assessment of the national policies/measures which correspond to ERA objectives[4]

	ERA objectives	Main policy changes	Assessment of strengths and weaknesses
1	Ensure an adequate supply of human resources for research and an open, attractive and competitive labour market for male and female researchers	- Launching of a policy measures (INSPIRE) to expand the base of human resources and attract students to science disciplines - Expansion of higher education in science and engineering to increase the GER	- Increasing trend in the applications for science and technology disciplines - Relative stagnation in the research budgets of high educational institutions - Inadequate supply of teaching faculty in engineering disciplines
2	Increase public support for research	-R&D budget increased in absolute terms but decreased from 1.13% to 1% of GDP between 2005 and 2008	-Slow investment by business enterprises in R&D -Government commitment of increasing to 2% of GDP is not yet reached
3	Increase coordination and integration of research funding	-India participates as member of FP7 and other EU based international/big science projects as ITER, Galileo etc	- India gets access to advance science and benefits in training scientists in big science projects
4	Enhance research capacity	There are a number of national policies initiated by State governments to enhance research capacities through State Science and Technology Councils	- Weak organisational and institutional capacity - Weak regional policies in research and low level of research funding
5	Develop world-class research infrastructures (including e-infrastructures) and ensure access to them	Launched 3 schemes during 2009-2011.	- obsolete scientific instrumentation in many institutions due to shortage of budget

4 Of course non-ERA countries do not strive to achieve ERA objectives. This part of the report is simply to allow a comparison with the activities of ERA countries on these issues

	ERA objectives	Main policy changes	Assessment of strengths and weaknesses
			- India is a late starter but catching up fast in world-class infrastructure
6	Strengthen research institutions, including notably universities	- Higher education budget in XI the plan increased by five times compared to earlier Xth Plan. - Several National Knowledge Commission recommendations accepted by government including to attain the target of 1500 universities in the decade.	-Expanding universities in quantity at the cost of quality and excellence - Humboltdian goal of increasing research intensity in universities is progressing very slowly.
7	Improve framework conditions for private investment in R&D	-Three new innovation measures and schemes including Venture Capital introduced to attract private investment -Strengthening knowledge hubs in major cities like Bangalore to attract FDI based R&D	- Policy measures and initiatives have begun to show an impact in the last three years. - Inadequate level of venture capital related funds
8	Promote public-private cooperation and knowledge transfer	- Renewed policy focus for PPP and knowledge transfer	- Policies begun to have an impact resulting in innovations as electric car, vaccines etc. - Weak economics and management mechanisms at DST and DSIR
9	Enhance knowledge circulation	Direct policy measures and initiatives for knowledge networking and circulation for the South Asia Region.	This is the weakest link in the national innovation system.
10	Strengthen international cooperation in science and technology	-India is part of FP7 and other big science projects in EU -Close science and technology cooperation with USA in energy, agriculture and nuclear technology.	-Policy initiatives begun to impact India accessing frontier sciences and technologies - Has residual impact on SMEs
11	Jointly design and coordinate policies across policy levels and policy areas, notably within the knowledge triangle	-Robust policy initiatives in Non-Conventional Sources of Energy. - New IPR Bill formulated to encourage public research systems	-Knowledge Triangle emerging in renewable energy technologies -weak horizontal coordination of policies across different departments dealing with economy, finance, science and technology and higher education and industry.
12	Develop and sustain excellence and overall quality of research	There are national policies concerning quality and excellence.	-The main weakness is that such policies are restricted to less

	ERA objectives	Main policy changes	Assessment of strengths and weaknesses
			than 25% of knowledge institutions including universities. -sustaining excellence is difficult due to low R&D budget levels
13	Promote structural change and specialisation towards a more knowledge - intensive economy	Policies on ICT, biotechnology space and telecommunications are geared towards knowledge intensive economy	- ICT and telecommunications prioritised over other sectors - Education access and low literacy rates are stumbling structural problems
14	Mobilise research to address major societal challenges and contribute to sustainable development	India has launched National Action Plan on Climate Change with Prime Minister steering the research agenda	- Special research and innovation focus on renewable energy and energy efficiency. - Low technological capabilities of firms in renewable energy technologies.
15	Build mutual trust between science and society and strengthen scientific evidence for policy making	-India has put in place relevant policies on risk for GM technologies, nuclear technologies	- Ad hoc decision making weakens evidence based policy making - Democratisation of science decision making is slow - Civil society organisations play an important part in evidence based policy

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1 Introduction

The main objective of the ERAWATCH International Analytical Country Reports 2010 is to characterise and assess the evolution of the national policy mixes for the non-EU countries in the perspective of the Lisbon goals and of the 2020 post-Lisbon Strategy, even though they do not pursue these policies themselves. The assessment will focus on the national R&D investments targets, the efficiency and effectiveness of national policies and investments into R&D, the articulation between research, education and innovation. In doing this, the 15 objectives of the ERA 2020 are articulated.

Given the latest developments, the 2010 Country Report has a stronger focus on the link between research and innovation, reflecting the increased focus of innovation in the policy agenda. The report is not aimed to cover innovation per se, but rather the 'interlinkage' between research and innovation, in terms of their wider governance and policy mix.

2 Performance of the national research and innovation system and assessment of recent policy changes

The aim of this chapter is to assess the performance of the national research system, the 'interlinkages' between research and innovation systems, in terms of their wider governance and policy as well as the most recent changes that have occurred in national policy mixes in the perspective of the Lisbon goals. Each section identifies the main societal challenges addressed by the national research and innovation system and assesses the policy measures that address these challenges. The relevant objectives derived from ERA 2020 Vision are articulated in the assessment for comparison reasons.

2.1 Structure of the national research and innovation system and its governance

This section gives the main characteristics of the structure of the national research and innovation systems, in terms of their wider governance.

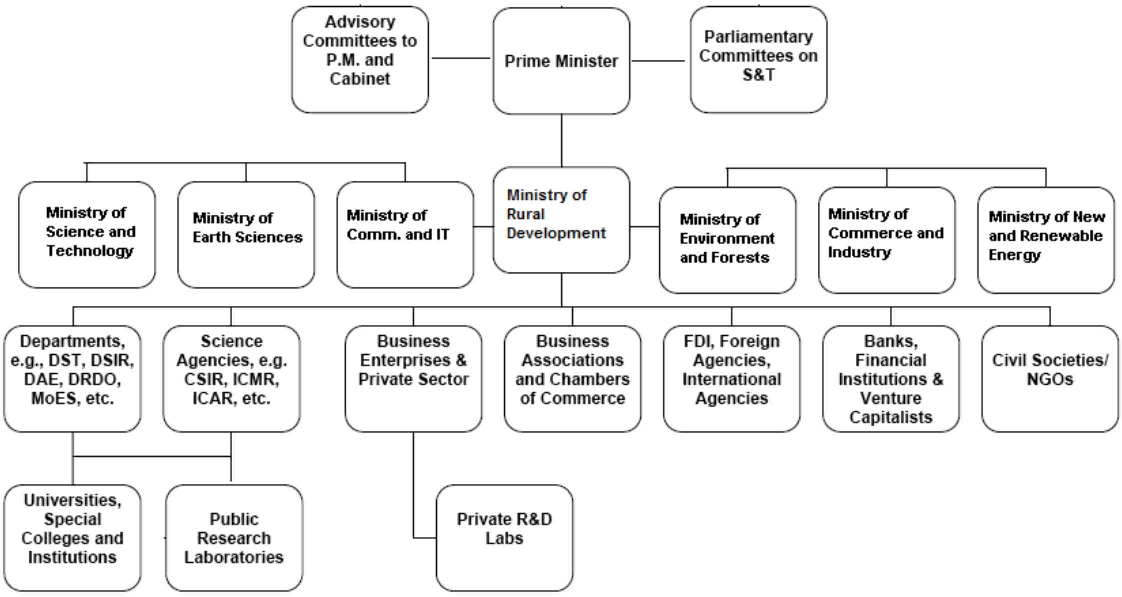
The Republic of India comprises of 28 states and seven union territories. India is the second most populated country in the world with 1.2 billion people according to recent census data. India has come to be recognised as the world's largest democracy. India is divided into six major zones: East India, West India, North India, South India, Northeast India and Central India. It is 7th largest country in the world and a leading economy in Asia after Japan and China. In the last four years, India has emerged as an important member in the BRICS and G20 influencing the decision-making systems in world finance, trade and climate change related domains and regimes.

After witnessing economic growth at an average rate of 8.8% for a five-year period (2003-2004 to 2007-2008) India’s growth rate decelerated to 6.7% in 2008-2009 according to the Economic Survey released by the government. India’s GDP growth rate for 2009-2010 stood at 8% and is expected to grow at 8.6% during 2010-2011. India is fourth largest economy in the world on PPP terms, and India’s per capita income is US $3176 or (2243 Euros) (PPP). The Service sector is the largest contributor to GDP accounting for 57.8%, while the industry and agriculture accounted for 28% and 14.2% respectively in 2010. A dominant proportion of GERD, around 68%, is met by the government sources and 30% from the business enterprise sector. India’s R&D intensity increased from 0.81% from 2002 to 1% during 2007-2008. Compared to EU’s average of above 2.2% of GERD/GDP, India’s figure is less than half. However, the most remarkable growth in R&D intensity has been from the business enterprise sector, which has witnessed a substantial increase from 18% in 2003 to nearly 30% of GERD in 2010.

Main actors and institutions in research governance

There are four main actors who initiate the policy setting for the R&D agenda and priorities of S&T sectors and coordinate efforts. These are: a) Planning Commission (through the Member In-charge of Science and Technology); b) Office of the Principal Scientific Advisor to the Government of India and Scientific Advisory Council to the Prime Minister; c) Ministry of Science and Technology and Ministry of Human Resource and Development represented through various agencies such as the University Grants Commission and science organisations such as DST, CSIR and others; and d) the representatives of the private business enterprises via the Confederation of Indian Industry (CII) and other industry and commerce associations. Besides, there are other actors from the civil society and various NGOs who take part in the policy setting process.

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



The institutional role of regions in research governance

Regions in the Indian context are the States. States, their governments and locally elected legislative bodies in India are relatively autonomous to formulate and implement state level research policies. Such policies are articulated generally through State level Science and Technology Councils and various State level ministries.

All States have the same status under Indian constitution in terms of power and autonomy to formulate research and higher education policies. Even though a predominant burden of research funding and research effort is under the Central Government, there is no specific distribution of sectors or fields of research between these two. Much of the planning and execution of science, technology and research policies in States come under respective Ministries and the State Science and Technology Councils.

Whereas in 2005-2006, 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 the Central Government.

Main research performer groups

Universities: Higher educational institutions witnessed considerable growth in the post-independence period after 1947. From 20 universities in 1947 the number increased to over 400 universities and 18.064 colleges affiliated to various universities in the country in 2008.

There are now 24 Central Universities, 232 State Universities, 114 Deemed to be Universities, 11 private Universities and 13 Institutes of National Importance established through Central legislation and 5 institutions established through State legislation. The number of colleges increased from 500 in 1947 to 18.064 in 2008.

In the technical education sector there were about 1.749 colleges comprising: 1.265 engineering and technology colleges; 320 medical and dental institutions; 107 architecture; and 40 hotel management colleges. In addition to these figures, there 958 post-graduate in management institutions and 1034 master in computer application based institutions in the country by 2004.[5]

The government through the University Grants Commission accorded special recognition of deemed university status to science agencies such as in space, atomic energy and other specialised agencies to train human resources. Recently in 2009-2010 the government made budget provisions to set up 8 new Indian Institutes of Technology, 20 Indian Institutes of Information Technology, 6 Indian Institutes of Management and 16 more Central Universities. The Science Minister recently in 2011 announced the commitment of the government to establish 14 world class universities. Among the new HEIs, mention may be made of the Rajiv Gandhi Centre for Biotechnology (RGCB), Indian Institute of Science, Education and Research (IISER) and the Institute of Space Science and Technology (IIST) all three institutions created in Kerala. These centres of higher learning are created to meet the increasing demand in high technologies and science based innovation in space, nanobiotechnologies and related areas.

