

Country Report: India

Introduction

India has experienced a renaissance of sorts in the last 25 years. After the initial burst of energy and enthusiasm in the early years after Independence, during which India broke decisively from over a century of lack of development and progress, the country passed into nearly two decades of crisis and slower growth. For many decades, innovation was the province of the U.S., Europe, and Japan. Those days are over. Innovation today is taking place at a rapid pace on a global scale, wherein the Transition Economies are the hot beds of activity. India has a proud record of innovation in a number of fields, e.g. satellite technology, mathematics, and particularly, pharmaceutical chemistry. Recently, the economic and social growth of India has made it a world focus for investment in innovation across a broad spectrum of industries; notably in IT, nanotechnology and pharmaceutical/biotechnology R&D. India has now regained its innovative spirit. As a result, creativity can be seen in all walks of life in India. Sectors such as software, computers, microelectronics, automobiles, Aerospace, telecommunications, biotechnology, Medicare, pharmacy, entertainment, construction, heavy engineering and others have greatly benefited by the spirit of Indian innovation.

The new challenge is to move from “mind to market” as quickly as possible. This is particularly relevant to rural and grassroots innovations. Along with CSIR, the Department of Science and Technology and the National Institute of Immunology (NII), which are major innovation centres, The National Innovation Foundation and Gujarat Grassroots Innovation Augmentation Network (GIAN) are all engaged in taking grassroots innovations to the market place. The Rural Innovation Network is another organization engaged in this sector.

To top it all, Government impetus through schemes, primarily run by the three divisions of the Ministry of Science and Technology are the prime engines of Innovation related growth in India. Given below is a brief comparison of the schemes and the areas they support. This text provides an overview of the different Centres of Science and their programs which encourage Innovation and provide the space for R&D Institutions, Academia, Networks and Individuals to think out of the box. This support to creative thinking enables different agencies and individuals to work towards forging Indian interests in the global arena. Figures 1 and 2 try to capture the S&T system in India, the various Central government S&T departments. Figure 3 shows the various institutions linked with the Department of Science and Technology which will be discussed in detail in later sections.

Figure 1- Science and Technology System in India

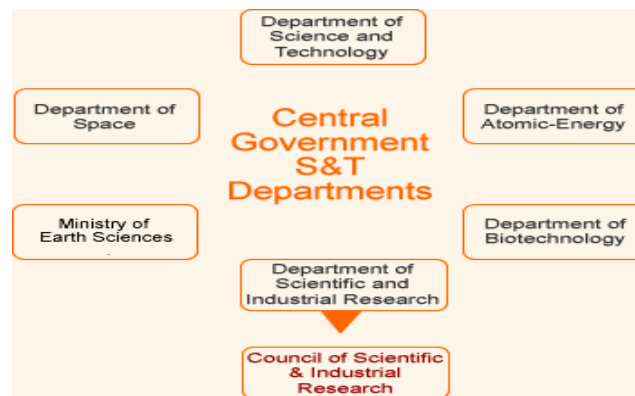


The section has been bifurcated according to the typology of support- direct support and indirect support. Under direct support, there are subsections on the various departments of science and technology supporting innovation through several schemes and programmes- Department of Science and Technology, Department of Scientific and Industrial Research and Department of Bio Technology. This is followed by other centres and programmes of science and technology. Under the section on indirect support there are subsections on different ministries that are indirectly related to innovation.

Direct Support

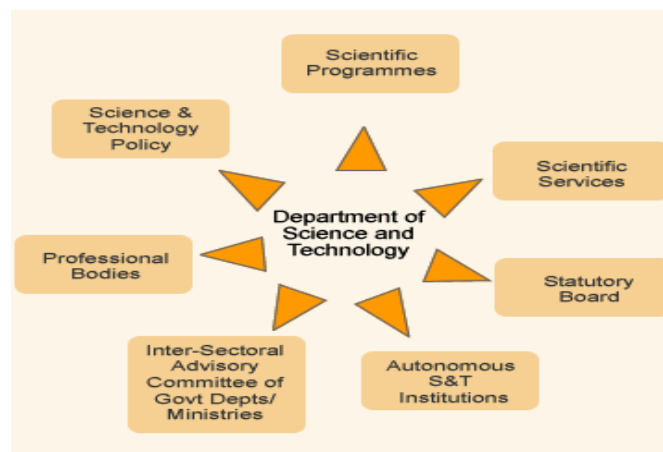
1. Department of Science & Technology (DST) (figure 2) was established in May 1971, with the objective of promoting new areas of Science & Technology and to play the role of a nodal department for organizing, coordinating and promoting S&T activities in the country. The Department plays a pivotal role in promotion of science & technology in the country. It has wide ranging activities from promoting high end basic research and development of cutting edge technologies on one hand to service the technological requirements of the common man through development of appropriate skills and technologies on the other.

Figure 2- Organogram of the Central Government S&T Departments



The organizational structure of the various departments within the DST is displayed in Figure 3. Some of the schemes of DST are detailed below.

Figure 3- Department of Science and Technology



(a) Technopreneur Promotion Program (TePP): Objective of the program is to tap the vast innovative potential of the citizens of India. TePP will be crucial to promote individual innovators to become technology based entrepreneurs (Technopreneurs)

- **TePP Phase I (innovation incubation):** Towards any independent innovator testing radically (Maximum support Rs 0.75 lakhs) new ideas with computer generated models. Any independent innovator/ start-up firm for (Max support Rs 15 lakhs) developing function proving prototypes.
- **TePP Phase II (enterprise incubation):**
 - i. Supplementary TePP Fund (STF) Successful TePP innovators of TePP Phase-I (max support Rs 7.50 lakhs) for licensing technology to a third party.
 - ii. Seamless scale-up support (S3T) Successful TePP innovators of TePP Phase-I (max support Rs 45 lakhs) for starting own enterprise.

(b) Scheme for Young Scientists (SYS-SS): The aim is to provide opportunities to young scientists for pursuing innovative research ideas which have direct bearing on social problems; to give them opportunities for interaction and exchange of ideas with the scientific community; to involve young scientists in national S&T development process through fellowships in selected NGOs and to take up activities which are conducive to attainment of the above objectives.

(c) The Entrepreneurship Development Cell (EDC): The Entrepreneurship Development Cell (EDC) scheme was initiated to develop institutional mechanism to create entrepreneurial culture in S&T academic institutions and to foster techno-entrepreneurship for generation of wealth and employment by S&T persons. The EDCs are established in academic institutions (science, colleges, engineering colleges, universities, management institutes) having requisite expertise and infrastructure. Objectives of EDC include:

- To act as an institutional mechanism for providing various services including information to budding S&T entrepreneurs.
- To create entrepreneurial culture in the parent institution and other institutions in the region and to promote the objectives of NSTEDB, including programs related to women and weaker sections of the society.
- To foster better linkages between the parent institution, industries and R&D institutions in the region and other related organisations engaged in promoting Small & Medium Enterprises (SMEs) including NGOs and other voluntary organisations.
- To catalyze and promote development of S&T based enterprises and promote employment opportunities.
- To respond effectively to the emerging challenges and opportunities both at national and international level relating to SMEs and micro enterprises.

(d) Science & Technology Entrepreneurship Development (STED): Launched in 1985, the scheme proposed to provide a basket of technically feasible and economically viable project profiles of enterprises that could be promoted by local S & T entrepreneurs using the local untapped resources. STED was reconstituted in 1996-97 to include eminent scientists, technologists, economists and social activists were invited as its members. Objectives of STED are as follows:

- To identify possible resource based projects in the region covering both rural and urban areas.
- To identify S&T intervention (like technology selection, modification, alteration and dissemination) for exploiting the opportunities by prospective entrepreneurs.
- To improve working of existing enterprises through S&T intervention to upgrade the technology and modernization of units.

- To organize regular enterprise awareness programs and skill development programs for creating suitable entrepreneurial environment in the district.
- To launch at least 200 micro-enterprises in the district during the four years of duration in which at least 50 technology-driven micro-enterprises are to be in technology specific areas as identified by the implementing agency earlier.

(e) The Science & Technology Entrepreneurs Park (STEP): The STEP program was conceptualized to reorient the outlook towards innovation and entrepreneurship and emphasize the role of information exchange, sharing of experience and facilities and opening new avenues for students, teachers, researchers and industrial managers to grow in a trans-disciplinary culture. Objectives can be defined as follows:

- To forge a close linkage between universities, academic and R&D institutions on one hand and industry on the other.
- To promote entrepreneurship among Science and Technology persons, many of whom were otherwise seeking jobs soon after their graduation.
- To provide R&D support to the small-scale industry mostly through interaction with research institutions.
- To promote innovation based enterprises.

