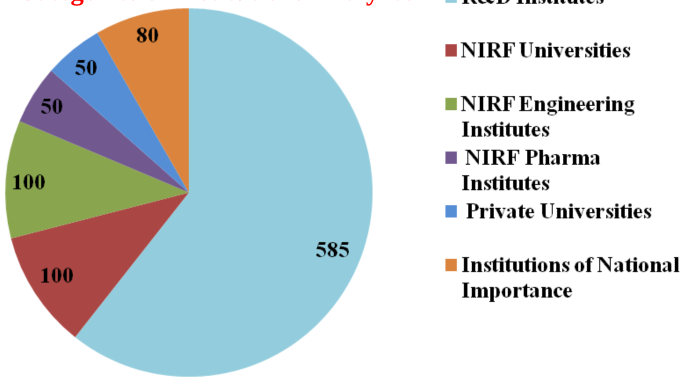
DST-Centre for Policy Research at PU, Chd.
(DST/PRC/CPR-03/2013)

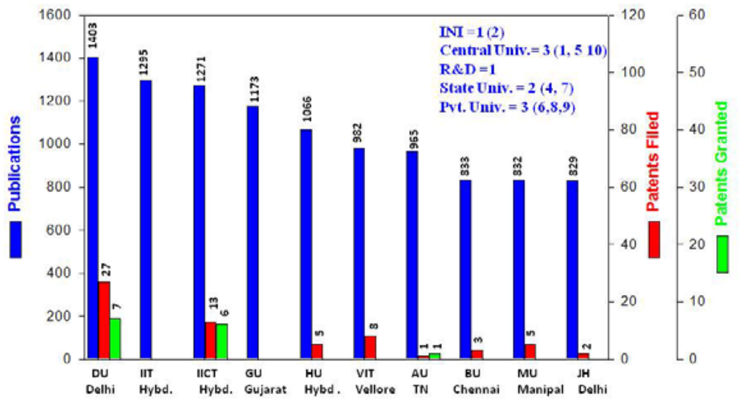
REPORT – 1 *(April, 2016 – July, 2017)*

Patents and Publications of HEIs & R&D Institutions in India

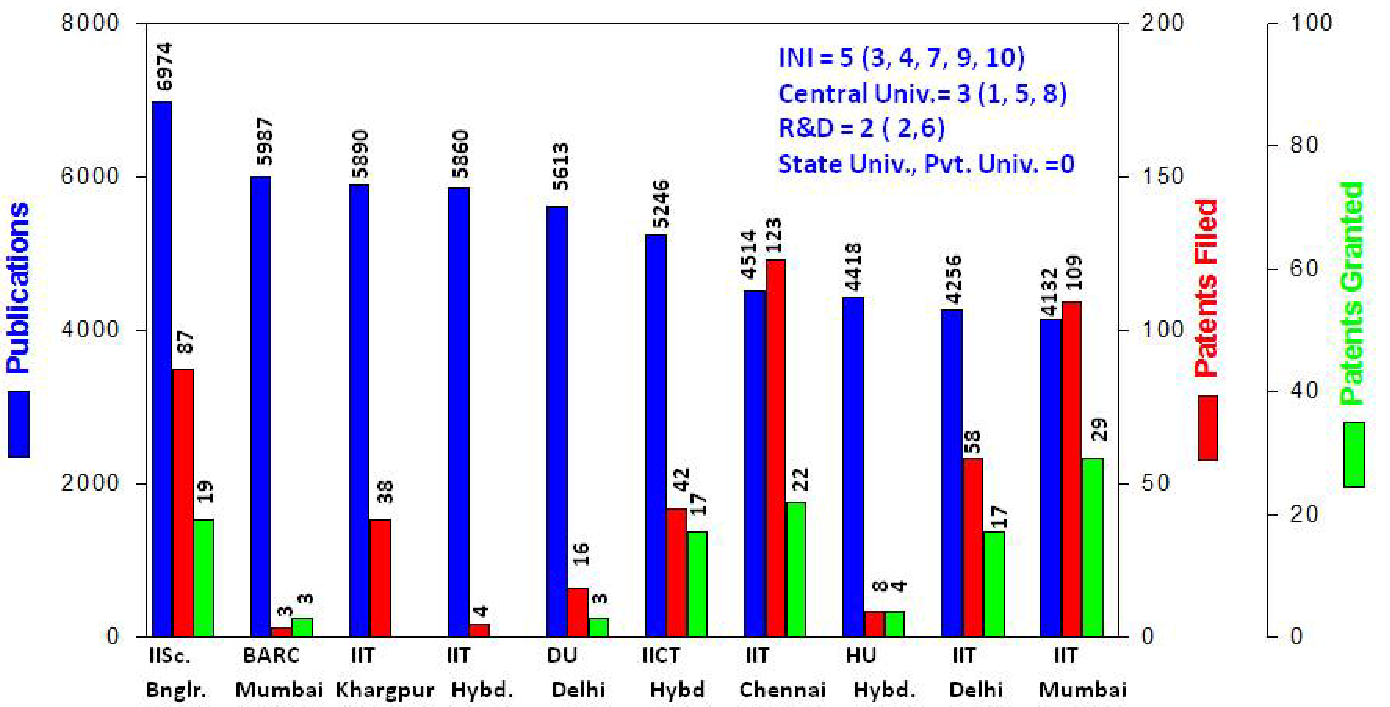
Categories of Institutions Analyzed



Top 10 Institutions in the Field of Pharma/Drug



Top 10 Institutions in the Field of Chemical Sciences



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Introduction

The knowledge-base of any society is its intellectual asset and it plays a strategic role in its overall progress and development. For this, availability of vibrant institutional framework and scientific temperament are essential ingredients. India is a very old and large democratic country and has its glorious past with inherent contradictions to generate and utilize knowledge but is still way behind the other countries.

In this era of knowledge and innovation, patents occupy a prominent position as global indicators for ranking of world economies. In general, there is a direct relation between the economy and the patent regime of a nation. India's dream of becoming a strong and developed nation cannot be fulfilled unless India improves its ranking in the domain of IPR. In order to achieve this, it is imperative that we understand the ecosystem of IPR, especially patents, existing in India. Keeping this in mind, DST-Govt. of India has given the objective "Adopt evidence based approach for identifying and promoting areas for generation of Intellectual Properties" to Centre for Policy Research (CPR) at Panjab University, Chandigarh. The DST-CPR undertook a responsibility to analyse the Indian patents profile and study about the stand of India on the global platform.

To achieve this objective, centre undertook a study for a total number of 914 institutions comprising of Institutions of National Importance (INI), top 100 National Institutional Ranking Framework (NIRF) universities, top 100 NIRF engineering institutes, top 50 NIRF Pharma institutes, top 50 private universities and 585 R&D institutes under various ministries (details in next pages). These 914 institutions have been analysed on the basis of research publications and patents filed/granted by them. This exercise was performed to figure out those institutes which are performing well in research publications, but lacking in converting their research into patents. Usually, in India, the reputation of any educational or R&D institutions is measured by quality and quantity of research publications by faculty, students, scientists and researchers of the institution. And it is being followed blindly in India, but the there must be another measuring parameter for the reputation building which is patents filed or granted to an institution. This factor will facilitate not only institution as a whole, but also it will encourage scientists, researchers and faculty members as well, whether, it is financially or morally. In advanced countries like USA, Singapore, Finland, this parameter is very crucial for the institutional as well as economic development.

International Scenario

For this report, the stand of India in IPR ecosystem has been compiled from WIPO (World Intellectual Property Office (WIPO) annual reports and online database. WIPO is a specialized agency of United Nations (UN) and was set up in 1967 (originally known as BIRPI- Bureaux for the Protection of Intellectual Property) with an objective to promote and protect IP throughout the world. Currently, WIPO comprises of 188 member states. Till date, WIPO has administered 26 international treaties for practising IPRs all over the world. WIPO became a dedicated agency under UN in the year 1974 with a mandate to promote innovations and provide impetus to technology transfer, for improving the socio-economic as well as cultural/artistic levels of the developing economies. WIPO is working in three distinct fields a) protecting IP b) designing policies and c) development and global cooperation.

The table given below depicts the patents profile of top 10 countries for last 7 years (2010 onwards). China is leading in patents applications filing (World Intellectual Property Indicator, 2016) with a total number of 1, 101, 864 applications filed in the year 2016. Out of 1, 101, 846 applications 968, 252 are filed by the residents and 133, 612 applications are filed by non-residents only. The trend for top 10 countries is shown in table-1.

Table 1: Patents Applications by Top 10 National Patent Offices

Global Rank*	Country	2010	2011	2012	2013	2014	2015
1.	China	293,066 (98,111)	415,829 (110,583)	535,313 (117,464)	704,936 (120,200)	801,135 (127,042)	968,252 (133,612)
2.	USA	241,977 (248,249)	247,750 (255,832)	268,782 (274,033)	287,831 (283,781)	285,096 (293,706)	288,335 (301,075)
3.	Japan	290,081 (54,517)	287,580 (55,030)	287,013 (55,783)	271,731 (56,705)	265,959 (60,030)	258,839 (59,882)
4.	Republic of Korea	131,805 (38,296)	138,034 (40,890)	148,136 (40,779)	159,978 (44,611)	164,073 (46,219)	167,275 (46,419)
5.	European Patent Office**	n.a. (146,150)	71,898 (70,895)	73,014 (75,546)	73,503 (74,484)	75,496 (77,167)	76,131 (83,897)
6.	Germany	74,401	73,216	73,905	73,929	73,826	72,217

		(12,198)	(12,458)	(14,720)	(15,814)	(17,811)	19,509)
7.	India	8,853 (30,909)	8,841 (33,450)	9,553 (34,402)	10,669 (32,362)	12,040 (30,814)	12,579 (33,079)
8.	Russian Federation	29,022 (13,778)	26,879 (14,919)	29,174 (15,510)	29,120 (16,149)	24,370 (16,236)	29,567 (16,248)
9.	Canada	4,550 (30,899)	4,754 (30,357)	4,709 (30,533)	4,567 (30,174)	4,198 (31,283)	4,277 (32,687)
10.	Brazil	4,228 (20,771)	4,695 (23,954)	4,798 (25,637)	4,959 (25,925)	4,659 25,683	4,641 (25,578)

Source: WIPO Statistics Database (last updated may, 2017)

http://www.wipo.int/ipstats/en/statistics/country_profile/

**World Intellectual Property Indicators Reports (2010-16)

* World Intellectual Property Indicators Report (WIPO), Ranking 2016

The statistics are based on data collected from IP offices or extracted from the PATSTAT database (for statistics by field of technology). Data might be missing for some years and offices or may be incomplete for some origin. The numbers written with in the bracket are the patents filed by non-residents.

As far as Indian scenario is concerned, it has been ranked at 7th position on the basis of patents filing. In 2016, the total applications filed were 45, 658, out of which 12, 579 applications were filed by residents and 33, 079 applications were filed by non-residents (IPO Annual Report 2015-16). The percentage of patents filing by the resident is 27%, whereas, the %age of patents filed by non-residents is 73%. The percentage of non-residents filing comprises of patents filed through convention or through PCT filing.

Indian Scenario

The patent system administered in India is done by the office of the Controller General of Patents, Designs and Trademarks (CGPDTM) under the Department of Industrial Policy and Promotion, Ministry of Commerce and Industries. The jurisdiction of Indian patent system is divided geographically into four regions i.e. Northern Region (Patent Office, Delhi), Western Region (Patent Office, Mumbai), Southern Region (Patent Office, Chennai) and Eastern Region (Patent Office, Kolkata), which also houses national head office.

The amendments brought in 2005 have spurred tremendous growth in the patenting activities because before 2005 only process patents were protectable and after this amendment product patents are also protected. Indian patenting trend between 2010 and 2015 has given below in the tabular form, which has been compiled from annual reports of office of the CGPDTM. The trend for last seven years for patents filing in India is shown below in table-2.

Table 2: Patents Profile of India for last seven years (2010-16)

Year		2010	2011	2012	2013	2014	2015	2016
Filed	***Residents***	7044	8,312	8921	9,911	10,941	12017	13,066
	Non-Residents	27,243	31,088	34,276	33,763	32,010	30,746	33,838
Granted		6,168	7,589	4,381	4,126	4,227	5,978	6,326
Revenue Generated (crores)		142.61	158.78	164.40	170.47	188.27	374.00	398.40
Expenditure (crores)		21.87	24.02	25.69	25.33	26.82	25.32	55.91

Source: *IPO Annual Reports, 2010-16*

Last 10 years compilation of IPO data shows ups and downs of patent regime in India. During the financial year 2015-16, a total of 46, 904 patents applications were filed exhibiting about 10% growth in patents filing as compared to the financial year, 2014-15. The trend of last 7 years in respect of patents filed, granted, revenue generated and revenue expended are mention above in **table-2.** During the year 2015-16, the total revenue generated by patents only is ₹398. 40 crores and planed & non-planed revenue expenditure for the year was ₹55.91 Crores.

Scope of the Study

This report has been compiled on the basis of articles publications and patents filed and granted by various institutions. The main objective of this analysis is to figure out potential institutes which are having a great profile in publications as well as patents profile. In other words, the scope of this study is to provide a scholarly glimpse of Indian higher education institution and research labs on the basis of article publications from data base known as SCOPUS which is owned by Elsevier. Usually, the research output in the form of research articles emanates from academics and research establishments and is communicated mainly through journals.

The institutes and R&D labs considered for this study have been mentioned in **table 3.** These are the higher education institutes, which are mainly contributing to developing highly skilled and educated manpower in India. These institutes comprise of Research and Development (R&D) laboratories under 27 ministries. The labs considered for this study are only those, which were doing core research in the various streams of science and technology. Another category is top 100 universities, top 100 engineering institutes, top 50 pharma institutes, ranked by National Institutes ranking framework (NIRF), which is approved by Ministry of human resources and Development (MHRD).

The last category comprises of INI, which is a status conferred to a premier govt. higher education institution in India by an Act of Parliament, and "serves as a crucial player in developing highly skilled personnel within the specified region of the country/state". The breakup for all the institutes is given below in **table-3.**

Table 3: HEIs & R&D Labs Considered for the Analysis

S. No.	Name of Institute	No. of Institutions
1	R&D Institutes (under 27 ministries)	585
2	NIRF Universities (Public + Private)	100
3	NIRF Engineering Institutes	57*
4	Top 50 NIRF Pharma Institutes	50
5	Top 50 Private Universities	42**
6	Institutions of National Importance	80
	Total	**914**

** 43 institutes are included in Institutions of National Importance*
*** 8 universities are included in the list of top 100 NIRF universities*

R&D Institutes

Research and development (R&D) is a prominent parameter of development and economic growth of a country. If there is a considerable growth in R&D, it has a direct impact on intellectual property regime in the country. The R&D status needs great emphasis which can be achieved by establishing world class infrastructure for R&D activities, encouraging technical institutions, national research labs and providing more financial aid to technologist and researchers. R&D enhancement is not the responsibility of the government of India; there should be the equal contribution of the private sector as well. The proportion of expenditure on R&D by the public and private sector is 3:1, so the creation of an environment to enhance private sector participation is much needed.

For the study 585, R&D institutions are covered by 27 ministries (out of 52) including two independent departments (Department of Space and Department of Atomic Energy). We have considered a total of 585 R&D labs, which comes under various ministries. The major R&D organization in India are Council of Scientific and Industrial research (CSIR), Indian Council of agricultural Research (ICAR), Indian Council for Medical research (ICMR), Defence Research and Development Organization (DRDO), Department of Science and Technology and Indian Space Research Organization (ISRO), etc. Most of the R&D labs are comprises of mainly these above-mentioned organisations. The main motive of these labs are doing the core research in various domains of science and to contribute to economic, social and environment benefits to the people of India. The number of labs and ministries considered for study are mentioned in **table-4**

Table 4: Ministries and Number of Labs Considered for the Study

S. No.	Name of Ministry	No. of Res. Labs
1	Ministry of Health and Family Welfare (mainly ICMR)	167
2	Ministry of Agriculture and Farmers Welfare (mainly ICAR)	92
3	Ministry of Science and Technology (DST, DSIR, DBT)	80
4	Ministry of Defence (mainly DRDO)	52
5	Department of Space	29
6	Ministry of Textiles	23
7	Ministry of Electronics and Information Technology	19

8	Ministry of Environment, Forest and Climate Change	17
9	Department of Atomic Energy	15
10	Ministry of Commerce and Industry	14
11	Ministry of Chemicals and Fertilizers	9
12	Ministry of Earth Sciences	9
13	Ministry of Petroleum and Natural Gas	9
14	Ministry of Communications	8
15	Ministry of AYUSH	5
16.	Ministry of Home Affairs	5
17.	Ministry of Micro, Small and Medium Enterprises	5
18.	Ministry of Human Resource Development	4
19.	Ministry of New and Renewable Energy	4
20.	Ministry of Water Resources, River Development and Ganga Rejuvenation	4
21.	Ministry of Food Processing Industries	3
22.	Ministry of Heavy Industries and Public Enterprises	3
23.	Ministry of Road Transport and Highways	3
24.	Ministry of Skill Development and Entrepreneurship	2
25.	Ministry of Steel	2
26.	Ministry of Rural Development	1
27.	Ministry of Urban Development	1
	Total Research Labs	**585**

National Institute Ranking Framework (NIRF), 2016

The National Institutional Ranking Framework (NIRF) was launched on 29th September 2015. This framework outlines a broad methodology to rank institutions across the country. The methodology for ranking universities and institutions has identified five broad parameters. Those are:

1. Teaching, Learning and Resources
2. Research and Professional Practices
3. Graduation Outcomes
4. Outreach and Inclusivity
5. Perception

Considering the fact that universities in India are essentially setup for postgraduate education and research, it was decided to assign higher percentage (40 per cent) weightage to "Research Productivity, Impact and IPR", 30 per cent weightage to **"**Teaching, Learning and Resources", 5 per cent weightage to "Graduation Outcomes", 5 per cent weightage to "Outreach and Inclusivity" and 10% weightage to "Perception". Weightages assigned for ranking of colleges were suitably modified. These five parameters further grouped into sub-categories. As mentioned above each broad category has an overall weight assigned to it, the sub-categories also have an appropriate weight distribution.

Pharma Institutes

The pharmaceutical industry discovers, develops, produces, and markets drugs or pharmaceutical drugs for use as medications. Pharmaceutical companies may deal in generic or brand medications and medical devices. They are subject to a variety of laws and regulations that govern the patenting, testing, safety, efficacy and marketing of drugs. For this study, we have selected top 50 pharma institutes ranked by NIRF, 2016.

Private Universities

In last three decades, the establishment of private universities has gained momentum, and their number as in 2016 is 349. A private university is a university established through a State/Central Act by a sponsoring body viz. A Society registered under the Societies Registration Act 1860, or any other corresponding law for the time being in force in a State or a Public Trust or a Company registered under Section 25 of the Companies Act, 1956. For this report, data has been extracted from ICI database to measure and evaluate the strengths and weaknesses of Private Universities. Here we are comparing the performance of private universities of the country based on their research papers in journals published from India. Based on research papers and citations received counts, a relative position of private universities have been computed and shown in Tables. The analysis reveals the relative position of a university among the comity of private universities. Based on this, all stakeholders can take a note to induct corrective and competitive measures. This report may not have names of few private universities due to the fact that either their contribution is not published in Indian journals or they are relatively new and yet to start scholarly activity. It has been observed that institute/university needs gestation period which may be in the range of 12 to 15 years to deliver expected scholarly output.

Institutions of National Importance (INI)

An Institute of National Importance, in India, is defined as one which serves as a pivotal player in developing highly skilled personnel within the specified region of the country/state. Only a chosen few institutes make it to this coveted list and are usually supported by the Government of India or even any other international institutes to develop centres of excellence in research, academics, and other such elite schools of education. In India, all of the IITs, NITs, AIIMS, NIPERs, ISI and some other institutes as Institutes of National Importance. It is also proposed to add to the list IIMs, IISERs, IIESTs and the new AIIMS under Pradhan Mantri Swasthya Suraksha Yojana (**PMSSY Scheme)** of GOI once they are empowered by the Government of India by enacting an act in the Parliament. The institutions come under this category is mentioned below in **table 5.**

Table 5: Breakup for Institutions of National Importance

S. No.	Institutes	No. of Institutes
1.	IITs	23
2.	NITs	31
3.	NIPER	1
4.	AIIMS	7
5.	IISERs	5
6.	School of Planning & Architecture	3
7.	Other Institutes	10
	Total	**80**

Data Collection

A. Publications: SCOPUS owned by ELSEVIER- Annexure-1

B. Patents: Talwar & Talwar Consultants, Mohali by using various patents search tools like –Annexure-2

- *XLPAT owned by TT Consultants (www.xlpat.com)*
- *Orbit owned by Questel (www.questel.com)*

- *Thomson Innovation owned by Thomson Reuters (info.thomsoninnovation.com)*
- *InPASS of Govt. of India (ipindiaservices.gov.in)*

Time Span

For the purpose of this report, data for both articles publication and patents (filed and granted) have been taken from 2010 to 2016, i.e. 7 years period. The time span of 7 years has been considered enough to analyse trends on parameters of articles publications and patents of the institutes. By doing this exercise we can develop an evidence based approach to identify the gaps in patenting and research publication. It can also help in recognising those institutes, who are having magnificent patenting and research publication profile.

Methodology

The methodology of data extraction & retrieval has been used to search and retrieve relevant data of research publications from SCOPUS for the time period from 2010 to 2016. The data extraction for patents (filed/ granted) was outsourced to a private firm because it was a tedious task. It was not possible to fetch the validated data from one source. The firm used various software to retrieve, verified and validated data for patents and promised ~ 80-90 % accuracy in data retrieved by them. The time span may be little short of the process of patent filing is a very lengthy affair and it takes 3 to 5 years to grant a patent from the day of filing to a successful disposal, either a grant or a final refusal by the patent office. We have been successful in achieving our objective of identifying strong institutes in both parameters (publications and patents). Now, we can study the eco-system in these institutes for recommending the same for other institutes, having a large number of publications but producing less number of patents. We will write to these institutes and ask about their strengths and efforts they are doing and will seek assistance and suggestions to promote and adopt their model in other institutes.

Limitations

The data extraction for patents filed and granted has been done on the basis of **“name of the applicant”** not on **“name of the inventor”,** which means the patent has been assigned or granted to a particular institute. Data extraction by the name of the inventor was a very time-consuming task and to perform this task the Centre required a huge amount of money which, was not feasible to bear this much of expenses. Talwar & Talwar Consultants has assured ~ 80-90 % accuracy in data extracted by them regarding patents filed and granted. There are only 12402 total patents filed (national & international) by these 914 institutes under our study, out of which 9074 are in application phase and 3328 have been granted to some institute or research lab. If any data error is found in the analysis, it could be due to errors in source data, typographical and computational, etc.

Literature

In the old Indian education system, teaching and learning process was confined to the personal domain and therefore, knowledge was not public property and neither was it treated as public good. The evolution path of the modern higher education system in India started with the establishment of Madras, Calcutta, and Bombay universities in 1857. After Independence, universal and compulsory education for all children in the age group of 6-14 was ensured by the government of India through *Article 45* of the Constitution.

Initially, teaching and learning were not the role of universities, they used to conduct examinations but now all is an integral part of the university system. Globally, now universities and research institutions are being assessed and evaluated based on their infrastructure, ecosystem and research productivity. Accordingly, the students/researchers are making their choice of study. The research output in terms of research papers, books, reports, patents, standards, etc. are measurable objects. For about 350 years, journals are the main and major source of research communication and over the period a concept of referred and high impact factor journals has evolved to monitor and maintain the quality standards of publications or research documents or research papers. In higher education and research establishments' publication counts in refereed journals and patents have become a globally recognized and accepted criterion. Therefore, the universities and research institutions are vigorously doing publications and creating patents out of that. Higher the counts of publications and patents received to them decides their relative superiority among the harmony of the academic world.

In the case of India, while measurement and evaluation are made for ranking purpose, that need to consider the fact, that in majority universities/institutes are teaching institutions and have a limited research mission or profile. Similar kind of situation seems true in the case of a global higher education system that is why only about a thousand or so out of the world's 18,000 universities or university level institutes find a place in so-called international rankings.

Factually, the measurement of academic and research productivity is not straight forward because the key function of teaching quality is seldom measured adequately. However, research productivity in terms of research papers is easier to measure than other kinds of academic work. National and global rankings count publications/research papers published in journals that are indexed in nationally, globally visible and available indices – such as the Web of Science, Scopus, Indian Citation Index and equivalents of respective disciplines. These indices list only a small number of journals of the world and tend to favour English language publications.

Articles Publications

Research journals have been in existence for over 350 years and are scholars' lifeline for scholarly communication. Schaffner (1994) identified five distinct, though somewhat overlapping roles that journals play in scholarly communities.

1. Journals build a collective knowledge base. Journals form the most comprehensive, up-to-date, authoritative archive of information in a given subject field. This authoritative archive of journals can also serve as a tool to check duplication, etc.
2. Journals act as a carrier of knowledge to scholars working in a subject area. The advent and advancement of ICT have revolutionized the scholarly mode of communication.
3. Journals validate the quality of research in maintaining community standards through peer review mechanism.
4. Journals distribute rewards and publications in peer-reviewed journals are considered to be of more value/quality. The roots of this go all the way back to the publication in English the "Philosophical Transactions of the Royal Society, London" in 1665.
5. Journals finely network a scholarly community together in a number of ways. A hallmark of a discipline's coming of age is the establishment of a new journal: in essence, staking out the intellectual territory of the new field.

Research Publications in India

The first journal titled as 'Asiatick Researches' was published in 1788 in India. Since then, journal publication has come a long way and as of now, over 6,000 journals in various forms and styles are being published from India. Though it is there from the beginning of journal's publication but it has gained a hyped momentum for about last three decades, that the use of term 'International Journal' in publications is in vogue among academic and scholarly community particularly of developing and less developed countries.

By publishing in the journal, scientists/researchers/academicians can establish ownership and fulfil the role of documenting the paternity of Intellectual Property (IP). Sometimes they are substantive and sometimes they extend to related areas such as the social implications of findings, funding, or training issues within the field. Journals also commonly serve as a forum for news such as new appointments to major positions or the passing of a well-known member of the scholarly community. While this role may be diminishing to some extent with the variety of communication options available, journals continue to play an important role in forming and maintaining scholarly communities. Four major reasons behind the exponential nature of growth of Indian papers are (a) Expansion of journals and Inclusion of Indian journals, (b) Increase in Institution involved in publishing activity (c) Increase in international collaboration (d) Activity in emerging research areas.

Patenting in India

Inventive activity is supposed to result in the invention, which further leads to technological advancement, economic welfare and industrial development. An old proverb says, 'Necessity is the Mother of Invention'. In the era of knowledge economy, this invention needs to be protected. The first major step taken in this regard was in 1970 when the government of India passed The Patent Act, 1970. In order to further fortify the inventions subsequent amendments too have been effected in the years 1999, 2002 and 2005. In 1994 India signed TRIPS agreement and on January 1, 2005, India became fully Trade-Related Aspects of Intellectual Property Rights (TRIPS)-compliant by bringing into effect its most important requirement of enforcing *product patents* in the fields of food, chemical substances, and pharmaceuticals.

Before TRIPS agreement, patents were exclusively governed by national jurisdiction, subject to local laws framed according to the national development goals and local needs. Another defining moment in patenting came in 1998 when India became a signatory of Patent Cooperation Treaty (PCT). As a result, inventers can now protect their inventions internationally through a single application. The Act protects the rights of inventor and encourages inventions. The amendments brought in 2005 have spurred tremendous growth in the patenting activities because before 2005 only process patents were protectable and after this amendment product patents are also protected. The patent is an exclusive and territorial right granted by regional or national government. Once granted, it remains valid for a maximum period of 20 years from the date of filing of the application, provided the periodic maintenance fees are duly paid during this period and the patent is not revoked or declared invalid by the court. The mandatory conditions required for protection of an invention are:

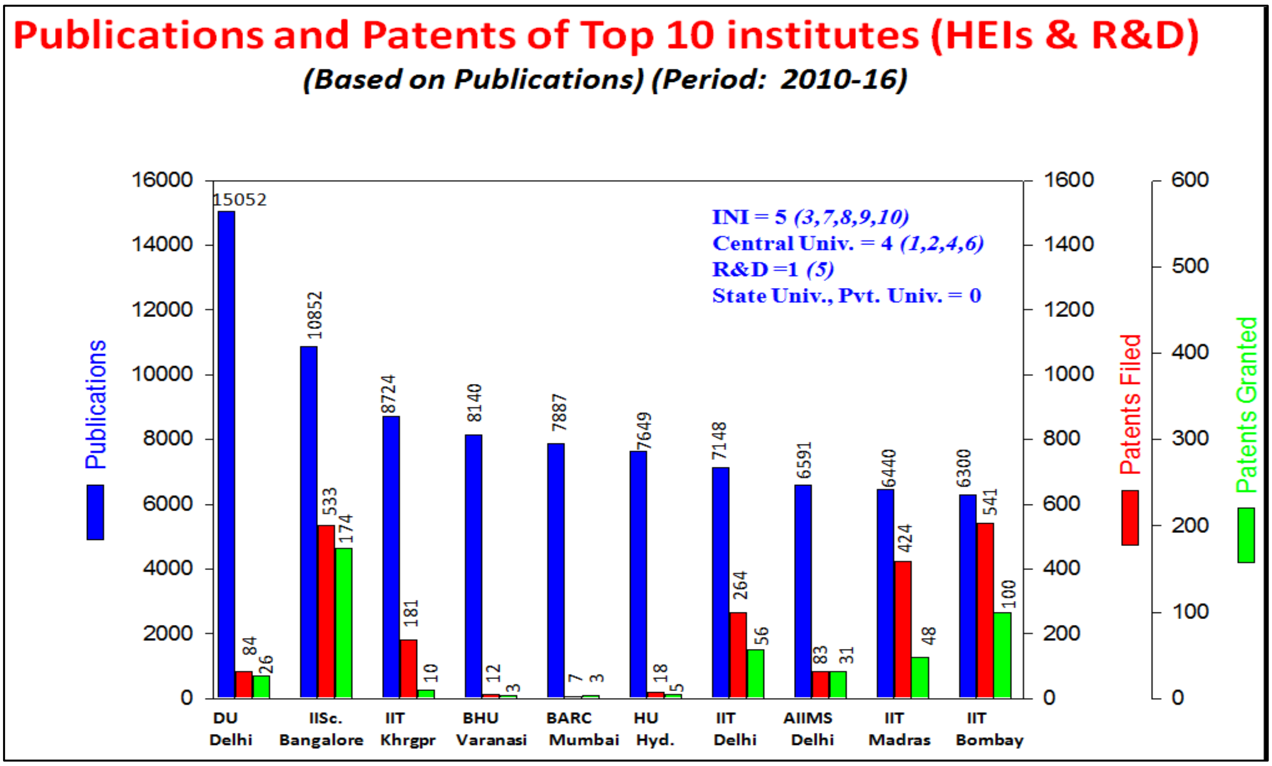
i) ***It must be novel***
ii) ***It relates to the process and product both***
iii) ***It must involve an inventive step i.e. non-obvious to a person skilled in the related field of the technology***
iv) ***It must be capable of industrial application and***
v) ***It should not come under the Section 3 and Section 4 of The Patent Act 1970.***

The patent system administered in India is done by the office of the Controller General of Patents, Designs and Trademarks under the Department of Industrial Policy and Promotion, Ministry of Commerce and Industries. The jurisdiction of Indian patent system is divided geographically into four regions i.e. Northern Region (Patent Office, Delhi), Western Region (Patent Office, Mumbai), Southern Region (Patent office, Chennai) and Eastern Region (Patent Office, Kolkata), which also houses national head office.