Currently the Gross Enrolment Ratio (GER) in higher education is relatively low at 15 percent[6] (that is 13 million students in HEIs in about 400 universities and 18064 colleges affiliated to these universities in 2007-2008).

Historically research and development in science and technology has been concentrated only in about 15% of the Universities and partly their affiliated colleges. The top 20% of the universities account for bulk of the R&D output from the university sector. R&D performed by higher educational sector is reported by different sources such as the DST statistics on R&D; National Education Planning and Administration, New Delhi and other independent research sources which range from 3% [7] to 7% of GERD[8]. Even though higher education sector constitutes relatively a miniscule of GERD, it however contributes over 52.2% of the total of India's S&T publications measured in SCI-Expanded Version. The expenditure on R&D should be taken to

[5] See S.Thorat, Nehru Memorial Lecture, University of Bombay, delivered on 24 Nov 2006. http://www.ugc.ac.in/more/chairman_nehru_lecture.pdf

[6] GER in higher education in India is referred in percentage. That is % of population in higher education in the age group 18 to 23.

[7] P.Agarwal, 'Higher Education in India: The Need for Change', *Working Paper No 180*, ICRIER, New Delhi, June 2006.

[8] See Krishna, V.V. 'Reflections on the Changing Status of Academic Science in India', 2001, *International Social Science Journal*, Unesco, pppp.231-46. It may be noted that this figure remains more or less unchanged in the present period.

measure the output, as extramural research funding from public sources for scholarships and higher education research is not included in the figure of R&D on higher education.

Public research organisations: In 2008 there were more than 1750 national laboratories and in-house R&D centres in public sector enterprises. In addition to this, there are R&D organisations established by various Indian State governments. While around 50% of the GERD is consumed by the strategic sectors, namely, atomic energy, space and defence research and development, the remaining 50% is accounted by the civilian R&D sectors.[9] Around 300.000 R&D personnel are engaged in public research organisations in the country. Public research ogranisations continue to play an important role in the national innovation system.

The main performers of research in the public research organisations are known as the 'mission oriented science agencies'.[10] Around 300 national laboratories are housed under these dozen leading public research organisations.

Business enterprise sector: While bulk of research is performed under the auspices of government science agencies and its constituent laboratories, private sector accounts for approximately, 30% of GERD in terms of R&D expenditures.[11] The private sector has come into sharp focus in the last 3-5 years as India has been a major destination of Foreign Direct Investment in R&D and an attractive knowledge based location for Transnational Corporations such as Microsoft, General Electric among others. 250 global firms (most of which are the fortune 500 companies) have set up their R&D centres/laboratories and units in Hyderabad, Bangalore, Delhi, Gurgoan, Pune and Noida.[12]

2.2 Resource mobilisation

This section will assess the progress towards national R&D targets, with particular focus on private R&D and of recent policy measures and governance changes and the status of key existing measures, taking into account recent government budget data. The assessment will include also the human resources for R&D. Main assessment criteria are the degree of compliance with national targets and the coherence of policy objectives and policy instruments.

[9] *Unesco Science Report 2005,* Paris: Unesco, 2005, p261 Chapter on 'South Asia'.

[10] 11 major public research organisations of India are: Council of Scientific and Industrial Research; Department of Atomic Energy; Department of Science and Technology; Department of Biotechnology; Department of Electronics; Department of Space; Defense Research and Development Organization; Indian Council of Agricultural Research; Indian Council of Medical Research; Department of Non-Conventional Sources of Energy; and Department of Ocean Development.

[11] 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 2005-06. The estimates of a World Bank study (see Mark A Dutz, *Unleashing India's Innovation – Towards Sustainable and Inclusive Growth*', World Bank, Washington, 2007) shows that total private R&D investment has risen from half a billion Euro in 2002 to 2.45 billion Euro in 2005. See also country Report India, 2009 -http://www.proinno-europe.eu/page/innovation-and-innovation-policy-india

[12] See V V Krishna and Sujit Bhattacharya,' Internationalisation of R&D and Global Nature of Innovation: Emerging Trends in India', Asia Research Institute Working Paper Series, 2010. http://www.ari.nus.edu.sg/publication_details.asp?pubtypeid=WP&pubid=1439

2.2.1 Resource provision for research activities

GERD witnessed an increase over 50% during 2006 and 2009. The compounded annual growth rate of R&D expenditure for the period 2002-2003 and 2007-2008 works out to be around 15- 16%. However, compared to EU and other countries it has remained quite low. While China has been spending between 1-1.4% of GDP, the Indian figure remains around 1% for the period between 2005 and 2009. It can be said that compared to the considerable increase in GDP for the decade 2000 - 2010, the relative share of GERD has not increased in proportion. The target of GERD/GDP ratio is difficult to achieve because of the very rapid growth rate of GDP.

Whilst the public funding and R&D effort continue to account for around 67% over the last five years, there has been noticeable increase in the proportion of BERD from 23% in 2006 to 30% in 2009-2010. It currently stands at 30% in 2010. The growth in the proportion of BERD is due to R&D based FDI coming into the country over the last decade. The trend of low R&D effort (4 to 5% of GERD) by the higher education sector continues as before. The policy discourse of pumping in more R&D money into higher education sector and making universities more research intensive has not yet come about to become visible in indicators.

Provision for R&D activities

The process of the Five Year Economic Planning assigns priorities and sets certain national goals for public investments in education, research and innovation. These priorities and goals are further assessed annually and appropriate targets are distributed in annual plans. The country does not have a systematic multi-annual R&D strategy but priorities are set in annual plans depending on the societal needs and demands. The analysis of strengths and weaknesses at national and regional level (i.e. state level) are followed in the Indian context but not orchestrated at the federal level. They are taken into account at the state level. For example, if there are gender imbalances as shown in the recent census data of 2010-2011, the states where there is acute gender imbalances take note of the findings into its socio-economic planning process.

Institutional and competitive funding

Of the total governmental support, 73% is earmarked for institutional support in 2008. India's major scientific agencies and departments[13] account for 56%; a little more than 5% is accounted by Public Sector Enterprises and 4.5% by higher education through the University Grants Commission and All India Council for Technical Education. It may be noted that the money is allocated based on research priorities as indicated by national policy discourse and advisory systems at the level of DST and Science Advisory Council. There is no performance assessment for allocating budgets in the institutional support mode to science agencies and other institutions such as UGC. The competitive funding is channelled through as project based funding.

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[13] The twelve science agencies are Council of Scientific and Industrial Research (CSIR), Defence Research and Development Organisation (DRDO), Department of Atomic Energy (DAE), Department of Biotechnology (DBT), Department of Science and Technology (DST), Department of Space (DOS), Ministry of Ministry of Earth Sciences (MOES), Indian Council of Agriculture Research (ICAR), Indian Council of Medical Research (ICMR), Ministry of Communication and Information Technology (MCIT), Ministry of Environment (MOEn) and Ministry of New and Renewable Energy (MNRE).

The major source for project based funding in India comes from DST. DST support of project funding is for advancing knowledge in basic research; achieving excellence in science & engineering; promotion of innovation in selected areas; encouragement for industrial partnership in projects under engineering and technology; training of manpower for future requirement and encouragement to young scientists and students. The total estimated figure for 2007-2008 for project based funding is EUR €300 million. It may be pointed out that this money is given to three categories of project based funding, namely, research programmes, research networks or coordinated projects and 'bottom-up' projects.[14]

Only a small portion of the total money allocated to DST, UGC, AICTE etc, mostly in the oriented basic research and applied development projects are allocated on competitive basis. In the DST, the Science and Engineering Council (which is now part of NSERB) is the main nodal agency for allocating R&D money on competitive bidding of projects submitted by various national labs and universities. For coordinated projects the competitive bids are evaluated by relevant concerned Departments or science agency and the DST.

a) Research Programmes: Science and Engineering Research Council (SERC) of DST [15] which was established in 1974 is one major source of project based funding for advancing scientific research. Scientists and faculty from both national laboratories under different science agencies and higher education sector are eligible to these funds every year. Even private industrial and business enterprise professionals in collaboration with scientists in public research institutions can be considered. All projects through SERC are subjected to a peer process and the priorities given include science excellence and quality, advancement to knowledge in newly emerging areas in science and engineering. The major focus of funding here is to nano-science and technology, drug discovery, green chemistry and technologies and low carbon emission and life sciences. It is estimated that 40% (EUR 120 million) of total project funding (EUR 300 million) is given to research programmes in 2007-2008.

b) Networks or coordinated projects: In 2007-2008 the DST has given considerable support to strengthening scientific research networks through supporting coordinated projects covering some twelve science agencies. The second source of coordinated project support funding comes from the Ministry of Agriculture, Ministry of Environment and Forests and Indian Council of Medical Research. It is estimated that a sum of EUR 105 million or (35% of the total project based funding in 2007-2008) is given to projects which come under this category.

c) Bottom-Up Projects: DST is allocating around EUR 75 million in 2007-08 (25% of total project based funding) for supporting projects in 147 departments or research groups in higher education sector, projects devoted to the development scientific research base in the North-East region of India, for sophisticated analytical instruments, strengthening science base in research groups and individuals, among other aspects.

[14] In India this is generally understood as projects which have special laboratory requirements for carrying out special projects and for achieving excellence in scientific research.

[15] It may be noted that twelve science agencies also allocate R&D funds on their discretion for projects in their respective areas of operation. This is not included here in the project based funding category. However, DST through SERC allocates funds on competitive basis both to individual and group researchers in public research organisations including higher education sector. It also allocates to projects, which come under public – private partnerships. All such projects are included here.

d) International Projects**:** India is participating in FP7 projects for the period 2007-2012 on the European Union's **International Thermonuclear Experimental Reactor** (ITER) nuclear fusion energy project; and the satellite based navigation system, **Galileo Project** (European version of USA's Global Positioning System). 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.

Other modes of funding

In this category of funding the most important mode of funding which deserves mention is the funding available from extra mural source of funding for research students or scholars at post-doctoral or individual scholars on special themes. Such funding is routed through the UGC and mainly science agencies such as CSIR. In 2002-2003 all sources of extramural source of funding amounted to rupees 4,480m (EUR 81.5 million). This is estimated to have increased to about EUR 120 m in 2007-2008. While UGC also funds more than 15 inter university centres of excellence in different universities, DST has a small window of funding for such programmes or centres. TIFAC under DST has source of funding for encouraging start-up firms which are basically a form of co-funding between the industry partner involved and the professional from public research institutions. For the development of weaker sections of Indian society, the Ministry of Human Resource Development (MHRD) and UGC have very good sources of funding for under privileged sections (called scheduled tribes and scheduled castes in India) with scholarships. DST, MHRD, CSIR and UGC have also a good source of funding to encourage women in science and technology. DST has also launched a programme to encourage women entrepreneurs in S&T related fields.

Major subsidies that are given in India relate to fertilisers, agriculture, petroleum and gas, software and renewable energy technologies such as the use of solar energy devices.

Indian government gives 100% tax exemption to private and business enterprises which invest in R&D subject to the stipulation that these firms are registered with the Department of Science and Technology. The tax scheme is administered through DST. Compared to countries such as South Korea, such schemes in India suffer from non-penal measures for firms which involve mainly in quality control under the garb of R&D. Recent study has revealed that India is spending around Rupees 2 billion (302 million Euros) per year on this tax incentive scheme. The study further revealed that firms in pharma, chemical, electrical, communication, automobile and auto parts and aircraft industries, which have drawn tax incentives from the government had indicated higher growth rates in R&D expenditures compared to other firms and sectors which were outside the tax incentive scheme.[16]

India is not dependent on foreign agencies for undertaking research. A very small proportion of 1.5 to 2% of the GERD funding is coming to India which is spent by large international private agencies such as Gates and Melinda Foundation, Ford Foundation and other agencies.

[16] Data and information drawn from a draft report by Sunil Mani on 'Financing of Industrial Innovation in India- How effective are tax incentives?', Centre for Development Studies, Trivandram, India.