(f) Technology Business Incubator (TBI): The need for instruments such as TBI has been recognized the world over for initiating technology led and knowledge driven enterprises. Studies also show that such mechanisms help not only in the growth of technology based new enterprises but also in improving their survival rate substantially (from 30 per cent to over 70 per cent). Some services under the scheme include business planning and training, technical assistance, syndicating finance among others. The objectives of the scheme are as follows:

- Creation of technology based new enterprises
- Creating value added jobs & services
- Facilitating transfer of technology
- Fostering the entrepreneurial spirit
- Speedy commercialization of R&D output
- Specialized services to existing SMEs

2. The Department of Scientific and Industrial Research (DSIR) has a mandate to carry out activities relating to indigenous technology promotion, development, utilization and transfer. The primary endeavor of this department is to promote R&D by the industries, support a larger cross section of small and medium industrial units to develop state-of-the art globally competitive technologies of high commercial potential, catalyze faster commercialization of lab-scale R&D, enhance the share of technology intensive exports in

overall exports, strengthen industrial consultancy & technology management capabilities and establish user friendly information network to facilitate scientific and industrial research in the country. It also provides a link between scientific laboratories and industrial establishments for transfer of technologies through National Research Development Corporation (NRDC) and facilitates investment in R&D through Central Electronics Limited (CEL).

(a) Industrial R&D Promotion Program (IRDPP) has as its primary function to grant recognition to in-house R&D units in Industry, Scientific and Industrial Research Organizations (SIROs); and registration to Public funded research Institutions, universities, IIT's, IISc, Regional Engineering College (RECs), other than hospitals. The broad objectives are to:

- Bring in-house R&D into sharper focus;
- Strengthen R&D infrastructure in industry and SIROs;
- Promote R&D initiatives of the industry and SIROs ;
- Ensure that the contributions made by the in-house R&D centers and SIROs dovetail adequately in the overall context of technological & industrial development

(b) Technology Development and Innovation Program has 2 following components-

- Technology Development and Demonstration Program (TDDP) Earlier known as “Program Aimed at Technological Self-reliance” (PATSER)] to promote industry’s efforts in development and demonstration of indigenous technologies, development of capital goods and absorption of imported technologies.
- Technopreneur Promotion Program (TePP) (*Refer to listing provided above*).

The program is targeted at catalyzing and supporting activities relating to technology absorption, adaptation and demonstration including capital goods development, by involving industry and R&D organizations. The specific objectives of the program are:

- supporting industry for technology development, demonstration and absorption of imported technology
- building indigenous capabilities for development and commercialization of contemporary products and processes of high impact.
- involvement of national research organizations in joint projects with industry
- technology evaluation in selected sectors.

(c) Technology Management Program is to enhance knowledge and skills in the efficient transfer and management of technology. The Division has steadily enhanced its operations over the years to meet changing demands in tune with the dynamic environment for innovation. This has also been due to global changes wherein several phenomena have been

taking place: innovation has gained focus, research has become of far greater consequence, technology life cycles have become much shorter, products have considerable variety and far shorter life spans, new product development has become paramount, rapid generation and commercialization of new technologies has become necessary.

(d) International Technology Transfer Program (ITTP) gains significance as Internationalization of technologies and production is becoming a common phenomenon for attaining and retaining global competitiveness. The program is aimed at supporting activities relating to promotion of international technology transfer and trade including export of technologies, projects, services and technology intensive products, with India as the focus. It was launched in 2005.

(e) Consultancy Promotion Program was begun in 2003 to strengthen consultancy capacities of domestic companies and for skills up gradation, since the consultancy profession growth in India has not kept pace with the industrial and economic developments over the years. Thus, there is a need to support and strengthen the domestic consultancy capabilities, in order to meet the emerging challenges and business opportunities in domestic and export markets, particularly in the context of new policy environment and WTO. Objectives can be outlined as:

- To promote and strengthen consultancy capabilities for both domestic and export markets.
- To support to Consultancy Development Centre (CDC) and other promotional organizations related to consultancy
- To take up Human Resource Development activities that includes fellowships to bright & promising engineers as apprentices with eminent consultancy organizations, arrange training etc.
- To Support R&D efforts of consultancy organizations and commercialization of indigenous technologies
- To organize Seminars, Workshops, etc. and document consultancy capabilities.
- Create awareness among users of consultancy

(f) Technology Information Facilitation Program” (TIF) is one of the components of Technology Promotion, Development and Utilization (TPDU) Program. In today’s scenario, given the quality of connectivity, it is being strongly felt that the Program should endeavor to strengthen the resource base of available information and provide a mechanism for optimal utilization of the resources in the country. TIF would also facilitate collaborative research among industries and institutions. TIF therefore, will be implemented as a co-operative and collaborative venture and built around the existing infrastructure, wherever possible. In this the strategy would be to:

- Concentrate on creation of Indian S&T content
- Avoid duplication of efforts
- Ensure minimum overlapping
- Promote maximum utilization of existing facilities
- Utilize the internet technology.

Broad objective of the program is to generate endogenous capacities for the development and utilization of digital information resources and provide inputs to S&T research and industrial development. Specific objectives:

- develop appropriate endogenous information capacities to support the R&D activities,
- support the production of local content and promote use of indigenous knowledge,
- promote information and knowledge networking at local, regional and national levels to facilitate flow and sharing of information resources,
- map the national S & T productivity in relation to the international trend,
- support education, training and R & D in digital content development and utilization
- promote national and international cooperation in related areas.

(g) Technology Development & Utilization Program for Women (TDUPW) has been formulated in order to meet the specific needs of women and to enhance the contribution of women towards technology capability building. Objectives include:

- Promoting the adoption of new technologies by women.
- Awareness creation and training of women on technology related issues with regard to women.
- Promoting Technological up gradation of tiny, small and medium enterprises run by women entrepreneurs.
- Showcasing of appropriate technologies and organizing demonstration programs for the benefit of women
- Design and development of products, processes beneficial to women

(h) New Millennium Indian Technology Leadership Initiative is the largest public-private-partnership effort within the R&D domain in the country. It looks beyond today's technology and thus seeks to build, capture and retain for India a leadership position by synergising the best competencies of publicly funded R&D institutions, academia and private industry. The Government finances and plays a catalytic role. NMITLI seeks to catalyze innovation centered scientific and technological developments as a vehicle to attain for Indian industry a global leadership position, in selected niche by synergizing the best competencies of publicly funded R&D institutions, academia and private industry.

3. The Department of Bio-Technology was set up in 1986 and has contributed significantly to the application of Biotechnology to various sectors such as health-care, environment, industry & agriculture etc. resulting in new products & processes. Technology transfers, filing of patents and interaction with the scientific community for adequate utilization of their expertise and close interaction with the state Governments for biotech application projects, are some important work areas.

A particular scheme of relevance to innovation, initiated in the year 2006, is the **Small Business Innovation Research Initiative (SBIRI)** whose distinctive feature supports high risk, pre-proof of concept research and late stage development in small & medium scale companies led by innovators with science background. It is unique feature to support private industries and to get them involved in development of products and processes which have high societal relevance. In addition is also strives to boost public-private partnership efforts in the country. Biotech industries being at the forefront, research in this area has an immense potential for commercial applications in areas of agriculture, environment, industry & health care. This unique scheme, which funds the industry directly, is a big boost for the small companies. Objectives:

- to provide support for early stage, pre-proof-of-concept research in biotechnology by industry,
- to support late stage development and commercialisation of new indigenous technologies particularly those related to societal needs in the healthcare, food and nutrition, agriculture and other sectors,
- to nurture and mentor innovative and emerging technologies/entrepreneurs, to assist new enterprises to forge appropriate linkages with academia and government.

4. Centres and Programs of Science and Technology: The three main Centres are the All India Council for Technical Education, the International S&T cooperation wing and the Asian and Pacific Centre for Transfer of Technology, all of which are discussed below.

(i) All India Council for Technical Education was established by an Act of Parliament in 1988 with a view to promote proper planning and co-ordinated development of technical education system throughout the country. As a part of its functions, AICTE provides financial assistance to promote research and development in technical institutions and to enhance industry Institute Interaction. All the schemes mentioned below are research related schemes of the Council:-

(a) Nationally Coordinated Project Scheme aims to plan, co-ordinate and execute integrated R&D programs, involving collaboration between several institutions, industry

user organizations at National Level for societal Development. The broad objectives include:

- To plan, co-ordinate and execute integrated R&D programs, involving collaboration between several institutions, industry user organizations at National Level for societal Development Program.
- To aim and achieve break- through technology in relevant specific areas of national importance.
- To enhance national and international interaction, research dissemination and exchange of ideas in the areas of national importance (*national societal problems- such as Disaster Mitigation, Air Pollution, Earth Quake resistant structures, Road Traffic Safety etc.*)
- To provide recommendations and guidelines which will help to evolve national policies and regulatory laws for enactment in concerned areas.
- To develop education program for awareness of masses and to suggest appropriate measures in concerned areas.