Analysis

The ranking is a natural thought process when plenty of things are available to do the same or similar things. In a globalised world, all have to compete in their area of activities to shine and sustain. The competition provides an opportunity to adjudge level of relative standing among the comity of stake holders and thus this relative standing is known as the rank of that particular competing stake holder and the procedure and system followed are known as a ranking system. Rankings generally spark competition and zeal to work more enthusiastically to compete with stakeholders. Rankings may have strengths and weaknesses; some may argue that competition indirectly improves overall quality in the higher education system; others may argue that the same competitive forces skew institutional policies in ways that might cause institute or university personnel to work against their own missions. Ranking of institutes/universities is a relative position based on defined parameters.

For this study, we are analysing a total of 914 institutions comprising of IITs, NITs, AIIMS, public & private universities, pharma & engineering institutes and research laboratories existing in India. Generally, the institutes with a greater number of research publications should also have a good number of patents. But that is not the case of India institutes. Indian academicians and researchers publish a large number of research papers, but they fail in converting their research in a patent, thus reducing chances of commercial exploitation of their innovative idea. As seen in **graph-1 & table-6**, (according to a number of articles publications) amongst the top 10 universities/ institutes University of Delhi, which is a central university, tops the list in publishing research papers, but fare poorly in getting it converted into a patent.



Graph-1: Top 10 Institutes Based on Research Publications

These records show that IISc, Bangalore has a strong grip on innovation and has the considerable ability to convert its research into patents or commercial commodity. Apart from IISc, Bangalore there are other two institutes, which are performing good in above-mentioned parameters, those institutes are IIT(IIT), New Delhi and Indian Institute of Technology, Madras. IIT, Delhi has published 7148 research publications between, 2010-16 and has filed 261 patents, out of which 56 patents are granted to the institute. Its counterpart IIT, Madras has 6440 publications to its credit and has filed 424 patents out of which 48 have been granted to the institute. But they still need an overhaul and need to concentrate on, converting a research into a patent or commercial product or process instead of publishing it.

As already mentioned, the institutes are analysed on the basis of articles publications, but as shown in the **table-6** although IIT, Bombay is placed at eleventh position on the basis of a number of publications, but it is more prone to convert its research publications into patents. IIT Bombay has 6300 publications to its credit and it has filed 541 patents in the last seven years. Moreover, it has been granted 100 patents till 2016. It shows the average of converting its research into patents is better than its counterparts IIT, Delhi and IIT, Madras.

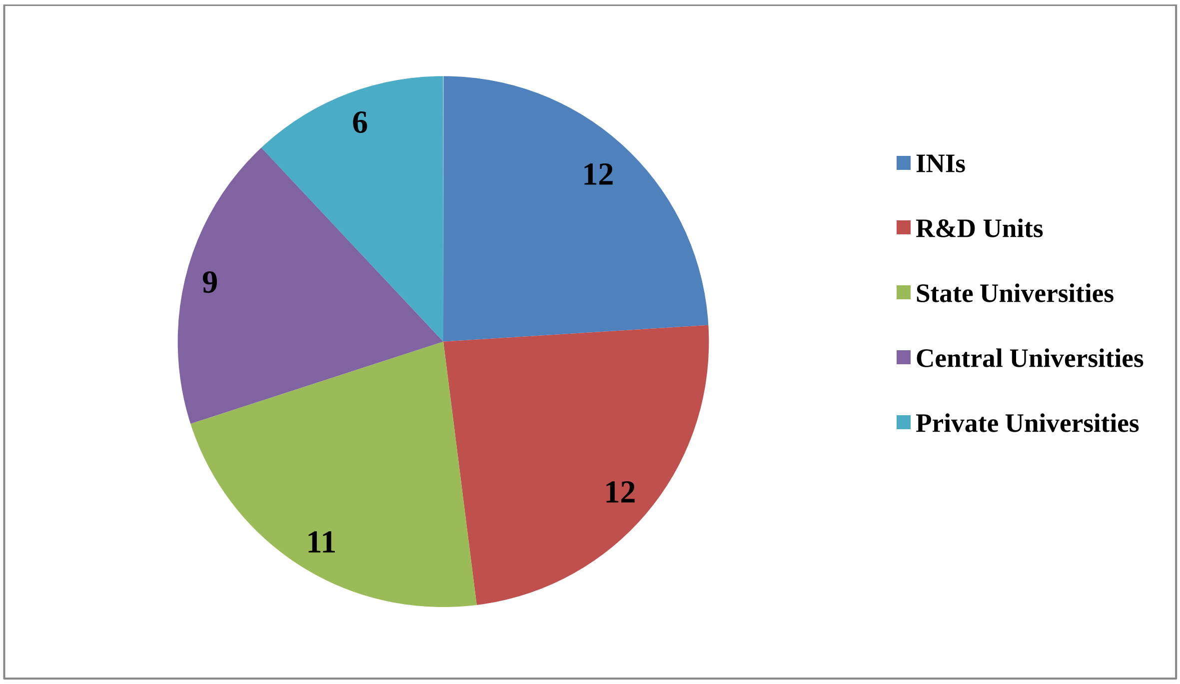
Table 6: Patents and Publications Profile of Top 50 Institutes* (HEIs & R&D) (2010-16)

S. No.	Institute	Status	Publications	Patents Filed	Patents Granted
1	University of Delhi, Delhi	Central Univ.	15052	84	26
2	IISc., Bangalore	Central Deemed Univ.	10852	533	174
3	IIT, Kharagpur	INI	8724	181	10
4	BHU, Varanasi	Central Univ.	8140	12	3
5	BARC, Mumbai	DAE	7887	7	3
6	University of Hyderabad, Hyderabad	Central Univ.	7649	18	5
7	IIT, New Delhi	INI	7148	264	56
8	AIIMs, Delhi	INI	6591	83	31
9	IIT, Chennai	INI	6440	424	48
10	IIT, Bombay	INI	6300	541	100
11	VIT University, Vellore	Pvt. Univ.	6267	54	3
12	IIT, Roorkee	INI	6028	26	1
13	IIT, Kanpur	INI	5622	296	44
14	Annamalai University, Tamil Nadu	State Univ.	5400	3	1
15	IIT, Hyderabad	INI	5398	28	2
16	PGIMER, Chandigarh	MHFW	5380	6	1
17	Gujarat University, Gujarat	State Univ.	4871	1	0
18	Panjab University, Chandigarh	State Univ.	4733	37	2
19	Aligarh Muslim University, Aligarh	Central Univ.	4588	7	2
20	Indian Institute of Chemical Technology, Hyderabad	CSIR	4534	76	32
21	Manipal University, Manipal	Pvt. Univ.	4444	56	13
22	IIT, Guwahati	INI	4205	23	0

23	Indian Agricultural Research Institute, New Delhi	ICAR	3934	7	2
24	S.R.M Institute of Science And Technology University, Chennai	Pvt. Univ.	3509	45	4
25	TIFR, Mumbai	DAE	3494	19	13
26	National Chemical Laboratory, Pune	CSIR	3232	4	3
27	Sathyabama University, Chennai	Pvt. Univ.	3211	8	0
28	Indian Association for the Cultivation of Science, Kolkata	DST	2961	21	2
29	Bharathiar University, Coimbatore	State Univ.	2948	1	0
30	Jawaharlal Nehru University, Delhi	Central Univ.	2739	19	6
31	Institute of Chemical Technology, Mumbai	State Univ.	2671	87	39
32	Saha Institute of Nuclear Physics, Kolkata	DAE	2543	2	2
33	Jammu University, Tawi	State Univ.	2524	0	0
34	Osmania University, Hyderabad	State Univ.	2467	7	0
35	National Physical Laboratory, New Delhi	CSIR	2378	0	0
36	Sri Venkateswara University, Tirupati	State Univ.	2344	1	0
37	IIT, Dhanbad	INI	2323	7	3
38	Jamia Millia Islamia, Delhi	Central Univ.	2320	10	0
39	NIT, Rourkela	INI	2275	6	0
40	Thapar University, Patiala	Pvt. Univ.	2269	10	0
41	Indira Gandhi Centre for Atomic Research, Tamil Nadu	DAE	2250	0	0
42	Indian Veterinary Research Institute, Izatnagar	ICAR	2242	4	2
43	Guru Nanak Dev University, Amritsar	State Univ.	2177	4	1
44	Pondicherry University, Puducherry	Central Univ.	2151	10	1

45	Central Drug Research Institute, Lucknow	CSIR	2125	3	2
46	University of Allahabad, Allahabad	Central Univ.	2109	3	0
47	Bharath University, Chennai	Pvt. Univ.	2082	111	0
48	Shivaji University, Kohlapur	State Univ.	2063	0	0
49	Indian Statistical Institute, Kolkata	INI	1886	41	13
50	Coimbatore Institute of Technology, Coimbatore	State Univ.	1854	2	0

*On the basis of Articles Publications



Graph 2: Categorization of Top 50 Ranked Institutes (HEIs + R&D Units)

Out of these top 50 institutions ranked according to number of publications, there are 12 institutions of national importance comprising of IITs, AIIMS, NIT and Indian Statistical Institute, Kolkata, nine central universities like Delhi University, which is on the top of the list, on basis of publications and 84 patents have been filed and 26 patents have been granted to its credit in last seven years, eleven State Universities, twelve R&D units under various ministries. Mainly institutions of national importance and research labs are dominating the ranking. But if we see the top 10 institutes **(graph-3)** based on research publications, the institutions like Banaras Hindu University (BHU), Bhabha Atomic Research Centre (BARC) and Hyderabad University (HU) these are lacking in patents profile as their publication profile is very impressive. The institutes like IISc.at Bangalore, three IITs (Delhi, Madras, Bombay) and All India Institute of Medical Science (AIIMS), Delhi are performing equally good in both parameters vis a vis patents (filing/grant) and research publications. Here it is imperative to mention that the BARC institute, which, comes under Department of Atomic Energy (DAE), might have so many patentable inventions, but as per the **Atomic Energy Act, 1962** *(http://dae.nic.in/?q=node/153),* the inventions falling within Section 20 of the Act, are not patentable. The details of this section are as follows:

Section 20 of Atomic Energy Act, 1962: Special Provision as to Inventions

i. *As from the commencement of this Act, no patents shall be granted for inventions which in the opinion of the Central Government are useful for or relate to the production, control, use or disposal of atomic energy or the prospecting, mining, extraction, production, physical and chemical treatment, fabrication, enrichment, canning or use of any prescribed substance or radioactive substance or the ensuring of safety in atomic energy operations.*

ii. *The prohibition under sub-section (1) shall also apply to any invention of the nature specified in that sub-section in respect of which an application for the grant of a patent has been made to the Controller of Patents and Designs appointed under the Indian Patents and Designs Act, 1911, before the commencement of this Act and is pending with him at such commencement.*

iii. *The Central Government shall have the power to inspect at any time any pending patent application and specification before its acceptance and if it considers that the invention relates to atomic energy, to issue directions to the Controller of Patents and Designs to refuse the application on that ground.*

iv. *Any person, who has made an invention which he has reason to believe relates to atomic energy, shall communicate to the Central Government the nature and description of the invention.*

v. *Any person desiring to apply for a patent abroad for an invention relating to or which he has reason to believe relates to atomic energy shall obtain prior permission from the Central Government before making the application abroad or communicating the invention to any person abroad, unless three months have elapsed since his request for permission was made to the Central Government and no reply was received by him.*

vi. *The Controller of Patents and Designs shall have the power to refer any application to the Central Government for direction as to whether the invention is one relating to atomic energy and the direction given by the Central Government shall be final.*

vii. *Any invention in the field of atomic energy conceived whether in establishments controlled by the Central Government or under any contract, sub-contract, arrangement or other relationship with the Central Government shall be deemed to have been made or conceived by the Central Government, irrespective of whether such contract, sub-contract, arrangement or other relationship involves financial participation of or assistance from the Central Government.*

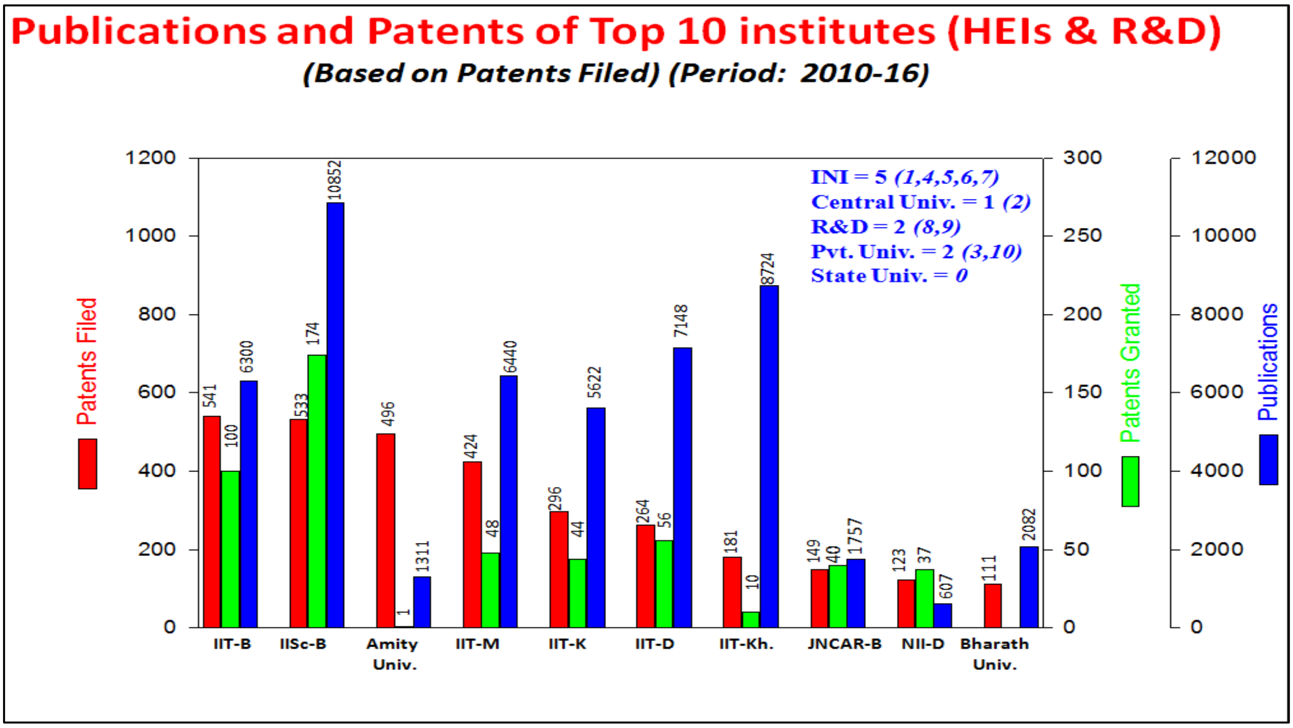
viii. *Notwithstanding anything contained in the Indian Patents and Designs Act, 1911, the decision of the Central Government on points connected with or arising out of this section shall be final.*

Role Models for other Institutions

There are some institutions in India, which are leading both in research publication and patenting as well. These institutes have been analysed by our centre and also approved by other national and international recognised reports and agencies as well. On the basis of the study, it appears that only IITs have taken responsibility in producing patents and presenting innovations before the world. They are actually justifying their name "Institutions of National Importance". The reasons for this commendable performance of IITs (mainly first generation IITs) are they are very much IPR savvy, their incentivisation setup is very strong, they have dedicated IPR cells and technology transfer cells also which is missing in a maximum of the institutions in India. On the basis of this study, the centre has analysed those institutes which can act as role models for rest of the institutes which are doing good research but are unable or un aware about how they can exploit their research and can file a patent for the same. The top ten institutes which have been ranked on the basis of patents filed and patents granted are mentioned in next section (**graph 3 and graph 4).**

a. Top 10 Institutions Based on Patents Filed

The top 10 institutes, which are leading in patents filing are shown in Graph-2 with the no. of patents granted and research publications by them. The top 5 positions are occupied IITs namely IIT Bombay (1), IIT Madras (4), IIT Kanpur (5), IIT Delhi (6) and IIT Kharagpur (7). In addition to these IITs, other institutes which are filing a good number of patents are IISc Bangalore (2), Amity University (3), Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore (8), National Institute of Immunology Delhi (9) and Bharath University Chennai (10). Some Universities are filing patents just for the sake of its reputation or brand building, whereas, their grant rate is zero. Here Amity University, Noida and Bharath University, Chennai are the suitable examples for this. As we can see in graph-2, for the period of 2010-16 Amity University has filed a total of 496 patents and they have only one patent granted to their credit for the same period. Apart from Amity University here is another private university which just believes in patents filing i.e. Bharath University situated in Chennai. Bharath University has filed a total of 111 patents for last seven years (2010-16) but their grant rate is nil. So the innovations by the students/scientist/researcher/faculty of any institute should be first evaluated at this institute level. For this purpose, every institution must have their dedicated IPR Policy, IPR Cell and Technology Transfer Cell etc. These cells will facilitate inventers by guiding them on how to protect their intellectual property or if their invention is protectable or not.

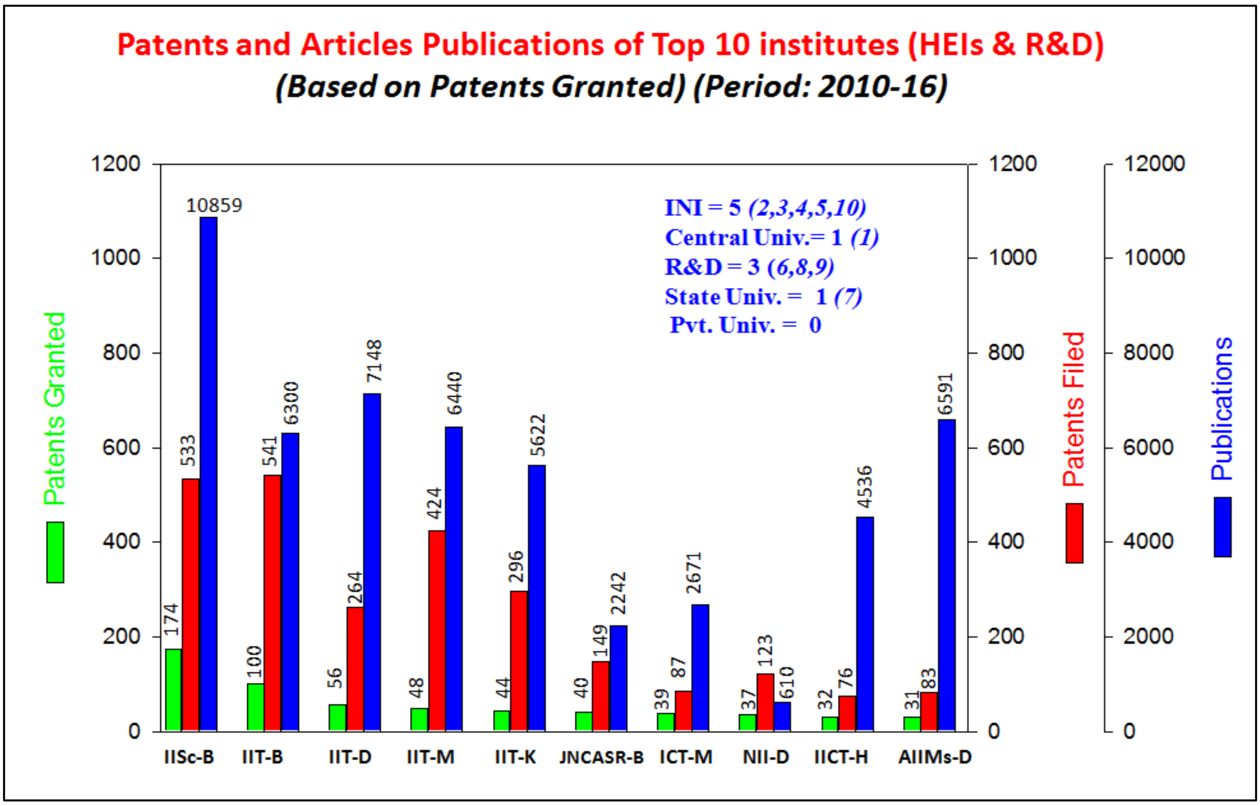


Graph-3: **Top 10 Institutions Based on Patents Filing**

b. Top 10 Institutions based on Patents Granted

In the ranking of top 10 institutes on the basis of patents granted between the years 2010 -16, there are five institutes belonging to the category of "Institutions of National Importance", which is commendable. These five institutions are IIT Bombay, IIT Delhi, IIT Madras and IIT Kanpur.

Along with these five IITs, other institutes are Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, ICT Mumbai, National Institute of Immunology New Delhi, Indian Institute of Chemical Technology, Hyderabad and All India Institute of Medical Science, Delhi. An institution having a well institutional setup and a good sense of the technologies exploitation, that institute, will always rise in all parameters related to science and technology. This statement is justified by selected institutes like IISc. Bangalore, IITs and some selected R&D institutes like Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, ICT Mumbai, National Institute of Immunology, New Delhi. The IPR regime in these institutes is very - very strong as their patents grant rate is impressive. So we need to study models of these institutes. That model should be followed in other institutes too.



Graph-4: Top 10 Institutions Based on Patents Granted

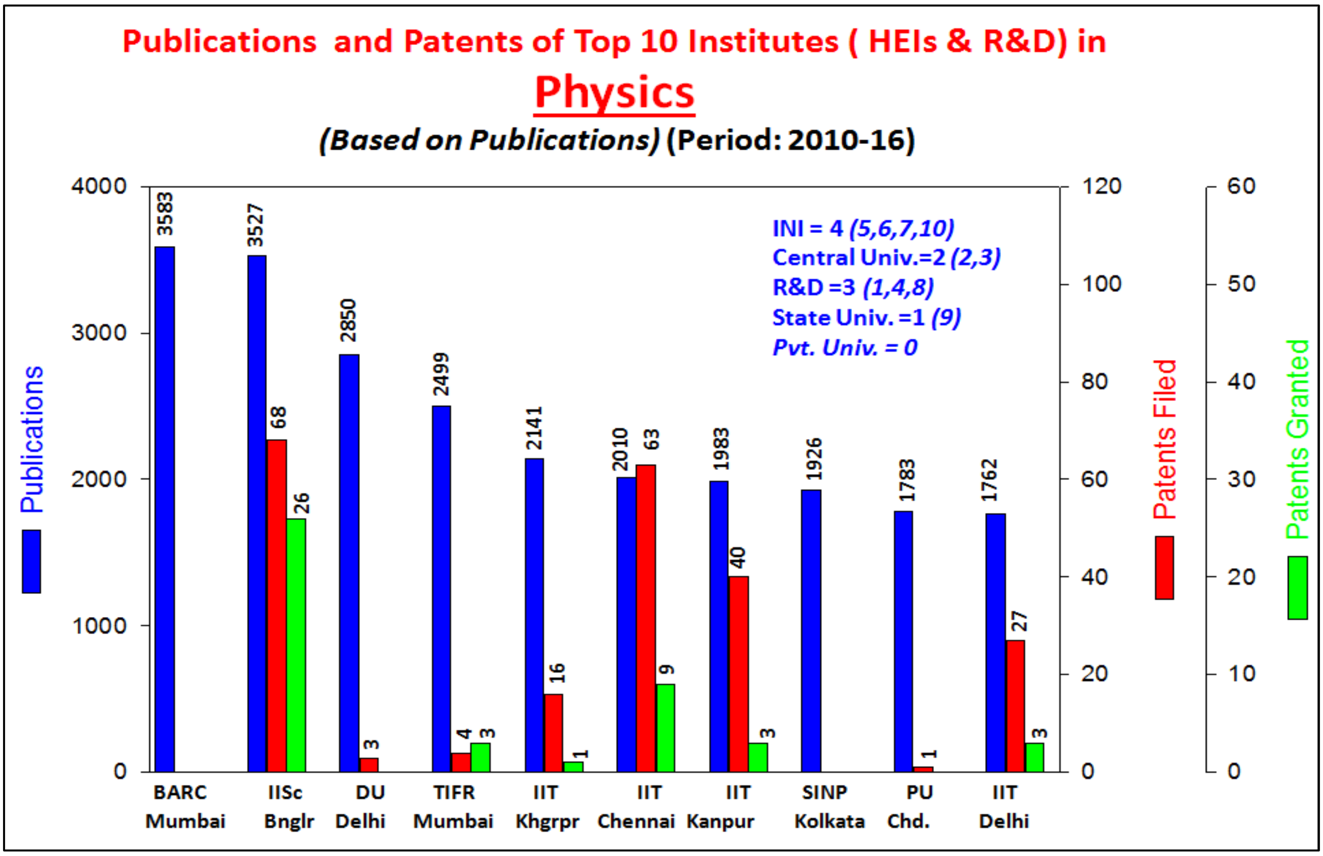
Field Wise Analysis of Institutions (914)

Academic institutions and universities are a storehouse of knowledge and knowledge givers, with new knowledge generated at these places on a continuous basis. Until recently the culture of protecting their inventive work legally through patents was almost nonexistent in these institutes, as most teachers felt that the knowledge should be shared freely through publications, seminars etc.