The recent policy changes affecting the funding relates to higher education and research, energy security and environment and poverty reduction. As already noted above in other sections, India has the potential to take advantage of demographic dividend with a large segment of the 1.21 billion people in the age group of 25 to 50. This realisation since the XIth Five Year Plan (2007-2012) has led to accord priority to policies such as Right to Education for all under the Indian Constitution, modernisation of industrial and vocational training institutes together with the establishment of skill development council under the Prime Minister's Office. The main thrust of such policies is to increase the skill base of human resources and expand opportunities to semi-urban and rural India. In the area of energy security, the recent policy changes draw attention to nuclear energy and renewable energy technologies. India has embarked on large and long-term strategies towards achieving energy security through building nuclear reactors and exploiting the solar and wind energy technologies.

The recent policy changes in the XIth Plan period, which will continue in the XIIth Plan period (2012-2017) relate to poverty reduction through institutional, organisational and technological innovations. The government has already launched more than seven schemes directed at generating income for poor people through employment, promotion of rural health and urban renewal, among other schemes. For example the Mahatma Gandhi Rural Employment Guarantee Scheme, which operates in all parts of India, guarantees employment to all people for a minimum of 100 days in a year. The wages are linked to inflation. Similarly, the rural health centres have witnessed a good deal of support from these inclusive development policies. The Department of Science and Technology has underlined the importance in the current annual plan to expand the scope and activities of National Innovation Foundation, which was established to spur grass root innovations.

In the domain of building science – society trust, India as other countries in the world are facing challenges of managing risk from new GM technologies. The recent Japanese nuclear disaster at Fukushima has exacerbated the challenges to avert such risk and hazards in the future. Even before Fukushima, India has been facing the demands from the 'people science movements' and civil society in the areas of environment, GM technologies and nuclear technologies. The post-Japanese situation has led to a series of policy measures to re-assess the risk element in the existing nuclear plans and towards appropriate designs for the future plants. Towards building science and society trust, the government and civil society organisations, particularly the people science movements, are stressing the importance of finding innovative institutional and organisational measures to promote public understand of science to bridge the trust deficit.

2.2.2 Evolution of national policy mix geared towards the national R&D investment targets

In 1990-1991 private sector of BERD[17] accounted for 13.8% of GERD which is increased to 20.3% in 2001-2002; 23% in 2006[18]; and further increased to 30% in

[17] BERD includes both private sector as well as industrial enterprises of the public sector.

[18] 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 2005-06. The estimates of a World Bank study (see Mark A Dutz, *Unleashing India's Innovation – Towards Sustainable and Inclusive Growth*',

2009. The public sector R&D enterprises account for around 5%. According to the data available for 2002-2003, out of the total industry R&D sector units of 1570 (which also includes public sector R&D units), private R&D units constituted 1477 (94%) and the rest 6% from the public sector. The industrial R&D involvement by BERD classified by leading industry sectors in 2005-2006 are as follows in the table below. Whilst the public sector R&D industrial units are involved in defence, chemicals, fuels and electronics serving the strategic sectors, the private enterprises are in ICT, chemicals, drugs and pharmaceuticals, transportation, industrial machinery and mechanical engineering related sectors.

- Policy mix towards increased private R&D investment in India relates to promoting greater awareness about governmental schemes on R&D incentives such as soft tax loans, R&D tax exemptions and about making firms aware about various public R&D schemes which facilitate commercialisation of R&D. There are now various training schemes introduced to aid the skill enhancement of firms. A good example is the Public Private Partnerships in Science Education for Innovations and Excellence in Research: The Ministry of Science and Technology has launched this special Fellowship programme in doctoral research in computer sciences and medical electronics in association with software companies association (NASSCOM) in 2008.
- Promoting the establishment of new indigenous R&D performing firms: The last decade witnessed the emergence of various indigenous R&D performing firms. These firms are in auto and ICT software sectors.
- Stimulating firms that do not perform R&D yet: Such policies relate to SMEs sector which have not yielded results that are appropriate to the sector as a whole which contribute approximately 12-15% of India's GDP.
- The main barriers for attaining higher proportion of BERD are twofold. The first is the heavy dependence of business enterprise on the proven foreign technology in the era of liberalisation. The firms are beginning to realise the importance of their in-house R&D and technological capabilities but the process of this realisation has come late and slow. Secondly, the business enterprise is nervous about the risk element in the success of R&D leading to commercialisation prospects. This feature continues to persist as venture capital sources of funding are just beginning to emerge in the Indian context. One may also add that the technology related bureaucracy is not very well trained and DST and other related science agencies are making efforts to bring in professionals who would be able to better manage.
- Public – Private Partnerships: Agencies such as CSIR have introduced various public – private partnership schemes where business enterprises are given access to vast number of national R&D labs across various disciplines. ***The New Millennium Indian Technology Leadership Initiative (NMITLI)*** **of CSIR** is a good example which meant for fostering partnerships between public research systems and industry and at the same to enable these partnerships to attain global leadership position in few selected niche areas. CSIR evolved 57 projects in which 80 industry partners and 270 R&D groups

World Bank, Washington, 2007) shows that total private R&D investment has risen from half a billion Euro in 2002 to 2.45 billion Euro in 2005.

from different institutions are involved with a budget of over rupees 5.000 million (approximately 78 million Euros).[19]

- Attracting R&D-performing firms from abroad: India is now encouraging foreign firms to set up R&D in Indian knowledge hubs. Policies which promote R&D based FDI have been quite successful as there over 250 Fortune 500 firms which have established R&D centers/labs in Bangalore, Delhi, Mumbai, Chennai and Hyderabad
- Increasing extramural R&D carried out in cooperation with the public sector: Such R&D is mainly concentrated in aerospace, atomic and renewable energy, defense R&D and to a small extent in the university sector. The proportion of extramural R&D in the GERD is rather quite marginal.
- Increasing R&D in the public sector: The trend during the last decade has witnessed some increase of R&D in the public sector, again, restricted mainly to atomic energy, space and defense sectors. As the trend indicates the public funding pattern and policies do aim at leveraging business and private sector investments. Another important feature of leveraging private funds is the policy attention being given to strengthen the innovation eco-system in the existing knowledge hubs of Bangalore, Hyderabad, Chennai and the Delhi region. For instance, both the federal and state governments are keen to strengthen the teaching and research base in the knowledge institutions in these regions.
- The policy mixes have the potential to allow the country to accelerate progress towards national R&D programmes. The problem in promoting policy mixes that encourage greater business sector enterprises in R&D related partnerships and other measures is heavy bureaucracy, which is impossible to manage professionally.

2.2.3 Providing qualified human resources

India with a population over 1.2 billion people[20] is generally seen to have a big demographic dividend as by 2030 and beyond, over 50% of population will be under the age of 25-29. However, HRST as share of total population is staggeringly low but in terms of absolute numbers India has a gross enrolment ratio (GER) of 12% which works out to be around 13 million students in the higher education sector in 2009-2010. As the science and technology policy discourse indicates, India is committed to increase the GER to around 25-30% by 2020. In terms of distribution of students in higher education sector in 2008-2009, about 50% are from science, engineering, agriculture, medicine and other technical subjects and the rest from social, business, arts and other subjects.

As per the data available for 2005, which is the latest available statistics, 391.149 FTE researchers are deployed in the R&D sector. Out of this, 48% are from engineering, 12% agriculture, 30% natural sciences, 8% medical sciences and only2% in social sciences. In terms of qualifications, 30% are graduates, 38% post graduates, 18% PhDs, 8% diploma holders and 6% belong to other categories. Institutional sector employed 76% of PhDs and 55% of post graduates in 2005-2006.

In addition to the above figure of FTEs, India has about 3.2 million professionals employed in the ICT software services and related sectors in 2009.

[19] See, http://www.csir.res.in/csir/external/heads/collaborations/NM.pdf
[20] This is according to the recent government census of 2010.

In India professionals and academic personnel in the universities are not strictly regarded as civil servants even though they are governed by civil service rules and norms. Civil servants are generally trained and employed in the bureaucracy and public sector undertakings.

The Indian education sector is by far the largest and fastest growing sector in India, with government spending of $30 billion in 2006, representing 3.7% of GDP, and a large network of one million schools and 18,000 higher education institutes. In the current Five-Year Plan (2007-2012), the government has allocated a six-fold increase in spending on education, yet this figure remains highly disproportionate to its target population. India's population of 572 million (2008) within the 0-24 years age group is the highest in the world and is expected to increase to 600 million by 2012. As a result, despite having one of the world's largest education supply infrastructures, India is currently unable to meet the demand for education at almost all levels. Only 219 million children (37%) are enrolled in schools and 11 million students attend colleges.

– Only 34% of Indian schools provide an education beyond the primary level, meaning that the majority of Indian citizens receive only six years' formal education

– 40% of pupils drop out of education each year, across all age groups, including primary school.

- Central and state-run institutes are directly funded by the central and the state governments respectively; there is no public funding of privately run institutions.[21]

Unlike free flow of people without strict visa conditions in the EU for European citizens, there is no such arrangement either within SAARC or South Asian countries, including India. Only people from Nepal and India have free mobility. Generally Indians need to obtain visa permits for all countries in the world. There are work visas known as HIB visas given to Indian software professionals in the USA and some work related permits in EU regions.

By the year 2020, 136 million Indian youngsters will join the global workforce. Compared to this enormous number which accounts 17% of total global workforce, China will add only 23 million people and the USA will increase its working age population by 11 million during this period. In contrast, there will be a decrease in the number of people between working ages of 18-60 in Europe and Japan by 21 million and eight million respectively.

Demographic Dividend[22]

Between 2000 and 2020, India's total population (currently a little over 1.2 billion) is projected to grow by another 200 million. Half of this population is project to be in the age group of 25 and 59. This "Demographic Dividend" or the large increase in India's working population is forcing changes in the world economic order.

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[21] Grant Thorton, Education in India: Securing the demographic dividend, UK- India Business Council Report , 2010

[22] Taken from N. Chandrasekharan, 'Delivering India's Demographic Dividend' (http://neurope.eu/2011/delivering-india%E2%80%99s-demographic-dividend/)

It is redefining India's role in the global economic order. Not only is it emerging as one of the fastest growing consumer markets in the world, but also a critical pool of supply for some of the best scientific and technological talent on a scale no other country can match in the long-term.

The United Nations estimates that India will account for almost 26% of the increase in global working-age population over the next 10 years. If the country is able to increase its focus and investment in the education sector, over the next decade India could emerge as the global leader is producing high-school and university graduates.

Articulation of education policies within the knowledge triangle

India with its vast human resource base, half of which is below the age group of 25 to 35, the main challenge for India is to drastically increase the GER of human resources in S&T. While India registers substantial number of young students in the higher education sector in absolute terms, the country's record of production of doctoral students i.e. PhDs is quite dismal. According to various sources indicated by India's major Software Association bodies and Human Resource Consultancy firms, the employability of graduates is rather low: Only 25% of the graduates coming out of institutions have appropriate skills required by the industry. In an effort to fill this lacunae all the major Indian software firms such as Tata Consultancy Services, Infosys, Wipro and Satyam – Mahindra groups run in-house training programmes for neophytes entering the ICT sector from higher educational institutions. Similar is the case of Transnational Corporations which operate about 250 R&D laboratories or Centers in India.

The National Knowledge Commission through its periodic reports in 2009 and 2010 has been advocating various policy measures to forge close links between universities, industry and government laboratories. This has led the current Five Year Plan 2007-2012 and the education ministry to give a major boost in education policies to increase the research intensity in universities and link them up with needs and demands of private and public enterprises. The Ministry of Education and the Ministry of Science and Technology have already articulated Indian version of Bayh-Dole Act in 2009-2010 which is currently waiting for approval from the Indian Parliament. This policy measure is mainly directed to catalyse university-based innovation in industry and society and promote commercialisation of R&D in the public research system.

Main societal challenges

The main challenge facing Indian higher education as far as the human resources in science and technology is concerned, is the objective to first attain a GER of nearly 30% by 2025; and secondly to see that at least 50% of this segment constitutes students in science, technology, engineering and mathematics and other technical subjects. While current educational policies are focused on attaining these twin objectives, much less attention is paid to the vocational and industrial training and in enhancing the skills base of informal sector, which constitutes over 80% of India's labour force.