(b) Scheme for Industry Institute Partnership Cells has as its objective to reduce the gap between industry expectations (practice) and academic offerings (theory) by direct involvement of industry to attain a symbiosis.

All the Stakeholders, namely: Institutions, Industry, Students and Society stand to gain as it can be a win-win partnership. The Institutions stand to gain by way of up to date curricula, source of revenue generation by consultancy and R & D, source of manpower for employment, societal relevance, and most importantly acquisition of brand name/equity; industry stands to gain by way of availability of employable manpower pool, and increased productivity; faculty stand to gain by way of exposure to latest industry practices for more effective teaching-learning processes, etc; students stand to gain by way of hands-on training, reduction of learning curve in industrial practices; and, society stands to gain by way of improved quality of goods and services.

The AICTE would provide financial assistance to the selected institution for meeting the recurring expenditure maximum of Rs.5.00 lakhs for maximum five full operational years subject to satisfactory yearly performance. The AICTE would also provide limited one time financial assistance, up to a maximum of Rs.5.00 lakhs, required for non-recurring expenditure. The parent institution should provide adequate building space for setting up of IIPC and also usage of classrooms for training, conference room, library, workshops, laboratories, etc. to the IIPC for its activities.

(c) Scheme for Entrepreneurship Development Cell is presented in the main text as it is also a scheme of National Science and Technology Entrepreneurship Development Board, DST.

(d) National Facilities in Engineering and Technology with Industrial Collaboration scheme was launched with the objective to establish National Facilities in the frontier areas of engineering and Technology in collaboration with industry. Some of the representative activities admissible under proposed National Facilities are as follows:

- To provide state-of-the-art R&D facilities in specific areas of engineering and technology for intramural research and development, education and training.
- To provide sophisticated testing, instrumentation and design facilities to industry in specialized/ emerging areas of engineering and technology.
- To provide necessary expertise, facilities and know-how for undertaking R&D projects on a turnkey basis, in emerging inter-disciplinary areas of relevance to industry.
- To aim and achieve break-through in relevant specific technology areas.
- To aim at intensifying technology transfer from participating Institution for the benefit of industrial development.

AICTE Seed Grant will be one time not exceeding RS 50,000, for the purpose of preparing a detailed project report. AICTE Financial Contribution will be 50% of the total estimated cost, for a maximum limit of Rs fifty lakhs for three years.

(e) Modernisation and removal of Obsolescence (MODROBS) scheme aims to modernize and remove obsolescence in the Laboratories / Workshops / Computing facilities (Libraries are excluded), so as to enhance the functional efficiency of Technical Institutions for Teaching, Training and Research purposes.

The equipment financed under the scheme up to a limit of Rs 15 lakhs could be ideally used for up gradation of equipment in existing laboratories; enhancement of performance parameter specification of existing equipment, incorporation of latest development in the field and replacement of old depreciated equipment by modern equipment.

(f) Research promotion scheme aims to create research ambience in the institutes by promoting research in engineering sciences and innovations in established and newer technologies; and to generate Master's and Doctoral degree candidates to augment the supply of research experience faculty and research personnel in the country.

The objective of this scheme is to create and update the general research capabilities of the faculty members of the various Technical Institutes. The proposal should include a specific project theme with a clear statement of the objectives, details of equipments and other research facilities proposed to be acquired and the expected deliverables from the project.

Towards fulfilment of its mandate, the Council has constituted two Advisory Boards to assist in the implementation of specific programs and schemes. The boards, viz. **Board of Research and Institutional Development** and **Board of Industry-Institute interaction** consist of eminent scientists, engineers, technologists, academicians and industrialists.

There are eight other Faculty Schemes are given in Box 1 so as to complete a comprehensive listing of the schemes available from AICTE but since they don't directly promote innovation, they are not being detailed.

Box 1: Faculty Schemes of AICTE

1.	Quality Improvement Program
2.	Early Faculty Induction Program
3.	Career award for young teachers
4.	Emeritus Fellowship
5.	National Doctoral Fellowship
6.	Faculty Development
7.	Staff Development
8.	Visiting Professorship

(ii) The Science & Technology International Cooperation Division 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 organizations. 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 (Box 2).

Box 2: Cooperation with countries

Cooperation with Countries
Argentina ; Armenia ; Australia ; Bangladesh ; Belarus ; Brazil ; Bulgaria ; Canada ; China ; Colombia ; Croatia ; Cuba ; Czech Republic ; Cyprus Egypt ; Estonia ; European Union ; France ; Germany ; Hungary ; Iceland ; Indonesia ; Iran ; Israel ; Italy ; Japan ; Kazakhstan; Dpr Korea (North Korea) ; Kyrgyzstan ; Laos ; Lebanon ; Libya ; Malaysia; Mauritius ; Mexico ; Moldova ; Mongolia ; Mozambique ; Myanmar ; Namibia ; Nepal ; Northern Ireland ; Oman ; Peru ; Philippines ; Poland ; Portugal ; Russia ; Romania ; Republic Of Korea (South Korea) ; Serbia ; Singapore ; Slovak Republic ; Slovenia ; South Africa ; Spain ; Sri Lanka ; Sudan ; Switzerland ; Syria ; Tajikistan ; Thailand ; Trinidad &Tobago ; Tunisia ; Turkey ; Ukraine ; USA ; United Kingdom ; Uzbekistan ; Venezuela ; Vietnam ; Yemen ; Zambia
Cooperation with Regional Organisations
ASEAN- Association of South East Asia Nation Indo STEPAN (Science & Technology Policy Asian Network) SAARC (India, Nepal, Bangladesh, Pakistan, Srilanka, Maldives, Bhutan) NAM- Non-Aligned Movement
Multilateral programs
UNESCO UNDP BIMST-EC (Bangladesh, India, Myanmar, Srilanka, Thailand) IOR- EC (Indian Ocean Rim) TWAS Indo European

Functions of the organization include research and analysis of trends, conditions and opportunities; advisory services; dissemination information and good practices; networking and partnership with international organizations and key stakeholders and last but not the least training of national personnel, particularly national scientists and policy analysts. The Focus areas include (a) technology transfer and specifically for SMEs, technology transfer and marketing mechanisms and search for technology buyers and sellers; (b) environmental technology and (c) innovation management.

Innovation Management: Small and Medium Enterprises (SMEs) in the Asia- Pacific region have to gear up and be up-to-date with various issues concerning innovation and innovation management. In cooperation with the a -Pacific countries, APCTT develops and implements national and international programs for building national capabilities to assist entrepreneurs and SME's in the area of:-

- Innovation and Managing Innovation
- New and emerging technologies
- Traditional technologies
- Intellectual Property Rights
- Technology Incubation

- High tech entrepreneurship development
- Green productivity

The table below (Table 1) provides a comparative analysis of all the direct programmes under the three departments- Department of Science and Technology, Department of Science and Industrial Research and Department of Bio technology.

Table 1- Comparative Analysis of Direct Programme on Innovation

Department of Science and Technology							Department of Science and Industrial Research								Dpt. of Bio Technology
Scheme	TePP	SYS	ED C	STE D	STEP	TB I	NMITL I	IRDPP	TDD P	TM P	ITT P	CMP	TIF	TDUP W	SBIRI
Stage															
Incubation	√	√	√	√	√	√		√	√		√	√	√	√	√
Growth							√			√					
Development															
Beneficiary/Proposer/Co-ordination Responsibility															
Firm	√		√		√	√		√							
Individual	√	√													
R&D Institutions			√	√	√	√	√	√	√	√		√	√		√
Academic Institutions			√	√	√	√	√			√		√	√		
NGO				√							√				
Scientific and Industrial Research Organization								√							
Industry							√		√	√					√
Consultancy										√	√	√			
State Government										√					
Central Government										√					
International Agencies/UN										√	√				
Association										√	√		√		
Area of support															

Grant	√	√	√	√			√								√
Market Survey				√		√						√			
Counseling				√	√	√									
Preparation of Opportunity Profiles				√		√									
Technical Assistance						√									
Syndicating Finance						√									
Arranging Legal and IPR issues						√									
Write off Revenue expenditure								√							
Write off Capital expenditure															
Duty free import								√							
Weighted Tax deduction								√							
Income tax exemption of 125% to donations								√							
Custom duty exemption								√	√						
Research										√	√	√	√		
Training					√	√					√	√			
Publicity and awareness creation											√		√		
Manpower													√		
Consumables													√		
Infrastructure					√										

Indirect Support

There are several Central Government Ministries and programs that indirectly complement innovation promotion initiatives for examples through skill training or through technology upgradation schemes; in particular the Ministry of MSME and the Ministry of Labor have schemes to support technology diffusion and skill development. In addition to these Central Government Ministries, programs of some institutions, in particular Small Industries Development Bank of India (SIDBI) and State Bank of India (SBI) have schemes promoting technology upgradation in SMEs.