There are some institutes in India which are doing exceptionally good in patents and publications like IIT Madras, IIT Mumbai, IIT Delhi, IISc., Bangalore and CSIR. The reason behind their magnificent performance may be they are having IPR cells, dedicated IPR Policy, a Good incentivisation mechanism for academicians, researchers and scientists for patenting etc. Now we are in the process of sending proforma **(Annexure-3)** to these institutes and seek their involvement in promoting and identifying gaps between research publications and its conversion into patents and commercial asset. We have also analysed the data on the basis of six fields for all these institutions (914). By doing this exercise the Centre has figured out the stream wise performance of the institutes and can rope in them in strengthening the same in other institutes as well. The various fields are mentioned in **table 7**:

Table 7: Fields Categorization for Patents & Publications

S. No.	Patents Fields	Publications Fields
1	Physics	Physics & Astronomy
2	Chemical Engineering	• Chemistry • Chemical Engineering • Material Science
3	Pharma/Drug	Pharmacology, Toxicology and Pharmaceutics
4	Medical Science	• Medicine • Health Profession • Dentistry • Nursing • Neuroscience
5	• Mechanical Engineering • ECE • Electrical Engineering	• Engineering • Computer Science
6	• Biotechnology/Biological Science • Food/Agriculture	• Agricultural and Biological Sciences • Biochemistry and Genetics and Molecular Biology • Immunology & Microbiology • Environmental Sciences



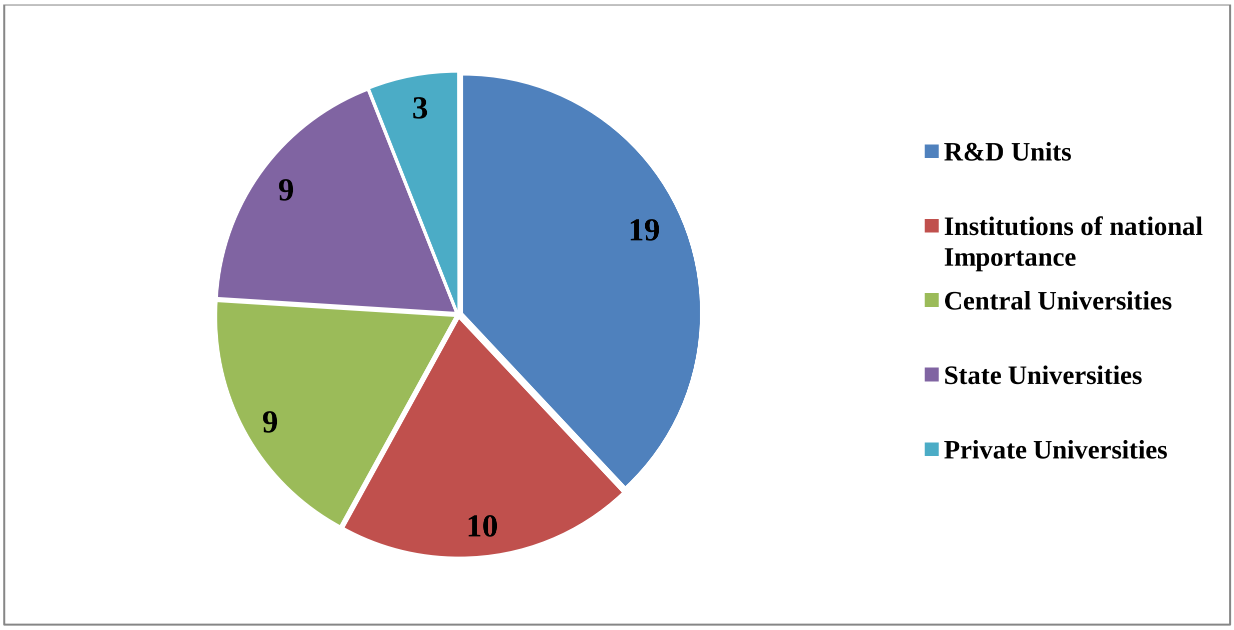
Graph-5: Top 10 Institutions in the Field of Physics

Table 8: Patents and Publications Profile of Top 50 Institutes based on Publications in Physics

S. No.	Institute	Status	Publications	Patents Filed	Patents Granted
1	Bhabha Atomic Research Centre, Mumbai	DAE	3583	0	0
2	Indian Institute of Science, Bangalore	Central Univ. (Deemed)	3527	68	26
3	University of Delhi, New Delhi	Central Univ.	2850	3	0
4	TIFR, Mumbai	DAE	2499	4	3
5	IIT , Kharagpur	INI	2141	16	1
6	IIT , Chennai	INI	2010	63	9
7	IIT, Kanpur	INI	1983	40	3
8	Saha Institute of Nuclear Physics, Kolkata	DAE	1926	0	0

9	Panjab University, Chandigarh	State Univ.	1783	1	0
10	IIT, New Delhi	INI	1762	27	3
11	IIT, Bombay	INI	1698	67	9
12	BHU, Varanasi	Central Univ.	1605	0	0
13	University of Hyderabad, Hyderabad	Central Univ.	1386	0	0
14	IIT , Roorkee	INI	1301	3	0
15	Indian Association for the Cultivation of Science, Kolkata	DST	1242	3	0
16	National Physical Laboratory, New Delhi	CSIR	1219	0	0
17	IIT, Guwahati	INI	1209	5	0
18	Indira Gandhi Centre for Atomic Research, Tamilnadu	DAE	1078	0	0
19	Institute for Plasma Research GIDC Bhat, Gandhinagar	DAE	866	2	1
20	Annamalai University, Tamilnadu	State Univ.	809	0	0
21	Institute of Physics, Bhubaneswar	DAE	778	0	0
22	Aligarh Muslim University, Aligarh	Central Univ.	759	0	0
23	Variable Energy Cyclotron Centre , kolkata	DAE	727	0	0
24	VIT University, Vellore	Pvt. Univ.	717	9	0
25	S.N. Bose National Centre for Basic Sciences, Kolkata	DST	714	4	4
26	Thapar University, Patiala	Pvt. Univ.	700	2	0
27	Physical Research Laboratory, Ahmedabad	DoS	687	0	0
28	Raja Ramanna Centre for Advanced Technology, Indore	DAE	681	0	0
29	Raman Research Institute, Bangalore	DST	669	9	3
30	Visva-Bharati University, West Bengal	Central Univ.	613	0	0

31	Indian Institute of Astrophysics, Bangalore	DAE	608	0	0
32	Gujarat University, Gujarat	State Univ.	597	0	0
33	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	DST	591	17	8
34	IIT, Hyderabad	INI	589	1	0
35	Harish Chandra Research Institute, Allahabad	DAE	587	0	0
36	Jamia Millia Islamia, New Delhi	Central Univ.	575	1	0
37	Bharathiar University, Coimbatore	State Univ.	568	0	0
38	Jammu University,Tawi	State Univ.	568	0	0
39	Sri Venkateswara University, Tripura	State Univ.	533	0	0
40	Central Glass Ceramic Research Institute, Kolkata	CSIR	530	0	0
41	IIT (Indian School of Mines), Dhanbad	INI	523	0	0
42	National Chemical Laboratory, Pune	CSIR	515	0	0
43	Shivaji University, Kolhapur	State Univ.	512	0	0
44	Guru Nanak Dev University, Amritsar	State Univ.	482	0	0
45	Cochin University of Science And Technology, Cochin	State Univ.	480	2	0
46	The Institute of Mathematical Sciences, Chennai	DAE	463	0	0
47	IISER, Pune	INI	455	1	0
48	Pondicherry University, Puducherry	Central Univ.	453	0	0
49	S.R.M Institute of Science And Technology University, Chennai	Pvt. Univ.	446	8	0
50	Tezpur University, Tezpur	Central Univ.	442	0	0



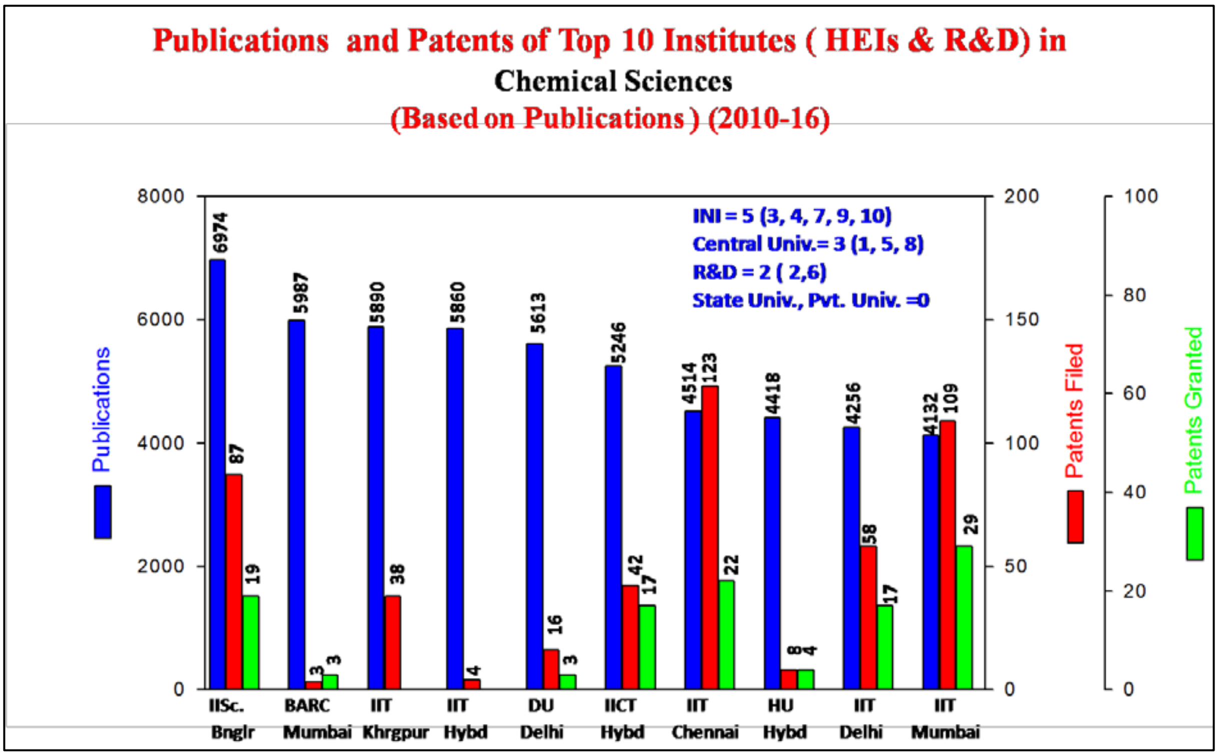
Graph 6: Categorization of Top 50 Ranked Institutes in the Field of Physics

Table 9: Top 10 Institutes on the basis of Patents Filed in Physics

S. No.	Institute	Patents Granted	Patents Filed	Publications
1.	IISc., Bangalore	26	68	3527
2	IIT, Mumbai	9	67	1698
3	IIT, Madras	9	63	2010
4	IIT, Kanpur	3	40	1983
5	Amity University, Noida	0	30	237
6	IIT, New Delhi	3	27	1762
7	Amrita Viswa Vidyapeetham, Coimbatore	3	17	119
8	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	8	17	591
9	IIT, Kharagpur	1	16	2141
10	Bharath University, Chennai	0	15	27

Table 10: Patents and Publications Profile of Top 10 Institutes in Physics (Based on Patents Granted) (Period: 2010-16)

S. No.	Institute	Patents Granted	Patents Filed	Publications
1.	IISc.Bangalore	26	68	3527
2	IIT Chennai	9	63	2010
3	IIT Bombay	9	67	1698
4	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	8	17	591
5	S.N. Bose National Centre for Basic Sciences, Kolkata	4	4	714
6	IIT Kanpur	3	40	1983
7	IIT New Delhi	3	27	1762
8	Indian Statistical Institute, Kolkata	3	6	304
9	Amrita Vishwa Vidyapeetham Coimbatore	3	17	122
10	Raman Research Institute, Bangalore	3	9	669



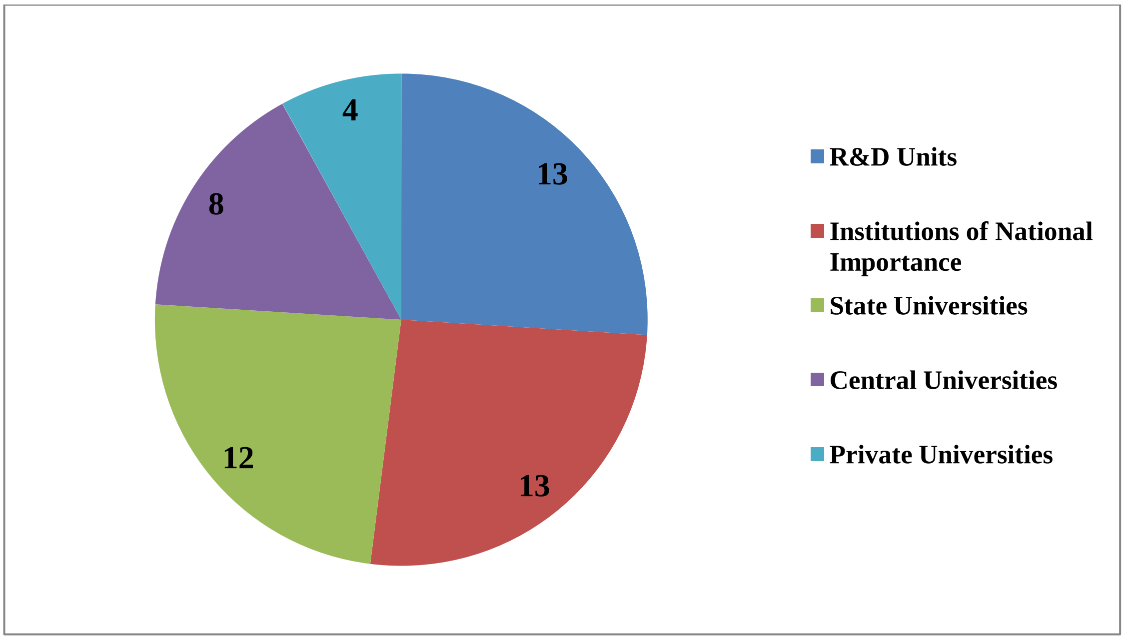
Graph: 7 Top 10 Institutions in the Field of Chemical Sciences

Table 11: Patents and Publications Profile of Top 50 Institutes based on Publications in Chemical Sciences

S. No.	Institute	Status	Publications	Patents Filed	Patents Granted
1	IISc., Bangalore	Central Univ. (Deemed)	6974	87	19
2	BARC, Mumbai	DAE	5987	3	3
3	IIT, Kharagpur	INI	5890	38	0
4	IIT , Hyderabad	INI	5860	4	0
5	University of Delhi, Delhi	Central Univ.	5613	16	3
6	Indian Institute of Chemical Technology, Hyderabad	CSIR	5246	42	17
7	IIT, Chennai	INI	4514	123	22
8	University of Hyderabad, Hyderabad	Central Univ.	4418	8	4
9	IIT, New Delhi	INI	4256	58	17
10	IIT, Bombay	INI	4132	109	29
11	IIT, Kanpur	INI	4060	86	17
12	National Chemical Laboratory, Pune	CSIR	4045	1	1
13	Banaras Hindu University, Varanasi	Central Univ.	3863	5	1
14	IIT, Roorkee	INI	3612	15	1
15	Indian Association for the Cultivation of Science, Kolkata	DST	3532	9	1
16	IIT , Guwahati	INI	3067	4	0
17	Institute of Chemical Technology, Mumbai	State Univ.	2917	47	20
18	VIT University, Vellore	Pvt. Univ.	2712	12	2
19	Gujarat University, Gujarat	State Univ.	2680	1	0
20	Annamalai University, Tamilnadu	State Univ.	2380	0	0

21	National Physical Laboratory, New Delhi	CSIR	2293	0	0
22	Indira Gandhi Centre for Atomic Research, Tamilnadu	DAE	2083	0	0
23	Aligarh Muslim University, Aligarh	Central Univ.	1974	5	2
24	Central Leather Research Institute, Chennai	CSIR	1754	0	0
25	Shivaji University, Kolhapur	State Univ.	1749	0	0
26	Panjab University, Chandigarh	State Univ.	1690	6	0
27	Bharathiar University, Tamilnadu	State Univ.	1651	0	0
28	Central Electrochemical Research Institute, Karaikudi	CSIR	1636	0	0
29	Central Salt Marine Chemicals Research Institute, Bhavnagar	CSIR	1584	0	0
30	Guru Nanak Dev University, Amritsar	State Univ.	1558	1	0
31	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	DST	1539	52	16
32	National Institute For Interdisciplinary Science and Technology ,Thiruvananthapuram	CSIR	1463	0	0
33	Sri Venkateswara University, Tirupati	State Univ.	1448	0	0
34	NIT, Rourkela,	INI	1361	1	0
35	S.R.M Institute Of Science And Technology, Chennai	Pvt.	1356	2	1
36	Tezpur University, Tezpur	Central Univ.	1345	4	0
37	Thapar University, Patiala	Pvt. Univ.	1326	5	0
38	Jamia Millia Islamia , New Delhi	Central Univ.	1260	3	0
39	IIT (Indian School of Mines), Dhanbad	INI	1247	2	0
40	Osmania University, Hyderabad	State Univ.	1216	3	0
41	Alagappa University	State Univ.	1197	0	0

42	Central Glass Ceramic Research Institute, Kolkata	CSIR	1174	0	0
43	Central Drug Research Institute, Lucknow	CSIR	1156	3	2
44	Pondicherry University, Puducherry	Central Univ.	1153	5	1
45	IIT (BHU), Varanasi	INI	1146	0	0
46	NIT, Karnataka	INI	1131	0	0
47	IISc.Education & Research (IISER), Kolkata	INI	1095	0	0
48	Kalyani University, West Bengal	State Univ.	1074	0	0
49	Birla Institute of Technology & Science, Pilani	Pvt.	1064	0	0
50	Cochin University of Science And Technology, Cochin	State Univ.	1015	0	0



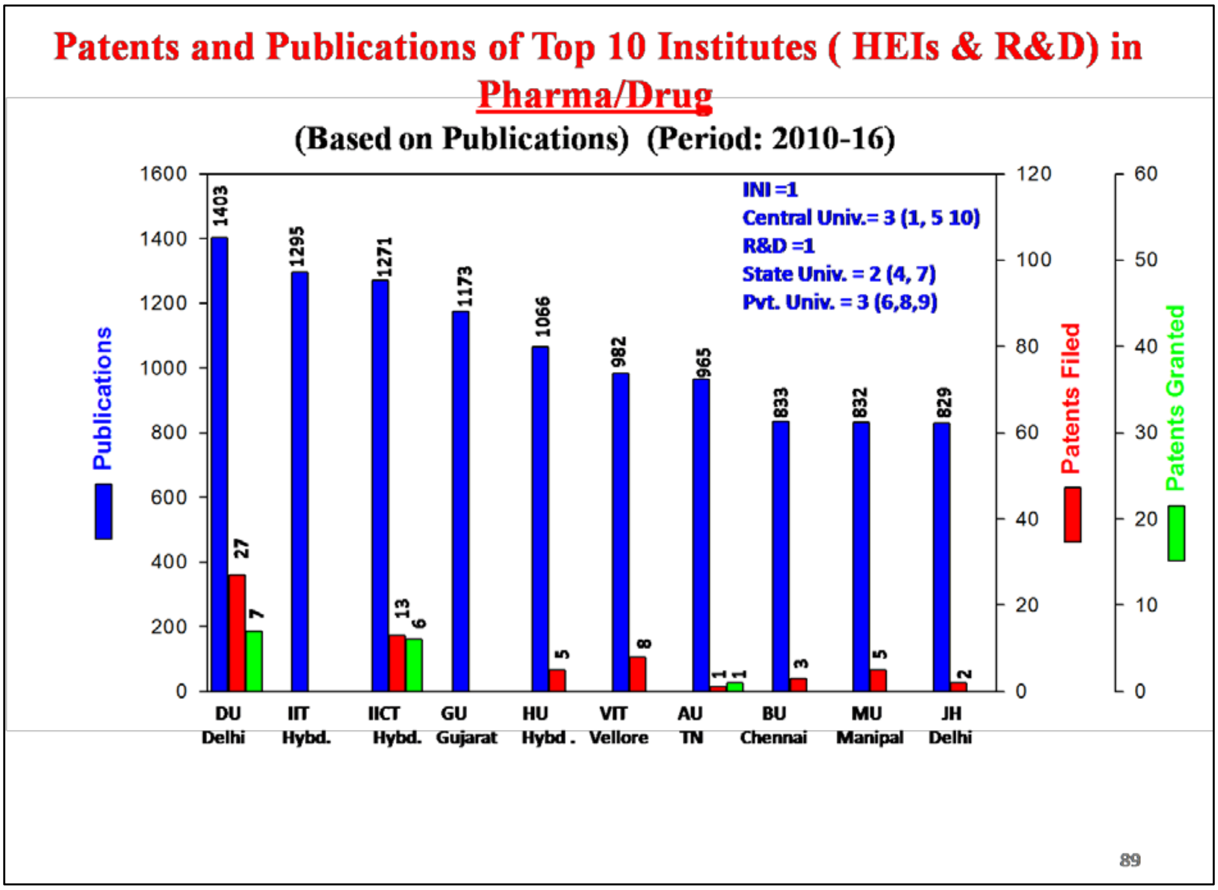
Graph 8: Categorization of Top 50 Ranked Institutes in the Field of Chemical Sciences

Table 12: Top 10 Institutes on the basis of Patents Filed in Chemical Sciences

S. No.	Institute	Patents Granted	Patents Filed	Publications
1.	Indian Institute of Technology, Chennai	22	123	4514
2	Indian Institute of Technology, Mumbai	29	109	4132
3	Amity University, Noida	0	105	496
4	Indian Institute of Science, Bangalore	19	87	6974
5	Indian Institute of Technology, Kanpur	17	86	4060
6	Indian Institute of Technology, New Delhi	17	58	4256
7	International Advanced Research Centre for Powder Metallurgy & New Materials, Hyderabad	6	52	383
8	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	16	52	1539
9	Institute of Chemical Technology	20	47	107
10	National Institute of Pharmaceutical, Educational and Research, Mohali	8	46	254

Table 13: Patents and Publications Profile of Top 10 Institutes in Chemical Sciences (Based on Patents Granted) (Period: 2010-16)

S. No.	Institute	Patents Granted	Patents Filed	Publications
1.	IIT, Mumbai	29	109	4132
2	IIT, Chennai	22	123	4514
3	Institute of Chemical Technology, Mumbai	20	47	2917
4	IISc., Bangalore	19	87	6974
5	IIT, Kanpur	17	86	4060
6	IIT, New Delhi	17	58	4256
7	Indian Institute of Chemical Technology, Hyderabad	17	42	5246
8	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	16	52	1539
9	NIPER Mohali, Punjab	8	46	252
10	Central Institute of Research on Cotton Technology, Mumbai	6	9	9



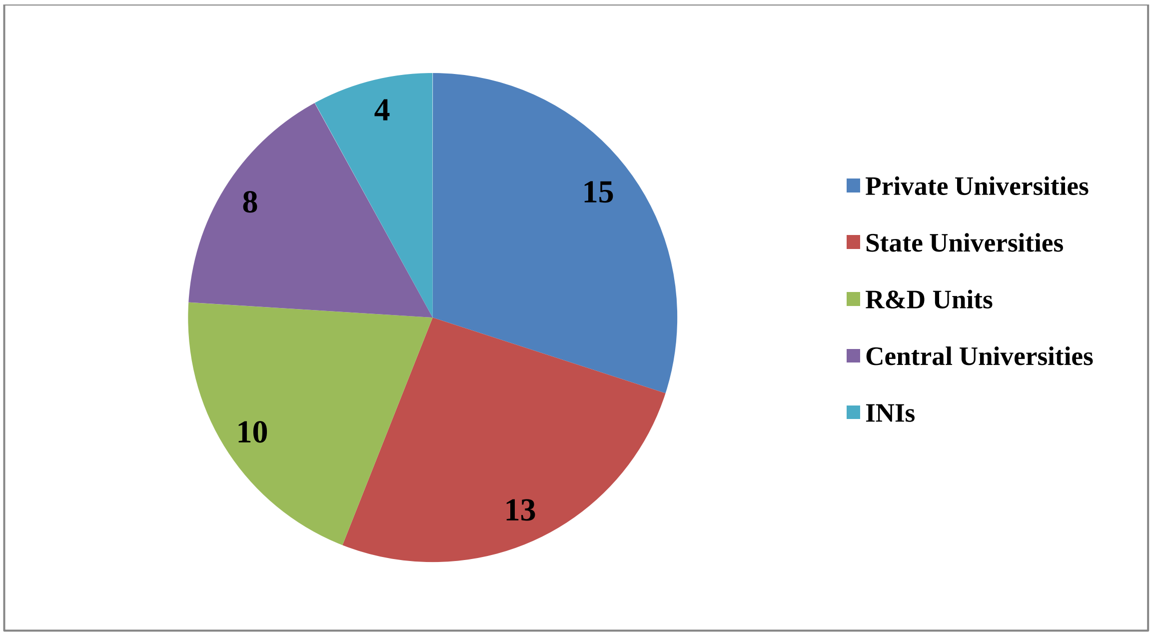
Graph: 9 Top 10 institutions in the Field of Pharma/Drug

Table 13: Patents and Publications profile of Top 50 Institutes based on Publications in Pharma/Drug

S. No.	Institute	Status	Publications	Patents Filed	Patents Granted
1	University of Delhi, New Delhi	Central Univ.	1403	27	7
2	IIT, Hyderabad	INI	1295	0	0
3	Indian Institute of Chemical Technology, Hyderabad	CSIR	1271	13	6
4	Gujarat University, Gujarat	State Univ.	1173	0	0
5	University Of Hyderabad, Hyderabad	Central Univ.	1066	5	0
6	VIT University, Vellore	Pvt. Univ.	982	8	0
7	Annamalai University, Tamilnadu	State Univ.	965	1	1
8	Bharath University, Chennai	Pvt. Univ.	833	3	0

9	Manipal University, Manipal	Pvt. Univ.	832	5	0
10	Jamia Hamdard, New Delhi	Central Univ.	829	2	0
11	Central Drug Research Institute, Lucknow	CSIR	802	0	0
12	Banaras Hindu University, Varanasi	Central Univ.	761	4	1
13	Sathyabama University, Chennai	Pvt. Univ.	723	0	0
14	S.R.M Institute of Science And Technology, Chennai	Pvt. Univ.	602	10	1
15	Panjab University, Chandigarh	State Univ.	591	27	2
16	Jawaharlal Nehru Technological University, Hyderabad	State Univ.	476	0	0
17	Osmania University, Hyderabad	State Univ.	472	0	0
18	Sri Venkateswara University, Tirupati	State Univ.	418	0	0
19	Manipal College of Pharmaceutical Sciences, Manipal	Pvt. Univ.	389	2	0
20	University Institute of Pharmaceutical Sciences, Chandigarh (Panjab Univ.)	State Univ.	385	4	0
21	Indian Institute of Integrative Medicine, Jammu	CSIR	346	11	7
22	Bharati Vidyapeeth, Pune	Pvt. Univ.	330	2	0
23	Bharathiar University, Coimbatore	State Univ.	329	0	0
24	Indian Institute of Toxicology Research, Lucknow	CSIR	327	0	0
25	Birla Institute of Technology & Science, Pilani	Pvt. Univ.	322	3	0
26	All India Institute of Medical Sciences, New Delhi	INI	320	24	9
27	Birla Institute of Technology, Ranchi	Pvt. Univ.	308	3	0
28	Karpagam University, Coimbatore	Pvt. Univ.	305	10	0
29	Poona College of Pharmacy Pune	Pvt. Univ.	298	0	0

30	Aligarh Muslim University, Aligarh	Central Univ.	286	2	0
31	JSS University, Mysore	Pvt. Univ.	271	5	0
32	JSS College of Pharmacy, Mysore	Pvt. Univ.	263	0	0
33	National Chemical Laboratory, Pune	CSIR	263	4	3
34	Guru Nanak Dev University, Amritsar	State Univ.	263	3	1
35	Indian Institute of Chemical Biology, Kolkata	CSIR	257	5	0
36	Periyar University, Tamilnadu	State Univ.	254	0	0
37	University College of Pharmaceutical Sciences, Warangal	State Univ.	226	0	0
38	Department Of Pharmaceutical Sciences, (Dibrugarh Univ.), Dibrugarh	State Univ.	226	2	0
39	University of Allahabad, Allahabad	Central Univ.	218	0	0
40	SRM University, Chennai	Pvt. Univ.	217	10	1
41	PGIMER, Chandigarh	ICMR	208	2	0
42	Central Institute of Medicinal Aromatic Plants, Lucknow	CSIR	204	0	0
43	Pondicherry University, Pudicherry	Central Univ.	201	0	0
44	IIT, Kharagpur	INI	200	5	0
45	NIPER Mohali, Punjab	INI	195	50	10
46	BARC, Mumbai	DAE	195	0	0
47	Nirma University, Ahmedabad	Pvt. Univ.	191	3	0
48	Jamia Millia Islamia, New Delhi	Central Univ.	185	0	0
49	Institute of Nuclear Medicine & Allied Sciences, Delhi	DRDO	177	0	0
50	Guru Jambeshwar University of Science & Technology, Hisar	State Univ.	172	2	0



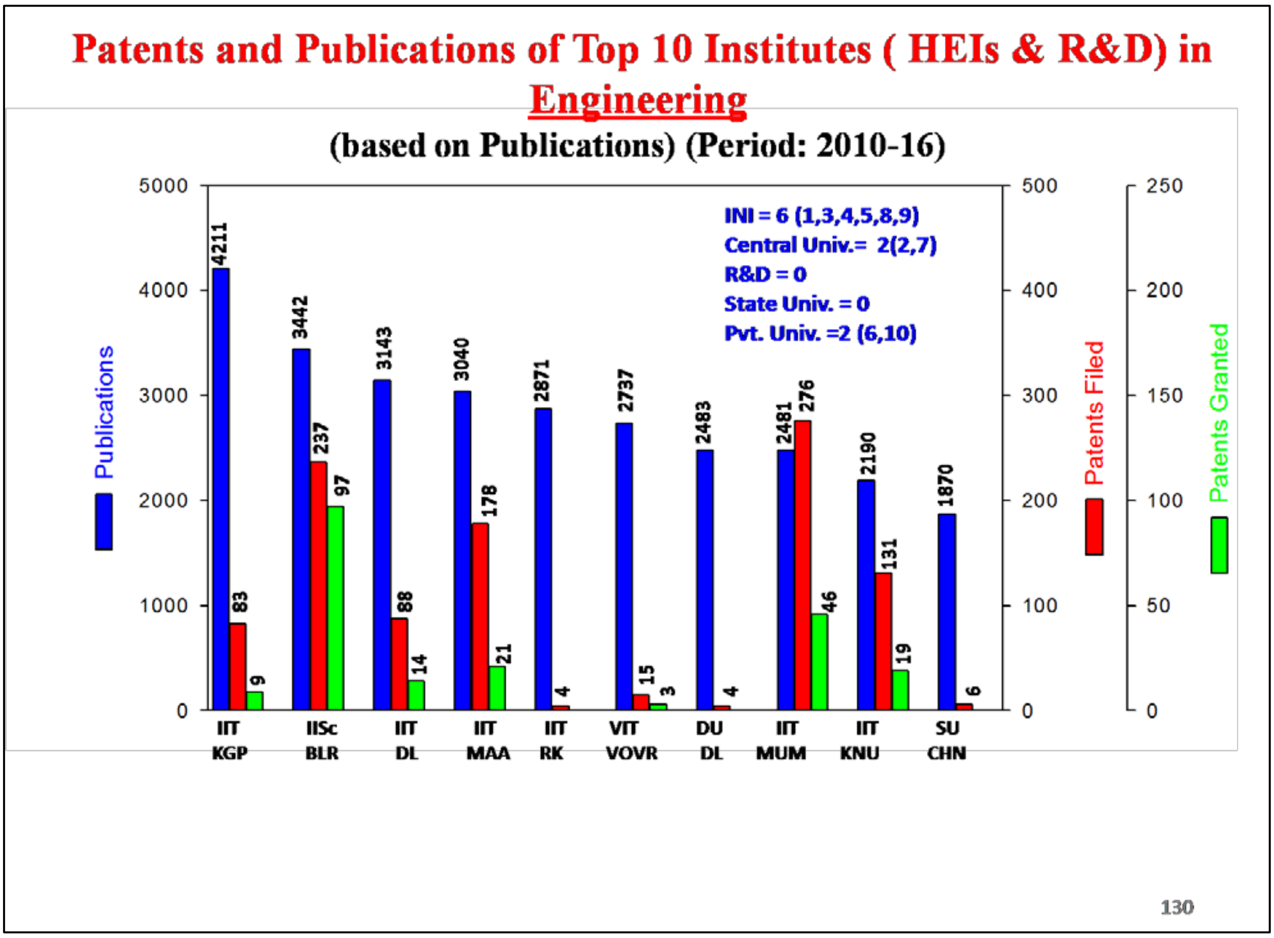
Graph 10: Categorization of Top 50 Ranked Institutes in the Field of Pharma/Drug