2.3 Knowledge demand

This section focuses on structure of knowledge demand drivers and analysis of recent policy changes.

The demand

India is one of the largest "importers of higher education", as 100000 students go to study abroad every year and part of them repatriates: $13 billion (9 billion Euros) is spent every year on education in the country. The National Knowledge Commission (NKC) estimates there is a need for 1,500 universities; only 350 currently exist. The Foreign Education Providers Bill is likely to open the higher education sector to international competition, which will help to increase the supply in India. Meanwhile, it is expected that an additional 800 private engineering, 60 medical and 300 MBA colleges will open by 2012.

Business driven knowledge demand

From the perspective of sectoral structure of the Indian economy, 57.8% of India's GDP comes from the services and the Industrial sector accounts for around 28%. About 14.2% is accounted from the agriculture sector. In the last five years, the most robust business driven knowledge demand has come from the sub-sectors of information and communication technology, biopharmaceuticals and chemicals, telecommunications, electronics, automotive and transportation and the aviation sectors. India has been able to attract a good deal of R&D based FDI as well as FDI in general in the last four years but however much less compared to countries such as China. Much of the FDI flows have gone into the sub-sectors as noted above.

Foreign investors[23] see the huge long-term growth possibilities that India presents according to Ernst & Young's first Indian Attractiveness Survey. 'Foreign direct investment (FDI) data shows that India is still in recovery mode from the drop off in inward investment reported in 2009 following the global financial crisis. With the slowdown in global investment flows, the number of FDI projects in 2010 remained constant compared to 2009 at around 750. Although project numbers and jobs created are still some way off the heights reached in 2008, when there were 971 projects, the long term trend over the last decade shows a consistent, if not dramatic upward movement. Overall project numbers in 2010 were up by 60% on 2003 and the number of jobs created up by 30%.'

The growing TNC business operations in India is seen not only by the country's economic growth potential, but also by perceptions about how the country will change as its GDP grows over the next decade. In late 2010 Ernst & Young interviewed more than 500 global business leaders about the future of business prospects about Indian market. A large majority believe that, 'as early as 2020, India will become a global leader in education, R&D, innovation, and as a producer of high value-added goods and services'.

Seventy-five percent of the global businesses which operate in India said that they would expand their operations. India is undergoing a transition, both in terms of investor perceptions of its market potential, and in reality as indicated by the survey.

Rajiv Memani, Country Managing Partner at Ernst & Young India said "With economic growth GDP projected to surpass 8% annually and the number of people in the Indian middle class set to treble over the next 15 years, with a corresponding impact on disposable income, domestic demand is expected to grow exponentially. India's young demographic profile also helps it provide an increasingly well-educated and cost-competitive labour force. These factors put India in a good position to attract an increasing proportion of global FDI."

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[23] This entire section of five paras are drawn from http://www.ey.com/GL/en/Newsroom/News-releases/Media---Press-Release---Indian-Attractiveness-Survey---2011(25 January 2011)

2.4 Knowledge production

The production of scientific and technological knowledge is the core function that a research system must fulfil. While different aspects may be included in the analysis of this function, the assessment provided in this section focuses on the following dimensions: quality of the knowledge production, the exploitability of the knowledge creation and policy measures aiming to improve the knowledge creation.

2.4.1 Quality and excellence of knowledge production

India is among the top nations of the world for the SCI based scientific publications for the decade 1996-2006. At the 10th position, India is preceded by Australia, Russia, Canada, France, China, Germany, Japan, UK and USA.[24] The total number of papers almost doubled from 20,514 in 1996 to 40,062 in 2006. However, India registered only a marginal increase in the world output of science publications from 2.1 to 2.3% during 2000 and 2005.[25]

India is spending around 1% of its GDP on research and development compared to 1.4% spent by China and over 2.2% by most OECD countries. By most commentators and experts on tracking science and technology strategies in India reckon it as grossly inadequate. India's Prime Minister, Dr Manmohan Singh reiterated this sentiment time and again during his inaugural address at the last three Indian Science Congress sessions. He has committed to increase this to 2% in the coming years. Given this low level of Indian GERD as proportion of GDP compared to China and other industrially advanced countries, its impact is already felt in the availability of quality research infrastructure in public research laboratories and science agencies such as Council of Scientific and Industrial Research (CSIR) and universities. However, compared to CSIR, science agencies such as Atomic Energy Commission and Indian Space Research Organisation are endowed with much larger R&D budgets and as well as research infrastructure. More than mission-oriented agencies such as CSIR, the quality of research infrastructure is relatively of low level in the Indian universities. From an overall perspective of university system in India, only 20 to 25% of the 400 universities can be counted as research based universities and the rest are to be categorised as more of teaching based universities with very low level of research base. The direct impact of low level of GERD as proportion of GDP and sub-critical research infrastructure in universities and public research agencies can be seen in the relative stagnation of scientific output. Even though India during 1996-2006 stood at the 10th position in the world output of SCI based scientific publications, India registered only a very marginal increase of science publications from 2.1% to 2.3% between 2000 and 2005 as noted in the above sections. At the same time, China which produced hardly one third of India's science publications in the 1990s surged ahead of India by over two and half times by 2009-2010.

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

The NATIONAL ASSESSMENT AND ACCREDITATION COUNCIL (NAAC) is an autonomous body established by the University Grants Commission (UGC) of India to assess and accredit institutions of higher education in the country. The NAAC has

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[24] See *Measures of Progress of Science in India*, Report for the Office of the Principal Scientific Advisor to the Government of India, by B.M.Gupta and S.M.Dhawan, PSA/2006/4

[25] See the key note address of Kapil Sibal, Minister for Science and Technology, at the 96th Indian Science Congress held during 3-7, 2009, at the North Eastern Hill University, Shillong, Meghalaya.

been established as an outcome of the recommendations of the National Policy in Education (1986) that laid special emphasis on upholding the quality of higher education in India.[26]

The system of higher education in India has expanded rapidly during the last fifty years. In spite of the built-in regulatory mechanisms that ensure satisfactory levels of quality in the functioning of higher education institutions, there has been criticism that the country has permitted the mushrooming of institutions of higher education with fancy programme and substandard facilities and consequent dilution of standards. To address the issues of deterioration in quality, the National Policy on Education (1986) and the Plan of Action (POA-1992) that spelt out the strategic plans for the policies, advocated the establishment of an independent national accreditation body. Consequently, the NAAC was established in 1994 with its headquarters at Bangalore. NAAC functions in coordination with the UGC and the Ministry of Education. The body is entrusted with the evaluation and grading of universities and colleges in allocating research money. It is also entrusted to evolve certain professional evaluation measures of publications, peer review etc.

The technical and Higher education: A US $300 or 209 Euros million budget is helping improve India's technical/engineering education was recently approved by the World Bank (TEQUIP II), following the successful completion of TEQUIP I. This will finance major reforms in 130 + competitively selected engineering institutions from around the country to improve quality of education and meet the demands of a fast growing economy. Further, several reports examine the increased demand for skilled workers in India and its importance for national competitiveness.[27]

The National Educational Testing Bureau of University Grants Commission (UGC) conducts National Eligibility Test (NET) to determine eligibility for lectureship and for award of Junior Research Fellowship (JRF) for Indian nationals in order to ensure minimum standards for the entrants in the teaching profession and research. The Test is conducted in Humanities (including languages), Social Sciences, Forensic Science, Environmental Sciences, Computer Science and Applications and Electronic Science.[28]

The Council of Scientific and Industrial Research (CSIR) conducts the UGC-CSIR NET for other Science subjects, namely, Life Sciences, Physical Sciences, Chemical Sciences, Mathematical Sciences and Earth Atmospheric Ocean & Planetary Sciences jointly with the UGC. The tests are conducted twice a year, generally in June and December. For candidates who desire to pursue research, the Junior Research Fellowship (JRF) is available for five years subject to fulfilment of certain conditions. UGC has allocated a number of fellowships to the universities for the candidates who qualify the test for JRF. The JRFs are awarded to the meritorious candidates from among the candidates' qualifying for eligibility for lectureship in the NET. JRFs are available only to the candidates who opt for it in their application forms.

India has a large public science and technology system stretching over a dozen science and technology agencies. Scientific and technical human resources engaged

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[26] See http://www.naac.gov.in/aboutus.asp#vision

[27] See http://www.worldbank.org.in/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/INDIAEXTN/0,,contentMDK:21493265~pagePK:141137~piPK:141127~theSitePK:295584,00.html

[28] See http://www.ugc.ac.in/inside/net.html#intro

in the national laboratories under these science agencies are not hired on contract basis but are given tenured positions right from their first appointment. Scientists and technologists are evaluated based on their research output periodically every 5-7 years, depending on the science agency they represent. Even though the assessment and evaluation of research output is subjected to some form of peer evaluation, by and large the system cannot be compared to international benchmark criteria. For instance, there is no systematic ranking of SCI and non-SCI based journals to evaluate research productivity. India produces over 1500 journals in various fields of science and technology and little less than one third of these journals are covered by one or other international databases and indexes such as SCI. Over the years, there has been a serious concern over the low level of peer evaluation procedures adopted by the Indian journals. Indian science agencies and universities have begun to initiate policy measures in 2010 to improve the quality and excellence of knowledge and research output.

2.5 Knowledge circulation

This section provides an assessment of the actions at national level aiming to allow an efficient flow of knowledge between different R&D actors and across borders.

2.5.1 Knowledge circulation between the universities, PROs and business sectors

The policy focus for knowledge circulation between universities, PROs and the business sectors has come into sharp focus in India in the last decade. India's Science and Technology Policy 2003 stressed that 'every effort will be made to achieve synergy between industry and scientific research. Autonomous Technology Transfer Organisations will be created as associate organisations of universities and national laboratories to facilitate transfer of the know-how generated to industry. Increased encouragement will be given, and flexible mechanisms will be evolved to help, scientists and technologists to transfer the know-how generated by them to the industry and be a partner in receiving the financial returns. Industry will be encouraged to financially adopt or support educational and research institutions, fund courses of interest to them, create professional chairs etc. to help direct S&T endeavours towards tangible industrial goals'. Following upon the policy prescriptions, the two major government departments (Department of Science and Technology and the Department of Scientific and Industrial Research) introduced some policy measures and instruments to promote the research and innovation linkages between universities, PROs and business enterprises. Some important policy instruments are as follows:

a) Technology Development and Demonstration Programme (TDDP) – 1993 & Technology Development Board (1996)

b) Small Business Innovation Research Initiative (SBIRI) -2007-08

c) New Millennium Indian Technology Leadership Initiative (NMITLI) - 2003

d) Home Grown Technology (HGT) Program - 1992

e) Innovation and Entrepreneurship Programme (from 1990s)

f) Pharmaceuticals R&D Support Program 2004

As already indicated in the above sections, a predominant proportion of GERD, about 68%, is met by the government and the private business enterprise accounts for about 30%. Even though the proportion of private business contribution has increased quite substantially from 18% in 2003 to 30% in 2009-2010, the low R&D intensity of firms in the business enterprise sector and their greater dependence on proven and tested foreign technology in the liberalised regime after 1991, poses a big challenge for the transfer of knowhow and technology from universities and public research laboratories to the industry. On the other hand, the low level of R&D intensity of the university sector, which accounts for only 4- 6% of GERD during 2005-2009, has prevented Indian university sector to build its innovation base for commercialisation of knowledge produced by it. For instance, the university sector's contribution to the patent endowment is also quite low compared to PROs and business enterprises. With the exception of India's major engineering institutions such as Indian Institutes of Technology, a great majority of Indian universities are yet to institutionalise innovation culture and innovation related institutions such as incubation and innovation centres on the university locales. The Ministry of Science and Technology has already introduced ***The Protection and Utilisation of Public Funded Intellectual Property Bill 2008*** which is pending for Parliament's ratification. This Bill is likely to enhance the innovation potential of the university sector and spur spin-offs via commercialisation of knowhow and technology.