India's innovative performance

India is generally referred to as an emerging knowledge superpower although her current record on this issue is rather mixed. We seek to analyse this record by employing a variety of conventional indicators as new indicators such as those emanating from innovation surveys are not available in the Indian context for the present¹. Three conventional indicators are used:

- i. Trends in R&D investment;
- ii. Trends in patenting;
- iii. Trends in technology trade balance

To the extent possible, the analysis is conducted in a comparative fashion by taking China as the comparator country.

¹ The Department of Science and Technology (DST), Government of India is in the process of conducting a pilot innovation survey by employing a CIS compliant survey instrument. The results of this pilot survey may become available through June 2008 and this is to inform a larger nation wide innovation survey to be conducted during the latter half of 2008.

Table 1: Trends in R&D Investment, 1980-81 through 2003-04 (Rs in Millions)

	Gross Expenditure on R&D (Rs in Millions)		Nominal growth rate (%)	Real Growth rate	GERD to GDP ratio
	At Current Prices	At Constant Prices (Base Year:1993-94)			
1980-81	7605.2	23421.6			
1981-82	9407.3	26297.1	23.70	12.28	0.58
1982-83	12060.3	31175.4	28.20	18.55	
1983-84	13811	32786.4	14.52	5.17	
1984-85	17815.5	39386.3	29.00	20.13	
1985-86	20687.8	42611.4	16.12	8.19	0.83
1986-87	24354	46868.1	17.72	9.99	0.88
1987-88	28530.7	50202.3	17.15	7.11	0.91
1988-89	33472.6	54345.1	17.32	8.25	0.9
1989-90	37257.4	55858	11.31	2.78	0.86
1990-91	39741.7	53972.4	6.67	-3.38	0.78
1991-92	45128.1	53867.9	13.55	-0.19	0.77
1992-93	50046	54947.8	10.90	2.00	0.79
1993-94	60730.2	60730.2	21.35	10.52	0.78
1994-95	66224.4	60425.3	9.05	-0.50	0.70
1995-96	74838.8	62634.4	13.01	3.66	0.70
1996-97	89136.1	69497	19.10	10.96	0.72
1997-98	106113.4	77507.6	19.05	11.53	0.76
1998-99	124731.7	84362.6	17.55	8.84	0.78
1999-00	143976	93751	15.43	11.13	0.82
2000-01	161988	101962.8	12.51	8.76	0.85
2001-02	170381.5	103720.9	5.18	1.72	0.82
2002-03	180001.6	105225.7	5.65	1.45	0.80
2003-04*	197269.9	111989.3	9.59	6.43	0.78
Average rate of growth (pre reform)			18.17	8.91	0.81
Average rate of growth (post reform)			13.22	6.57	0.77

Source: Department of Science and Technology (2006)

Note: Pre reform refers to the period 1980-81 through 1990-91 and post reform refers to the period 1991-92 through 2003-04; For the pre reform period it is GERD to GNP ratio, but given the fact that in India the ratio of GDP to GNP works out to unity, it does not really matter whether one takes to ratio of GERD to GDP or GNP.

The following inferences can be drawn from the above Table: (a) Both in nominal and in real terms, there has been a decline in the overall GERD; and (b) Even the GERD to GDP ratio too have declined during the post reform period. From this, one has to be very cautious in drawing any strong inferences about the innovative potential of the country. This is because much of the overall R&D (GERD) of the country is performed in the public sector in defense, space, atomic energy, health and agriculture. Industrial R&D forms only about 20 per cent of the GERD. However the share of the industrial sector has shown much increase (Table 2) during the period.

Sector of performance of R&D: See Table 2. In India much of the R&D is actually performed by the government or public sector. However the share of the business enterprises sector has shown some sharp increases. It now accounts for about 20 per cent of the R&D. The corresponding figure for China is as much as 64 per cent. The higher education sector represented by universities and research institutes accounts for only 5 per cent of total R&D performed in the country. Notwithstanding the data problems, it is clear that the share of this sector has only shown some slight increases during this period.

Table 2: Sector of performance of GERD in India, 1970-70 through 2004-05 (% shares)

	Government	Industry	Higher Education
1970-71	89.55	10.45	
1975-76	88.13	11.87	
1980-81	84.13	15.87	
1985-86	87.82	12.18	
1990-91	86.16	13.84	
1995-96	78.26	21.74	
1998-99	75.79	21.17	3.04
1999-00	77.21	18.46	4.33
2000-01	77.94	18.05	4.02
2001-02	76.48	19.33	4.20
2002-03	75.56	20.27	4.17
2003-04	75.44	20.05	4.51
2004-05	73.92	19.81	4.88

Source: Department of Science and Technology (2006)

Growing privatization of Industrial R&D: Mani (2007) had shown that increasingly much of the industrial R&D is actually expended by private sector enterprises. I extend this analysis to the most recent period for which data are available (Table 3) and finds that this is indeed the case. An important hypothesis that these data (as contained in Table 1 through 3), is that one sees a decline in the growth rate of industrial R&D when increasingly that R&D is performed by private sector enterprises. Does this mean that the private sector is experiencing any *Arrowian appropriability* problems? This hypothesis makes the study of external financing of industrial R&D in India a relevant one. During this phase when investments in R&D are declining one sees that the government is putting in place a number of financial support measures that seeks to reverse this declining trend. A study of the effectiveness of these financial measures thus assumes much significance.

Table 3: Growing privatization of industrial R&D in India, 1985-86 to 2002-03 (Rs in Millions at current prices)

	Government			Private Sector enterprises	Industrial R & D	Share of Private Sector In Total Industrial Development
	Public Sector Enterprises	Govt. Research Institutions	Total government			
1985-86	1986.18	1622.7	3608.88	2519.44	6128.32	41.11
1986-87	2356.99	1723.36	4080.35	2916.33	6996.68	41.68
1987-88	2884.66	1851.29	4735.95	3102.67	7838.62	39.58
1988-89	3421.24	2093.28	5514.52	4176.25	9690.77	43.10
1989-90	4129.01	2395.21	6524.22	4905.94	11430.16	42.92
1990-91	4145.33	2491.88	6637.21	5499.81	12137.02	45.31
1991-92	4843.88	2745.50	7589.38	6369.44	13958.82	45.63
1992-93	5139.50	2993.65	8133.15	8362.47	16495.62	50.70
1993-94	5428.11	NA	NA	9825.37		
1994-95	4146.09	3564.00	7710.09	13188.70	20898.79	63.11
1995-96	4275.76	4116.99	8392.75	16270.69	24663.44	65.97
1996-97	5360.52	4440.00	9800.52	23307.50	33108.02	70.40
1997-98	5392.40	5641.30	11033.70	24382.50	35416.20	68.85
1998-99	6738.70	7133.20	13871.90	21766.10	35638.00	61.08
1999-00	7576.30	7808.82	15385.12	21781.10	37166.22	58.60
2000-01	8428.80	8641.20	17070.00	24114.00	41184.00	58.55
2001-02	7673.70	8922.60	16596.30	27874.80	44471.10	62.68
2002-03	8089.50	9512.50	17602.00	30649.30	48251.30	63.52

Source: Department of Science and Technology (2006)

Industry-wide distribution of R&D: Within the industrial sector six industries (pharmaceutical, automotive, electrical and electronics, chemicals and defence) account for about two-thirds of the total industrial R&D (Table 4). Among these various industries one just stand out from the rest, namely the pharmaceutical industry as the industry alone accounts for about 20 per cent of the total R&D expenditures. In fact later on I will show that even in the case of output indicators it is the pharmaceutical industry that is the best. In short it may not be incorrect to say that India's national system of innovation is dominated by the sectoral system of innovation of the pharmaceutical industry. Another second in the line is the automotive industry. This industry is composed of both the vehicle manufacturers and the auto parts sub sectors. Both the industries are also characterised by competitive structures with a number of foreign and domestic manufacturers co-existing and competing with each other. The auto parts subsector of the industry has a rather high export intensity of nearly 20 per cent and this meant that the subsector has been continuously investing in technology to upgrade itself and meeting the technological challenges posed by its foreign buyers.