Table 14: Top 10 Institutes on the basis of Patents Filed in Pharma/Drug

S. No.	Institute	Patents Granted	Patents Filed	Publications
1.	Amity University, Noida	0	158	156
2	NII, New Delhi	25	76	71
3	IISc., Bangalore	18	58	256
4	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	13	54	33
5	NIPER Mohali, Punjab	10	50	195
6	IIT, Mumbai	14	41	140
7	Amrita Viswa Vidyapeetham, Amrita Nagar	5	33	162
8	University of Delhi, New Delhi	7	27	1403
9	Panjab University, Chandigarh	2	27	591
10	AIIMS, New Delhi	9	24	320

Table 15: Patents and Publications Profile of Top 10 Institutes in Pharma/Drug (Based on Patents Granted) (Period: 2010-16)

S. No.	Institute	Patents Granted	Patents Filed	Publications
1.	NII, New Delhi	25	76	71
2	IISc., Bangalore	18	58	256
3	IIT, Mumbai	14	41	140
4	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	13	54	33
5	NIPER Mohali, Punjab	10	50	129
6	AIIMS, New Delhi	9	24	320
7	University of Delhi, New Delhi	7	27	1403
8	Indian Institute of Integrative Medicine, Jammu	7	11	346
9	National Centre for Cell Science, Pune	7	8	34
10	Jamia Hamdard, New Delhi	6	23	829



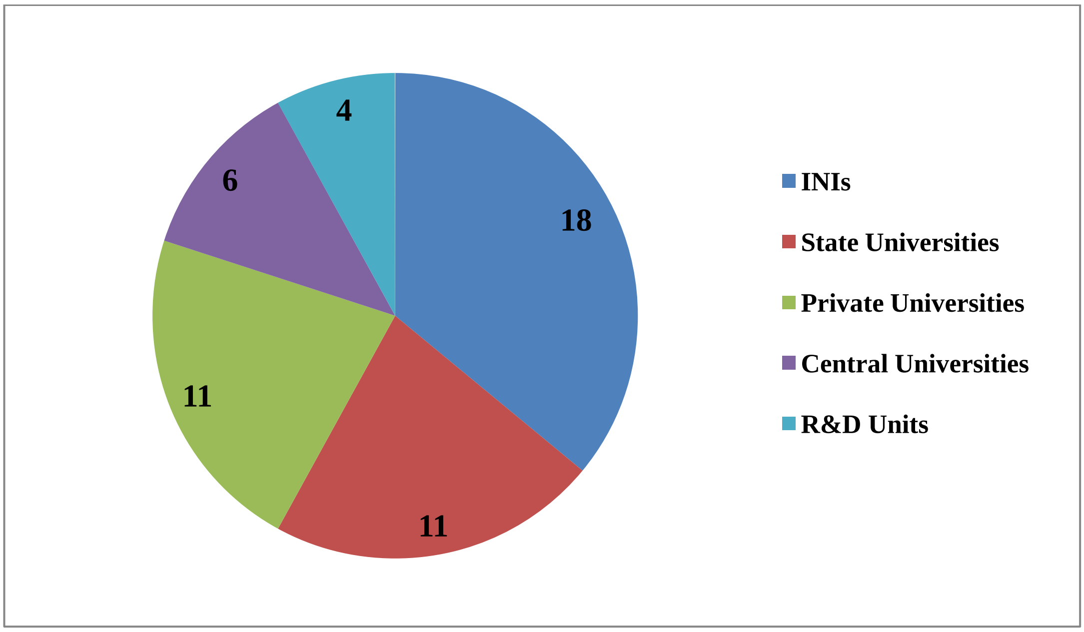
Graph-11: Top 10 Institutions in the Field of Engineering

Table 16: Patents and Publications Profile of Top 50 Institutes based on Publications in Engineering

S. No.	Institute	Status	Publications	Patents Filed	Patents Granted
1	IIT, Kharagpur	INI	4211	83	9
2	IISc., Bangalore	Central Univ. (Deemed)	3442	237	97
3	IIT, New Delhi	Central Univ.	3143	88	14
4	IIT, Chennai	INI	3040	178	21
5	IIT, Roorkee	INI	2871	4	0
6	VIT University, Vellore	Pvt. Univ.	2737	15	3
7	University of Delhi, New Delhi	Central Univ.	2483	4	0
8	IIT, Bombay	INI	2481	276	46
9	IIT, Kanpur	INI	2190	131	19
10	Sathyabama University, Chennai	Pvt. Univ.	1670	6	0
11	S.R.M Institute of Science And Technology, Chennai	Pvt. Univ.	1545	20	2
12	IIT , Guwahati	INI	1501	6	0
13	Bhabha Atomic Research Centre, Mumbai	DAE	1379	0	0
14	Coimbatore Institute of Technology-Coimbatore	State Univ.	1344	1	0
15	NIT, Rourkela,	INI	1298	2	0
16	Thapar University, Patiala	Pvt. Univ.	1285	1	0
17	University of Hyderabad, Hyderabad	Central Univ.	1235	1	0
18	Annamalai University, Tamilnadu	State Univ.	1233	1	0
19	BHU, Varanasi	Central Univ.	1225	2	0
20	IIT (Indian School of Mines), Dhanbad	INI	1055	2	1

21	PSG College Of Technology, Coimbatore	Pvt. Univ.	980	11	1
22	Amrita Viswa Vidyapeetham, Amrita Nagar	Pvt. Univ.	920	36	2
23	Bharathiar University, Coimbatore	State Univ.	870	0	0
24	Indira Gandhi Centre for Atomic Research	DAE	869	0	0
25	SRM University, Chennai	Pvt. Univ.	860	20	2
26	Indian Statistical Institute, Kolkata	INI	824	26	9
27	NIT, Durgapur	INI	794	1	0
28	Thiagarajar College of Engineering, Madurai (Anna Univ.)	State Univ.	767	10	5
29	IIT, Hyderabad	INI	744	20	2
30	NIT, Karnataka,	INI	705	0	0
31	Jamia Millia Islamia, New Delhi	Central Univ.	703	5	0
32	National Physical Laboratory, New Delhi	CSIR	662	0	0
33	Panjab University, Chandigarh	State Univ.	647	1	0
34	Aligarh Muslim University, Aligarh	Central Univ.	633	0	0
35	NIT, Calicut	INI	596	6	0
36	Motilal Nehru Institute of Technology, Allahabad	INI	596	2	0
37	Birla Institute of Technology, Ranchi	Pvt. Univ.	582	6	3
38	Institute of Chemical Technology, Mumbai	State Univ.	576	5	1
39	Shivaji University, Kolhapur	State Univ.	575	0	0
40	IIT (BHU), Varanasi	INI	563	0	0
41	NIT, Warangal	INI	557	0	0
42	Gujarat University, Gujarat	State Univ.	555	0	0

43	BITS, Pilani	Pvt. Univ.	533	0	0
44	Sri Venkateswara University, Tripura	State Univ.	512	0	0
45	Karunya University, Coimbatore	Pvt. Univ.	510	0	0
46	NIT, Kurukshetra	INI	498	1	0
47	Bharath University, Chennai	Pvt. Univ.	498	45	0
48	College of Engineering, Pune	State Univ.	497	7	0
49	Defence Metallurgical Research Laboratory, Hyderabad	DRDO	484	0	0
50	Cochin University Of Science And Technology, Cochin	State Univ.	473	2	0



Graph 12: Categorization of Top 50 Ranked Institutes in the Field of Engineering

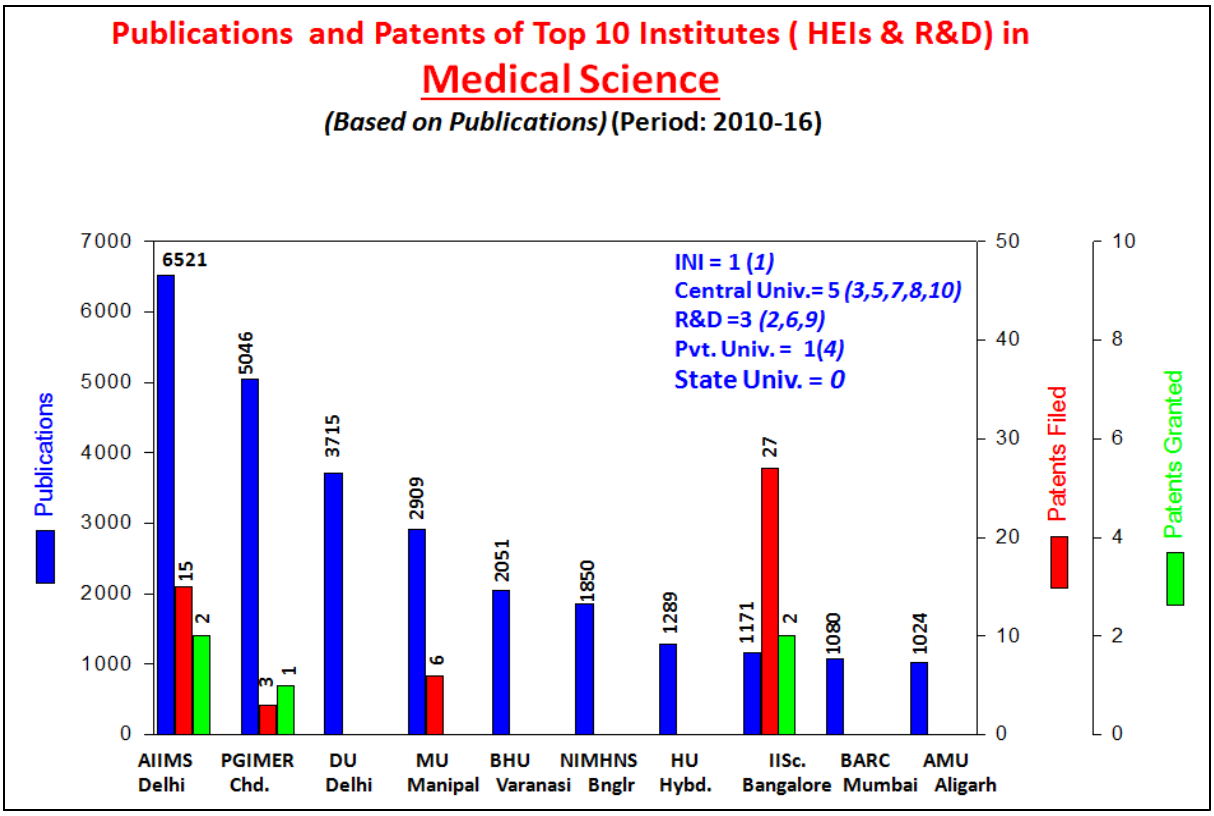
Table 17: Top 10 Institutions on the basis of Patents Filed in Engineering

S. No.	Institute	Patents Granted	Patents Filed	Publications
1.	IIT, Bombay	46	276	2481
2	IISc., Bangalore	97	237	3442

3	IIT, Chennai	21	178	3040
4	IIT, Kanpur	19	131	2190
5	IIT, New Delhi	14	88	3143
6	IIT, Kharagpur	9	83	4211
7	Amity University, Noida	0	79	403
8	Bharath University, Chennai	0	45	498
9	Centre for Development of Telemetric, Delhi	6	40	7
10	Amrita Viswa Vidyapeetham, Amrita Nagar	2	36	920

Table 18: Patents and Publications Profile of Top 10 Institutes in Engineering (Based on Patents Granted) (Period: 2010-16)

S. No.	Institute	Patents Granted	Patents Filed	Publications
1.	IISc., Bangalore	97	237	3442
2	IIT, Mumbai	46	276	2481
3	IIT, Chennai	21	178	3040
4	IIT, Kanpur	19	131	2190
5	IIT, New Delhi	14	88	3143
6	Manipal University, Manipal	11		442
7	IIT, kharagpur	9	83	4211
8	Indian Statistical Institute, Kolkata	9	26	824
9	Central Institute of Research on Cotton Technology, Mumbai	9	28	2
10	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	9	32	185



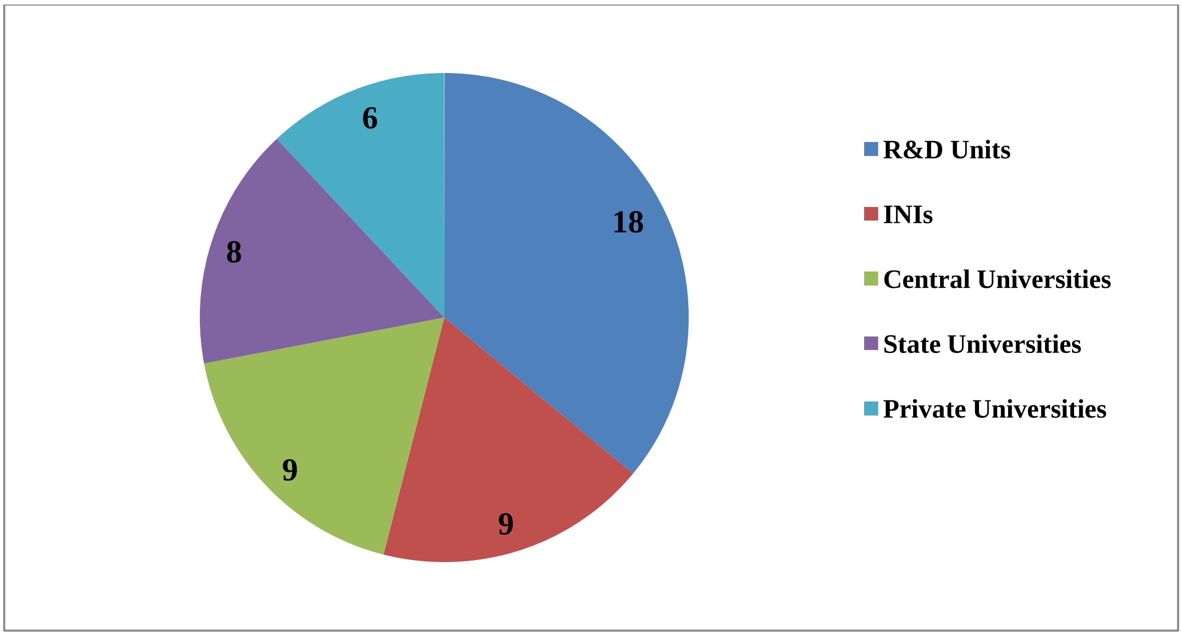
Graph 13: Top 10 Institutions in the Field of Medical Sciences

Table 19: Patents and Publications Profile of Top 50 Institutes based on Publications in Medical Sciences

S. No.	Institute	Status	Publications	Patents Filed	Patents Granted
1	AIIMS, New Delhi	INI	6521	15	2
2	PGIMER, Chandigarh	ICMR	5046	3	1
3	University of Delhi, New Delhi	Central Univ.	3715	0	0
4	Manipal University, Manipal	Pvt. Univ.	2909	6	0
5	BHU, Varanasi	Central Univ.	2051	0	0
6	National Institute of Mental Health & Neuro Sciences, Bangalore	MHFW	1850	0	0
7	University of Hyderabad, Hyderabad	Central Univ.	1289	0	0
8	IISc., Bangalore	Central Univ. (Deemed)	1171	27	2
9	BARC, Mumbai	DAE	1080	0	0

10	Aligarh Muslim University, Aligarh	Central Univ.	1024	0	0
11	Panjab University, Chandigarh	State Univ.	952	3	0
12	King George Medical University Lucknow	State Univ.	912	1	0
13	Annamalai University, Tamilnadu	State Univ.	901	1	0
14	Central Drug Research Institute, Lucknow	CSIR	882	0	0
15	Sree Chitra Tirunal Institute for Medical Sciences and Tech., Thiruvananthapuram	Pvt. Univ.	832	36	1
16	Gujarat University, Gujarat	State Univ.	716	0	0
17	VIT University, Vellore	Pvt. Univ.	671	2	0
18	Jamia Hamdard, New Delhi	Central Univ.	654	2	0
19	Jawaharlal Nehru University, New Delhi	Central Univ.	640	0	0
20	IIT, Kharagpur	INI	575	13	0
21	Institute of Genomics and Integrative Biology, Delhi	CSIR	558	0	0
22	Indian Institute of Chemical Biology, Kolkata	CSIR	544	0	0
23	Armed Forces Medical College, Pune	Indian Armed Forces	498	0	0
24	Centre for Cellular Molecular Biology, Hyderabad	CSIR	492	0	0
25	Indian Veterinary Research Institute, Izatnagar	ICAR	489	0	0
26	IIT , Hyderabad	INI	486	2	0
27	Bharathiar University, Coimbatore	State Univ.	483	0	0
28	Osmania University, Hyderabad	State Univ.	467	0	0
29	Institute of Post Graduate Medical Education and Research, Kolkata	ICMR	450	0	0
30	S.R.M Institute Of Science And Technology, Chennai	Pvt. Univ.	448	0	2
31	IIT, New Delhi	INI	444	1	19

32	Bharati Vidyapeeth, Pune	Pvt. Univ.	438	0	0
33	Indian Institute of Chemical Technology, Hyderabad	CSIR	435	0	0
34	IIT Chennai	INI	433	1	27
35	Jamia Millia Islamia, New Delhi	Central Univ.	426	0	0
36	Indian Institute of Toxicology Research, Lucknow	CSIR	386	0	0
37	Bose Institute, Kolkata	DST	373	0	0
38	Guru Nanak Dev University, Amritsar	State Univ.	358	1	0
39	Institute of Nuclear Medicine & Allied Sciences, Delhi	DRDO	343	0	0
40	IIT Bombay	INI	339	36	3
41	Medical Council of India, New Delhi	ICMR	338	0	0
42	IIT, Kanpur	INI	336	14	1
43	IIT, Guwahati	INI	334	5	0
44	IIT , Roorkee	INI	332	1	0
45	JSS University, Mysore	Pvt. Univ.	331	0	0
46	Central Food Technological Research Institute, Mysore	CSIR	319	0	0
47	National Institute of Immunology, New Delhi	DBT	313	10	3
48	Jammu University, Tawi	State Univ.	311	0	0
49	University of Allahabad, Allahabad	Central Univ.	302	0	0
50	NCL, Pune	CSIR	295	0	0



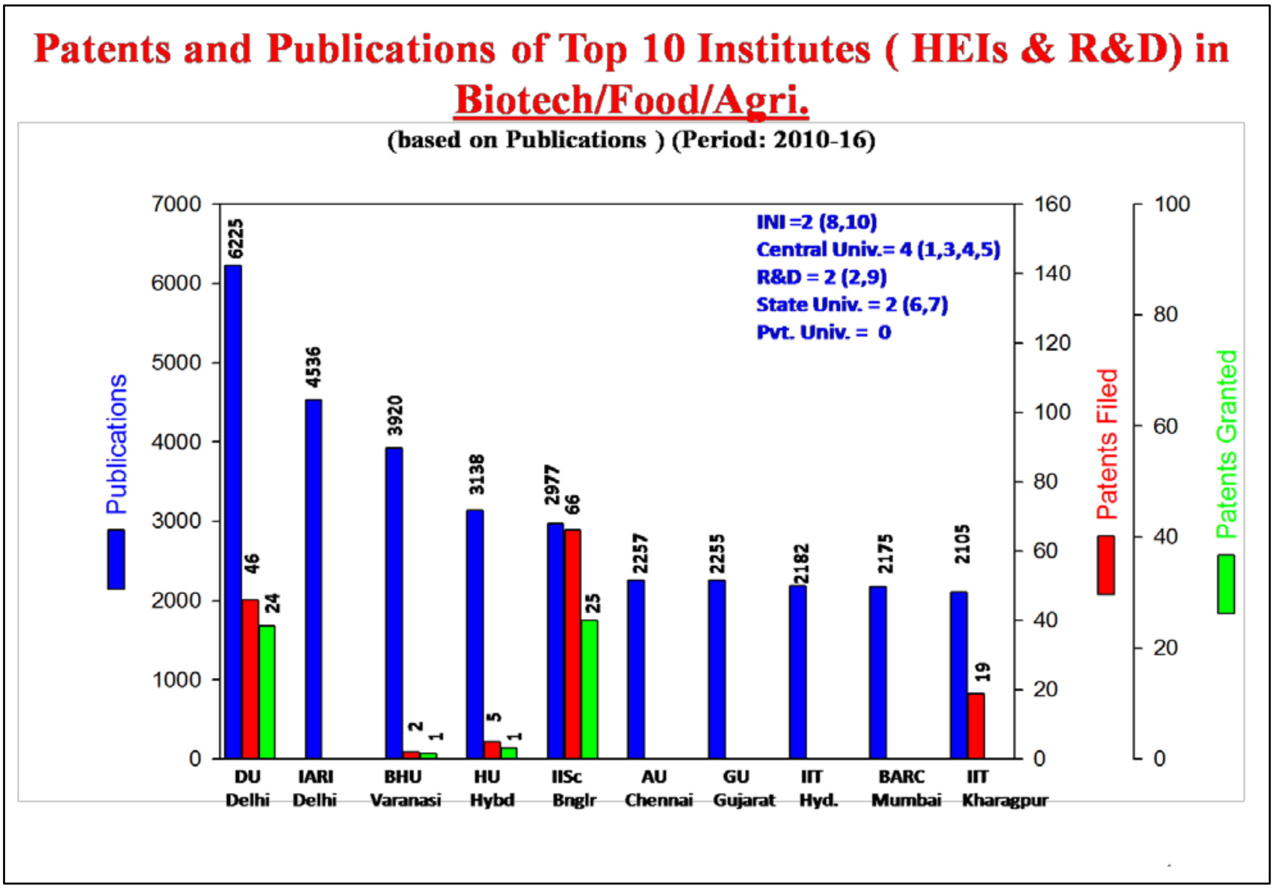
Graph 14: Categorization of Top 50 Ranked Institutes in the Field of Medical Sciences

Table 20: Top on the basis of Patents Filed in Medical Sciences

S. No.	Institute	Patents Granted	Patents Filed	Publications
1.	Sree Chitra Tirumal Institute for Medical Sciences and Technology, Thiruvananthapuram	1	36	832
2	IIT, Mumbai	3	36	339
3	IIT, Chennai	1	28	433
4	IISc., Bangalore	2	27	1171
5	IIT, New Delhi	1	20	444
6	AIIMS, New Delhi	2	15	6521
7	IIT, Kanpur	1	14	336
8	IIT, Kharagpur	0	13	575
9	Bharath University, Chennai	0	12	130
10	Amity University, Noida	0	11	225

Table 21: Patents and Publications Profile of Top 10 Institutes in Medical Sciences (Based on Patents Granted) (Period: 2010-16)

S. No.	Institute	Patents Granted	Patents Filed	Publications
1.	IIT, Mumbai	3	36	339
2	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	3	6	240
3	NII, New Delhi	3	10	313
4	Institute of Life Sciences, Bhubaneswar	3	7	151
5	AIIMS, New Delhi	2	15	6521
6	IISc., Bangalore	2	27	1171
7	IIT, Chennai	1	28	433
8	IIT, Kanpur	1	14	336
9	IIT, New Delhi	1	20	444
10	Sree Chitra Tirunal Institute for Medical Sciences & Technology, Thiruvananthapuram	1	36	214



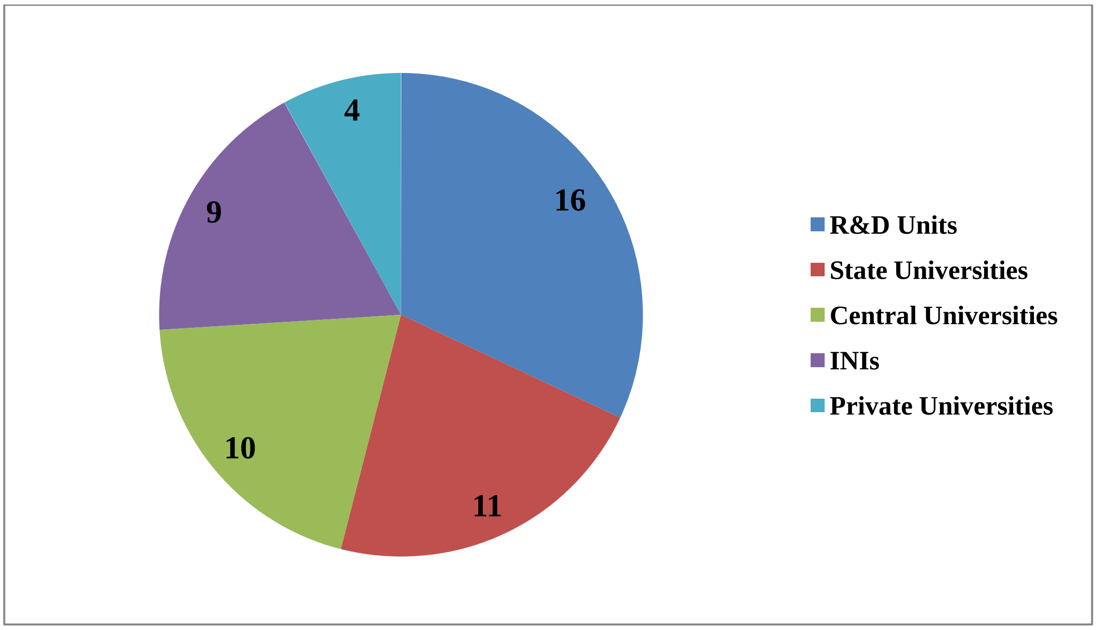
Graph: 15 Top 10 Institutions in the Field of Biotech./Food/Agri.

Table 22: Patents and Publications Profile of Top 50 Institutes based on Publications in the Field of Biotech/Food./Agri.

S. No.	Institute	Status	Publications	Patents Filed	Patents Granted
1	University of Delhi, Delhi	Central Univ.	6225	46	24
2	Indian Agricultural Research Institute, New Delhi	ICAR	4536	7	2
3	Banaras Hindu University, Varanasi	Central Univ.	3920	2	1
4	University of Hyderabad, Hyderabad	Central Univ.	3138	5	2
5	IISc, Bangalore	Central Univ. (Deemed)	2977	66	25
6	Annamalai University, Tamilnadu	State Univ.	2257	0	0
7	Gujarat University, Gujarat	State Univ.	2255	0	0
8	IIT, Hyderabad	INI	2182	0	0
9	BARC, Mumbai	DAE	2175	0	0
10	IIT, Kharagpur	INI	2105	19	0
11	Indian Institute of Chemical Technology, Hyderabad	CSIR	2066	17	8
12	IIT, New Delhi	INI	2029	26	5
13	Indian Veterinary Research Institute, Izatnagar	ICAR	1929	2	0
14	Aligarh Muslim University, Aligarh	Central Univ.	1908	1	1
15	VIT University, Vellore	Pvt. Univ.	1868	8	0
16	AIIMS, New Delhi	INI	1784	37	20
17	Manipal University, Manipal	Pvt. Univ.	1666	2	0
18	JNU, New Delhi	Central Univ.	1625	15	5
19	IIT, Roorkee	INI	1492	1	0
20	Panjab University, Chandigarh	State Univ.	1472	0	0

21	Central Drug Research Institute, Lucknow	CSIR	1442	0	0
22	Central Food Technological Research Institute, Mysore	CSIR	1436	0	0
23	National Dairy Research Institute, Karnal	ICAR	1422	0	0
24	IIT, Bombay	INI	1357	44	9
25	Jammu University, Tawi	State Univ.	1352	0	0
26	IIT , Guwahati	INI	1294	2	0
27	National Chemical Laboratory, Pune	CSIR	1220	0	0
28	IIT, Chennai	INI	1161	27	5
29	PGIMER, Chandigarh	ICMR	1118	1	0
30	Osmania University	State Univ.	1113	6	0
31	Bharathiar University, Coimbatore	State Univ.	1098	1	0
32	Institute of Genomics and Integrative Biology, New Delhi	CSIR	1079	0	0
33	Institute of Chemical Technology, Mumbai	State Univ.	1053	24	12
34	Centre for Cellular Molecular Biology, Hyderabad	CSIR	1030	2	0
35	National Botanical Research Institute, Lucknow	CSIR	1025	0	0
36	S.R.M Institute Of Science And Technology, Chennai	Pvt. Univ.	1018	2	0
37	Sathyabama University, Chennai	Pvt. Univ.	1004	0	0
38	Indian Institute of Chemical Biology, Kolkata	CSIR	955	2	0
39	Pondicherry University, Puducherry	Central Univ.	927	2	0
40	Jamia Hamdard, New Delhi	Central Univ.	924	1	0
41	University of Allahabad, Allahabad	Central Univ.	924	1	0
42	Bose Institute, Kolkata	DST	909	7	4

43	Sri Venkateswara University, Tripura	State Univ.	899	1	0
44	Institute of Microbial Technology, Chandigarh	CSIR	888	1	0
45	IIT, Kanpur	INI	881	21	4
46	Shivaji University, Kilhapur	State Univ.	877	0	0
47	Guru Nanak Dev University, Amritsar	State Univ.	872	0	0
48	Central Institute of Medicinal Aromatic Plants, Lucknow	CSIR	848	0	0
49	Jamia Millia Islamia, New Delhi	Central Univ.	847	0	0
50	Kalyani University, West Bangal	State Univ.	746	0	0



Graph 16: Categorization of Top 50 Ranked Institutes in the Field of Biotech/Food./Agri.