2.5.2 Cross-border knowledge circulation

Cross-border Knowledge circulation, in terms of collaboration and cooperation between Indian and foreign agencies or institutions, takes place in two modes. In the first mode of PROs, the S&T International Cooperation Division of the Department of Science and Technology deals with the International Scientific and Technological Affairs including the negotiations and implementation of Scientific and Technological Cooperation Agreements and responsibility for scientific and technological aspects of activities of international organisations. The co-operations are sought under bilateral, multilateral or regional framework modes for facilitating and strengthening interactions among governments, academia, institutions and industries in areas of mutual interest. The Division operates in close cooperation with the Ministry of External Affairs, the Government of India, Indian missions abroad, foreign missions in India and UN bodies. India currently has bilateral S&T cooperation agreements with 73 countries.[29]

The most notable cooperation in recent years has been concluded with USA, France and Russia in the nuclear energy for building nuclear reactors to meet India's growing energy demands. Four major agreements have already been entered with these countries to build ten nuclear reactors in the coming decade. The Second major cooperation has come into sharp policy support in the aerospace industry sector. Indian Space Research Organisation has entered into research cooperation with Russia, USA and the European Union.

In FP7, already more than 140 projects in Indian research organisations have been selected for funding in over 90 projects so far in 2011.

India has been considered as a valuable partner for the EU in major international projects. The main programmes of international cooperation with EU are listed below:

[29] http://www.stic-dst.org/

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.[30] 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.[31] 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 the above agreement committed an investment of EUR 5 million by each party. The projects have commenced in 2008.

The Second mode of knowledge circulation and international collaboration is in the private sector. One of the international foundations that entered into research and delivery cooperation with a number of agencies in the public and private domain is the Gates Melinda Foundation in the area of health.

2.5.3 Main societal challenges

India has launched a National Action Plan for Climate Change (NAPCC) which is steered by the Prime Minister's Office. The main principles guiding the NAPCCC are:

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

- Protecting the poor and vulnerable sections of society through an inclusive and sustainable development strategy, sensitive to climate change.
- Achieving national growth objectives through a qualitative change in direction that enhances eco-logical sustainability, leading to further mitigation of greenhouse gas emissions.
- Devising efficient and cost-effective strategies for end-use Demand Side Management.
- Deploying appropriate technologies for both adaptation and mitigation of greenhouse gases e-missions extensively as well as at an accelerated pace.
- Engineering new and innovative forms of market, regulatory and voluntary mechanisms to promote sustainable development.

There are Eight National Missions such as solar energy, water, sustainable habitat, energy efficiency, Himalayan ecosystem etc, that form the core of the National Action Plan, representing multi-pronged, long-term and integrated strategies for achieving key goals in the context of climate change. The research tasks and principles set out by the NAPCC is designed to forge close linkages between different actors (universities, PROs and business enterprises) in the Indian national innovation system so as to enable the flow of research and innovation activities.

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.

2.6 Overall assessment

Table 1: Summary of main policy related opportunities and risks

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	• Increase incentives to business enterprise to invest in R&D • Implementation and realisation of 2% GERD/GDP committed by the government. • Expansion of higher education to increase Gross Enrolment Ratio	• Lack of appropriate monitoring and evaluation mechanisms • Relative stagnation of GERD/GDP over the last two years • Improving teaching quality assessment mechanisms in public and private universities • Resistance of universities to tie up with business enterprises
Knowledge demand	• Policies promoting knowledge intensive economy, rural industrialisation and ICT for development • More incentives for SMES to become more research intensive	• Expansion of educational and knowledge institutions in rural areas sustaining the quality and skills including training • Resistance and problems in standardisation, quality control mechanisms
Knowledge production	• Increase in R&D funding and expansion of higher	• Policy measures to ensure quality and excellence in

	education • Increased research intensity in business enterprise sector	knowledge production • Risks related to commercialisation of local technology and liberal policies for import of technology
Knowledge circulation	• Mobility of professionals across public and private enterprises and institutions • Attracting indigenous talents and skilled personnel in US and Europe	• Implications of raising incentives and monetary compensation in the public sector institutions • Giving extra incentives and facilities to expatriates will create problems

Table 2: Main barriers to R&D investments and respective policy opportunities and risks

Barriers to R&D investment	Opportunities and Risks generated by the policy mix
Under development of Knowledge Triangle between industry, government labs and universities	The endogenous innovation potential in some sectors such as aerospace, transportation, infrastructure etc remains unexploited and increases the dependency of foreign and proven technology which is costly and not up to date.
Low level of research intensity in university sector	Missing the opportunity of expanding R&D base in the university sector. Universities will remain marginalised to national innovation system.
Lack of innovation culture in the university sector. Lack of innovation culture and low level of attention to R&D benefits by private firms.	The opportunity of catalyzing knowledge triangle is lost. Will remain isolated and confined to teaching only. The opportunity of competing both at national and global levels is lost.
India's overspending in defence, security and other governmental expenditure is eroding resources for S&T.	The opportunity to create highly effective endogenous research eco-system remains underdeveloped. The national innovation system continues to operate at sub-optimal level.

3 National policies which correspond to ERA objectives

3.1 Labour market for researchers

3.1.1 Stocks and mobility flows of researchers

India with a population over 1.2 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 but in terms of absolute numbers India has a gross enrolment ratio (GER) of 12% which works out to be around 13 million students in the higher education sector in 2009-10. It has witnessed an increase from 11.5 million in 2006-2007 to 13 million in 2009-2010. As the science and technology policy discourse indicates, India is committed to increase the GER to around 25-30% by 2020. In terms of distribution of students in higher education sector in 2008-2009, about 50% are from science, engineering, agriculture, medicine and other technical subjects and the rest from social, business, arts and other subjects.

As per the data available for 2005, 391.149 FTE researchers are deployed in the R&D sector. Out of this 48% are from engineering, 12% agriculture, 30% natural sciences, 8% medical sciences and only 2% in social sciences. In terms of qualifications, 30% are graduates, 38% post graduates, 18% PhDs, 8% diploma holders and 6% others. Institutional sector employed 76% of PhDs and 55% of post graduates in 2005-06.

In addition to the above figure of FTEs, India has about 3.2 million professionals employed in the ICT software services and related sectors in 2009.

3.1.2 Providing attractive employment and working conditions

The employment opportunities and working conditions in the Indian context present broadly two domains or scenarios in so far as the modern industrial and service sectors of economy are concerned. The first is the private business enterprise sector in ICT and telecommunications, finance and banking, biopharmaceuticals, automotive, ports and shipping and transportation. The working conditions are much better off and salaries in this sector are at least three to four times more compared to those offered in the public sector or government related sector including PROs, universities and science agencies under the auspices of government. Whereas the salaries in the private sector are comparable to South East Asian and East Asian regions, they are however below the levels in Western Europe and North America. Since the cost of living in Indian cities is at least 40 -50% lower than those in USA or Western Europe, employment opportunities in Indian context become comparable to those in the West. The situation is however not the same for researchers and academic professionals in the government sector. For instance, an Indian professor's salary is around 2,000 Euros per month compared to those in USA and Western Europe earn at least three times or even four times more. The universities, PROs and science agencies are regulated through all India based salary scales and these institutions do not have any autonomy to increase the salaries. The private universities and research laboratories are exception to these norms and they are allowed to adopt their own salary structures.

Whilst the private sector employs people on specific contractual basis, which are renewed periodically, the employment in the government sector operates on permanent or tenured positions. The working conditions in the government funded universities and PROs are better compared to private sector in so far as the career breaks and sabbatical leave are concerned.

There are no formal gender based norms and rules governing the employment of professionals in universities and PROs. However, there exists some form gender sensitisation which operates more on the informal and morally driven basis rather than rule based normative procedures, which persist in political bodies and parliament and legislatures.

India was really concerned in the 1980s and 1990s about brain drain and brain gain but this is not a major concern presently as India benefitted from brain circulation in recent times, particularly in the ICT software, bio-pharmaceuticals and other services sectors of Indian economy.

The government has given high importance to gender sensitisation both in the academic and research institutions as well as in the government administration and services. The policies on gender sensitisation give a good deal of protection and legal supportive measures to women in cases such as discrimination, harassment etc. The principle of equality of opportunity and in cases of work remuneration is maintained. Working women in formal organisations/institutions can avail career breaks for improving their educational qualifications and work prospects. Women are also given special leave during and after childbirth. India's main problem in terms of gender bias and other related factors, which are dysfunctional to egalitarian society, is intimately related to age-old traditions and customs which are likely to be eliminated with educational for all. The right to education bill is closely related to this problem.

3.1.3 Open recruitment and portability of grants

In India, academic staff in the universities and colleges and professionals in PROs and science agencies under the government are regulated by norms, which prevent non-nationals to be considered for various positions. They are not open but however, the institutions are autonomous to invite foreign experts on contractual basis. Private universities, colleges and research institutions have to obtain prior permission to recruit foreign nationals. The recruitment in academic and professional institutions is based on merit and peer evaluation. The recruitment at first level of teaching in universities and colleges is based on National Eligibility Test (NET) organised by the University Grants Commission (UGC) and other science agencies such as CSIR.

There are norms and clear system in place for the recognition of professional qualifications and academic degrees from foreign universities. UGC and Ministry of Human Resource Development regulate these.

Much of the recruitment in professional organisations and universities are advertised in all major Indian newspapers and other media. However, the private and business enterprises advertise it globally.

Much of the funds in research projects do not allow portability from one institution to the other. Even the foreign travel and field research is restricted on all major R&D and S&T projects unless they are justified at the project proposal and approval stage.

3.1.4 Meeting the social security and supplementary pension needs of mobile researchers

All academic institutions and science agencies and national laboratories partly or wholly funded from government have a good system of social security and pension schemes. They are however detrimental to mobile researchers if they are moving from public to private within India and to any other organisation or firm outside Indian except UN organisations.

3.1.5 Enhancing the training, skills and experience of researchers

India has over 400 universities and more than 1000 post graduate colleges which offer PhD or doctoral programmes. The UGC prescribes certain guidelines for the entry to doctoral programmes such as the requirement of pre-PhD course called Masters in Philosophy (MPhl) which is generally a two year programme. While all universities run their teaching and research programmes mostly in English they also have remedial courses and English as spoken language courses. However there is no standardisation except urban-based universities and colleges where over 60% of these institutions are located.

Most of the leading science agencies such as CSIR and Department of Biotechnology have put in sabbatical and post-doctoral scholarships that enable researchers and professionals' mobility to international institutions to gain experience and acquire skills in the latest techniques. Professionals taking up such scholarships need to enter into some form agreement that these professionals will be serving their home institutions for a certain stipulated period of time after their foreign assignments and training schemes. Non resident Indian and persons of Indian origin in major institutions, firms and universities in Western Europe and USA do have advantageous career paths in institutions such as Indian Institutes of Technology, Indian Institute of Science, Bangalore and CSIR based laboratories as they are given higher positions compared to locally trained professionals with equal number of years of experience. This puts them on faster career paths in respective organisations.

3.2 Research infrastructures

Research infrastructures (RIs) 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.

3.2.1 National Research Infrastructures roadmap

An Editorial in the *Current Science* drew attention to various aspects of national research infrastructure. For example, high field NMR spectrometers (with proton frequencies as high as 800 MHz), X-ray diffract meters equipped with CCD detectors, tandem mass spectrometers, confocal and atomic force microscopes, cell sorters and automated DNA sequencers are becoming commonplace in biological laboratories across the world. As the editorial observes, 'The unparalleled spatial and temporal resolution provided by pulsed lasers has allowed chemical and biological phenomena to be addressed in a manner that could not have been anticipated a few years ago. Early watchers of the genome sequencing programs could hardly have foreseen the enormous technological advances that would bring genomics to its present, preeminent position, in such a short time. Increasing sophistication in the tools of science has resulted in a widening of the gap in performance between the well-endowed laboratories of the developed world and the institutions located in the less developed countries'. [32]

In the 1970s the Department of Science and Technology, created the Regional Sophisticated Instrumentation Centres (RSICs). Similar facilities also housed expensive equipment, such as spectrometers of various kinds and provided analytical services primarily for chemists who were generally drawn from Universities and local industries. With time, some major research facilities, like high field NMR ('mid- field' by today's standards) became available at a few places, dispersed across the country. The allocation of research funds in the 1980s is reported to have ensured that similar sophisticated instruments became available even in some individual laboratories. As the editorial comments, 'RSICs work and house activities currently cannot be described as sophisticated and up to date'.[33]

Considering the present status of the S&T sector in the universities and related academic institutions the government of India in the year 2000 announced a major new initiative titled "Fund for Improvement of S&T infrastructure in universities & higher educational institutions (FIST)" to rebuild the Science & Technology infrastructure in the country.