Trends in Patenting

We consider both US and triadic patents secured by Indian inventors. We start with the US patents. Among the BRICS (Brazil, Russia, India, China and South Africa) countries, India has registered the highest growth rate in patenting (Table 5). From an earlier analysis (Mani, 2007), it is seen most of the Indian patents are by domestic companies and that too in the

pharmaceutical area². However in the more recent period, the share of patents secured by affiliates of MNCs based in India is on the increase.

Table 4: Industry-wide distribution R&D (cumulative share in % 1998-99 through 2002-03)

Industry	Share
Drugs & Pharmaceuticals	19.30
Transportation	15.16
Electricals & Electronic Equipment	8.94
Chemicals(other than Fertilisers)	8.35
Defence Industries	8.32
Fuels	6.12
Information Technology	4.69
Metallurgical Industries	4.21
Telecommunications	3.75
Miscellaneous Industries	2.38
Soaps, Cosmetics & Toilet Preparations	2.37
Industrial Machinery	1.84
Biotechnology	1.59
Food Processing Industries	1.39
Agricultural Machinery	1.33
Misc. Mechanical Engineering Industries	1.22
Textiles(Dyed, Printed, Processed)	1.21
Consultancy Services	1.05
Other industries	6.77
Total	100.00

Source: Department of Science and Technology (2006)

Table 5: Trends in US Patenting of Indian Inventors, 1994-2007 (number of utility patents)

	Pre 1994	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Compound rate of growth
China, P.Rep	431	48	62	46	62	72	90	119	195	289	297	404	402	661	772	23.82
South Africa	2390	101	123	111	101	115	110	111	120	113	112	100	87	109	82	-1.59
China, Hong Kong	702	57	86	88	81	160	155	179	237	233	276	311	283	308	338	14.67
India	428	27	37	35	47	85	112	131	178	249	342	363	384	481	546	26.02
Russian Federation	3	38	98	116	111	189	181	183	234	200	203	169	148	172	188	13.09
Brazil	752	60	63	63	62	74	91	98	110	96	130	106	77	121	90	3.17

Source: [USPTO](#) (accessed on April 11 2008)

Triadic patent data (patents secured by an inventor from three different patent offices (namely the USPTO, European Patent Office and Japanese Patent Office) also shows that India has

² Bulk of the US patents granted to Indian inventors are in two US patent classes namely, in 532 Organic Compounds (includes Classes 532-570), and in 424 Drug, Bio-Affecting and Body Treating Compositions (includes Class 514).

registered one of the highest growth rates in Triadic patent grants during the period 1975 through 1995.

The performance of the country in patenting thus confirms the results obtained in R&D investments, namely that most of the patents are secured by domestic private sector companies that too in the area of pharmaceutical technologies. In other words the patenting data further supports the evidence that I found earlier in terms of India's innovation system being dominated by the sectoral system of innovation of her pharmaceutical industry.

Trends in technology trade balance: India's technology trade balance has been negative and rising all through the more recent years (Table 5). However during the

Table 6: Trends in technology trade balance, 2000-2006 (in millions of US \$)

	Payments	Adjusted Payments	Receipts	Adjusted Receipts	TBoP	Adjusted TBoP
2000	311		54		-257	
2001	236		60		-176	
2002	361		22		-339	
2003	352		23		-329	
2004	444		32		-412	
2005	712	1890	71	1709	-641	-181
2006	729	2514	129	5288	-600	2774

Note: Adjusted payments and receipts are arrived at after adding the payments and receipts under R&D, architectural, engineering and technological services to the payments and receipts of royalties and technical know-how fees.

Source: Reserve Bank of India (2008)

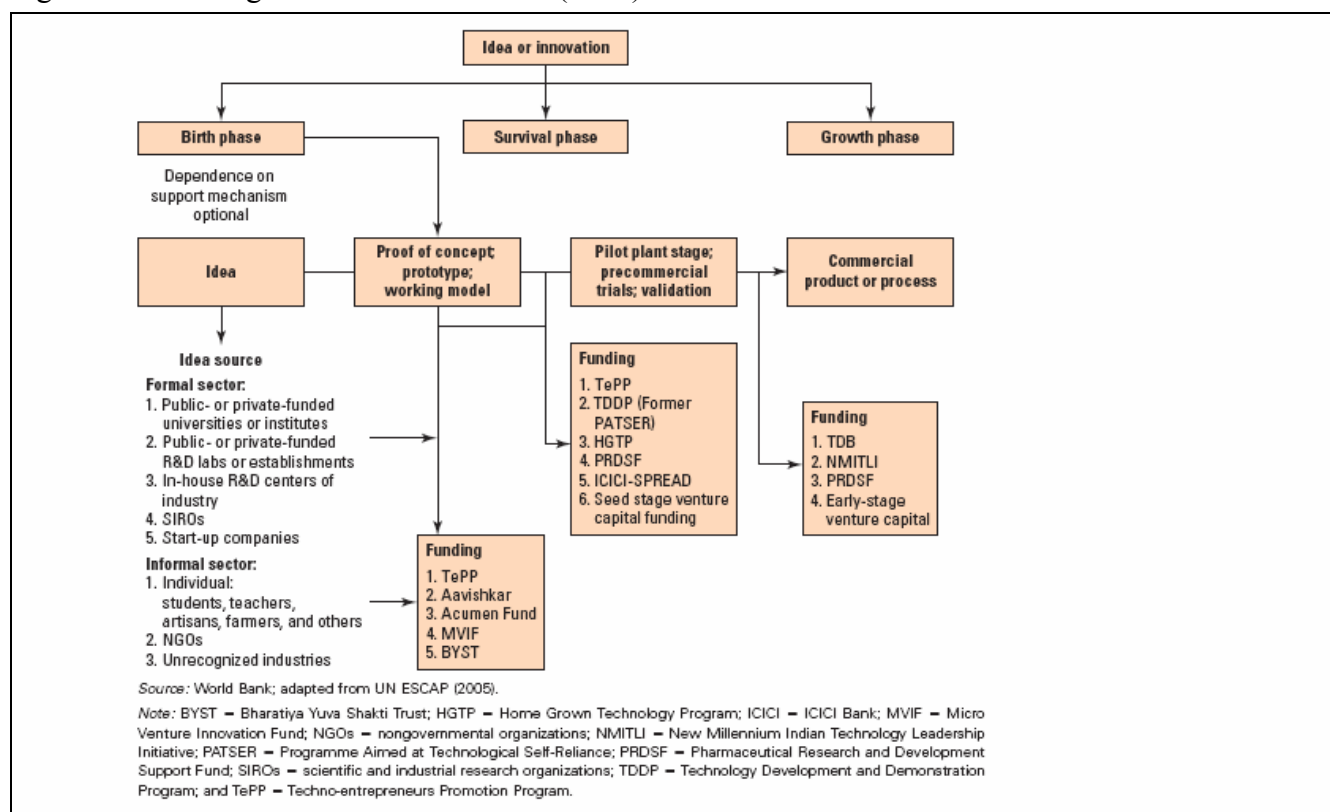
period since 2005, it has turned positive essentially due to the receipts under R&D outsourcing. India, along with China has now become a major recipient of R&D outsourcing deals. Most of India's R&D outsourcing deals is in the areas of pharmaceutical and telecommunications industries.

Thus, based on the evidence presented it can safely be concluded that India's innovation performance has actually improved if one takes the output measure of R&D. But the investments in R&D, both in the country as a whole and in the industrial sector have actually declined. Another point that came out of the analysis was that the country's innovative performance is concentrated in certain specific industries such as the pharmaceutical one and as such is not widespread. In fact we tend to demonstrate that the government too has targeted this industry for enhancing its innovative output by offering a variety of financial incentives. In the following we survey these various instruments for financing innovation.