Table 24: Top 10 Institutes on the basis of Patents Filed in Biotech/Food/Agri.

S. No.	Institute	Patents Granted	Patents Filed	Publications
1.	Amity University, Noida	1	97	592
2	IISc.Bangalore	25	66	592

3	University of Delhi, New Delhi	24	46	6225
4	IITMumbai	9	44	2182
5	All India Institute of Medical Sciences, Delhi	20	37	1784
6	National Institute of Immunology, New Delhi	11	35	598
7	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	9	32	560
8	IITChennai	5	27	1161
9	IITNew Delhi	5	26	2029
10	Institute of Chemical Technology, Mumbai	12	24	1053

Table 25: Patents and Publications Profile of Top 10 Institutes in Biotech/Food./Agri. (Based on Patents Granted) (Period: 2010-16)

S. No.	Institute	Patents Granted	Patents Filed	Publications
1.	IISc.Bangalore	25	66	2977
2	University of Delhi	24	46	6225
3	All India Institute of Medical Sciences, New Delhi	20	37	1784
4	Institute Of Chemical Technology	12	24	1053
5	National Centre for Cell Science, Pune	12	17	543
6	National Institute of Plant Genome Research, New Delhi	12	21	721
7	DBT -National Institute of Immunology, New Delhi	11	35	598
8	IIT Mumbai	9	44	1357
9	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	9	9	560
10	Indian Institute of Chemical Technology, Hyderabad	8	17	2088

Conclusion

Academic institutions place emphasis on research publication because it is being considered as an indicator of excellence in its faculty/ researchers/ scientists. Usual parameters for evaluating the research output of institutions are citations and papers in reputed journals. We aimed to fill the gap between research publications and their conversion into patents. The academic institutions that have been able to raise their patent filing have initiated foreign collaborations, have special cells for relations with industry, and have some operational mechanisms to ensure patents filings. Teaching institutions face similar problems of the public sector in general regarding raising patent activity. A number of patents filed by universities is low as compared to IITs. One reason behind this trend is that universities have very little funds or no funds for carrying out R&D. In India, most of the R&D funding comes from government ministries. The University Grant Commission (UGC) also provides funds to various universities/ academic institutions on the condition that the outcome is patented (WIPO, 2007). Their funding is not comparable to the funds received by R&D institutions which are meant to carry out R&D. Similarly, infrastructure support available to universities is also limited. Most academicians have to imbibe the fact that they should not publish their research work without first filing patent applications. One of the reasons for the increase in patent filing by academic and teaching institutions of India is that many Government departments have instituted systems for helping universities to protect their inventive work.

As mentioned before academic institutions in India are more research oriented but to convert this research into patents and the commercial product and process is the need of the hour. The poor patent regime in India is the result of lack of awareness among inventers/researchers and gaps in IPR policies and also the absence of an institutional framework for ensuring the protection of IP rights. Most important is the lack of awareness and those who are aware, they are hesitant in patent filing as the process of patent filing is very time consuming and costly too for an individual person. So first intervention should be the time and process of filing of patents needed to be streamlined. As of awareness about IPR, there should be at least an introductory chapter about IPR at the school level. It is also suggested that five universities, each located in a northern, southern, western, eastern and central part of India, be designated as nodal centres for IPRs, which will run short term ‘Certificate’, ‘Diploma’ and ‘Advanced’ courses on IPR, open for public and private sector both.

Patents are of no value unless the commercial worth of the product or technology is demonstrated and exploited. Many patentable inventions have failed not because they didn't work, but because the inventor was unable to exploit them commercially. So there is a need for policy in India on this. If an institution or an individual is unable to utilize and commercialize the patent, they should entrust their patent to a specialized agency for its management, utilization or disposal. Also, the government should set up technology transfer offices in research labs, research centric universities and institutes.

Patent litigation is another area of concern. It is a sensitive and expensive issue. The academician/researcher/scientist may not be aware of how to deal with legal issues related to IPR. So to avoid wastage of time on IPR issues, there must be a dedicated chamber in courts to take care of IPR issues. So, if infringement is proved, damages may be awarded to the owner on time. It will prove a deterrent to those who infringe other’s inventions. The government is trying for the dissemination of IPR related issues, The National IPR Policy-2016 of India stresses upon making Indian researchers and scientists IPR savvy. To achieve this goal, DIPP has created a special body, Cell for IPR Promotion and Management, with the mandate of creating awareness about IPRs amongst the students and scientists of the country by delivering lectures at various places i.e. schools, colleges, universities and R&D institutes.

Academic institutions and universities are a storehouse of knowledge and knowledge givers, with new knowledge generated at these places on the continuous basis. Until recently the culture of protecting their inventive work legally through patents was almost nonexistent in these institutes, as most teachers felt that the knowledge should be shared freely through publications, seminars etc. There are some institutes in India which are doing exceptionally good in patents and publications like IIT Madras, IIT Mumbai, IIT Delhi, IISc., Bangalore and CSIR. The reason behind their magnificent performance may be they are having IPR cells, dedicated IPR Policy, a good incentivisation mechanism for academicians, researchers, and scientists for patenting etc. Now we are in the process of sending proforma **(Annexure-3)** to these institutes and seek their involvement in promoting and identifying gaps between research publications and its conversion into patents and commercial asset. We are also analysing data on the basis of fields for all these institutions. By doing this exercise we can analyse the stream wise performance of the institutes and can rope in them in strengthening the same in other institutes. The fields are shown in table-14.

Recommendations

As patents publications and research publications are two main means to bring technical and scientific knowledge to the public. Usually, educational institutions concentrate on basic research and applied science is usually being carried out in industries only. But this scenario needs to be changed. DST-CPR has drowned some recommendations to enhance technology transfer and patent regime in India.

- IP cells in higher education and R&D institutions are very - very crucial and these cells should be fully supported by institute's administration.
- The industry-academia interaction is a very important factor for patent commercialization. Whatever research is being undertaken in the labs should be communicated to the industry and should concentrate on industry based research. If a patent is not commercialised there is no use of patenting. In most of the developed economies, I-A interactions are the main parameter for IP commercialization.
- The role of IP cells in any R&D /Academic Institutes is extremely important for promotion of IPR culture as well as for increasing IPR Filings.
- There ought to be mechanism in every educational institution and R&D units that every research publication being carried out in institute should first go to the IP cell before publication to check for patentability of the research work. This screening before publication will surely increase the IPR filing rates.
- In any research partnership, there should be an emphasis on product development /deliverables from the very beginning of the research activities.
- One of the reason institutes like IISc., Bangalore and IIT, Mumbai have very good record of both publications and patents is that they have IP setup within the institute premises. So, other universities should also set up IP cells to match up publication and patenting numbers.
- Enough work has been done for IPR dissemination. There should be dedicated awareness programmes on IPR filing and commercialization.
- A condition must be incorporated for Ph. D. Students, that they should have at least one patent filed to their credit to complete their Ph. D.
- Every HEI and R&D units must have a robust IPR Policy in place to guide and educate researchers.

- IPR cells and technology transfer cells should be clubbed since they need to work in close association.
- There should be knowledge sharing between academia and industry, so that they can exploit each other's innovation and knowledge.
- Each institute should not only concentrate on IPR cells within the institutes, but also promote technology transfer and business incubator simultaneously.
- IPR cell, technology transfer cells and business incubators should work in tandom. This model has been implemented by many developed countries and need to be adopted in India as well.
- For making students IPR savvy, there should be at least introductory chapter at school level so that they have knowledge about IPR and get to know how to exploit there ideas and innovations.
- There should be a separate IP commercialization cell along with IP protection cell which can reach out to industry with available technologies/patents for commercialization. It should be considered as an independent business unit with sufficient autonomy to take decision. Reaching out to industry will not only enable relation development, faster commercialization, avoidance of duplication but will also be helpful in need based research in academia.
- Include students also in IPR related activities; it will inculcate the IPR knowledge to students and make them IPR savvy.
- Some Universities are filing patents just for the sake of its reputation or brand building, whereas, their grant rate is zero. So technologies and innovations must be evaluated before filing patent. By doing this other processes such as examination will be faster.
- All the technical institutes should collaborate with the local Patent Information Cell (PIC) established by TIFAC (DST) in 20 states (http://pfc.org.in/index.htm) and all PICs should be actively participate in IPR dissemination and help then in all IPR activities and commercialization being carried out in those institutes.
- The incentivisation set up in HEIs and R&D labs except IITs is very weak so there is a scope of improvement in rest of the institutions.

Future Activities to be Undertaken

- Patents classification on the basis of International Patents Classification (IPC) codes from WIPO and also classification of the patents information on the basis of institutes.
- Analyse the research publications viz-a-viz a number of PhD scholars for all institutes.
- Analysis of institutes on the basis of patents granted/filed and patents licensed.
- Cunduct Case studied on the institutes which, are having strong hold on both parameters i.e. publications and patents.
- Designing of the questionnaires with the consultation of 'Advisory Committee' for case studies on these institutes.
- Study the correlation between funding amount given by public funding agencies to HEIs and R&D labs and revenues they are getting in return by commercializing technologies**.**
- Upload the classified patents data on centre's website.
- For IPR generation or dissemination, link the website or sources of all schemes, facilities and programmes of ministries and other public and private agencies on centre's webpage.
- Collaborative research/ technology transfer/IP commercialization data by classifying the patents list available with the centre.
- Data collection of SMEs pertaining to IPR which can be find from 32 IPFCs and also technologies transferred to them by academia.
- Patents landscaping for industries and analysis of data on the basis of collaborative research by industry and academia.

- **Study IPR Policies of**
  - I. Developed Countries: UK, USA, Germany etc
  - II. Asian Countries: S. Korea, China and Japan etc

- **Case Studies on:**
  - ➢ Top 5 Scientists in filing patents
  - ➢ Top 5 industries in PCT applications
  - ➢ Top 5 R&D units
  - ➢ Top 5 HEIs

Annexure-1

Scopus

Scopus is the largest abstract and citation database of peer-reviewed literature: scientific journals, books and conference proceedings. Delivering a comprehensive overview of the world's research output in the fields of science, technology, medicine, social sciences, and arts and humanities, Scopus features smart tools to track, analyse and visualize research. The Scopus covers 17,000 journals in natural and social sciences including humanities.

As research becomes increasingly global, interdisciplinary and collaborative, you can make sure that critical research from around the world is not missed when you choose Scopus.

To keep track of what's happening in your research world, turn to Scopus. Across all research fields—science, mathematics, engineering, technology, health and medicine, social sciences, and arts and humanities—Scopus delivers a broad overview of global, interdisciplinary scientific information that researchers, teachers and students need to stay informed.

Features of Scopus:

Document search: Search directly from the homepage and use detailed search options to ensure you find the document(s) you want

Author search: Search for a specific author by name or by ORCID (Open Research and Contributor Identifier) ID

Affiliation search: Identify and assess an affiliation’s scholarly output, collaborating institutions and top authors.

Language Interface: The Scopus interface is available in Chinese and Japanese. Content is not localized, but you can switch the interface to one of these language options (and switch back to English, the default language) at the bottom of any Scopus page. Note: By default, Scopus will appear in the language selected in your browser settings, unless your institution has specified otherwise or the language is not supported by Scopus (in which case, the interface will be in English).

Field Wise (Fields Covered)

- Physics and Astronomy
- Medicine
- Biochemistry, Genetics and Molecular Biology
- Chemistry
- Engineering
- Pharmacology, Toxicology and Pharmaceutics
- Materials Science
- Computer Science
- Chemical Engineering
- Agricultural and Biological Sciences
- Business management and Accounting
- Social Sciences
- Economics, Econometrics and Finance
- Immunology and Microbiology
- Arts and Humanities
- Earth and Planetary Sciences
- Mathematics
- Environmental Sciences
- Multidisciplinary
- Decision Science

Documents Coverage:

- Book
- Book Chapter
- Conference Paper
- Conference Review
- Articles
- Review
- Article in Press
- Editorial
- Short Survey
- Business Article

Search Options:

- Authors
- First Author
- Source Title
- Article Title
- Abstract
- Keywords
- Affiliation Name
- Affiliation City
- Affiliation Country
- References
- Chemical Name
- Language
- ISSN
- Conference

Annexure-2

Talwar and Talwar Consultants

TT Consultants is an Intellectual Property service provider established in the year 2006. TT Consultants is consistently serving many of the Fortune 1000 companies, start-ups, incubators, investors and law firms from the last ten years by providing insights on technology intelligence, assisting in strategic alliances, and managing intellectual property assets.

TT Consultants primarily provides solutions that cover the complete technology/product life cycle, from conception till commercialization. These solutions include R&D / Innovation Management, In-licensing Support, Go-to-market Strategy, Out-licensing, Product Development Support, Competitive Intelligence, Due-Diligence, Deal-Structuring & Negotiation, Opportunity Assessment, Business Plan Review, Patent & Trademark Prosecution, Portfolio Optimization, Litigation Support, and Prior-art Search.

As a company, TT Consultants strive toward providing excellence to its customers. Therefore, the company's efforts till date are aligned with a vision to innovate for proliferating innovation. XLPAT solution, an automated solution applying artificial intelligence on unstructured patent data, is one of the most critical innovation of TT Consultants.

XLPAT solution has also received multiple accolades such as Best Product of the Year 2013 by STPI, START TELAVIV 2015, IBM Smart Camp 2015. XLPAT solutions extract its intelligence by implementing technologies like Natural Language Processing, Artificial Intelligence, Watson, Search Intelligence, Image Recognition and knowledge from our 10 years of experience in IPR.

TT Consultants has its global presence in sales and all the projects are delivered through three operation centres - situated in India, the US and Taiwan. To date, the company has demonstrated its expertise to clients in more than 30 major geographies.

Annexure-3

Proforma

DST- Centre for Policy Research

at

PANJAB UNIVERSITY, CHANDIGARH-160 014 (INDIA)

(Estt. Under the Panjab University Act VII 1947 enacted by the Govt. of India)

The filled up Questionnaire can either be emailed at dstprc2014@pu.ac.in or a hard copy may be sent to

Prof. Rupinder Tewari
Coordinator
DST – Centre for Policy Research
Panjab University
Sector-14, Chandigarh-160014.

Name of the Institute:

Complete Postal Address:

E-Mail Address

Contact Number:

	Does the Institute have a dedicated “IPR Cell” or its equivalent?	
	Does the Institute have a dedicated “IPR Policy” or its equivalent?	
	Does institute provide courses/ training to faculty/students related to IPR?	
	Does the Institute hold workshops/ conferences/ seminars on IPR	
	No. of Faculty members completed course on IPR	
	Does institute have research collaborations with industries?	
	Does institute have research collaborations with other academic institutions?	

	Is there any Industry sponsored research fellowship in the Institute?	
	Exchange Programmes (National/international)	
	Are there any special incentives for faculty members/researchers who have obtained patents/ transferred technology?	
	Does the Institute have an IPR Cell/ Entrepreneurship Cell/ Placement Cell/ Technology transfer Cell/ any other (pl. mention)?	
	Please fill in the appropriate details relevant to the Institute (Till now) **(a) Number of Patents** (i) Granted................ (ii) Filed................. **(b) Number of Technology transfers** (i) Commercialized................... (ii) Under process................. **(c) Number of MoU with the Industries** (i) Signed................ (ii) Under process................	

FEEDBACK & SUGGESTIONS: ....

Name

Designation

Signature

For query: *Ms. Mamta Bhardwaj, Email: mamtab@pu.ac.in; dstprc2014@pu.ac.in.*

सत्यमेव जयते
Department of Science & Technology
Govt. of India

DST-Centre for Policy Research at PU, Chd.
(DST/PRC/CPR-03/2013)

REPORT – 2

Stimulation of Private Sector Investment in R&D: A Global Comparison

(April, 2016 – July, 2017)

Countries	Tax credits	Tax deductions	Patent box	Financial support	Risk coverage	IP jurisdiction (location specific)
USA	✓	✗	✗	✓	✓	✗
UK	✓	✓	✓	✓	✓	✓
China	✗	✓	✓	✓	✓	✗
Japan	✓	✗	✓	✓	✓	✗
S. Korea	✓	✗	✓	✓	✓	✗
Singapore	✗	✓	✓	✓	✓	✗
France	✓	✗	✓	✓	✓	✗
Israel	✓ (Reduction in corporate tax rate)		✗	✓	✓	✗
India	✗	✓	✓ (2017 onwards)	✓ (limited support)	✗	✗

Table of Contents

1. Introduction

With the onset of the 21st century, emerging need and importance of knowledge and research driven industries for sustainable growth and economic development of the nation is being widely realized. One of the major key drivers for the country's development is generation and uptake of scientific innovations. These innovations are the result of high-end innovative research practices undertaken by the public (government and academia) and private sectors (industry). Developed and developing nations are continuously strengthening their national research and development (R&D) ecosystem by revisiting R&D support mechanisms. Worldwide, countries have come up with impactful steps in their R&D strategy to stimulate increased involvement and expenditure in research by public and private sectors. Globally, total R&D investments for the year 2016-2017 has accounted nearly 2.099 million (USD in purchasing power parity; Global R&D Forecast 2017) and the large lump of investments is contributed by the private sector. Private sector composed of industrial units is one of the foremost contributors to the economic development of any country. To enhance the competitiveness of a business, innovations have become an important driver for generating new genera of products/processes/technologies addressing socio-economic needs of the nation. Globally, most of the national governments have come up with the R&D incentivization programs specific for the private sector in order to boost their productivity and contribution to the R&D to evolve as competitive companies. In most of the developed economies (USA, Japan, Singapore, etc.) and emerging economies (China, S. Korea, etc.) of the world, private sector investments in R&D are almost double in comparison to the public sector investments in R&D. On the other hand, in India 2/3rd of R&D investments are incurred by the public sector and the only 1/3rd of the R&D investments are delivered by the private sector. India needs to strengthen and stimulate the private sector for investing in R&D to generate more competitive companies at par with foreign companies to deliver cost-effective. Indian Government has continuously made efforts to stimulate private sector investment in R&D by introducing a tax benefit regime for private sector engaged in R&D along with funding support for pursuing R&D projects. In spite of continuous efforts, the aim of the Indian government to achieve public to private investments in R&D under 1:1 range by 2017 remains yet to be accomplished.

Keeping in mind, the need to stimulate private sector engagement in R&D in India, we need to understand the R&D incentives availed globally to identify relevant R&D enablers practiced globally for the invigorating private sector in R&D. In this context, the government came up with the Joint Committee of Industry and Government (JCIG) under the aegis of Department of Science and Technology in 2013. The committee issued the white paper on 'Stimulation of Investment of Private Sector into Research and Development in India' in 2013 concentrating on five major tasks, which were as:

1. Studying global practices and classification of R&D heads as practiced globally
2. Revalidating the data on private sector investments into R&D in India
3. Identifying key enablers for stimulating private sector investments into R&D
4. Studying various policy instruments deployed by other countries for maximizing the provisions and benefits of PPP for R&D as tools of change in manufacturing and
5. Suggesting measures for implementation with industrial sector driving the desired changes in the private sector

In order to address the majors tasks defined by the committee, DST-Centre for Policy Research at PU, Chd. has undertaken a study on comparative analysis of global R&D incentives in select countries (USA, China, Japan, Germany, S. Korea, Singapore, U.K., France and Israel) to draw relevant lessons for India. The above-mentioned countries were selected on basis of their large share in global R&D investments and foremost participation of private sector in R&D ecosystem (nearly 80%) in comparison to the public sector (nearly 20%) of these countries respectively.

The report consists of following sections:

Section 1: Global R&D investments and selection of countries for comparative analysis

Section 2: Pattern of R&D investments in select countries

Section 3: R&D incentivization implemented in select countries

Section 4: Relevant lessons for India

Section1: Global R&D Investments

Innovative research practices have become one of the key sources for generation of new processes, products, and technologies that can be explored in national and international markets to bring out mankind's benefit. Substantial investments in R&D activities are required to promote national innovation ecosystem. The R&D processes and the costs associated with R&D varies from country to country and year to year. The total global share of R&D expenditure touched $ 2.066 trillion in power purchasing parity in 2017 with the growth of 3.4% for 115 countries worldwide (Global R&D Forecast 2017). As per the continental share in world R&D expenditure, Asia with 24 countries is leading in R&D investments (more than 42% of total R&D expenditure) in total followed by Europe (34 countries), North America (12 countries), Russia (5 countries), Middle East (13countries) and South America (10 countries) (Figure 1). Asian countries such as China, India, Singapore, South Korea, etc. from past decade has undertaken impactful initiatives to enhance their R&D investments for building self-reliant technological advancements.

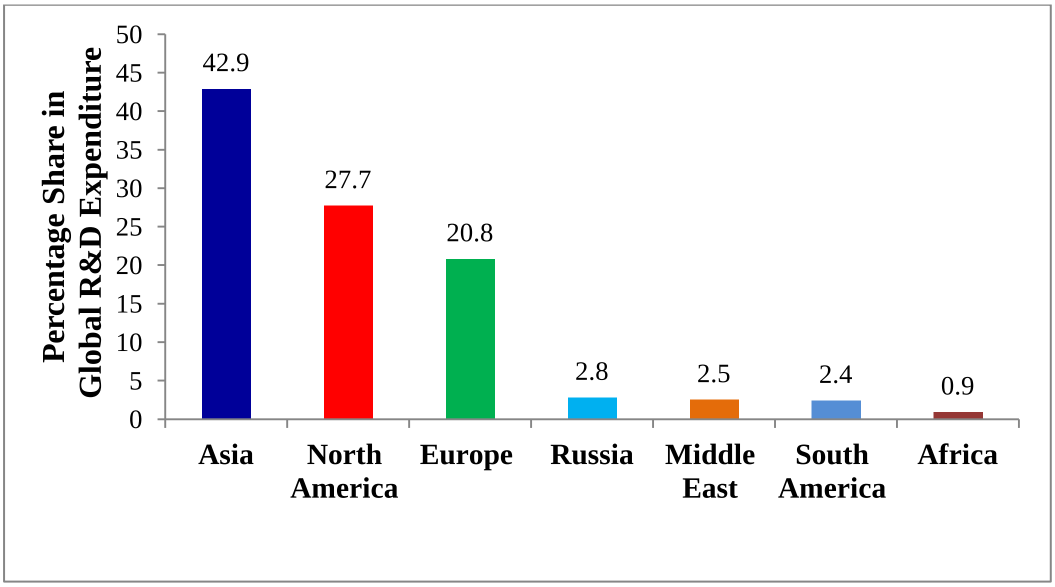


Figure 1: Percentage share of global R&D experience of continents in 2017 (forecasted)
Source: *Global R&D Forecast 2017. (http://digital.rdmag.com/researchanddevelopment/2017_global_r_d_funding_forecast?pg=1#pg1)*

Figure 2 represents top 10 nations of the world that significantly invest in R&D in terms of Gross Expenditure on Research and Development (GERD) value. The US holds the topmost position in the chart with $ 527.46 billion PPP in 2017 (forecasted) followed by China ($ 429.54 billion PPP). From past 50 years, US is been outpacing other nations in R&D investments. The strong network of academic institutions, research organizations along with industrial units and number of federal programs to support R&D activities in the US have led to advancing R&D activities in the country that has drawn the substantial amount of investments. On the other hand, China has shown the significant increase of 7.1% in their R&D spending in 2017 compared to 2015. It is expected, China with the current growth rate of R&D investments will out pass US numbers in R&D spending by 2026.

Countries such as Japan and Germany fall under the bracket of $ 100-200 billion in PPP investments in R&D. Rest of the countries depicted in figure 2 have less than $ 100 billion in PPP GERD numbers starting with South Korea, followed by India, France, Russia, U.K., and Brazil. India ranks 6th globally in terms of GERD, being the first developing nation to compete with developed nations (France, Russia, and U.K.) in R&D investments.

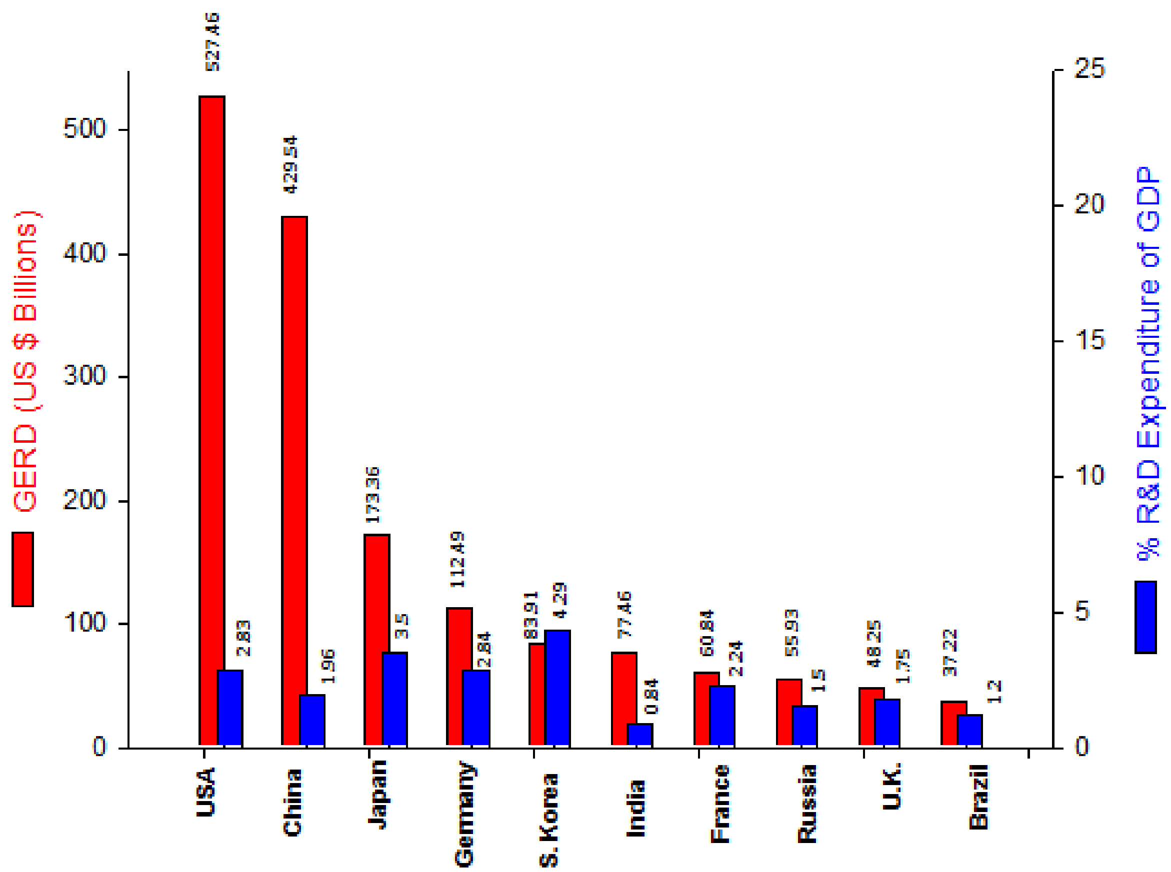


Figure 2: Top 10 countries as per GERD values (2017 forecasted) and their % R&D expenditure as % of GDP

Source: *: Global R&D Forecast 2017. (http://digital.rdmag.com/researchanddevelopment/2017_global_r_d_funding_forecast?pg=1#pg1)*

In spite of India being in the top 10 list of R&D investments, it has the lowest percentage of R&D Expenditure (0.84%) as part of total GDP of the country. South Korea with 4.84% of R&D expenditure from its GDP spends highest globally for R&D from its total GDP value followed by Japan (3.50%), Germany (2.84 %), US (2.5 %), France (2.24%), China (1.96%), U.K. (1.75%), Russia (1.50%) and Brazil (1.20%). South Korea is strongly committed to the R&D expansion in the country by strengthening workforce and generation and fortification of knowledge-intensive competitive firms with well-built infrastructure.

Technological advanced nations of the world-USA, China, Japan, Germany, S. Korea, U.K., Singapore, France and Israel which are exceptionally doing well in R&D (Global R&D Forecast 2017) were selected for carrying out detailed review of R&D incentivization followed in these countries to draw relevant lessons for India.