The FIST was initiated in Financial Year 2000-2001 and so far 9 rounds of support have been provided, with the 9th round still in progress. The scheme is operated at two levels i.e. Level-I & Level-II for 6 subject areas i.e. Life, Physical, Chemical, Engineering, Earth and Atmospheric and Mathematical Sciences. The scheme also covers all sectors of Scienceand Technology departments including Agriculture, Veterinary and Medical having Post-graduate teaching & research program of 3 years in existence. There is a two-tier mechanism, i.e. Subject Expert Committee & FIST Advisory Board (FISTAB) for identification and recommendation of support to a Department/Centre/School. Around 1350 Departments identified and supported at a total budget of almost Rs. 1000 crores (152 million Euros). 337 Academic institutions covered.[34] International cooperation in science and technology, particularly with EU and US has established research infrastructure in some crucial areas of national security, energy and satellite based geographical information systems. In energy India has entered into a deal with US on nuclear energy which has opened up India at National Suppliers Group based in Vienna. This opens up India's nuclear commerce paving way for private participation in building nuclear reactors. Indian Space Research Organisation is collaborating with Russia and USA in GIS related joint research exploration in space and ocean.

3.3 Strengthening research institutions

This section gives an overview of the main features of the national higher education system, assessing its research performance, the level of academic autonomy achieved so far, dominant governing and funding models.

[32] See *Current Science* 25 February 2000, Editorial (India's leading science journal)
[33] ibid
[34] http://www.fist-dst.org/html-flies/highlight1.htm

3.3.1 Quality of National Higher Education System

Higher educational institutions witnessed considerable growth in the post-independence period after 1947. From 20 universities in 1947 the number increased to over 400 universities and 18,064 colleges affiliated to various universities in the country in 2008. Some quantitative data with regard to the expansion and structure of higher education's system can be found in the earlier sections

Historically research and development in science and technology has been concentrated only in about 15% of the Universities and partly their affiliated colleges. The top 20% of the universities account for bulk of the R&D output from the university sector. R&D performed by higher educational sector is reported by different sources such as the DST statistics on R&D; National Education Planning and Administration, New Delhi and other independent research sources which range from 3% [35] to 7% of GERD.[36] Even though higher education sector constitutes relatively a miniscule of GERD, it however contributes over 52.2% of the total of India's S&T publications measured in SCI-Expanded Verison. The expenditure on R&D should be taken to measure the output, as extramural research funding from public sources for scholarships and higher education research is not included in the figure of R&D on higher education.

Research performance

Despite a very low level of GERD devoted to HEIs, the sector accounted for nearly two third19s of total S&T output measured in terms of peer reviewed publications in SCI Extended version data base during 1985-86, 1994-1995 and 2001-2002(See Table below). Between the1980s and 2007, even though the proportion of HEIs contribution in the national output has come down from 69% in 1985-1986 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 (universities and Institutions of national importance)	PRI	Business Enterprises	Others	Total
1985-86 (SCIE)	16085 (69%)	6569 (28%)	411 (1.7%)	235(1%)	23300
1994-95 (SCIE)	17302 (62%)	9218 (33%)	496 ((1.8%)	562((2%)	27578
2001-02 (SCIE)	23578 (60%)	13329(34%)	708 (1.8%)	1237 (3%)	38852
2007-2008 (scopus)	22945 (52%)	19415 (44%)	1325 (3%)	441 (1%)	44126

[35] P.Agarwal, 'Higher Education in India: The Need for Change', *Working Paper No 180*, ICRIER, New Delhi, June 2006.
[36] See Krishna, V.V. 'Reflections on the Changing Status of Academic Science in India', 2001, *International Social Science Journal*, Unesco, pppp.231-46.

As the above table indicates, business enterprise is not a major player in the S&T output as it hardly accounted between 1 -3% during the last two and a half decades. Another important study on publication output (based on Scopus data base) by India's top HEIs, reveals somewhat similar trends. For the decade 1997-2007, HEIs accounted for 52% of total cumulative S&T publications, whereas PRIs accounted for 44% for the same period. The above indicators clearly point out low level of R&D funds devoted to HEIs sector. At the same time they also raise an important issue of the extent of research base and research intensity in the universities and colleges in India.

The National Assessment and Accreditation Council (NAAC)[37] was established by University Grants Commission (UGC) to assess and accredit institution of higher learning in the country. The NAAC was originally formed in 1992 as a result of recommendations from 'National Policy on Education - 1986' which emphasises on deteriorating quality of higher education in the country.

The NAAC certifies institutions of higher learning (Colleges, Universities, Institutes, etc) in the country; however, it does not include the institutes providing technical education. The assessment of technical education institutes is performed by the National Board of Accreditation (NBA), an organisation established by All India Council for Technical Education (AICTE), New Delhi. The NAAC has opened its office in Bangalore, Karnataka.

The National Assessment and Accreditation Council (NAAC) stresses on making quality assurance, an integral part of the functioning of any higher education institution. The mission statements of the NAAC aim at translating the NAAC's vision into reality, defining the following key tasks of the organisation:

- to arrange for periodic assessment and accreditation of institutions of higher education or units thereof, or specific academic programme or projects;
- to stimulate the academic environment for promotion of quality of teaching-learning and research in higher education institutions;
- to encourage self-evaluation, accountability, autonomy and innovations in higher education;
- to undertake quality-related research studies, consultancy and training programme; and
- to collaborate with other stakeholders of higher education for quality evaluation, promotion and sustenance

3.3.2 Academic autonomy

The higher education system is a State subject and hence the control and governance is regulated through both federal and state governments. Whilst the higher education system in the states are controlled and regulated by the state governments they function with much lesser autonomy compared to central universities. However, in both cases universities in India enjoy considerable research and teaching autonomy. Both the state and central governments interfere with regard

[37] See http://www.indiaeducation.net/apexbodies/naac/

to fees regulation, financial and other managerial aspects but do not normally interfere with academic appointments. The Vice Chancellors in both cases are appointed by the respective heads (state governors and President of India) on the recommendations of selection committees constituted by the education ministries. The Vice Chancellors in turn appoint Rectors and Deans in their respective institutions. Somewhat a similar pattern is followed in the private universities except that these universities appoint the main donors (who are generally family run business enterprises) as the Vice Chancellors or heads of their respective institutions.

The higher educational system is gradually being opened up for change and decentralisation. In particular, the federal and state governments are gradually giving higher education institutions more decision-making and spending power. This represents a move away from detailed government control over spending and curriculum decisions, which required frequent approval from federal or state government officials. Besides the 11th Five Year Plan, several feature point towards this trend:

- Many institutions have become autonomous during the 10th Five Year plan through an increase in the number of autonomous institutions: Central Universities (2), State Universities (39), "deemed-to-be" Universities (50), and Private Universities (10).
- Two recent reports from the Central Advisory board of Education (CABE) on the 'autonomy of higher education institutions" and 'financing of higher and technical education' respectively recommend changes to governance of the higher education institutions.
- The Oversight Committee on the Implementation of the New Reservation Policy in Higher Educational Institution equally recommends increased autonomy to institutions within recruitment and remuneration of faculty and admission policies to find the right balance between equity and excellence for each institution.[38]

Over the last decade, more than 80% of the expansion in higher education has taken place in the private sector and this has caused a number of problems as they enjoy more autonomy in teaching and research for the reason that they are not dependent on the governmental support. This feature has led to serious concerns among intelligentsia. For instance as Anandakrishnana (2010: 19) observes, 'with the rapid growth of privately funded institutions, the nature of their governance system has become an area of major concern. The extent to which the members of the trust or society consisting of close family members or their relatives engage in micro-managing all aspects of the institutions including appointment of the heads of the institution and the faculty, their remuneration, investment in academic facilities, the admission policies, fee collection and so on, has caused considerable damage to the credibility of the higher education system in India'.[39]

[38] See World Bank Report on this subject of autonomy and governance: http://web.worldbank.org/WBSITE/EXTERNAL/WBI/WBIPROGRAMS/KFDLP/0,,contentMDK:21812442~menuPK:461215~pagePK:64156158~piPK:64152884~theSitePK:461198,00.html (accessed 21 April 2011)

[39] Anandakrishnan, M., "Accountability and Transparency in University Governance", in University News, Vol. 48, No. 45, November 8 – 14, 2010 (special issue on Governance in Higher Education), Association of Indian Universities, pp. 18 – 23)

Most universities in India are governed by university based Councils, Senate and the Court. In an effort to make the teaching and research in universities relevant to society and economy, these bodies involve a minority of external members.

3.3.3 Academic funding

Universities in India face financial constraints. Only 0.5% of India's GDP is spent on higher education, which is somewhat comparable to EU 27(0.48), U.K (0.5) and Sweden (0.9).[40] However, about 75% of expenditure is spent on salaries and pensions, and 15% is absorbed by claims such as rents, electricity, telephones and examinations.[41]

Universities occupy a significant position in terms of national R&D effort in industrially advanced countries. Universities in OECD - 25 countries accounted for 20% and Japanese universities accounted for around 15% of GERD in 2004-2005. Whilst universities and colleges in China account for around 10% of GERD in 2005-06, Indian universities and colleges accounted for mere 4-5% in 2005. In contrast, the business enterprise sector accounted for 30% and public research institutions sector accounted for around 62% of GERD during 2006-08.

Due to the shortcomings in the quality and capacity of the public education system, there has been significant recent investment in the private sector education providers, which is now valued at $50 or 34.8 Euro billion, rising to an expected $85 or 59 Euro billion by 2012 (at a compound annual growth rate (CAGR) of 14%).

Over the last three to five years a completely new, unregulated segment – 'non-formal' private education (comprising pre-schools, coaching/tutoring classes, the provision of multi-media and information and communication technologies (ICT) to aid teaching in schools and colleges, vocational training and the books market) – has emerged and now represents 20% of the private education industry. Almost all elements of the private education sector are growing at very healthy rates (15%-30% per annum).

The size of the higher education industry is expected to increase from $8.7 billion in 2008 to $32 billion in 2012 as the private sector takes a greater stake.

3.4 Knowledge transfer

This section will assess the national policy efforts aimed to promote the national and trans-national public-private knowledge transfer.

3.4.1 Intellectual Property Policies

After January 2005, when India became signatory to the WTO – TRIPS regime, the country came into a 20 year protection regime from its earlier 7 years protection regime under the 1970 Indian Patent Act. For a very long time until 2008, India did not have a uniform law or normative framework governing publicly funded research in government funded labs and science agencies and in the vast number of universities.

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[40] The figure for India is taken from High Education Ministry sources (8 Aug 2011). For EU and other countries, See: http://epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/data/main_tables

[41] Report of the CABE Committee on Financing of Higher and Technical Education, June 2005; "Report to the Nation: 2006-2009," National Knowledge Commission; "Financing Requirements in Higher Education during XI Plan Period," Sudhanshu Bhushan, Chapter 10 in Higher Education in India: Issues related to Expansion, Inclusiveness, Quality and Finance, UGC, Nov 2008.

Universities and PROs were framing their own institution-based norms for IPR and this institutional variation in IPR norms in a large measure were not very conducive for technology transfer from lab to industry. At the same time there was no pressure or obligation for scientists and professionals to obtain IPR out of publicly funded research and much of the research output was in the form of research publications.