Survey of instruments for financing innovations: The country has three different types of financial arrangements for financing innovations. They are: (i) Research grants; (i) Tax

incentives; and (iii) Venture capital. The former two are almost entirely provided by various governmental agencies while the latter is now very much in the private sector. Implicitly the innovation policy makers in the country has adopted a linear view of innovation with three distinct phases: birth, survival and growth phases. All the research grants and venture capital are in the birth phase of the innovation chain while the tax incentives are almost entirely in the growth phase. See Figure 1. Although this might appear to be a very idealistic picture from the financing of innovation point of view with research grants and venture at the birth stage where the market failures are great and tax incentives at the growth phase when firms have established themselves and are in a position to engage in formal intramural R&D activities, in actual operation the research grants and venture capital financing does address only a small segment. Most of the research grants are either addressed to public sector enterprises or individual researchers. There are of course notable exceptions to this. The venture capital in the industry although growing by leaps and bounds is increasingly intertwined with the private equity industry and is therefore cannot be taken in its entirety as equivalent to technology financing. With these caveats we attempt at a survey of the various instruments that are available. The purpose here is to just map out the plethora of instruments that are available for technology financing actually available in the country at present. In the next section, we take one of these namely the tax instruments for some in depth examination in terms of its effectiveness in driving up R&D investments.

Figure 1: Financing of innovation in India (2007)



Source: Dutz (2007)

We organize our discussion of these schemes into three broad areas by type of instruments, namely (a) research grants; (b) venture capital; and (c) tax incentives.

(a) **Research grants:** Under this we consider three grant or loan schemes. They are: (i) Finances from the Technology Development Board (TDB); (ii) Techno-entrepreneurs Promotion Programme (TePP); and (iii) the New Millennium India Technology Leadership Initiative (NMITLI).

(i) **TDB:** The TDB was created by an Act of the Parliament in 1995 and commenced operation from 1996. TDB basically seeks to support financially the commercialization of indigenous technology (whether obtained or developed from a publicly funded R&D or not including aspects such as improvements, modifications replacement of imported inputs, conformance to domestic and global regulatory standards, etc. and even for adapting and commercializing imported technology that entail crucial modifications to suit domestic markets and or further development of a 'proof of concept or design'. The TDB provides financial support through: a) a loan of up to 50 per cent of the project costs at simple interest (of 6% earlier and now lowered to 5%) with repayment in five years after project completion (and a royalty payment during the period of loan, which has now been dropped); b)

participation in equity of companies up to 25% of paid up capital; and c) Grants-in-aid. As of March 2005, TDB had supported around 141 projects with an estimated project cost of Rs.20450 million (of which TDB sanctioned assistance is of around only Rs.6650million). This means that the TDB assistance works out to only a third of the total project costs. TDB has predominantly used the loan instrument for support; it has participated in equity of only one company and given just three grants-in-aid;. The grant of Rs 540 million by TDB to National Aerospace Laboratories (NAL) for development and type certification of a 14 seater aircraft is the largest project support ever made by TDB – normally no private sector venture capital fund would have financed the NAL development. TDB's reluctant use of equity as a mechanism for support is a clear indication that it has been risk averse in funding start-ups and new ventures.

The Health and Medical sector accounts for 25 per cent of TDB funding followed by Engineering (15 per cent) and Road Transport (14 per cent). Some successful projects supported by TDB are: development and production of Hepatitis B vaccine (as a result of which the domestic price has dropped to one tenth), Recombinant Streptokinase (second in the world), corDECT, the Wireless in Local Loop access technology, Bharat II variant of Indian car Indica, the first Indian electric vehicle REVA and so on.

Hitherto has been only one review of its first five year of its operation- by the Administrative Staff College of India, Hyderabad (ASC). The ASCI survey showed that around 50 per cent of the agreements were successful i.e., products released in the markets and repayments to TDB commenced, another about 12 per cent were foreclosed but payments were committed/received, 8 per cent were failures and the rest about 20 per cent were those where success was doubtful. Of the successful projects, in over 70 per cent of the cases, the technology originated outside of publicly funded R&D system.

(ii) TePP: The programme was launched in 1998 to help realize the vast latent innovative potential of the people. The basic objective of TePP is for individual innovators to emerge as technopreneurs – technology oriented entrepreneurs. TePP support is provided for in all areas except software development for which there are other avenues of support. It helps the inventor to identify and network with an appropriate R&D/academic institution for guidance, technical consultancy, development of models/prototypes, etc., assists in for filing and securing of intellectual property rights and finally linking up with appropriate source of finances for commercialisation of the product. TePP by itself provides financial support of up to Rs.1 million as a grant-in-aid to prove the idea and a similar amount for the second phase for commercialisation. Since its inception seven years ago, the programme has received over 5500 applications of which around 1200 have been assessed and of these, 207 projects supported.

(iii) NMITLI: The scheme was announced at the dawn of the Millennium in February 2000 by the then Finance Minister in his budget speech of 2000. The objective was to catalyse innovation-centered scientific and technological developments as a vehicle for select Indian industry to attain a global leadership position. The state run Council of Scientific and Industrial Research (CSIR) was assigned to manage the scheme. The Scheme departed from the past practice and policy and adopted a strategy of identifying, selecting and supporting technological and industry winners. The Government funds the entire project (in most cases) as a grant-in-aid for publicly funded R&D/academic partners and as a soft loan (3 per cent simple interest payable in 10 installments) to the industry partner and also underwrites the risk of failure. Intellectual property rights aspects are equitably managed – generally IPRs belongs to the group (s) developing it, which are licensed on a first right of refusal basis to the industrial partner on mutually agreed terms with NMITLI managers as the umpire.

During 2000-2006 period, it has funded 42 projects with an outlay of about Rs.3000 million, involving 222 publicly funded R&D/academia groups and 65 industrial firms as partners. Predominantly the projects have been in the broad area of biotechnology (40 per cent) and in drugs and pharmaceuticals and chemicals (15 percent each) – areas in which CSIR has recognized core competencies. NMITLI projects, which are wholly funded by the government, enjoy an average of about Rs.70 million project funding – highest of all government technology development programmes. From the projects funded three products have been developed, viz.,

- Biosuite,
- a versatile portable software for bioinformatics,
- A PC based high end 3D visualization platform for computational biology; and
- Sofcomp, a simple and cost effective office-computing platform under Rs.10000 (\$ 220 or so)

(b) Venture capital: The history of the venture capital industry in India may be traced to 1988 when a few (mostly state owned) venture capital funds were established on a loan from the World Bank. The industry is now one of the fastest growing in the world and according to some estimates the VC industry in India will overtake the UK one by 2009 or so. However increasingly the VC industry in India is only a small portion of the total private equity industry: in fact its relative share has gone down from 7 per cent in 2006 to about 4 per cent in 2007 although in number terms it works out to about a quarter of all such deals.

Table 7: Share of Venture Capital in Total Private Equity Industry in India, 2006 and 2007

Stage of Company Development	Volume/No. of Deals	Column	Value/Amount (In million US\$)	Column2	Column3	Column4
	2006	2007	2006	Percent share-2006	2007	Percent Share 2007
Venture Capital	94	98	505	7.06	542	3.81
Growth PE	14	32	364	5.09	1321	9.28
Late	104	136	3396	47.46	5070	35.62
Pre IPO	4	14	43	0.60	434	3.05
PIPE	60	80	1401	19.58	4210	29.58
Buyout	13	7	370	5.17	173	1.22
Buyout-Large	1	3	765	10.69	474	3.33
Other	8	17	312	4.36	2010	14.12

Source: Indian Venture Capital Association (2008)

Much of the VC investments are in the Banking, Financial Services and Insurance industries followed by telecom, IT and ITES sectors.

(c) Tax incentives : India offers a variety of tax incentives to enterprises for committing resources to domestic R&D, both intramural and extramural. They can broadly be classified into those which are input based and those which are output based (Table 8). Of these two broad categories, the input based one is more popular. Within the input based category although there are eight different types of tax incentives, the one which has a long history and which enjoyed by maximum number of companies is the one that provides a weighted deduction of 150 per cent on any expenditure on intramural R&D (See A (a) in Table 8). This has been in operation in its present form since 1998 and it applies to about 10 different types of industries³ although the 8th and the 9th industries (namely seeds and agricultural implements) were added only in the latest budget for the fiscal year 2008-09.

This is not a permanent scheme and the incentives under this head are available according to the term stipulated in the successive Union budgets. Given that this is the most comprehensive tax scheme for R&D, we undertake an analysis of its effectiveness.

³ The ten industries are pharmaceuticals, biotechnology, chemicals other than pharmaceuticals, electronic equipment, computers, telecommunications equipments, automobiles , auto parts, seeds and agricultural implements.