Section 2: Pattern of R&D investments in select countries

The industry is the major propellers for the R&D in most of the innovation based countries worldwide. Innovative practices adopted by the companies has led them to emerge as competitive and self-sufficient. Many of the industries have rightly exploited their R&D potential for generating in-house intellectual property (IP) to evolve as a leader in their research domain. Along with the active participation industry, national governments also put substantial investment in R&D to promote the technological growth of the country. It is essential to review public to private sector contribution to R&D to determine major R&D players and devise ways to strengthen them for national economic development. The pattern of R&D funding under different sources such as government, industry and other nongovernment service organizations for select countries in terms of global R&D investments is presented in Figure 3.

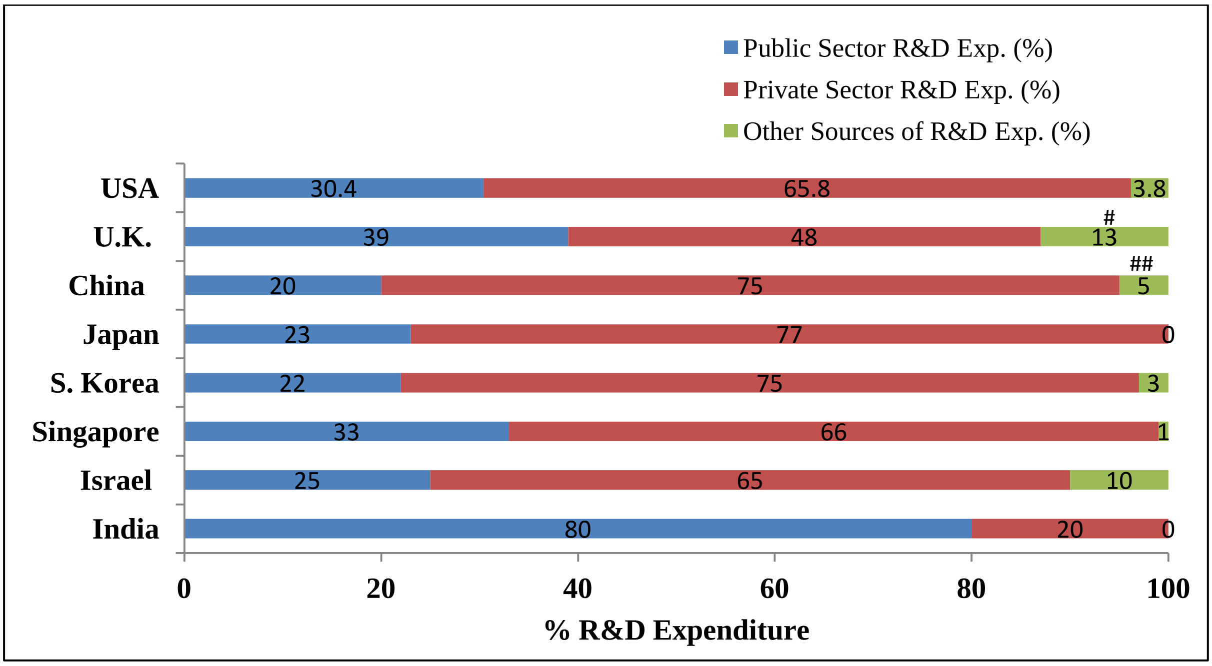


Figure 3: Pattern of R&D Funding in Leading Countries
Source: *Global R&D Forecast 2017; Patil A and Biswas S, 2014; http://ec.europa.eu/eurostat/statistics*
Other sources consist of NGOs, non profit organizations, etc.
#: consist of non for profit and offshore accounts; ##: in sourcing

International Scenario

As highlighted in Figure 3, all the select countries have more than double private to public sector contribution for R&D investments. In the US, the majority of R&D (two-thirds) is carried out by various industrial organizations. Top five innovative industrial organizations in US are presented in Table 1.

Table 1: Top five Innovative Companies of US

2016 Global Rank	Company	Research Domain	R&D Spending ($ Billions)
1.	Amazon	Software & Internet	12.5
2.	Alphabet	Software & Internet	12.3
3.	Intel Co.	Computing & Electronics	12.1
4.	Microsoft	Software & Internet	12.0
5.	Johnson & Johnson	Healthcare	9.0

Source: *2016 Global Innovation 1000 Study(https://www.strategyand.pwc.com/innovation1000)*

Under public sector, academic institution mainly goes ahead with basic research, while private sector heavily invests in developmental and applied research. On the other hand in China, industry invests in R&D three time more in comparison to the government, some of the major publically listed companies, highly investing in R&D in China are described in Table 2.

Table 2: Top R&D Investing Companies of China

S. No.	Company	Research Domain	Global ranking
1.	Alibaba Group Holding Ltd.	Internet	61
2.	ZTE Corp.	Telecommunications	70
3.	PetroChina Co. Ltd.	Petroleum	73
4.	China Railway Group Ltd.	Mechanical Engineering	86
5.	Baidu Inc.	Internet	88

Source: *http://www.chinadaily.com.cn/business/tech/2016-10/27/content_27185564.htm; https://www.strategyand.pwc.com/innovation1000*

The industry carries out business-related R&D, while the basic research is carried out by different government agencies of China. Much of R&D is directed by Chinese Academy of Sciences (CAS) under Ministry of Science and Technology (MoST) (Global R&D Forecast 2017). Under CAS, more than 20 enterprises (such as, KYKY Technology Co., Ltd.; Shanghai Bi Ke Clean Energy Technology Co., Ltd.; Shenzen CAS IP Investment Ltd.; CAS Science and Technology Service Co., Ltd.; SKY Technology Development Co., Ltd., etc.) have been set to direct industrial research in the country (http://english.cas.cn/institutes/companies/index.shtml). In Japan also, the industry contributes majorly to the R&D funding (77%) and private sector is the major sector that has undertaken research in Japan under independent in-house research centers and through academic collaborations (Global R&D Forecast 2017). The similar pattern is also noticed in South Korea, where industry carries out magnums amount of research that has strongly contributed to the emergence of South Korea as one of the major industrial revolutions in shortest time frame. Singapore has become the favorite destination for multinational companies setting up their research centers in Singapore. The industry is also the major R&D performer (66%) in Singapore followed by academic institutes (23%) and research organizations (10%). In spite of the small size, Singapore is leading in the number of scientist, engineers, and researchers generated per capita (Global R&D Forecast 2017).

Indian Scenario:

In comparison to other major R&D investing countries, the pattern of R&D funding in India is totally reverse. In India, one third of R&D is supported by the private sector and rest of two third of R&D is funded by the government sector. India has developed one of the largest higher education systems in the world and majority of R&D is carried out in universities, institutes of national importance and national research laboratories. However, these universities are not world class and lack in R&D profile in terms of publications and patents. The huge amount of R&D funding (nearly 75% of total country's R&D expenditure) is carried out by various government agencies under major 27 ministries in India (JCIG, White Paper 2013). On the other hand, private sector contribution in scientific research is appallingly low at 25% of total R&D expenditure. The pattern of R&D expenditure by the public and private sector in various domains is specified in Table 1 and 2 (http://www.nstmis-dst.org/). As highlighted in Table 1, the data shared by GoI for 2009-10, the public sector was a major contributor to the research in almost every field (e.g. defense, space, energy, agriculture and basic research, etc.).

Table 1: Sector-wise R&D Investments under Public and Private Sectors in India (2009-10)

S. No.	Sector	Public sector's R&D Expenditure (₹ in lakhs)	Private Sector's R&D Expenditure (₹ in lakhs)	Total R&D Expenditure (₹ in lakhs)	Public to Private Sector R&D Expenditure Ratio
1.	Agricultural	6836.79	913.14	7749.93	**7.5**
2.	Environment	427.15	153.43	580.58	**2.8**
3.	Defence	9479.16	227.04	9706.21	**41.8**
4.	Space Technology	4312.1	20.48	4332.58	**210.5**
5.	Exploration of the Earth	1512.76	221.27	1734.02	**6.8**
6.	Industrial Production and Technology	3236.98	2621.06	5858.04	**1.2**
7.	Infrastructure	584.61	4290.78	4875.39	**0.13**
8.	Non-oriented Research (Basic Research)	5578.09	292.18	5870.26	**19.1**
9.	Energy	3474.04	344.28	3818.32	**10.1**
10.	Human Health	2021.33	5654.29	7675.62	**0.35**
11.	Social Structures and Relationships	188.06	133.43	321.5	**1.4**
12.	Other Aims	84.69	181.79	266.48	**0.5**
13.	**Total R&D Expenditure**	**37735.76**	**15053.17**	**57121.51**	**2.5**

Source: *http://www.nstmis-dst.org/ (2009-10); last updated in 2015(after extensive prior art search, our centre was unable to track latest information on Public and private sector expenditure in R&D, lack of such information may hinder in analysing and bringing out recommendations for stimulating private sector investments in R&D in India)*

Table 2: Breakdown of Public Sector Investments in R&D in India (2009-10)

S. No.	Sector objectives	Central Government's R&D Expenditure (₹ in lakhs)	State Governments' R&D Expenditure (₹ in lakhs)	Other Public Sector's R&D Expenditure (₹ in lakhs)	Total Public sector's R&D Expenditure (₹ in lakhs)
1.	Agricultural	3239	3590.57	7.22	6836.79
2.	Environment	402.5	24.65	0	427.15
3.	Defence	8498.89	0	980.27	9479.16
4.	Space Technology	4312.1	0	0	4312.1
5.	Exploration of the Earth	796.79	44.56	671.41	1512.76
6.	Industrial Production and Technology	2082.37	79.87	1074.74	3236.98
7.	Infrastructure	553.41	5.44	25.76	584.61
8.	Non-oriented Research (Basic Research)	5527.45	50.6	0.04	5578.09
9.	Energy	3419.23	2.56	52.25	3474.04
10.	Human Health	1952.08	66.37	2.88	2021.33
11.	Social Structures and Relationships	187.44	0.62	0	188.06
12.	Other Aims	84.69	0	0	84.69
13.	Total R&D Expenditure	31055.95	3865.24	2814.57	37735.76

Source: *http://www.nstmis-dst.org/ (2009-10)*

Moreover, only 0.8% of the country's GDP is targeted for R&D, which is quite low in comparison to other countries such as South Korea (4.29); Japan (3.5); China (1.96); Singapore (2.19) etc. The major reasons behind low private sector involvement in Indian R&D ecosystem lie in a) majority of Indian industries fall under medium and small scale bracket and b) lack of government support for private companies engaged in R&D business. India globally ranks second in number of MSMEs in the world which employs more than 40% of the workforce and associated with 45% of manufacturing activities (http://msme.gov.in; http://www.gktoday.in; 2015). Due to lack of funding, these enterprises do not actively take up research to improve their stature. Government programs for funding private sector research are quite limited in India in comparison to other western nations in North America and Europe where federal governments provide more than 55% of total funding to private sector research (Global R&D Forecast 2017).

The 12th five-year plan aimed at increasing percentage R&D investment to 2% of GDP from current value of 0.8% of GDP of which public and private sector should invest 50:50 (http://planningcommission.gov.in/plans/planrel/12thplan/welcome.html). India is at the end of its 12th five-year plan has not been able to achieve its ambitious target of achieving enhance private sector engagements in R&D investments in India. To address the need for engaging private sector in R&D NITI Aayog constituted 'Expert Committee on Innovation & Entrepreneurship'. The major highlights of the committee report were as:

Major challenges for Innovation and Entrepreneurship in India:

- *Trust deficit between the government and private sector*
- *Lack of incentive structures*
- *Lack of adequate business incubators*
- *Gaps in education and work-readiness*
- *A disabling business environment*
- *Stigma over failure*

Steps needed to overcome challenges:

- *Harnessing corporate funds to finance R&D*
- *Improving the efficiency of incubators*
- *Strengthening links between the corporate sector and incubators*
- *Strengthening the intellectual property (ip) rights regime*
- *Foster a culture of coordination and collaboration*
- *Improving the ease of doing business: this has targeted for enhancing the private sector involvement in R&D activities*
    - ✓ *Digitization of government permits*
    - ✓ *Revisit the companies act*
    - ✓ *Tax compliance*
    - ✓ *Move service tax back to actuals rather than accruals*
    - ✓ *Improving access to capital*
    - ✓ *Creating an online portal to aggregate information on funding*
    - ✓ *Creation of a separate regulatory category for new business*

Source: *Report of the Expert Committee on Innovation and Entrepreneurship, 2015 http://niti.gov.in/writereaddata/files/new_initiatives/report-of-the-expert-committee.pdf*

Government is continuously seeking for private sector participation in R&D as stated in various government released white papers (Stimulation of Investment of Private Sector into Research and Development in India, 2013; Sectoral Innovation Council on Industrial R&D, 2013) and expert committee reports [Report of the Expert Committee on Innovation and Entrepreneurship, 2015; Committee Report on Corporate Participation in Higher Education (Narayana Murthy Committee Report) 2012; Innovation in India, NKC, 2007]. To stimulate private sector engagements in R&D, it is essential to review present system of incentivization of private sector by government to promote R&D and determine the gaps in incentivization scheme by carrying out comprehensive analysis of the incentivization programme executed by federal governments of select countries as discussed in coming section.

Section 3: Global Comparison of R&D Incentives

For the present report, we have studied in depth the R&D incentives prevailing in countries (USA, China, Japan, Germany, S.Korea, Singapore, U.K., France and Israel) based on their top ranking in terms of global R&D investments and active participation private sector in countries R&D regime.

Through this report, our Center has categorized various R&D incentivization under following categories as presented in figure 3.

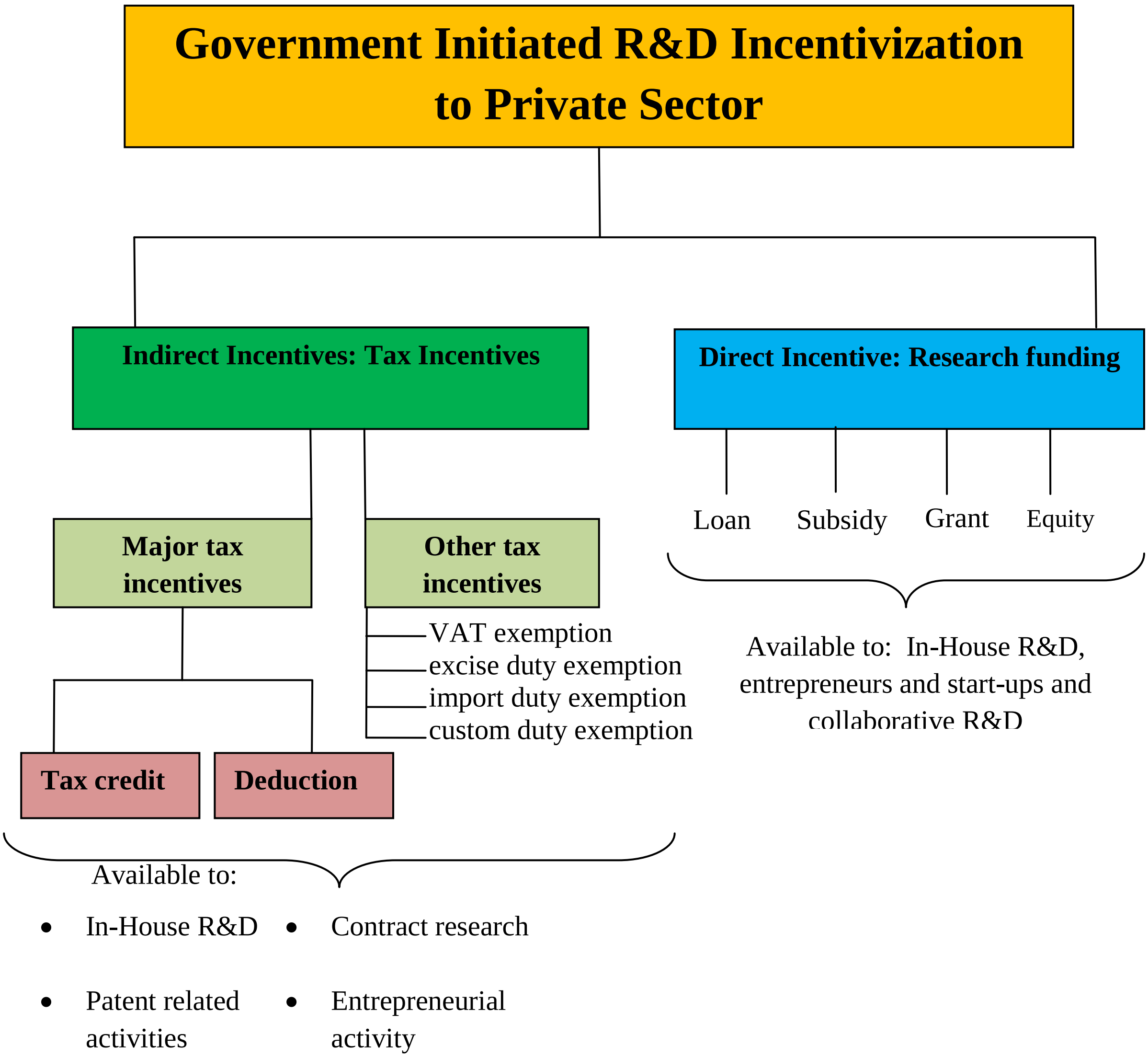


Figure 3: Categorization of R&D Incentives Availed Globally

Worldwide, there are two types of incentives for R&D. The first category is the direct incentive that includes funding industrial R&D and second category includes indirect incentivization by provided tax incentives on R&D expenditure. The share of both direct and indirect incentivization for R&D excelling countries considered in our study is presented in figure 4. In countries like S. Korea and Japan, significant percentage of GDP (0.19 and 0.14) is subjected to R&D tax incentives, respectively. Whereas, in country like USA, significant percentage of GDP (0.18) is accounted for financially supporting private industries in pursuing their R&D projects. Majorly utilized R&D incentivization falls under tax incentives. The tax support provided in countries USA, China, Japan and South Korea is presented in figure 5.

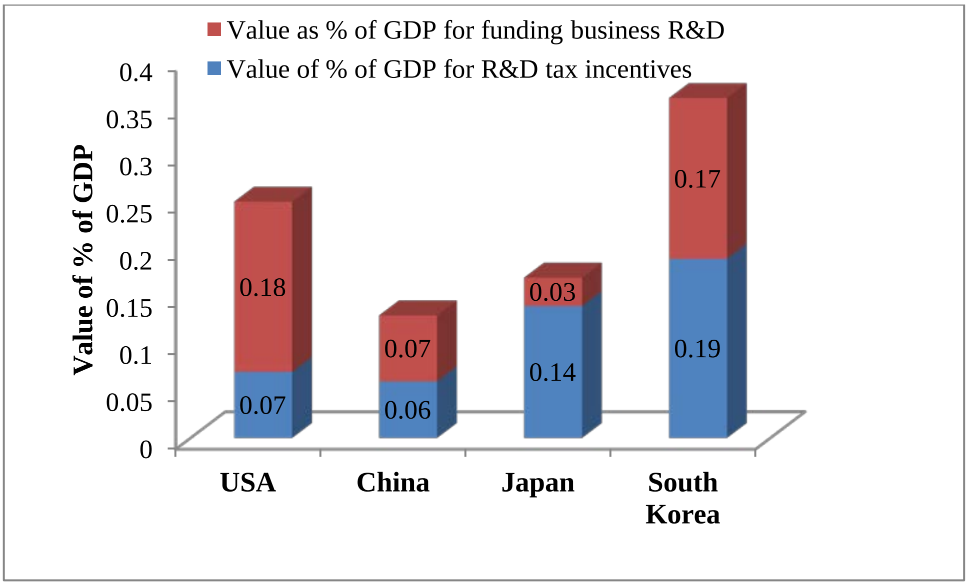


Figure 4: Share of Indirect and direct incentivization in country's GDP

Source: *http://www.oecd.org/sti/rd-tax-stats.htm; data is for 2014*

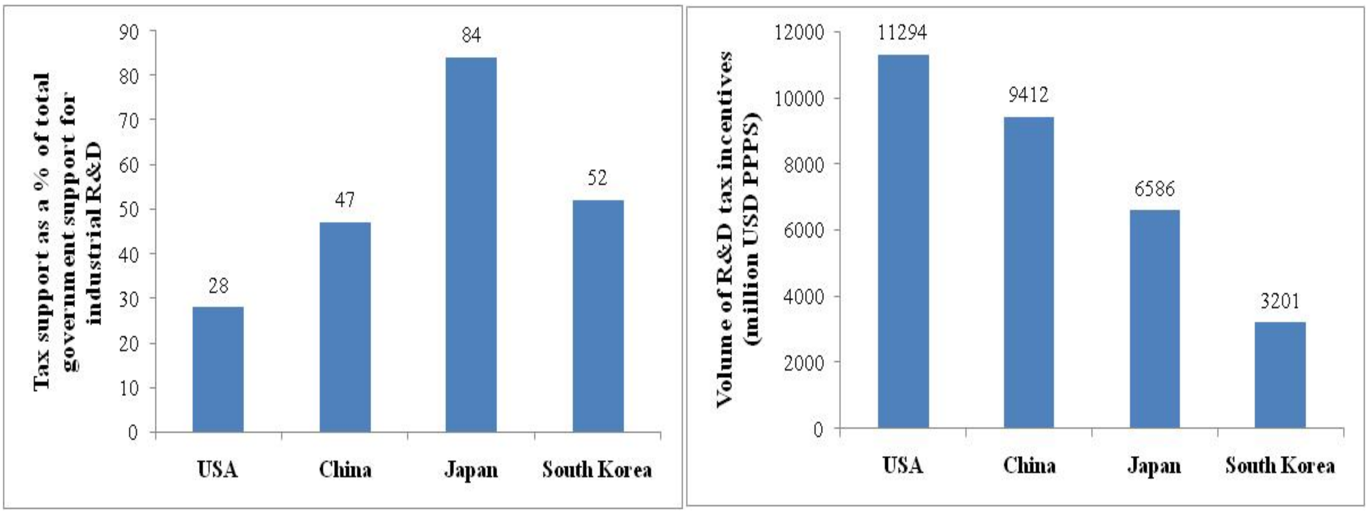


Figure 5: Volume of tax support for industrial R&D

Source: *http://www.oecd.org/sti/rd-tax-stats.htm; data is for 2014*

Our study comprise of the comparative analysis of the R&D incentivizing government schemes for private sector engaged in R&D. The comparative analysis has been carried out under four subheads which are as:

- ***Eligibility and qualified research expenditure***
- ***Intellectual property (IP) and R&D location Jurisdiction***
- ***Tax Incentives***
- ***Funding support***

The context of each subhead in terms of R&D incentivization has been described in Appendix I.

Table 2: R&D Incentivization followed in Select Countries

Country	Funding Support	R&D Tax (Combined)	R&D Tax Credit	R&D Tax Deduction	Volume Based	Incremental Based	Refundable	Carry Forwarded	Preferential Tax Incentives		Patent Box	CAPEX Incentives
									SMEs	Collaboration		
USA	√	√	√	n.s.	×	√	√ (Payroll taxes for start-ups)	√	√ (for start-ups)	×	√	√
China	√	√	n.s.	√	×	×	×	×	×	×	√	×
Japan	√	√	n.s.	n.s.	√	√ (for high end R&D intensity)	×	×	√	√	×	√
Germany	√	×	×	×	×	×	×	×	×	×	×	√
S. Korea	× (limited)	√	√	n.s.	×	√	×	√	√	×	√	√
Singapore	√	√	n.s.	√	×	×	×	×	×	×	×	×
UK	√	√	√	√	√	×	√ (for SMEs)	√	×	×	√	√
France	√	√	√	n.s.	√	×	√	√	√	√	√	√
Israel	√	√	n.s.	√	×	×	×	×	×	×	×	×
India	× (limited)	√	n.s.	√	√	×	×	√ (only in case of losses)	×	×	√	√

Compiled from2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-pwc; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD
n.s: .not specified

Details of other countries is provided as Appendix II

Comparative analysis of R&D Incentivization carried out in Select Countries

1. Eligibility and Qualified Research Expenditure:

Countries	Eligible Industries	Qualified Research Expenditure	Nonqualified Research Expenditure
USA	All industries	➢ Wages for in-house labor ➢ 65% of contract research ➢ Supplies used in the research process ➢ Costs incurred to construct a pilot model ➢ Expenses incurred for developing software	➢ Overhead expenditure ➢ Capital expenditure
China	All industries except negative list industries which are: ➢ Tobacco ➢ Hospitality and catering ➢ Wholesale and retail ➢ Real estate ➢ Rental and commercial services ➢ Entertainment	➢ Labor expenses (including labor costs for external personnel) ➢ Direct expenses incurred in the R&D project ➢ Depreciation expenses* (even if the equipment is not used exclusively for R&D) ➢ Amortization expenses** ➢ Design and testing expenses (including testing expenses for trial products) ➢ Expert consultation ➢ High and new technology R&D insurance*** ➢ IP application costs ➢ Travel and meeting costs. ➢ Up to 80% of fees paid to contractors to perform research on the taxpayer's behalf qualify	Expenses related to R&D activities carried out by contractors that are foreign organizations or individuals

**Depreciation expense* *is the allocated portion of the cost of a company's fixed assets that are appropriate for the accounting period indicated on the company's income statement. It includes noncash payments associated with the industry work will add to the income of the industry (definition by Accounting Coach)*

***Amortization* *is the paying off of debt with a fixed repayment schedule in regular installments over a period of time. It includes spreading out of capital expenses for intangible assets over a specific duration (usually over the asset's useful life) for accounting and tax purposes. (Definition by Investopedia).*

****R&D insurance* *is an innovative insurance product that allows companies in the R&D chain to cover their unique risk exposures in the context of their business and funding models (http://www.riskcan.ca/r-d.html).*

Japan	All industries	➢ In-house labor costs ➢ R&D supplies ➢ Overhead**** ➢ Depreciation on fixed assets ➢ Contract costs	Research expenses that are funded by unrelated entities (government agencies, customers, suppliers, etc.)
Germany	Industries in following sectors: ➢ Manufacturing and production processes ➢ Automotive and transportation ➢ Biotech and life sciences ➢ ICT ➢ Energy and utilities	➢ Personnel Costs ➢ Materials ➢ Overhead ➢ Subcontracting ➢ Amortization ➢ Travel Costs	-
S. Korea	Dedicated R&D center of the corporation or the corporation's internal R&D department, both of which should be registered with the Government	➢ Labor costs (salaries, wages, bonuses, etc.) ➢ Materials costs (samples, parts, and raw materials used in the conduct of R&D) ➢ Rent for R&D equipment ➢ Commissions paid to the qualifying body ➢ Training costs ➢ Other costs (trademark development costs, design development costs, consulting fees, and quality guarantee costs).	➢ Legal and administrative activities such as protection of patent rights, etc. ➢ Research activities on contract basis

*****__Overhead__ expenses are all __costs__ on the income statement except for direct labor, direct materials, and direct expenses. Overhead expenses include accounting fees, advertising, insurance, interest, legal __fees__, labor burden, rent, repairs, supplies, taxes, telephone bills, travel expenditures, and utilities.*

Singapore	All industries	➢ Wages and salaries ➢ Materials ➢ Utilities incurred directly for R&D activity	Capital expenditure on plant, machinery, land, or buildings, or on alterations, additions, or extensions to buildings, or in the acquisition of rights arising in or arising out of R&D
U.K.	All industries	➢ R&D Staff costs ➢ Software or consumable items used in the R&D ➢ Payments to volunteers for participating in clinical trials ➢ 65% of R&D-related subcontracting costs(for SMEs) ➢ Can claim subcontracting costs only if they are paid to a university, health authority, charity, scientific research organization, individual, or a partnership of individuals (Large Companies)	Expenditure on rent, land, patents, and patent protection
France	All industries *(Contractors performing research on a time/materials basis can claim tax credits for their qualified research expenses)*	➢ R&D staff expenses ➢ General and administrative expenses ➢ Depreciation allowances for assets used for R&D activities in France ➢ Patent costs ➢ Contract research costs (*there is a cap on private subcontracted expenses equal to three times all other qualifying expenses, but in no event can the subcontracted R&D fees exceed EUR 12M*) ➢ Costs of technological monitoring	Materials used in the research process
Israel	All Industries approved by Innovation Authority	➢ In-house R&D costs	Not specified

	The Innovation Authority implements the government's policy to encourage and support industrial R&D that is likely to lead to new export products and international commerce. Incentives may be available if an applicant is approved by the Innovation Authority and meets "disruptive technology" innovation standards.	➢ Materials and consumables ➢ Consultant and subcontractor costs ➢ Patent registration, application costs for regulatory approval ➢ Capital investments and overhead	
India	**All industries** Some of the major tax incentives can only be availed by DSIR recognized industries with following essential requirements: ➢ The R&D unit must be located in a separate earmarked area ➢ The R&D unit must have its own personnel ➢ The company must maintain a separate account for each approved facility, which must be audited annually ➢ Assets acquired with respect to the development of scientific R&D facilities may not be disposed of without the approval of the Secretary of the DSIR	➢ Wages ➢ Supplies ➢ Utilities ➢ Other expenses directly related to R&D ➢ Expenses incurred in clinical drug trials only if pre-approved by the regulatory authority under a central, state, or provincial act and a patent application is filed under the Patents Act (1970) for the new drug/therapy developed through the clinical trials.	➢ General and administrative costs ➢ Depreciation ➢ Overhead and allocated expenditure ➢ Expenditure on R&D in following fields: beer, wine, alcoholic spirits, tobacco and tobacco preparations, cosmetics and toilet preparations, toothpaste, dental cream, tooth powder and soap, aerated waters, confectionary and chocolates, gramophones, projectors, photographic equipment and office machines, such as calculators and cash registers.