To compete in a global environment, India realised the need to protect and utilise the intellectual property created out of public funded research and development. The Protection and Utilisation of Public Funded Intellectual Property Bill (2008) was introduced in the upper house of Parliament on December 15, 2008. The Bill has been modelled on the United States Patent and Trademark Law Amendments Act, commonly known as Bayh-Dole Act (BDA). The Bill generated a lot of criticism and it was referred to the Standing Committee on Science and Technology, Environment and Forests. The Bill has been revised drastically since then, relaxing patenting norms for inventions and giving the government more control over the institutions. A total of 52 amendments have been made to the original draft. In August 2010, the Bill was again laid on the tables of upper and lower house of the Parliament which is still pending for approval. The Bill is likely to be passed before the end of 2011.

The Bill aims to provide for patenting as an obligation, technology transfer as a responsibility and royalty as a right to the scientists. This Bill further gives an obligation to the scientists to patent when there is something patentable because a lot of scientists do not want to patent or do not patent. Further, it makes obligatory on the scientists and the institutions to negotiate with companies for technology transfer. Additionally, educational institutions will benefit of royalties, increasing technological innovation and the growth of a skilled workforce. The income from intellectual property will promote self-reliance and will minimise dependence of universities, academic and research institutions and other recipient organisations for Government funding.

Universities in India did not have a tradition of establishing mechanisms for innovation such as Technology Transfer Offices (TTOs) with the possible exception of Indian Institutes of Technology. It is only recently, that the discourse on the new Bill has generated a good deal of policy discourse on the need to create TTOs in universities. As noted earlier, only 25 to 30% of 400 universities are engaged in research and this is the segment which will promote TTOs once the new Bill is finally adopted and becomes a law.

In the absence of an appropriate Bill, researchers in PROs and universities follow variable rules and norms for patent ownership and the revenues coming out from patent commercialisation. Most universities and research institutions allow between 50 to 70% of revenues to inventors and to project In-charge from patent and research commercialisation. These incentives are subject to national taxation laws, which stand at around 20 to 25%.

The Bill also seeks to address technology transfer issues by providing an intellectual property management committee or TTOs within the organisation. Not less than 30 % of the income or royalty coming out of the commercialisation of patents or technology transfer has to be given to the intellectual property creator. The income from intellectual property is deemed to promote self-reliance and minimise dependence of universities, academic and research institutions, and other recipient organisations for Government funding.

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

Spin-offs

Support systems for facilitating spin-offs in the universities have come into policy discourse only in the last few years. In India, universities are not well known for incubation and spin-offs for the knowledge transfer to industry. However, the Indian Institutes of Technology (IITs), seven of them located in different parts of India and recognised worldwide as leading engineering academic institutions have been quite active both in creating incubation units and producing spin-offs. Almost all IITs have institutionalised mechanisms to establish some form of incubation and technology transfer offices. As per the systematic data available up to 2008, the Five IITs have produced 86 spin-off firms mostly in telecommunications, ICT and electronics. IIT Madras has created Science Park in 2009 to further aid commercialisation of R&D.

On the other hand all PROs such as CSIR have well institutionalised mechanisms and organisational entities for incubation and spin-offs. An organisation called National Research Development Corporation (NRDC) already exists to commercialise CSIR technology and perform some venture capital type of activities in funding early stage research. CSIR holds one of the largest portfolio of patents in India. To augment the innovation capacity of CSIR an independent company, namely, CSIR Tech Private Limited has been created recently during May 2011.The two main objectives of CSIR Tech are:

- Leverage the energy and motivation of entrepreneurs and create start up companies as well as licensing opportunities to commercialise technology arising out of CSIR IP;
- Attract private investments to advance and commercialise early stage discoveries including proof of concept or seed investments to create spin offs.

CSIR Tech as a private firm will provide entrepreneurial, flexible organisation, capable of functioning in a competitive environment while at the same time ensuring the best returns on investment in R&D to CSIR. It works in close collaboration with CSIR laboratories to commercialise CSIR technologies and intellectual property primarily (but not exclusively) through the spin□off route (that is, by creating technology start ups) by identifying suitable spin□off opportunities, developing them further and then spinning them off as start□up enterprises.

CSIR has established an Open Source Drug Discovery (OSDD) mechanism to network institutions and various actors to share and exploit essential drugs with partner institutions.

Risk funding in India has come a long way from the 1980s, when the risk funding arm of ICICI Bank, Technology Development and Information Company of India Ltd (TDICI) was the only public sector VC funder in India. Though the first wave of VC funding in India came about with internet boom of late 1990s, the industry has matured over the years. The type of funding has changed too over time. While the initial funding was for established technologies, currently a whole lot of investors are focusing on technologies developed by domestic players. The VC industry is now populated by nearly 150 firms and the total investment has crossed over EUR14 b in 2009.

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

Since the phase of liberalisation and economic reforms after 1991, the business enterprise sector associations such as the Federation of Indian Chambers and Commerce and Confederation of Indian Industry together with Chambers of Commerce in different states have come to occupy an important position in the decision making process. The well known CEOs of business enterprises such as Ratan Tata of Tata Group of Companies, Anil Ambani and Mukesh Ambani of Reliance Industries, Asim Premji of WIPRO, Narayan Murthy of INFOSYS, Adity Birla of Birla Group, Mittals from Steel, among others, have come to occupy important positions in governing bodies of universities and PROs such as CSIS.

Inter-sectoral mobility

Institutional norms and rules governing researchers and professionals in India are not very conducive for the inter-sectoral mobility between public and private institutes as well as from universities to government funded PROs. Professionals will have to tender their resignation or give up employment in one sector to get into the other.

Promoting research institutions - SME interactions

The department of Scientific and Industrial Research has initiated several research and innovation schemes to forge science and industry links, particularly with the SMEs. Some important innovation schemes 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 & Utilisation Programme for Women. Two notable programmes under DST are Home Grown Technologies and Technology Development Board programme. The *Home-grown Technologies* programme is administered through the Technology Information and Forecasting and Assessment Council (TIFAC) under DST. Mainly projects are supported to commercialise Indian processes and technologies with easy loans and equity participation. Another important scheme from the Ministry of Information and Communication Technology that has had a big impact on regional development in the Indian context is the Software Technology Parks. There are some 45 Software Technology Parks including the famous Bangalore, Chennai, Hyderabad, Noida and Gurgoan, near Delhi. These Parks have catalysed PROs and SMEs interaction in a number of ways.

All the above schemes are not specifically formulated to impact regional development in the Indian context. But since the firms and business enterprises which take advantage of these schemes are located in different parts of India, these schemes have in fact impacted the regional development in India.

3.5 Cooperation, coordination and opening up national research programmes with the EU

This section assesses the effectiveness of national policy efforts aiming to improve the coordination of policies and policy instruments across the EU.

3.5.1 National participation in intergovernmental organisations and schemes

In FP7, already more than 140 projects in Indian research organisations have been selected for funding in over 90 projects so far in 2011[42].

India has been considered as a valuable partner for the EU in major international projects such as the International Thermonuclear Experimental Reactor (ITER) project, GALILEO, the European Satellite Navigation system, and the interlinking of India's Education Research Network, ERNET, to its pan European equivalent GEANT2.

The construction of **ERA** and its discourse in the European context has begun to have some influence on the research policies of India. The policy makers since 2008 have paid some attention to ERA as great opportunity for science and technology cooperation in 'big science' and 'high technology' areas. For instance, India entering into a deal with US and Nuclear Suppliers Group in 2008 has opened up a new era of cooperation in nuclear energy with some European countries such as France and Germany. The other S&T area which has some influence on India is space research as it launched satellites from European countries in the last two years. Rather than a threat, Indian political and S&T leaders see EU as an important area for science and technology cooperation. Secondly, India sees ERA as a good potential to expand business in the ICT software sector, particularly in the mobility of its software professionals. EU's ICT policy such as i2010 which aims at EU for Information Society has a tremendous potential as it promotes inclusive society accommodating diverse interests.

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 the period 2007-2013 has given a special focus on helping India meet the 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 2007-2008 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 XIth Plan 2007-12.

Participation in the EU Framework Programmes

2008 witnessed EU – India strategic partnerships in clean energy and climate change, ICT and nano technologies. In 2008, the two parties adopted a Joint Work Programme for EU-India Co-operation on Energy, Clean Development and Climate Change. Follow-up activities were confirmed at the Summit in November 2009, when the EU and India agreed to expedite cooperation activities on Climate Change mitigation, clean energy (clean coal technology, nuclear energy) energy efficiency and renewable energy (in particular solar energy).

India has become the fourth largest international partner for the EU under the 7th (2007-2013) EU Framework Programme for Science and Technological development

[42] See http://euroindiaresearch.org/fp7_india_indiaFP7.htm

(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 b 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 b since 2000.

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.[43] 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.[44] 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.

[43] ibid see also the article by R. Ramachandran
[44] 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.

Other EU developments

India now is also a partner in the European Union based Facility for Antiproton and Ion Research (FAIR) project contributing $US 35 m (28 million Euros). Apart from S&T cooperation, EC's cooperation with India for the period 2007-2013 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 2007-2008 with additional focus on higher education cooperation between leading EU universities and Indian universities.

3.5.2 Bi- and multilateral RDI agreements with EU countries

India has entered into bilateral agreements with a number of countries in the world across various sectors and areas of science and technology. The most important countries are USA, France, UK, Germany, Australia, Japan and some South East Asian Countries. The bilateral agreements currently in operation are shown in table below.

Country	Bilateral Agreement	Area/Sector	Indian Organisations
USA	Yes	Nuclear Energy, Agriculture, Energy, Space research, health	ISRO, DAE, ICAR,
France	Yes	Nuclear energy, fundamental research across various S&T Fields	ISRO, Indo-French Centre for Advance Research
Russia	Yes	Nuclear energy, Missile and cryogenic technology	DAE, ISRO
Germany	Yes	Renewable energy, power	Department of Non-Conventional Sources of Energy
Australia	Yes	Biological sciences, Astronomy, Quantum electronics	DBT, Raman Research Institute, IISc Banaglore
UK	Yes	Nano technology, biofuels, composite structures and advance electronics	CSIR, IISc, IITs
Japan	Yes	Biosensors, biomedical sciences, physical sciences	Universities in Delhi, Bangalore and Hyderabad, CSIR, IISc Banglaore

India has entered into multilateral agreements with EU, ASEAN and SAARC in various fields of science and technology.

3.5.3 Other instruments of cooperation and coordination between national R&D programmes

Not relevant for India

3.5.4 Opening up of national R&D programmes

In the Indian context there are no publicly funded national R&D programmes, which are open to foreign agencies. The foreign agencies and foreign researchers are allowed to participate in the national R&D programmes only through bilateral or multi-lateral agreements or through institution sponsored programmes in the mode of collaboration. The R&D programmes, operating on public – private partnerships in ICT software, biopharmaceuticals, space and nuclear energy, are open for foreign nationals to undertake research assignments from the side of Indian private partners.

3.6 International science and technology cooperation

3.6.1 International cooperation (beyond EU)

India accords high importance to international cooperation with third countries, particularly the industrially advanced countries such as USA, France, UK, Germany, Japan and Russia. Many of these countries dominate and lead in world scientific frontiers, while emerging countries such as India are catching up fast with these countries. Hence India is keen to promote international cooperation in emerging science frontiers such as nanotechnology, health related vaccines, biologics, space, nuclear and renewable technologies. Indo-US nuclear cooperation, which has opened up nuclear commerce for India through National Suppliers Group at IAEA, is a good example. In the face of challenges imposed by climate change and demand for energy, India has already initiated scientific cooperation with Germany and USA this area. The other good example is India's cooperation and participation in EU programmes on: a) **Facility-for-Antiproton-and-Ion-Research (FAIR)** project aimed at understanding the tiniest particles in the universe; b) European Union's **International Thermonuclear Experimental Reactor** (ITER) nuclear fusion energy project; and India's participation in the satellite based navigation system, **Galileo Project** (European version of USA's Global Positioning System).

Many of the cooperation projects identified above are of long term nature as these projects concern investigations more at the level of fundamental research with the exception of building nuclear reactors.