Table 8: Input and output based tax incentives for R&D in India (c2008)

A. Input based tax incentives
(a) a weighted deduction of 150 per cent on any expenditure on in-house scientific research
(b) weighted tax deduction for sponsored research in publicly funded R&D and on approved in-house R & D projects;
(c) customs duty exemption on capital equipment, spares, accessories and consumables imported for R & D by approved R&D units, institutions and SIROs;
(d) excise duty waiver on indigenous items purchased by approved institutions/ SIROs for R & D;
(e) accelerated depreciation allowance on plant and machinery setup based on indigenous technology;
(f) customs duty exemption on imports for R & D projects supported by the Government;
(g) ten year tax holiday for commercial R & D companies; and
(h) a weighted deduction of 125 per cent on any payment made to companies engaged in research and development
B. Outcome based tax incentive
(a) excise duty waiver for 3 years on goods produced based on indigenously developed technologies and duly patented in any two of the following countries: India, European Union (one country), USA and Japan.

Source: Department of Scientific and Industrial Research (2007); and Ministry of Finance (2008)

Effectiveness of R&D tax incentives in India

An excellent review of the evidence on effectiveness of tax incentives for R&D and the methodologies used is found in Hall and Van Reenen (2000) and Mohnen (2007). However much of this evidence is based on the experience of OECD countries and notably that of the United States. The authors both describe and criticize the methodologies used to evaluate the effect of the tax system on R&D behaviour and the results from different studies. In the current (imperfect) state of knowledge Hall and van Reenen conclude that a dollar in tax credit for R&D stimulates a dollar of additional R&D. Studies on the effectiveness of tax incentives in the context of developing countries are rare⁴.

The specific type of R&D tax incentive followed in India conforms to those that are in proportion to the level of the expenses on R&D. Further it manifests itself as an immediate write-off or expensing.

Within the specific context of India no such studies are available. The government itself has been rather concerned with the revenue foregone as a result of various tax concessions given to the corporate sector. Consequently beginning with the Union Budget for 2004-05, the government has been publishing data on the amount of tax revenue foregone as result of

⁴ There is a recent study evaluating the performance of R&D support programmes in the context of Turkey. See Özçelika and Taymaz (2008)

various tax incentives or concessions given to the corporate sector. The revenue foregone as result of R&D tax incentives has been computed and this is presented in Table 9.

Table 9: Tax foregone due to R&D tax incentives in India (Rs in Millions)

	R &D tax incentives	All tax incentives	Share of R&D tax incentives in all tax incentives
2004-05	23180	578520	4.01
2005-06	28390	346180	8.20
2006-07	15540	450340	3.45
2007-08	20240	586550	3.45

Source: Government of India, Ministry of Finance (various issues)

With the exception of 2005-06, it has averaged around Rs 2 billion per year and works out to about 3.5 to 4 per cent of the total revenue foregone. As result of the operation of these tax incentives the effective corporate tax rate for some of the industries covered under the scheme is significantly lower with the pharmaceutical industry garnering much of the incentives (Table 10).

Table 10: Effective corporate income tax rate for those industries covered under the R&D tax incentive scheme, 2006-07

Sl No:	Industry	Statutory Corporate Income Tax Rate (in %)	Effective Tax Rate (%)
1	Drugs and pharmaceuticals	33.66	13.91
2	Electronics, including computer hardware	33.66	17.04
3	Fertilizer, chemicals and Paints	33.66	22.17
4	Automobile and Auto parts	33.66	26.03

Source: Government of India, Ministry of Finance (2008), p. 59

Based on these our hypothesis is that the effect of this tax incentive will vary across industries according to the effective tax rate. Although the incentive is same across the targeted 10 industries the effective rate can vary according to whether the firms in the industry has actually taken advantage of this scheme or not. Further it must also be borne in mind that the effective rate is a function of the sum of tax incentives enjoyed by a particular industry. It may be the fact that the pharmaceutical industry also enjoys a number of other tax concessions that their overall tax commitment is much lower than other industries in our sample.

In order to see whether the tax incentives have really lead to increased investments in R&D, we do two exercises. Firstly, we compile data⁵ on R&D expenditures of seven of the eight original industries (Table 11). The only industry that is left out is the biotechnology industry

⁵ The data on R&D expenditures are compiled from the Prowess database of the Centre for Monitoring Indian Economy (CMIE), Mumbai.

as the data on this industry are not available⁶. The growth rate of the R&D expenditure of this sample is then compared with the growth rate of the R&D investments of the entire private corporate business enterprise sector (as contained in Table 3 above). The resulting analysis shows that the average growth rate of the industries receiving tax incentives is much higher than all the industries⁷ (with the sole exception of 2000- the decline in R&D expenditure of all the firms enjoying R&D tax incentives in that year may purely be a statistical artifact).

Table 11: R&D expenditure of firms receiving R&D tax incentives, 1996-2006 (Rs in Millions)

Industry	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Pharmaceutical	3954.1	7110.1	4627.3	6075	5674.7	7610.8	8937	11218.4	16609.5	22928.1	29595
Chemical industry other than pharmaceutical	1997.8	4842.9	2377.2	3178.3	2275	2368.2	2094.9	2407.6	2697.1	3303	4791
Electronics including computer	88.4	132.7	41.4	39.2	87.3	108	57.3	12.6	349.6	71.5	417.9
Communication Equipments	112.9	499.9	395.5	383.1	429	641.1	750.4	603.7	1025.1	896.3	727.4
Automobiles	1552.2	2459.6	2856	2143.8	1453.1	1742.9	2878.2	3357.9	4183	7506.9	8848.1
Autoparts	407.2	516	682.9	757.7	947.2	1081.7	1121.1	1485.7	1691.3	2194.6	2505.9
Aircrafts	NA	NA	NA	NA	NA	NA	NA	2650.6	3091.4	3066.3	4336.2
Total	8112.6	15561.2	10980.3	12577.1	10866.3	13552.7	15838.9	21736.5	29647	39966.7	51221.5
Growth Rate(%)		91.82	-29.44	145.1	-13.6	24.72	16.87	37.23	36.39	34.81	28.16
Growth Rate of all Industries(%)		18.01	34.24	6.97	0.63	4.29	10.81	7.98	8.5		
Ratio		5.1	-0.086	2.2.09	-21.72	5.77	1.56	4.67	4.28		

Source: Own compilation based on the Prowess database of Centre for Monitoring Indian Economy (CMIE).

This of course does not mean that the incentive is effective. All that it implies is that the government appears to have targeted the right sort of industries for granting this concession.

Elasticity of R&D expenditure to tax foregone

First of all we estimated the total amount of tax foregone. This is based on the difference between the statutory corporate income tax rate and its effective rate (See the estimates of it in Table 10 above). Two caveats have to be borne in mind. First, the estimates are available only for four of the eight industries receiving tax incentives. Second, the estimates of effective tax rates are on the conservative side as it includes all tax concessions received by the industries and not just R&D tax incentive alone. Consequently the coefficient elasticity of R&D expenditure is likely to be lower than if one were to do these computations using the effective rate just for R&D tax incentives alone. For estimating the elasticity, we fitted the

⁶ We do not consider this as a major problem as much of the Indian biotechnology industry is made up of the Biopharmaceutical industry and since we have the data on R&D expenditures of the Pharmaceutical industry, the data on R&D expenditures of the Biotechnology industry is included as well.

⁷ Even according to Table 4, the industries such as pharmaceuticals, automotive and auto parts, chemicals other than pharmaceuticals, electronics and information technology account for over 50 per cent of the total R&D expenditure of the industrial sector a whole.

following log linear equation by pooling the data across the four industries over the five year period and we used the OLS estimation procedure:

$$\text{LnR\&D}_{it} = a + b \cdot \text{LnTax foregone}_{it} + c \cdot \text{time trend} + u_{it} \text{-----} (1)$$

Given the fluctuations in the data, we fitted a second functional form with time trend² as an additional explanatory variable:

$$\text{LnR\&D}_{it} = a + b \cdot \text{LnTax foregone}_{it} + c \cdot \text{time trend} + d \cdot \text{time trend}^2 + u_{it} \text{-----} (2)$$

Both (1) and (2) have been estimated using the data on R&D expenditures and the estimated tax foregone with respect to four of the industries during the period 2002 through 2006⁸ and the results obtained are presented in Tables 11 and 12.

Table 11: Elasticity of R&D expenditure wrt tax foregone- Specification 1

Source	SS	df	MS			
Model	29.7026467	2	14.8513233	Number of obs =	20	
Residual	25.112761	17	1.47722123	F(2, 17) =	10.05	
				Prob > F =	0.0013	
				R-squared =	0.5419	
				Adj R-squared =	0.4880	
Total	54.8154076	19	2.88502145	Root MSE =	1.2154	
lnrd	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lntaxfor	.8771449	.199374	4.40	0.000	.4565026	1.297787
t	.3536497	.1968202	1.80	0.090	-.0616046	.768904
_cons	-.4154336	1.905677	-0.22	0.830	-4.43606	3.605193

⁸ The basic data used for the estimation are presented in Annexure 1.