Source: *2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-PWC; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD*

2. IP Jurisdiction and location limitations

Countries	Location specificity for R&D activities	Location specificity for IP specificity
USA	YES	NO
China	YES ➢ R&D activities must be conducted in China ➢ Less than 40% of the R&D expenses qualifying for the high-new technology enterprise (HNTE) incentive is allowed to be incurred outside China.	YES The IP must be held by the Chinese applicant in China
Japan	NO The qualifying costs incurred by a Japanese company are eligible for the research credit even if the research is conducted outside of Japan.	NO
Germany	YES	NO ➢ The IP created through the research (initially) remaining in Germany/E ➢ Large multinational companies with IP relocated to headquarters outside Germany also may qualify for funding under certain conditions.)
S. Korea	NO R&D activities of the company regardless of where the R&D activities are carried out, except for research subcontracted to academic institutions; which must be located in South Korea.	NO
Singapore	YES ➢ R&D activities undertaken in Singapore. ➢ If R&D payments are made by a Singapore entity to a R&D organization for R&D performed outside Singapore, a claim for deduction may be allowed. ➢ Special approval from the Minister (advance application with the Singapore Economic Development Board is required) for RISC/IDC grants.	Not specified
U.K.	NO	NO
France	NO	NO
Israel	NO	NO

India	YES ➢ The company must be registered in India. ➢ The main object of the company must be scientific R&D ➢ The company must be approved by the Chief Commissioner of Income Tax and DSIR, GoI	NO ➢ No location restriction with respect to IP ➢ IP can reside outside the country subject to ownership remaining with the Indian Company who has undertaken such R&D ➢ Foreign patent filing expenditure is not allowed as a weighted deduction.

Source: *2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-PWC; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD*

3. Tax Incentives

Countries	**Tax Incentives**			
	Direct Tax Incentive	**Indirect Tax Incentive**	**Patent Related Tax Incentives**	**Start-up incentives**
USA	**1. Research Tax Credits** ➢ Incremental specific (Computed on an increment of qualified research spending exceeding a base amount.) ➢ Nonrefundable ➢ Unused credits can be carry forwarded for 20 years and carry back for 1 year ➢ Three types: ***a. Traditional Research credit: 20%*** (Credit on incremental Spending with Limitations) ***b. Alternative Research credit: 14%*** (Credit on incremental Spending without Limitations ***c. Targeted Research credit: 20%-basic research; 20%-Energy Research Consortium & 50%-clinical research for orphan drugs***	No	No	➢ Research credits to offset Alternative Minimum Tax (AMT) by companies with average annual gross receipts <50 million ➢ Research credits can be used to reduce payroll taxes by companies with average annual gross receipts <5 million.
China	1. **Super deduction** ➢ Non-refundable ➢ 50% Deduction on volume	➢ VAT/Custom duty incentives (Non-	Annual income from qualified technology transfers is exempted	No

	➢ Can be carried forward for 5 years (in case of losses) 2. **Reduced tax rates for High-New Technology Enterprise (HNTE)-15% reduced** 3. **Reduced tax rates for Technology Advanced Service Enterprises (TASE)-15% reduced** 4. **Preferential Tax Incentives (10% tax credit) for using energy saving technologies**	refundable) ➢ Tax Holidays for software companies ➢ Exemption from import duties for software companies	from enterprise corporate tax	
Japan	1. **Volume-Based Tax Credit** ➢ Nonrefundable ➢ Unused tax credits may not be carried forward. ➢ 17% tax credit for Small and Medium-Sized Entities (SMEs) ➢ 6-10% tax credit for Large Companies ➢ 30% tax credit for special R&D costs **(**R&D with a university or public research institution) 2. **Additional Incremental tax credits (capped at 30% based on incremental R&D Expenditure): increment in period of two years** 3. **50% tax credit for machinery and R&D equipment/fixtures used in specified businesses within the zones that are conducive to international competitiveness or the formation of hubs for international business.**	No	No	No
Germany	No	No	No	No
S. Korea	**1. Tax Credit** ➢ Nonrefundable ➢ Unused R&D credits may be carried forward for the following five years. ➢ A tax credit for SMEs: 50% on incremental and 25% on volume. ➢ A tax credit for medium sized companies: 40% on	No	➢ A patent box also is available to SMEs: 50% tax exemption on IP transfer and 25% of	No

	incremental and 8% on volume. ➢ A tax credit for large sized companies: 30% on incremental and 3% on volume. 2. **30% Additional R&D tax incentives** on qualified expenditure related to New growth engine industry 3. **Investment tax credit for R&D equipment (1% for large companies; 3**% for medium-sized companies and 6% for SMEs) 4. **Additional Tax credit for investing in facilities for energy-saving (1% for large companies; 3**% for medium-sized companies and 6% for SMEs)		lending) ➢ SMEs acquire a patent (7% exemption on the amount paid to acquire the patent.) ➢ SMEs lend a qualified paten t (25% of the related income from such lending is exempt from tax.)	
Singapore	1. **Super deduction under Productivity and Innovation Credit (PIC) Scheme** ➢ Nonrefundable ➢ When R&D expenses exceed taxable income, the excess may be carried forward and set off against future taxable profits ➢ 100% deduction depending on the approval from the related authority. 2. **50% additional deduction if it falls under the year 2009-2025 period.** 3. **Additional super deduction for R&D projects carried out in Singapore and approved by the Economic Development Board (EDB)** 4. **Double tax deduction (200%) on R&D expenditure incurred on approved projects.**	No	Provides reduced or no withholding tax on royalty payments to access advanced technology and know-how.	Angel investors 50% tax deduction for two year holding period.
U.K.	1. **Volume-based super deductions (230% deduction)** ➢ Super deduction scheme is available for SME (fewer than 500	No	➢ 10% rate of corporation tax	

	employees and either gross revenue not exceeding EUR 100M or gross assets not exceeding EUR 86M.) ➢ Refundable ➢ Carry forward for indefinite period **2. Research and Development Expenditure Credit (RDEC) Scheme: Volume-Based Tax Credits (11%)** ➢ Tax credits are available for large companies ➢ Higher tax credit of 49% available for companies working in petroleum oil extraction (these companies also has higher corporate tax rates on their respective profits in comparison to other countries) ➢ Non refundable ➢ Carry forward for indefinite period **3. Cash credits for SMEs in loss positions, up to 33.35% of qualifying expenditure**		to profits generated from qualifying patents and developing technology associated with it. ➢ The "new" regime requires claimant companies to track their R&D expenses and how they relate to specific patents, products, or product families, creating a much stronger link between the R&D tax relief and the patent box regime.	
France	**1. Volume-Based R&D Tax Credit** ➢ Nonrefundable for large companies ➢ SMEs, new companies, young innovative companies, and companies with financial issues can request immediate refunds of unutilized credits. ➢ carried forward for three years ➢ R&D credit equal to 30% of the first EUR 100M of qualified R&D expenditure incurred during the tax year. The rate is reduced to 5% for qualified R&D expenditure exceeding that amount, and the 30% rate is increased to 50% in overseas territories.	No	Income from licensing (and the sub-licensing of eligible IP rights as from 2011) or the sale of patent or patentable technology are taxed at a maximum rate of 17%	Young innovative company (YIC) status: Specific measures apply to support new companies investing more than 15% of their spending on R&D. these measures are: • Two-year decreasing corporate income tax exemption (100% for the first profitable year and

	2. Innovation tax credit, is available to SMEs for certain pilot-model and prototype developments that do not qualify for the 30% R&D credit.			50% for the second year) • Exemption from taxes such as the *taxe foncière, Contribution Foncière des Enterprises (CFE),* and *Contribution sur la Valeur Ajoutée des Entreprises* (CVAE) upon request for up to seven years • seven-year capped exemption of certain employer social security contributions for R&D staff remuneration
Israel	**1. Alternative tax program** ➢ Non-refundable ➢ Carry forwarded ➢ Tax benefits are granted to industrial companies that export more than 25% of their total turnover to a market larger than 14 million persons. ➢ A corporate tax rate of 7.5% applies to companies located in "Priority Area A," and a 16% applies to companies located in other areas. **2. Strategic program incentives** ➢ The program is intended for multinational companies whose annual gross receipts exceed ILS 10B, invest a minimum of ILS 100M in R&D projects, and hire at least 250 new employees. ➢ Reduced tax rate of 5% in Priority Area A and 8% in other areas.	No	No	Angel Investor Scheme: A tax benefit is granted to individuals investing in qualified Israeli R&D companies, allowing them to deduct their investment from any other source of income. The amount of the deduction is capped at ILS 5M per investor, per eligible company.

India	1. **Super Deduction for in-house R&D expenditure** ➢ Nonrefundable ➢ If the taxpayer is in a loss situation, unused benefits may be carried forward for the following eight years, but cannot be carried back. ➢ The R&D facility must be approved by the Department of Scientific and Industrial Research (DSIR) for a company to qualify for the super deduction. ➢ 150% super deduction for carrying out R&D activities in the in-house center 2. **150% super deduction for specified payments made to certain scientific research associations, approved universities, colleges, or other institutions.** **3. 100% super deduction for specified payments made to a scientific research company/ research association/university/college/other institution for the purpose of scientific and statistical research.** **4. 100% tax exemption for the first five years, starting from the year manufacturing commences, followed by a 50% tax exemption for the following five years on export profits earned from a new undertaking set up in a Special economic zones.**	➢ Customs duty exemption on goods imported for R&D ➢ Duty-free import for Biotech and pharma units ➢ Central excise duty waiver for 3 years ➢ Reimbursement of countervailing duties (CVD) and excise duties on capital equipment under M-SIPS	10% tax rate on royalty income from the patent.	100% deduction for start-ups if engaged in field of innovation Or Tax holiday for three consecutive years.

Source: *2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group PWC; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD*

4.Funding Support

Countries	Major Funding Agency	Some of the Major Funding Programmes
USA	US Federal Government	➢ Small Business Innovative Research Program (SBIR) ➢ Small Business Technology Transfer Program (STTR) ➢ Advanced Research Projects Agency-Energy (ARPA-E) ➢ Partnerships for Innovation: Accelerating Innovation Research - Research Alliance (PFI:AIR-RA) ➢ Partnerships for Innovation: Accelerating Innovation Research - Technology Transfer (PFI:AIR-TT) ➢ Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) ➢ NIH Centers for Accelerated Innovations (NIH/NCAI) ➢ Public-Private Investment Programme (PPIP)- Legacy Securities and loans are provided ➢ Industry/University Cooperative Research Center (I/UCRC) Program ***Risk undertaking Guarantee Scheme:*** State Small Credit Initiative (SSBCI): The state provides collateral and accepts burden of repayment to the financial institution
China	➢ Ministry of Science and Technology (MoST) ➢ National Natural Science Foundation of China (NSFC) ➢ Chinese Academy of Science (CAS) ➢ China Scholarship Council (CSC)	➢ National High-Tech Research and Development Programme ➢ National Key Technologies R&D Program ➢ Agriculture S&T Achievement Industrialisation Fund, etc. ➢ Innovation and Technology Support Programme (ITSP) ➢ The Research Grants Council Collaborative Research Fund ➢ The Research Grants Council Joint Research Schemes
Japan	Japan Science and Technology Agency (JST)	➢ Collaborative Research Based on Industrial Demand ➢ Center of Innovation (COI) Program ➢ A-STEP (Adaptable and Seamless Technology Transfer Program through Target-driven R&D) ➢ S-Innovation (Strategic Promotion of Innovative Research and Development) ➢ Technology Development Program for Advanced Measurement and Analysis (Program-T) ➢ Software Development Program for Advanced Measurement and Analysis (Program-SW) ➢ Prototype Validation / Practical Realization Program for Advanced Measurement and Analysis

		(Program-P) ***Risk undertaking Guarantee Scheme:*** Japan Bank for International Cooperation Loan Guarantee Scheme: Government organization guarantees and accepts the burden.
Germany	➢ German Research Foundation (DFG) ➢ German Academic Exchange Service (DAAD)	➢ Grants for R&D ➢ KMU-innovativ ➢ Central Innovation Program for SMEs (ZIM) ➢ German Federal State Funding ➢ New High-Tech Strategy Programme ➢ Horizon 2020 *For large enterprises, cash grants are awarded of up to 50% of eligible costs, with a 10% bonus possible for SMEs, depending on the specific calls.* ***Risk undertaking Guarantee Scheme:*** German United Loan Guarantees: Government provides financial guarantees for loans should the firm be unable to repay.
S. Korea	➢ National Research Foundation ➢ Korea Institute for Advancement of Technology (KIAT)-specifically woking for industrial technology ➢ Korea Energy Technology Evaluation and Planning (KETEP) ➢ Small & Medium Business Administration (SMBA)	➢ New Technology Purchasing Assurance ➢ Korea Credit Guarantee Fund ➢ Knowledge Partnership Korea Fund for Technology and Innovation ➢ Research funds under National R&D Program ➢ Creative Research Initiative
Singapore	**Singapore Government under:** ➢ SPRING ➢ Agency for Science,	➢ Industry Alignment Fund ➢ Capability Development Grant (CDG) ➢ SPRING's Partnership (PACT) programme ➢ TechBridge Ventures

	Technology, and Research (A*STAR)	➢ SME Energy Efficiency Initiative ➢ Singapore government start-up tech ➢ Critical Infocomm Technology Resource Programme Plus (CITREP+) ➢ Global Company Partnership (GCP) Grant ➢ Innovation & Capability Voucher (ICV) ➢ Operation & Technology Roadmapping (OTR) ➢ Productivity Innovation Project (PIP) Scheme ➢ SME Talent Programme (STP) ➢ Technology Adoption Programme (TAP) ➢ Research Incentive Scheme for Companies (RISC)/Innovation ➢ Development Scheme (IDS)
U.K.		➢ R&D grant (EU) ➢ R&D grant (national)
France		**If a company receives a subsidy or grant for an R&D project, this may affect how much tax relief it can claim.* *The aid rates generally amount to around 25% for large and medium-sized companies and 40% for small companies.*
Israel	Innovation Authority *The main program of the Innovation Authority supports R&D projects in Israel by offering conditional grants of up to 50% of approved R&D expenditure (up to 60% in Priority Area A and up to 75% in the area surrounding the Gaza Strip). If the R&D project is successful, the company must repay the grant by making royalty payments from future related revenue.*	➢ Tnufa program ➢ MAGNET program ➢ Binational funds ➢ Horizon2020 ➢ EUREKA funding platform *Special benefits for selected areas: Israel offers special benefits for R&D undertaken in special fields, including: (i) traditional industries, such as food and beverages, textiles, print, metal, and plastics; and (ii) non-traditional industries, such as cyber security, the space industry, and alternative fuels. There also are special benefits for start-ups and new companies.*
India	➢ Technology Development Board (TDB), Department of Science and Technology (DST) ➢ Department of Scientific and Industrial Research (DSIR)	TDB, DST, GoI: ➢ Project Finance Scheme ➢ Seed Support Scheme ➢ Venture Capital Fund ➢ International S&T Co-operation: setting up of Indo-French Centre for Promotion of Advanced Research (IFCPAR / CEFIPRA), Indo-US Science & Technology Forum (IUSSTF) and Indo-German Science &

	➢ Biotechnology Industry Research Assistance Council (BIRAC), Department of Biotechnology (DBT) ➢ Ministry of Electronics and Information Technology (MeitY)	Technology Centre (IGSTC) DSIR, GoI: ➢ Building Industrial R&D and Common Research Facilities (BIRD-CRF) ➢ Patent Acquisition and Collaborative Research and Technology Development (PACE) ➢ Promoting Innovations in Individuals, Start-ups, and MSMEs (PRISM) ➢ Access to Knowledge for Technology Development and Dissemination (A2K+) ➢ Technology Development and Demonstration Program (TDDP) ➢ Technopreneur Promotion Programme (TePP) ➢ Technology Management Programme (TMP) BIRAC, DBT, GoI: ➢ Small Business Innovation Research Initiative (SBIRI) scheme ➢ Biotechnology Industry Partnership Programme (BIPP) ➢ Promoting Academic Research Conversion to Enterprise (PACE) ➢ SEED Fund ➢ AcE Fund - Accelerating Entrepreneurs ➢ Biotechnology Ignition Grant Scheme (BIG) MeitY, GoI: ➢ Financial Assistance under Modified Special Incentive Package Scheme(M-SIPS) and Electronic Manufacturing Clusters EMCs schemes

Source: *2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-PWC; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD*

Details of each country with R&D incentivization is provided in Appendix III.

Section 4: Relevant Lessons for India

The comparative analysis of the R&D incentivization executing in USA, China, Japan, Germany. S. Korea, Singapore, U.K., France and Israel, our centre has come up with suggestion for enhancing Indian R&D Incentivization programme by drawing relevant lessons from the above mentioned countries.

1. Increasing scope of qualified research expenditure

In India, expenditure incurred on the manpower, materials and equipment and utilities and services is qualified for the R&D incentives by the government. There is demanding need to enhance the scope of qualified expenditure in research which includes following:

Inclusion of following attributes in qualified research expenditure	**Reference country**
Investments for availing R&D Insurance in domains of high technology investments	China
Investment cost for IP filling and maintenance	China
Investments incurred for performing contract research work	USA, China, Japan,
Overhead expenses	Japan, Germany
Expenses incurred in constructing and maintaining pilot plant facility	USA, France

India has set list of negative products which do not fall under R&D Incentivization such as, beer, wine, alcoholic spirits, tobacco and tobacco preparations, cosmetics and toilet preparations, toothpaste, dental cream, tooth powder and soap, aerated waters, confectionary and chocolates, gramophones, projectors, photographic equipment and office machines, such as calculators and cash registers. Certain product range from cosmetics to dental creams and powders, toothpaste, toilet preparations, confectionary items and electronic products like projectors and office machines are continuously evolving in their standards in accordance to the consumer's budget and quality expectation by implementing R&D activities. These products should be qualified for R&D incentivization scheme. In accordance to the recommendations from The Joint Committee of Industry and Government (JCIG) presented in white paper entitled 'Stimulation of Investment of Private Sector into Research & Development in India' released by GoI in 2013, private sector R&D investments should also cover up costs incurred for translating R&D work involving test designing and development, standardization and field testing along with pre commercialization trial.

2. Eligibility criteria

The simplifying process of granting eligibility status to the industries to avail R&D incentives. Most of the countries implementing R&D incentivization program have simplified process of availing R&D incentives provided by the government. Indian system involves the long and complicated system of granting government recognition to the industry by means of dedicated autonomous agency 'Department of Scientific and Industrial Research (DSIR)' under Ministry of Science and Technology Recognition. DSIR provides recognition certificate that has to be renewed after every 3 years period (minimum) subjected to the lengthy process of government evaluation and assessment. It is particularly difficult for companies mainly small and medium-sized to input considerable efforts to avail incentives from the public sector.

3. Enhancing R&D tax incentivization

The majority of industries recognized under DSIR are availing tax incentives and only a few of them are dependent on R&D public funds. Figure 7 outlays the amount of tax foregone by the government in comparison to the R&D undertaken by the private sector.

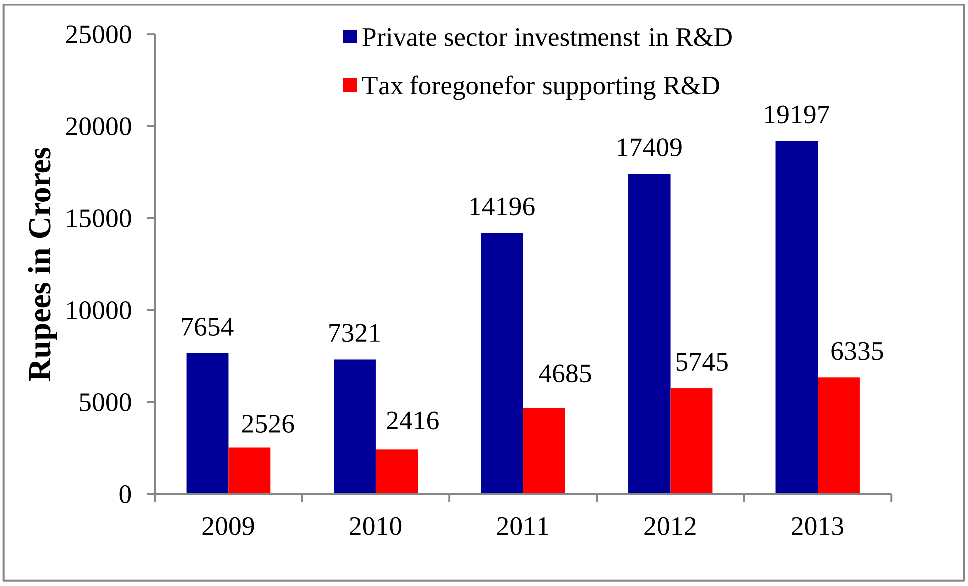


Figure 7: Tax Foregone by government for supporting R&D (2009-13)

Source: *Stimulation of Investment of private sector into research and development, DST, 2013*

Some of the suggestion for improving Indian tax incentivization in lines with R&D tax incentivization followed in other countries are presented below:

Tax incentives	Brief details	Reference country
Introduction of research credit scheme	Tax credits are more favourable than tax deductions or exemptions because tax credits reduce tax liability rupees for rupees. While a deduction or exemption still reduces the final tax liability, they only do so at an individual's marginal tax rate. Unlike deductions and exemptions, which reduce the amount of taxable income, tax credits reduce the actual amount of tax owed.	USA, Japan, South Korea
Incremental tax incentivization	In India, volume based tax incentivization is executed that benefits large tax deduction for large investments and low tax deductions for low investments. Under incremental tax incentives, the incremental amount of research expenditure in comparison to the base amount is calculated and based on increment in research expenditure tax incentivization is provided.	USA, Japan, South Korea
Target based tax incentivization	Targeted research credits/deduction should be available in India for different subject areas depending on national needs and societal improvement. In USA different tax credit slabs are functioning for research in different areas such as 20% tax credit for basic research and energy research and 50% tax credit for clinical research of orphan drugs. In China targeted group of high-new technology enterprise is provided with enhancing tax deductions. On similar lines, GoI should identify key priority areas and provide special incentives to stimulate R&D investments in these identified areas. Moreover, government should release specified are funds from its budget to promote public-private partnerships for addressing the national key challenges of the country.	USA, China, Japan, Israel
Different tax incentivization rates	Industrial research mainly comprise of large scale, medium scale, and small scale industries. Different tax	South Korea, UK

for large, medium and small enterprises	incentive slabs depending on the scale of industries should be introduced in Indian R&D tax incentivization schemes. As observed in South Korea tax credit of 50% for SMEs, 40% is for medium sized companies and 30% for large sized companies. Similarly, Japan follows 17% tax credit rates for SMEs and 6-10% for large sized companies. Implementation of such incentives will stimulate research in SMEs. As in U.K., special tax incentives to SMEs is provided that face loss situations.	
Patent related incentives	From March 2017 onwards, Patent related incentive as a fixed tax rate of 10% is available for royalty income generated from patenting activities. Whereas in other countries cost incurred in the patent filing and patent maintenance and amount spent in acquiring a patent is also considered for tax incentivization and the extent of incentivization varies with the scale of the industry.	South Korea
Incentives for angel investors	India has come up with start-up based tax incentives by providing 3 year tax holiday. In order to promote participation of private sector in start-ups through angel investing, special incentives can be provided to them.	Singapore, Israel
National tax agency for R&D	Creation of national tax agency to simplify the process of approval and accreditation of tax incentives to R&D companies as on lines of Japan should be promoted in India. This should be persuaded to simplify the process of getting government accreditation in time effective manner.	Japan
Development and expansion related tax incentives	Special development and expansion related tax incentivization as applied in Singapore can be introduced for Indian companies who wish to expand their R&D business. Despite having one of the lowest corporate tax rates in the world, Singapore offers a wide range of investment incentives for investors, including tax holidays, preferential tax rates, and grants to attract substantive Singapore inbound investment and to support business expansions in Singapore. Such fiscal tools have been used by Singapore since her independence to	Singapore

	promote economic development in the country.	
Special Tax incentives for Academic Collaborated Research	Industries pursuing collaborative research with academic institutions should be eligible for getting additional tax incentives on R&D expenditure in collaborative research work in order to strengthen Industry-Academia research participation in India. Moreover, Service Tax waiver for I-A research projects.	Japan

5. Monitoring and enhancing public funding support to the private sector

Most of the expenditure on R&D in India is contributed by the public sector. The substantial amount of R&D funding in universities, institutes of national importance and national research laboratories is sponsored by the Indian government under respective ministry heads. Direct R&D funding to the private sector is very limited. Ministry of Science and Technology through Department of Science and Technology (DST), Department of Biotechnology (DBT) and Department of Scientific and Industrial Research (DSIR) supports industrial R&D carried out by the industry itself. DST and DBT have created dedicated autonomous body namely Technology Development Board (TDB) and Biotechnology Industry Research Assistance Council (BIRAC), to cater the funding needs of private sector industry in the field of High-end research in sciences specifically focussing life sciences and biotechnology. Ministry of Electronics and Information Technology has also come up with special programs for supporting Electronic System Design Manufacturing (ESDM) sector in India.

However, to support and boost private sector R&D, Indian government should come up with dedicated programmes for supporting industrial R&D and fixed percentage of funds in each ministry should be allotted to support private sector R&D as on lines of USA, Singapore and Germany. Funding programs initiated by Singapore's government such as Industry alignment fund, tech bridge ventures, innovation and capability voucher, SME talent program and Research Incentive Scheme for companies are the perfect role model for setting up dedicated funds for industrial R&D. Moreover, in financially supporting R&D persuaded by private sector in India, it is necessary to introduce financial guarantee scheme on lines of USA (State Small Business Credit Initiative), Japan (International Cooperation Loan Guarantee Scheme), Germany (German United Loan Guarantees and cash subsidy scheme), South Korea (Korea

Credit Guarantee Fund) and Israel (MAGNET programme and cash subsidy scheme through innovation authority) to provide guarantee in order to secure huge amount of money invested by industry in R&D. Funding programs introduced by Germany and China based on targeted specific and country needs should also be introduced in Indian system to support and strengthen the innovation ecosystem as per the industrial, societal and economic needs. Horizon 2020 program initiated in Germany, National High-Tech Research and Development Programme in China and RISC and IDS programs of Singapore, can act as a role model for introducing funding programs in support of future innovations through the private sector. Especially to encourage MSMEs for contributing in R&D, a special guarantee scheme should be introduced by government through which banks can give loan to MSMEs by considering IP as the mortgage able asset (recommended by JCIG, 2013).

Miscellaneous:

- In order to carry out realistic based estimation of R&D investments by private sector, government should come up with set of guidelines in accordance to which all companies engaged in R&D activities should be mandated to disclose R&D expenditure in their annual reports and balance sheets (recommended by JCIG, 2013).
- Government should come with provisions to write off loans issued by public sector to private sector for R&D activities in case of genuine failure under one window apex system (recommended by JCIG, 2013).
- Introduction of conditional grant to private sector for commercializing their R&D outcomes (recommended by JCIG, 2013).
- A fixed percentage of commercial products, developed through R&D under PPP mode, should be purchased by the Govt.
- Adoption of robust confidentiality agreement in public institutions for joint R&D
- Creation of Special Fund for global partnership in R&D by Public and Private sector
- Extend R&D incentives to companies such as beer, wine and other alcoholic drinks; confectionary, tooth pastes, steel furniture etc. These private sectors have been restricted for seeking R&D incentives
- A right mix of loan, equity and grant-in-aid according to the stage of technology development and risk factor involved in PPP mode
- The R&D investments of private sector made under PPP, which benefits society, should be considered as a part of Corporate Social Responsibility (CSR).

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Appendix I

Eligibility and qualified research expenditure: This subhead provides the details of types of industries and their respective activities engaged in R&D that are eligible for government benefits. This section also compares the expenditure incurred on research activities that fall under qualified and non-qualified research expenditure on which the government provides various benefits.

Intellectual property (IP) and R&D location Jurisdiction: In this section, we have tried to cover location and IP specific jurisdiction of the company for availing government initiated incentives.

Tax Incentives: One of the major government initiated incentives for the private sector R&D falls under tax-related incentives for the industrial R&D expenditure taken up by a company. Tax incentives can be provided through two means, one is direct tax incentive through which tax credits and super deduction to the R&D expenditure incurred by company is availed and another one is indirect tax incentives in form of Value Added Tax (VAT), custom duties (import duties and excise duties), etc. can be availed on R&D related import and export activities. Other than direct and indirect tax incentives, some of the countries provide tax incentives on IP and entrepreneurship-related activities. Brief about the major tax incentives as mentioned below availed by the private sector in select countries is provided.

- ***Direct Tax Incentives (Tax Credits and tax deduction)***

1. *Tax Credit*: is an amount in accordance with the credit scheme which is subtracted from the total tax liability owned by the taxpayer to the government. Tax credits are generally provided to individuals or businesses under specific classification or location.
2. *Tax Deduction*: is a reduction in income that has to be taxed in the result of specific activities undertaken by individual or businesses to produce additional income.

- ***Indirect tax incentives (VAT, customs duty, import duty, excise duty, etc.)***

1. VAT: broadly based consumption tax assessed on the value added to goods and services.
2. Import duty: duties levied on import of goods
3. Excise duty: duties levied on exported goods

- ***Patent related tax incentive***
- ***Start-up tax incentives***

Funding support: This subhead provides the brief details of the major government funding agency and funding programs for supporting industry for their R&D projects. Funding is provided by four means such as:

- ***Loan:*** a sum of money that is provided by the government agency for R&D purpose which needs to be returned to an industry with added interest in specified time frame.
- ***Grant:*** a sum of money given by the government to the industry for the specific purpose without the need to return it back to the grant provider.
- ***Equity:*** a sum of money provided by the government to the company for the specific purpose of which in return government holds a portion of the share of the same company in accordance to the investment.
- ***Subsidy:*** a sum of money is provided by the government to the company to maintain the price fluctuation of the specific products.