3.6.2 Mobility schemes for researchers from third countries

There are no specific mobility schemes for researchers from third countries.

4 CONCLUSIONS

4.1 Effectiveness of the knowledge triangle

India has taken a long time to make a transition from science and technology policies, which had a focus on the input side of the R&D spectrum, to embark upon a path of innovation policies. Currently, the country is developing its overall innovation policy where three distinct planks are easily discernible, namely, research, innovation and educational promotion. At the national level, the emerging innovation policy is attempting to forge close linkages between three main actors of the innovation system: the higher education (including research), the government and the business sector (public and private enterprises).

Given that around 68% of GERD is financed by the government, it is the main driver of knowledge triangle. Over the last five years, the Ministry of Science and Technology has initiated and operationalised a series of institutional measures and policy schemes to promote and strengthen the knowledge triangle. The Indian experience shows that knowledge triangle has evolved mainly in two sectors, namely, biotechnology and biomedical; and ICT software.

In biotechnology, the DBT, Biotechnology Consortium of India (which has over 150 biotech firms and institutions) and public research institutions including universities have evolved partnerships in developing and marketing vaccines, essential drugs and diagnostic products. The DBT has introduced a major innovation scheme known as Small Business Innovation Research Initiative (SBIRI).[45] As the website of DBT observes, 'the distinctive feature of SBIRI is that it supports the high-risk pre-proof-of-concept research and late stage development in small and medium companies lead by innovators with science backgrounds which is unique in nature to support private industries and to get them involved in development of such products and processes which have high societal relevance'.[46] To further support the biotechnology innovation, the DST also launched a BIPP, which forges the links between public and private enterprises.

Similar, knowledge triangle policies and innovation mechanisms have led to ICT software and pharmaceutical innovation knowledge hubs in Bangalore, Hyderabad, Delhi, Chennai and Pune. India has attracted over 250 Fortune-500 firms to set up R&D units or centers in these cities. This has also given a new thrust to Indian participation in the globalisation of innovation. Space research and innovation is another field where knowledge triangle has evolved in the last five years. Over 200 firms partner with Indian Space Research Organisation and Department of Space in designing and launching satellites. The sector is now set to compete with European and Russian space agencies in launching satellites.

The knowledge triangle based policies in science, technology and innovation have been quite effective in high technology sectors, catering to the emerging middle classes, the main problem and as well as challenge of knowledge triangle concerns the rural enterprises and sectors of economy. It is here that the poverty is quite widely prevalent.

[45] This innovation policy mechanism is modeled on the US SBIR programme.
[46] See http://dbtindia.nic.in/uniquepage.asp?id_pk=136 (accessed 8 Aug 2011)

To stimulate research intensity and generate demand for knowledge in the business enterprises sector, the government is recurrently strengthening various innovation policy measures and mix of policies ranging from tax incentives, soft loans and building infrastructure in the existing knowledge hubs. One of the main problems in administering these innovation policy measures is that DST and DSIR have not evolved adequate monitoring and evaluation methods.

In international cooperation, India has entered into R&D collaboration and partnered with countries in the EU in some high technology and 'big science' projects. This has opened up India's access to frontier science and technology fields in high energy physics, material sciences, space and ICT. In nuclear energy, India is partnering with Russia, USA and France to build over dozen new nuclear reactors in the coming decade.

The government, however, has committed a massive policy and budgetary provision to promote more than six or seven national programmes on inclusive development. India's innovation policies are still tilted in favour of high technology and global competition. What is needed is an appropriate institutional and governance structure which coordinates and networks the formal R&D structures and universities with the needs and demands of inclusive development programmes. For instance, there is only one major institutional structure in the form of the National Innovation Foundation established by the DST, Ministry of Science and Technology. Given the multiple challenges in health, urban renewal, the employment guarantee to poor, roads and infrastructure, among other programmes, all the major R&D agencies and laboratories and universities need to make institutional provisions and research centres for impacting India's rural economy and society.

One of the major problems for an economy the size of India's, compared to other emerging nations and the international context, is the very low level of gross expenditure on R&D. India is spending just over 1.13% of GDP on R&D, compared to 1.2% to 1.4% for Brazil and China and around 2.2% in the case of the OECD and EU. The economic down slide of 2008 has to some extent impacted Indian science and technology in the allocation of higher budgetary provisions for R&D to reach the committed level of 2% of GERD of GDP.

Table 3: Effectiveness of knowledge triangle policies

Knowledge Triangle	Recent policy changes	Assessment of strengths and weaknesses
Research policy	• National Science and Engineering Research Board (NSERB) for funding basic research • Innovation in Science Pursuit for Inspired Research (INSPIRE) for attracting young talents in science and technology • Nano Mission to build capacity in PROs toward global leadership • National Action Plan on Climate Change to promote 8 national missions	• Expanding basic research base in national innovation system • Underdevelopment of research – industry linkages • R&D budget thinly spread over many projects
Innovation policy	• Biotechnology Industry partnership Programme (BIPP) to promote public – private partnership and global	• Focus on SMEs and good response from biotech industry

	competitiveness in bio innovation. • The New Millennium Indian Technology Leadership Initiative (NMITLI) for technological leadership in some niche areas. • Establishment of National Innovation Council to strengthen the national innovation system and forge links between different actors.	• Poor university-industry relations • Underdevelopment of Venture Capital institutions
Education policy	• The Protection and Utilisation of Publicly Funded Intellectual Property Bill, 2008 • Encouraging and Development of Commercialisation of Inventions and Innovations - A New Impetus. • Right to education Bill	• Resistance from universities to focus on innovation and patenting over publications • Lacks of adequate incentives and fringe benefits to researchers to encourage mobility between different research and academic institutions. • Lack of teachers and slow expansion of educational institutions to train teachers to implement
Other policies	• India's Look East Policy • Policies on inclusive development	• Enhancing South – South Cooperation • India signed free trade agreements with ASEAN, Australia and SAARC countries • Creating employment opportunities in rural areas • Inadquate budget for inclusive development

4.2 Comparison with ERA 2020 objectives - a summary

Table 4: Assessment of the national policies/measures which correspond to ERA objectives

	ERA objectives	Main Policy Changes	Assessment of strengths and weaknesses
1	Ensure an adequate supply of human resources for research and an open, attractive and competitive labour market for male and female researchers	- Launching of a policy measures (INSPIRE) to expand the base of human resources and attract students to science disciplines - Expansion of higher education in science and engineering to increase the GER	- Increasing trend in the applications for science and technology disciplines - Relative stagnation in the research budgets of high educational institutions - Inadequate supply of teaching faculty in engineering disciplines
2	Increase public support for research	-R&D budget increased in absolute terms but decreased from 1.13% to 1% of GDP between 2005 and 2008	-Slow investment by business enterprises in R&D -Government commitment of increasing to 2% of GDP is not yet reached
3	Increase coordination and integration of research funding	-India participates as member of FP7 and other EU based international/big science projects as ITER, Galileo etc	- India gets access to advance science and benefits in training scientists in big science projects

	ERA objectives	Main Policy Changes	Assessment of strengths and weaknesses
4	Enhance research capacity	There are a number of national policies initiated by State governments to enhance research capacities through State Science and Technology Councils	- Weak organisational and institutional capacity - Weak regional policies in research and low level of research funding
5	Develop world-class research infrastructures (including e-infrastructures) and ensure access to them	Launched 3 schemes during 2009-2011.	- obsolete scientific instrumentation im many institutions due to shortage of budget - India is a late starter but catching up fast in world-class infrastructure
6	Strengthen research institutions, including notably universities	- Higher education budget in XI the plan increased by five times compared to earlier Xth Plan. - Several National Knowledge Commission recommendations accepted by government including to attain the target of 1500 universities in the decade.	-Expanding universities in quantity at the cost of quality and excellence - Humboltdian goal of increasing research intensity in universities is progressing very slowly.
7	Improve framework conditions for private investment in R&D	-Three new innovation measures and schemes including Venture Capital introduced to attract private investment -Strengthening knowledge hubs in major cities like Bangalore to attract FDI based R&D	- Policy measures and initiatives have begun to shown an impact in the last three years. - Inadequate level of venture capital related funds
8	Promote public-private cooperation and knowledge transfer	- Renewed policy focus for PPP and knowledge transfer	- Policies begun to have an impact resulting in innovations as electric car, vaccines etc. - Weak economics and management mechanisms at DST and DSIR
9	Enhance knowledge circulation	Direct policy measures and initiatives for knowledge networking and circulation for the South Asia Region.	This is the weakest link in the national innovation system.
10	Strengthen international cooperation in science and technology	-India is part of FP7 and other big science projects in EU -Close science and technology cooperation with USA in energy, agriculture and nuclear technology.	-Policy initiatives begun to impact India accessing frontier sciences and technologies - Has residual impact on SMEs
11	Jointly design and coordinate policies across policy levels and policy areas, notably within the knowledge triangle	-Robust policy initiatives in Non-Conventional Sources of Energy. - New IPR Bill formulated to encourage public research systems	-Knowledge Triangle emerging in renewable energy technologies -weak horizontal coordination of policies across different deparments dealing with economy, finance, science and technology and higher education and industry.
12	Develop and sustain excellence and overall	There are national policies concerning quality and	-The main weakness is that such policies are restricted to

	ERA objectives	Main Policy Changes	Assessment of strengths and weaknesses
	quality of research	excellence.	less than 25% of knowledge institutions including universities. -sustaining excellence is difficult due to low R&D budget levels
13	Promote structural change and specialisation towards a more knowledge - intensive economy	Policies on ICT, biotechnology space and telecommunications are geared towards knowledge intensive economy	-ICT and telecommunications prioritised over other sectors - Education access and low literacy rates are stumbling structural problems
14	Mobilise research to address major societal challenges and contribute to sustainable development	India has launched National Action Plan on Climate Change with Prime Minister steering the research agenda	- Special research and innovation focus on renewable energy and energy efficiency. - low technological capabilities of firms in renewable energy technologies.
15	Build mutual trust between science and society and strengthen scientific evidence for policy making	-India has put in place relevant policies on risk for GM technologies, nuclear technologies	- Ad hoc decision making weakens evidence based policy making - Democratisation of science decision making is slow - Civil society organisations play an important part in evidence based policy

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List of Abbreviations

AEC	Atomic Energy Commission
AICTE	All India Council of Technical Education
ASEAN	Association of South East Asian Nations
BIPP	Biotechnology Industry Partnership Programme
CABE	Central Advisory Board of Education
CSIR	Council of Scientific and Industrial Research
DBT	Department of Biotechnology
DSIR	Department of Scientific and Industrial Research
DST	Department of Science and Technology
FAIR	Facility for Antiproton and Ion Research
FDI	Foreign Direct Investment
FTEs	Fool Time Equivalents
HEIs	Higher Educational Institutions
HGT	Home Grown Technology
HRST	Human Resources in Science and Technology
GER	Gross Enrolment Ratio
ICAR	Indian Council of Agricultural Research
INSPIRE	Innovation in Science Pursuit for Inspired Research
IISER	Indian Institute of Science, Education and Research
ISST	Institute of Space Science and Technology
ISRO	Indian Space Research Organisation
ITER	International Thermonuclear Experimental Reactor
JRF	Junior Research Fellowship
MHRD	Ministry of Human Resource and Development
NAPCC	National Action Plan on Climate Change
NASSCOM	National Association of Software Service Companies
NACC	National Assessment and Accreditation Council
NAB	National Board of Accreditation
NET	National Eligibility Test
NREGS	National Rural Employment Guarantee Scheme
NSERB	National Science and Engineering Research Board
NKC	National Knowledge Commission
NMITLI	The New Millennium Indian Technology Leadership Initiative
RGCB	Rajiv Gandhi Centre for Biotechnology
RSIC	Regional Sophisticated Instrumentation Centers
SAARC	South Asian Association for Regional Cooperation
SBIRI	Small Business Innovation Research Initiative
SERC	Science and Engineering Research Council
TDDP	Technology Development and Demonstration Programme
TIFAC	Technology Information Forecasting Assessment Council
UGC	University Grants Commission