Table 12: Elasticity of R&D expenditure wrt tax foregone- Specification 2

Source	SS	df	MS	Number of obs = 20		
Model	30.8650372	3	10.2883457	F(3, 16) =	6.87	
Residual	23.9503705	16	1.49689815	Prob > F =	0.0035	
				R-squared =	0.5631	
				Adj R-squared =	0.4811	
Total	54.8154076	19	2.88502145	Root MSE =	1.2235	
lnrd	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lntaxfor	.9348086	.2110958	4.43	0.000	.4873055	1.382312
t	1.275171	1.064347	1.20	0.248	-.9811444	3.531486
t2	-.1515374	.171965	-0.88	0.391	-.5160868	.213012
_cons	-1.995622	2.625937	-0.76	0.458	-7.56236	3.571116

The co-efficient of the elasticity of R&D, according to both the specifications are less than unity, but statistically significant at 5 per cent. Although, strictly speaking, this implies that the tax incentive failed to raise R&D expenditures more than proportionately, one should be very careful in drawing such an inference as given the two caveats and especially the second one, the co-efficient was expected to be lower than what it ought to have been. A hypothesis is that not all companies which have availed of this incentive have been able to perform increased R&D with it owing to the shortage of skilled R&D scientists and engineers. The fact that the industry is expressing a skill gaps lends some credence to this hypothesis (Sengupta, 2006). So all that one can say, based on this exercise is that the tax incentive scheme has been targeted well and it has been somewhat successful in raising R&D expenditures of the targeted industries. However it is also important that we need better estimates of tax foregone and thereby the effective tax rate to arrive more robust estimates of the coefficient of elasticity of R&D expenditure. Although we have raised clear question at the beginning of this study namely whether tax incentives for R&D are really effective or not, we are not in a position to provide an unambiguous answer. This is entirely due to the handicaps in data.

Conclusions and Recommendations

Policy framework and Innovation: The tripartite of government, enterprise and universities/ educational institutes play a vital role in fostering innovation of a country. In case of India the role of universities in R&D expenditure is very limited. This is quite evident from table 2, where we can observe that the role of universities/ educational institutes in innovation was initiated only in 1989-99. However, the share remains very nominal in comparison to

developed countries. Similarly, the role of industry also remains limited and has not shown major changes over the last decade. Instead the share has decreased during this period as shown in table 2. In India, the linkage between government, industry and universities needs special focus and attempts should be made to include such linkages in the schemes of support and institutions responsible for implementing and coordination innovative activities under particular ministry.

National governance structure promoting innovation: In India, the Ministry of Science and Technology is the only ministry coordinating innovation related activities in the country. The Ministry has three main departments- Department of Science and Technology, Department of Science and Industrial Research and Department of Bio Technology under which, there are several schemes and programmes supporting innovation activities both general and sector specific. However, as we have mentioned earlier that for successful implementation of innovation policies, inter-ministerial coordination is important. For example, Ministry of MSME and the Ministry of Labor have schemes to support technology diffusion and skill development but are not inter linked operationally nor at the level of schematic design with the Ministry of Science and Technology. To foster such inter-ministerial linkage presence of a high level committee is imperative.

Regional Governance Structure: As inferred from the international studies, local conditions are best comprehended locally. But this demands the presence of a proper regional innovation system in place. In case of India, the regional innovation framework is weak and in some states such structures does not exist, except few states like Karnataka and Gujarat⁹. The share of available fund directed towards innovation at the regional level is very low in comparison to that at the national level. District level innovation framework is virtually absent. To strengthen regional and district level innovation framework, one needs to enhance capacity building of the existing local level institutions that are currently undertaking activities related to networking and provide them the mandate, authority and resources so that they can analyse the potentiality of that particular region and act as a local clearing house.

Scheme of assistance to promote innovation: During the recent period since economic liberalisation there have been improvements in the innovative output of Indian industry. However this has been restricted to a few industries such as the pharmaceutical industry as shown in Table 4 of this section. Also the scheme of assistance is mainly directed towards strengthening infrastructure of public research institutions and less on enhancing public-private partnership and clusters. Efforts should be taken to ensure commercialisation of

⁹ Refer to MSME Foundation study for TIFAC, “Strengthening Innovation and Technology Absorption in SMEs.

research outputs generated by the public research institutions by linking them to private enterprises and also increase the sectoral coverage. There is a spectrum of sectors like software, computers, micro electronics, automobiles, aerospace, telecom, biotechnology, medicare, entertainment and heavy engineering that should also be included under scheme of assistance for innovation.

Cluster approach to address innovation promotion: Cluster approach is a very prevalent innovation approach among most of the countries studied under volume I. As inferred from the international studies, the funding pattern of several schemes can be typified as- (i) less than EUR 100 000 per cluster per year for three years or less where the aim is to engage actors (ii) between EUR 100 000 to approximately EUR 1 million per cluster annually over several years where the goal is to support collaborative projects and (iii) over EUR 1 million per cluster annually for periods up to ten years for heavy R&D projects. In India, the support to foster innovation in clusters is very limited. Other instruments that we witnessed in the country studies- network promotion, technology district creation (in Italy), knowledge cluster around universities (Japan), innovation cluster cities (Korea) and mapping of cluster initiatives- are totally absent in India. Efforts should be made to take up such instruments depending on the local environment in India.

Objective of Innovation: In case of developed countries the main focus of innovation is on national wealth creation and stimulation of high end knowledge intensive job opportunities. Now given the Indian backdrop, where there is predominance of traditional industries (handicraft, handloom, leather goods, jewellery, foundry, knitwear etc) that contributes significantly to the national economy and employment the focus should also be on sustenance and incremental innovation. The support objective should be including focus on energy usage and environmental conservation in the face of global climate changes. Attempts should be made to introduce innovation that helps to improve efficiency of operations in the existing clusters.

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Data used for estimating the coefficient of elasticity of R&D

R&D Expenditure of firms receiving R&D tax Incentives(Rs. In Millions)					
Industry	2002	2003	2004	2005	2006
Pharma	8937	11218.4	16609.5	22928.1	29595
Chemical - Pharma	2094.9	2407.6	2697.1	3303	4791
Electronics, Computers	573	126	349.6	71.5	417.9
Automobiles, Autoparts	3999.3	4843.6	5874.3	9701.5	11354
Tax Forgone(in million Rs.)					
Industry	2002	2003	2004	2005	2006
Pharma	36668.0963	4334.30063	5767.04348	6572.14789	8523.93883
Electronics Including Computer Hardware	4443.3792	436.75344	689.4756	346.15368	267.51024
Fertilizer, Chemicals & Paints	50910.2487	6454.37241	10481.75577	12706.26237	16308.63261
Automobile & Autoparts	5171.2184	1815.14974	3501.58677	5207.23646	6221.48777
Data used for regression					
				log values	
Industry	Year	R&D	Tax foregone	lnR&D	lnTaxfor
Pharma	2002	8937	36668.0963	9.097955241	10.50966235
Pharma	2003	11218.4	4334.30063	9.325310566	8.374315545
Pharma	2004	16609.5	5767.04348	9.7177301	8.659914833
Pharma	2005	22928.1	6572.14789	10.04011851	8.790595982
Pharma	2006	29595	8523.93883	10.29536071	9.050633817
Chemical - Pharma	2002	2094.9	50910.2487	7.647261099	10.83781963
Chemical - Pharma	2003	2407.6	6454.37241	7.78638568	8.772513073
Chemical - Pharma	2004	2697.1	10481.75577	7.899932401	9.257391479
Chemical - Pharma	2005	3303	12706.26237	8.102586425	9.449850251
Chemical - Pharma	2006	4791	16308.63261	8.474494437	9.699449855
Electronics, Computers	2002	573	4443.3792	6.350885717	8.399170447
Electronics, Computers	2003	126	436.75344	4.836281907	6.079368825
Electronics, Computers	2004	349.6	689.4756	5.856789644	6.535931309
Electronics, Computers	2005	71.5	346.15368	4.26969745	5.846882838
Electronics, Computers	2006	417.9	267.51024	6.035242169	5.589157846
Automobiles, Autoparts	2002	3999.3	5171.2184	8.293874625	8.550863607
Automobiles, Autoparts	2003	4843.6	1815.14974	8.485413525	7.503923245
Automobiles, Autoparts	2004	5874.3	3501.58677	8.678342183	8.160971508
Automobiles, Autoparts	2005	9701.5	5207.23646	9.180035792	8.557804564
Automobiles, Autoparts	2006	11354	6221.48777	9.337325384	8.735764348