Appendix II

R&D Incentivization Followed Worldwide

R&D Incentives / Country	Funding Support	R&D Tax (combined)	R&D Tax Credit	R&D Tax Deduction	Volume based	Incremental based	Refundable	Carry Forwarded	Preferential Tax Incentives		Patent Box	CAPEX incentives
									SMEs	collaboration		
Angola	×	×	×	×	×	×	×	×	×	×	×	×
Australia	√	√	√	**n.s.**	√	×	√ **(for SMEs)**	√	√	×	×	√
Austria	√	√	√	**n.s.**	√	×	√	×	×	×	×	√
Belgium	√	√	√	√	√	×	√	√	×	√	√	√
Brazil	×	√	**n.s.**	√	×	×	×	×	×	×	×	√
Canada	√	√	√	**n.s.**	√	×	√ **(for SMEs)**	√	√	×	×	√
Croatia	√	×	×	×	×	×	×	×	×	×	√	√
Czech Republic	√	√	**n.s.**	√	×	×	×	×	×	×	×	√
Greece	√	√	**n.s.**	**n.s.**	×	×	×	×	×	×	√	√
Hungary	√	√	√	√	√	×	×	√	×	√	√	√
Iceland	√	√	**n.s.**	**n.s.**	√	×	√	×	×	√	×	×
Ireland	√	√	√	**n.s.**	√	×	√	√	×	×	√	√
Italy	√	√	√	**n.s.**	×	√	×	×	×	×	√	√
Latvia	√	√	**n.s.**	√	×	×	×	×	×	×	×	√
Lithuania	√	√	**n.s.**	√	×	×	×	×	×	×	×	√
Malaysia	×	√	**n.s.**	**n.s.**	×	×	×	×	×	×	×	√
Mexico	√	√	**n.s.**	**n.s.**	×	×	×	×	×	×	×	×
Netherlands	√	√	**n.s.**	**n.s.**	×	×	×	×	×	×	√	√
Poland	√	√	**n.s.**	√	×	×	×	×	×	×	×	√
Portugal	√	√	√	**n.s.**	×	√	×	√	√ **(for**	×	√	√

									start-ups)			
Romania	√	√	**n.s.**	√	×	×	×	×	×	×	×	√
Russia	√	√	**n.s.**	√	×	×	×	×	×	×	×	√
Slovakia	√	√	**n.s.**	√	×	×	×	×	×	×	×	√
South Africa	×	√	**n.s.**	√	×	×	×	×	×	×	√	√
Spain	√	√	√	**n.s.**	×	√	×	√	×	×	√	√
Turkey	√	√	√	√	×	×	×	×	×	×	√	√

Compiled from2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-pwc; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD
n.s: .not specified

Appendix III

1. USA

Attributes	Brief Details
Eligible Industries and Qualifying Costs	• The incentive is intended to benefit all industries conducting qualified research. Consequently, all industries are eligible for the research credit. • Qualifying costs include: wages for in-house labor, 65% of contract research, and supplies used in the research process. • Costs incurred to construct a "pilot model" are qualified research expenses. • Expenses incurred for developing software that is primarily for internal-use can qualify for the research credit only if the software is highly innovative, which is an additional test to qualify for eligible R&D. The final regulations define software developed primarily for internal-use to include only software developed to perform general and administrative (G&A) functions. • Overhead and capital expenditure are excluded.
IP and jurisdictional restrictions	There is no restriction on the location of any resulting IP. Qualifying activities must be performed within the US and a US taxpayer must incur the related qualifying costs (although such costs may be reimbursed by a foreign affiliate).
Technology or innovation zones	There are no technology or innovation zones providing R&D incentives in the US.
Role of governmental bodies in administering incentives	The taxing authorities may audit research credits and deductions claimed by any taxpayer after the filing for the credit or deduction. Although there is no special audit or preapproval process required, there are special procedures, such as Pre-Filing Agreements (PFAs), available to taxpayers who wish to have their federal research credit and/or deduction audited in advance of filing their tax returns.
Administrative requirements	As with any credit or deduction, a taxpayer must maintain business records to support credits and deductions claimed. There are no special procedures for research credits or deductions. No preapproval process is required for the R&D incentives.
Statutory reference	• Federal research credit: Section 41 of the Internal Revenue Code • Federal R&D deduction: Section 174 of the Internal Revenue Code • State credits and deductions: various provisions based on each state's statutory framework
R&D Incentives	
1. Tax Incentives	
Tax Attribute	**Brief Details**
Current level of corporate Tax Rate	• Most states also impose an income tax at rates ranging from 4.6% to 12%. The average combined federal/state corporate tax rate is 39.1%
Research Tax Credit *under section 41 of the Internal Revenue Code (IRC) (Which became permanent at the end of*	• The research tax credit is a credit computed on an increment of qualified research spending exceeding a base amount. • Forty-five states offer a research tax credit that is similar to the federal tax credit, but generally at a lower credit rate. There are, however, a few states that offer refundable credits. Moreover, some states offer sales and use tax refunds or exemptions for property purchased to be used in the R&D process.

2015) 14-50%; Non refundable	• Eligible small businesses(companies with average annual gross receipts not exceeding USD 50M for the three preceding taxable years) can, for the first time, utilize research tax credits to offset alternative minimum taxes (AMT). • Qualified small businessescan utilize research credits to reduce payroll taxes. This new law applies to very small start-up companies that: (i) have gross receipts for the credit year of less than USD 5M (ii) have no gross receipts for any taxable year before the five taxable year period ending with the current taxable year, i.e., for the sixth year preceding the credit year and any years prior to the sixth year.
Traditional research tax credit **20%; non refundable** Credit on incremental spending with limitations	• The traditional credit is equal to 20% of the amount of the qualified research expenses (QREs) exceeding a base amount for the period 1984-88. • There is, however, a minimum base amount of 50% of the current year QREs, thereby limiting the incremental QREs to 50% of the determined amount. • This can be challenging considering that records dating back to the early 1980s are often not readily available. For this reason, and the complex base amount rules, very few companies elect to report the traditional research credit. • There is a minimum base amount applicable only to the traditional credit equal to 50% QREs.
Alternative Simplified Credit 14%; Non Refundable Credit on incremental Spending without Limitations	• The alternative simplified credit (ASC) is equal to 14% of the excess of the QREs over 50% of the average of the previous three years' QREs. • The ASC base amount is, therefore, much easier to determine than under the traditional method and most taxpayers elect the ASC. • There is no minimum base amount for the ASC. However, if there is no qualified research spending in any one of the previous three years, the credit is equal to 6% of qualified research spending in the current tax period.
Targeted research credits 20% (Basic Research); 20%(Energy Research Consortium) & 50% (Clinical Testing work) Non refundable	• There are other research credits under US law targeting specific types of research, including basic research credit (i.e., for funding research undertaken by universities and research organizations that have no commercial objective), energy research consortium, and a clinical testing relating to orphan drugs. • These additional credits cannot be taken on the same QREs included for the regular research credit.
Computational adjustments Non refundable Excess credits may be carried back 1 year and forward 20 years	• There are several computational adjustments that significantly reduce the true value of US R&D tax credits. While qualifying R&D expenses are currently deductible, taxpayers must reduce the current deduction by the amount of the tax credit (thereby reducing the net benefit of the traditional research tax credit and the ASC to 13% and 9.1%, respectively). • Alternatively, taxpayers may elect to forego the reduction to its current deduction and just report the traditional credit at 13% or the ASC at 9.1%. This election must be made annually on a timely filed original income tax return.
2. Government Funding Support	
Federal Grants	There are over 900 programs offered by the US federal government providing grants for: • developing commerce and business • improving food and nutrition, health, and environmental quality • improving, promoting, and assisting agriculture and agricultural activities • improving energy resources • training, employment, and labor management

	• development and/or implementation of science and technology
3. Investment	
Wind Production Tax Credit (PTC)	IRC section 45 provides a 10-year production tax credit of USD 02.3 per kw/hr for electricity produced from specified resources and sold to a third party. Specified resources include wind, biomass, landfill gas, waste to energy, and others.
Power Investment Tax Credit (ITC)	IRC section 48 provides a 30% investment tax credit for specified property used to produce electricity from renewable sources. These sources include solar, fuel cells, and combined heat/power systems (10% credit).

Source: Camp's 2014 legislation; 2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-pwc; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD

2. China

China offers a variety of tax incentives for R&D, including super deductions and reductions in the enterprise income tax rate.

Attributes	Brief Details
Eligible Industries and Qualifying Costs	Non Eligible Industries (Negative List) • Tobacco • Hospitality and catering • Wholesale and retail • Real estate • Rental and commercial services • Entertainment • Other industries to be specified by the Ministry of Finance and State Administration of Taxation Expenses eligible for the super deduction include: • Labor expenses (including labor costs for external personnel) • Direct expenses incurred in the R&D project • Depreciation expenses (even if the equipment is not used exclusively for R&D) • Amortization expenses • Design and testing expenses (including testing expenses for trial products) • Other directly related R&D expenses such as expert consultation, "high and new technology" R&D insurance, IP application costs, and travel and meeting costs. Eligible expenses in this category are limited to 10% of all eligible expenses for expenditure incurred on or after 1 January 2016 • Up to 80% of fees paid to contractors to perform research on the taxpayer's behalf qualify for the super deduction as long as the fee and related terms reflect an arm's length transaction • Expenses related to R&D activities carried out by contractors that are foreign organizations or individuals are not eligible for the super deduction. Activities not eligible for super deduction • Normal upgrades of products (services) • Direct application of research findings

	• Support activities following commercialization of a product • Duplication or simple alteration of existing products, services, technology, materials, or processes • Market research, efficiency studies, or management research • Quality control, testing, and analysis or repair and maintenance activities that are related to industrial (service) processes or are routine in nature • Research in the social sciences, the arts, or humanities • where an Chinese enterprise entrusts the R&D activities to overseas organizations or individuals, the incurred R&D expenses are not eligible for R&D super deduction.
IP and jurisdictional restrictions	• The IP must be held by the Chinese applicant • While less than 40% of the R&D expenses qualifying for the high-new technology enterprise (HNTE) incentive is allowed to be incurred outside China, the authorities may consider whether IP has been created and retained in China in granting HNTE status.
Technology or innovation zones	• There are many National Economic and Technological Development Zones (NETD Zones) in China, and various preferential treatments of financial subsidies are provided to companies established inside the NETD Zones. R&D incentives provided by each NETD Zone are diverse, according to the different development status and development policies of each NETD Zone. • R&D incentives are mainly provided by local authorities of NETD Zones by way of rewards or subsidies. The types of R&D incentives include land/office price reduction, one-off subsidy and financial subsidies to attract the R&D headquarters/center or technological companies, technology innovation project/ program financing, additional subsidies to the original R&D incentives, subsidies to the talents engaging in scientific and technological innovation, and rewards for the technology innovation honors.
Role of governmental bodies in administering incentives	• A preapproval or information registration is required to claim R&D tax benefits. Taxpayers need to submit all relevant information, including the R&D project budget, descriptions of specific R&D projects, categories of R&D expenditure, and management or board meeting documents authorizing R&D project(s), to the Government authorities as early as possible. • The incentives related to the R&D expenses super deduction should be claimed during the annual CIT filing, which is due within five months after the end of the tax year (the statutory annual filing deadline). The application package should be submitted with the relevant forms in the CIT filing return, which include the Basic Information Form on Taxpayers
Administrative requirements	• It is no longer necessary to obtain advance approval from the relevant tax authorities, i.e., taxpayers merely have to follow tax return filing procedures • Companies undertaking R&D projects at the provincial or ministerial level or above, or projects that span multiple years and that already have been verified, are not required to obtain annual verification by the competent science and technology authorities. • A company can apply for the super deduction retroactively, within three years after the expenses are incurred. • Companies are not required to set up special accounts for R&D expenses; however, in addition to complying with the standard accounting treatment under the prevailing financial accounting rules, companies must prepare supplementary financial records to accurately track the actual expenses that are eligible for the super deduction in the current year. • The tax authorities are required to intensify their administration of super deduction claims filed by taxpayers, through regular inspections and monitoring, with audits covering no less than 20% of all cases annually.

Statutory reference	• SAT, tax authorities at local levels and the science and technology authorities at city level or above for super deductions • The MOST, MOF and SAT are responsible for the guidance, management and supervision of the HNTE recognition procedures nationwide. • MOF, SAT, the Ministry of Commerce (MOC), MOST, and the National Reform and Development Commission (NRDC) for TASE • Regulations Effective year Incentives related to HNTE • Article 27, 28 and 30 of CIT Law 2007 • Article 90, 93 and 95 of Implementation Regulation of CIT Law 2007 • SAT Announcement [2013] No. 62 2013
R&D Incentives	
1. Tax Incentives	
The statutory Enterprise Income Tax (EIT) rate	25%
Super deduction 50%; 150% (pwc report) Non-refundable; Deduction on volume & can be carried forward for 5 years	• A super deduction provides an extra 50% deduction for eligible R&D expenses. Tax losses attributable to R&D super deductions may be carried forward up to five years.
VAT/Custom duty incentives Non-refundable	• An exemption from VAT (with input VAT refundable) is available for providing R&D, offshore outsourcing services, or transferring technologies to foreign entities. • An exemption (with input VAT not creditable or refundable) also is provided for technology transfers or R&D services (including relevant consulting services) between domestic parties. • Qualified foreign-invested R&D centers may be eligible for an exemption from import duty, VAT, and consumption tax on the import of equipment, devices, and instruments through 31 December 2018. • Qualified private non-enterprise technology institutions may be eligible for an exemption from import duty, VAT, and consumption tax on the import of items for scientific R&D use.
2. Funding Support	
Local Financial Subsidies	Granted by local governments to support R&D activities upon approval
3. Patent Box	
Technology/Software Companies	• The first CNY 5M of annual income from qualified technology transfers (including income from a non-exclusive license with a license term of no less than five years) is exempt from EIT. • Annual income from qualified technology transfers (including income from a non-exclusive license with a license term of no less than five years) in excess of CNY 5M is taxed at 50% of the normal EIT rate. • Newly established software companies often are granted tax holidays.

	• Taxable software companies may be granted VAT preferential treatment on qualified revenue. • Qualified software companies may be eligible for an exemption from import duties on self-used equipment and materials. Reduced tax rates are offered to companies developing new technologies, products, etc.
Income on Technology Transfer	Scope of qualified technology transfer: • Transfer of patent technology • Transfer of computer software copyright • Transfer of right of integrated circuits layout designs • Transfer of new species of plant • Transfer of biopharmaceutical products • Transfer of other technology authorized by the MOF and SAT
4. Investments	
Reduced tax rates for High-New Technology Enterprise (HNTE)	• A reduced 15% EIT rate is available for companies granted HNTE status. HNTE status is granted for a three-year term, with an annual review of the status during the three-year period. HNTEs normally are eligible for a 50% super deduction for qualified R&D expenses, in addition to the reduced EIT rate.
Reduced tax rates for Technology Advanced Service Enterprises (TASE)	• The reduced 15% EIT rate also applies to TASE that are located in 21 designated cities. This incentive has been extended through 31 December 2018. TASE status is obtained by submitting an application and will be reviewed each year. TASEs generally are not granted the 50% super deduction for qualified R&D expenses, in addition to the reduced EIT rate.
Promote Foreign Investment	• The local governments are authorized to support investment projects that make a substantial contribution to local employment, economic development, and technological innovation to lower the cost of the investment and operation of foreign enterprises. • Most incentives offered by local governments are based on negotiation on a case-by-case basis. Incentives commonly include tax refunds, tax credits, free leasing of office spaces, etc.
Preferential Tax Incentives	• Support different kinds of production and the use of energy-saving technologies and products. For example, investment in designated energy-saving equipment and facilities is entitled to an EIT credit equal to 10% of the total investment.

Source: 2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-pwc; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD

3. Japan

Attributes	Brief Details
Eligible Industries and Qualifying Costs	• Research credits are not limited to specific industries, although the activity must be technological and scientific in nature. • The expenses must be incurred by the Japanese entity. Research expenses that are funded by unrelated entities (government agencies, customers, suppliers, etc.) are not eligible for the research credit. • To qualify for the credit, the expenses must be incurred to manufacture products or to improve, design, formulate, or invent techniques. Qualifying expenditure includes • In-house labor costs & supplies

	• Overhead • Depreciation on fixed assets • Contract costs.
IP and jurisdictional restrictions	• Japanese law does not expressly require that companies claiming research tax incentives own the IP created through their R&D activities. • The qualifying costs incurred by a Japanese company are eligible for the research credit even if the research is conducted outside of Japan.
Technology or innovation zones	There are no technology or innovation zones providing R&D incentives in Japan.
Role of governmental bodies in administering incentives	The National Tax Agency administers the R&D tax credit (i.e., eligibility for the tax credit is scrutinized by tax authorities upon future tax audits).
Administrative requirements	• No prior approvals from government/regulatory agencies are required. Credit should be claimed on the tax return for the relevant period. Claims on amended tax returns generally are accepted in cases of a change to the tax credit limitation amount. • The R&D tax credit is available to "blue return" filers. Blue form tax return status is obtained by submitting an application to the appropriate tax office. Record-keeping substantiation requirements apply. • To claim a tax credit, certain forms (schedule 6(6), 6(7), 6(8) and/or 6(9)) must be attached to the corporate tax returns, which are due two months after fiscal year-end (a one-month extension is generally allowed).
Statutory reference	• Article 42-4 of the Special Taxation Measures Law
R&D Incentives	
1. Tax Incentive	
General National Corporate Income Tax Rate	Corporate income tax rate in Japan is 23.4% for fiscal periods beginning on or after 1 April 2016 and this tax rate will be reduced to 23.2% for fiscal periods beginning on or after 1 April 2018.
Volume-Based Tax Credit Non refundable; Unused tax credits may not be carried forward.	• The tax credit for general R&D costs is a volume-based credit and varies depending on whether the company claiming the credit is a SME or a large company.
a. Small and Medium Sized Entities (SMEs) 12%	• SMEs may claim a tax credit equal to 12% of total R&D expenditure. The tax credit cannot exceed, however, 25% of the corporation tax liability before the credit is applied.
b. Large companies 8-10%	• The tax credit for large companies is 8% to 10% of total R&D expenditure. The tax credit cannot exceed, however, 25% of the corporation tax liability before the credit is applied.
c. Tax credit for special R&D costs 30%	• A 30% credit is provided for joint R&D with a university or public research institution or where the R&D is contracted to such entities. • This provision is applicable to "blue" tax return filers, which includes both SMEs and large companies. • Royalty payments made to SMEs also qualify for this special tax credit. The credit is 20% where the R&D is with other non-public entities

Incremental tax credits Capped at 30%	• Additional incremental tax credits (for both SMEs and large companies) also are available. • Where the current period R&D expenditure exceeds: (i) An amount 5% greater than the annual average of the R&D expenditure for the three preceding fiscal years (ii) The highest annual R&D expenditure for the previous two fiscal years, the company may claim a credit for a percentage of the increase in R&D expenditure, where the percentage applied is equivalent to the percentage increase in R&D expenditure
Tax Reform 2017	
2017 Tax Reform: Revision of the R&D Credit Regime	The proposals, which are subject to amendment, are expected to be finalized and enacted into law by 31 March 2017, and will impact the following incentives.
a. Volume-based tax credit	• The tax credit for SMEs will be increased up to 17% of total R&D expenditure, under a two-year transitional measure, where the R&D cost is increased by more than 5%. • The tax credit for large companies will be changed from 8%-10% to 6%-10% of total R&D expenditure. The upper limit, however, may be increased to 14% under a two-year transitional measure.
b. Credit limitations	• The credit limitation generally still will be 25% of the corporate tax liability. • However, where the incremental tax credit is not taken, the volume-based tax credit limitation may be increased as follows: if R&D costs for an SME is increased by over 5%, the cap will be increased by 10% (i.e., to 35% of the corporate tax liability); and if R&D costs for large companies exceed 10% of average sales, the cap may be increased by 0% to 10% (i.e., up to 35% of the corporate tax liability).
c. Incremental tax credits	• The basic calculation method will be abolished, but the alternative calculation method will be extended for two years.
d. Expanded scope of R&D costs eligible for tax credit	• The scope of R&D costs eligible for the tax credit will be expanded to include costs for service development in relation to the "fourth industrial revolution" (businesses using IT, big data, artificial intelligence, etc.)
2. Funding Support	
R&D grants	• Japan offers many different grants for R&D across a wide range of fields. For example, the Small Business Innovation Research "SBIR" program encompasses cash grants from various government ministries
3. Investments	
CAPEX—Special depreciation/tax credit for revitalization of local economies (42-11-2)	• Tax incentives are available to encourage the revitalization of regional economies through the relocation of head office functions from large cities to local regions, and the expansion of head office functions at existing regional facilities. • Special depreciation of 25% of the acquisition cost of buildings may be available in the case of relocation, and 15% in the case of expansion. • Alternatively, a tax credit (capped at 20% of the corporation tax liability) may be taken for 7% of the acquisition costs in the case of relocation, and 4% of the acquisition costs in the case of expansion.

CAPEX—Special depreciation/tax credit in national strategic special zones (42-10)	• Special depreciation or a tax credit may be available for the acquisition cost of eligible assets in designated national strategic special zones. • Special depreciation depends on the type of asset acquired: 25% for buildings and structures, and 50% for machinery and R&D equipment/fixtures used in specified businesses within the zones that are conducive to international competitiveness or the formation of hubs for international business. • Alternatively, a tax credit (capped at 20% of the corporation tax liability) may be taken for 8% of the acquisition costs of buildings and structures; and 15% for the costs of machinery and R&D equipment/fixtures used in specified businesses.

Source: 2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-pwc; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD

4. Germany

Attributes	Brief Details
Eligible Industries and Qualifying Costs	Eligibility is not limited to particular industries. Companies in the following industries typically seek cash grants: • Manufacturing and production processes • Automotive and transportation • Biotech and life sciences • ICT • Energy and utilities Qualifying expenditure includes: • Personnel Costs • Materials • Overhead • Subcontracting • Amortization • Travel Costs Qualifying activities include the following: • Industrial research: Research with a specific practical objective aimed at developing new products, processes, or services, or at improving existing ones. • Experimental development and demonstration actions: Demonstration of new applications and/or research results. • Development of business models: Analysis and implementation of innovative (digital) business models. The selection criteria for eligible projects include: • Extent of innovation level • Extent of technical risk • Exploitation plan • Positive environmental effects.
IP and jurisdictional restrictions	R&D activities must be conducted in Germany and R&D costs shall incur in Germany. The exploitation of project results regularly will have to take place in Germany/EU, with the IP created through the research (initially) remaining in Germany/EU. Nevertheless, large multinational companies with IP relocated to

	headquarters outside Germany also may qualify for funding under certain conditions.
Technology or innovation zones	• There are no technology or innovation zones providing R&D tax incentives in Germany. However, Germany supports the creation of innovation clusters in certain areas. • Innovation clusters consist usually of different partners from academia and industrial stakeholders. Funding up to €5 million can be provided to the cluster by regional governments for a duration of up to 10 years. • Additionally, the creation of new R&D centers (or production premises) can be funded in specific regions in Germany.
Role of governmental bodies in administering incentives	• Funded R&D and investment projects may commence only after the cash grant has been approved for a beneficiary. Cash grants are disbursed after costs have been incurred and claimed with the funding body. Costs incurred prior to approval (e.g., before the project started) do not qualify as eligible costs.
Administrative requirements	• Public incentives for companies with a legal entity in Germany are provided by the EU, the German federal government, and the individual federal states.
Statutory reference	• EU legislation • Communication from the Commission – Framework for State Aid for Research and Development and Innovation (2014/C 198/01) • Commission Regulation (EC) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Art. 107 and 108 of the Treaty (General Block Exemption Regulation) • Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises (2003/361/EC) • German legislation • National level General Conditions of the Federal Ministry of Research and Education for the Allocation of Benefits for R&D Activities to Commercial Companies on a Cost Basis as of April 2006 • National funding guidelines for investments and innovation clusters
R&D Incentives	
1. Tax Incentive Germany is one of the few countries that does not offer tax incentives for R&D activities. Although there is a political debate about the implementation of tax incentives, quick adoption is not expected in the short-to mid-term.	
2. Funding Support	
Federal R&D grants- Cash grants	• Cash grants for R&D are awarded up to 50% of qualified research expenses • Application-based, non-repayable cash grants for R&D projects and demonstration projects. • The average grant rate for R&D projects is 35%-45% of eligible project costs although higher rates may be available for SMEs.
Targeted R&D grants	a. Energy: This federal program focuses on R&D activities that increase energy efficiency in the following areas: industrial production, buildings, cities, power supply and storage, or renewable energy.

	b. Digitization and automation of production processes: This innovation area has received considerable attention, with three major framework programs: • Innovation for the production, services and work of tomorrow • Convergent ICT • Human-Machine Interaction c. New vehicle technologies This program offered by the Federal Ministry for Economic Affairs focuses on research on technologies for future vehicles d. Innovations for hydrogen and fuel cells This program supports industrial research and experimental development in the following sectors: transport, including hydrogen infrastructure; hydrogen production; industrial applications; and special markets for fuel cells. e. SME innovative The SME programs focus on SME-driven R&D projects in areas such as bio- and nano-technology, production processes, and medical technology. For SMEs, cash grants are awarded up to 60%. f. Health The two framework programs, 'Health research' and 'Medical technology' support basic R&D projects on diseases and preventive measures, as well as the development of innovative medical technologies. g. Microelectronics The framework program supports R&D projects in all types of microelectronic applications (e.g., mobility, energy, industry 4.0). h. Shipping technologies The two funding programs, 'Innovative Port Technologies' and 'Maritime technologies of the next generation' provide funding for innovations in the context of waterway transportation. For large enterprises, cash grants are awarded of up to 50% of eligible costs, with a 10% bonus possible for SMEs, depending on the specific calls.
Horizon 2020	• Enterprises located in Germany can apply for R&D grants under several EU programs. However, stiff competition for EU funding, especially in the current funding program Horizon 2020
3. Investments	
Investment Incentives	• Investment incentives are available for initial investments • There are investment grants available for initial investments within a privileged region for taxpayers setting up a new plant/business premises or undertaking new activities that lead to a diversification of the assets of an establishment.
Targeted Investment grants-a. GRW program	• Set-up of business premises and runs until 2020, and supports companies in setting up new plant or business premises in specific structurally weaker regions (mainly in Eastern Germany). • Maximum funding quotas range from 20% for large companies to 40% for SMEs
Targeted Investment	• additional investment costs for eco-friendly innovative investments can be

grants-b. Environment innovation program	funded with non-repayable cash grants or interest-reduced loans. • Cash grants are awarded up of to 30% of eligible costs or interest-reduced loans of up to 70% of eligible costs.
Targeted Investment grants-c. Acquisition of electric vehicles and charging infrastructure	• funding is available for private investors, cities and municipalities for building a nationwide loading charging infrastructure for electrical vehicles with 15,000 load stations.

Source: 2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-pwc; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD

5. South Korea

Attributes	**Brief Details**
Eligible Industries and Qualifying Costs	• Dedicated R&D center of the corporation or the corporation's internal R&D department, both of which should be registered with the Government (i.e., Ministry of Science, Information & Communication Technology and Future Planning in Korea). Eligible expenses include • cost of machinery, facilities, tools, office machines, telecommunications instruments, testing machines, optical instruments, etc. used to carry out the R&D activities. Ineligible expenditures include: • General management and supporting activities • Market research and promotional activities or general quality testing • Repetitive information-gathering activities • Activities to improve management or staff efficiency • Legal and administrative activities such as protection of patent rights, etc. • Exploration and investigation activities related to reserves of natural resources including minerals • Research activities on contract basis Qualified R&D costs include: • Labor costs (salaries, wages, bonuses, etc.) • Materials costs (samples, parts, and raw materials used in the conduct of R&D) • Rent for R&D equipment • Commissions paid to the qualifying body • Training costs • Other costs (trademark development costs, design development costs, consulting fees, and quality guarantee costs). However, R&D subsidized by the government is not eligible for R&D tax credit.
IP and jurisdictional restrictions	• All R&D expenditure directly related to the R&D activities of the company may be claimed in the tax credit computation, regardless of where the R&D activities are carried out, except for research subcontracted to academic institutions; which must be located in South Korea. • Any resulting IP does not have to be held by the South Korean company.
Technology or innovation zones	• If qualified, the companies located within an R&D Special Zone are able to enjoy certain tax exemptions.

Role of governmental bodies in administering incentives	• Each year, the Korean National Tax Service reviews R&D tax incentive applications that have been submitted with a CIT return and processes the R&D tax credit claims. • The R&D tax credit claims may also be subject to written information requests or a tax audit in the future.
Administrative requirements	• According to the Basic Research Promotion and Technology Development Support Act, a dedicated R&D center or R&D department set up by a company should be registered with the Ministry of Science, Information & Communication Technology and Future Planning in order to benefit from R&D tax incentives.
Statutory reference	• The Tax Incentives Limitation Law (TILL) • Tax credit for R&D expenditures- Article 10 of the TILL • Tax credit for investment in R&D facilities-Article 11 of the
R&D Incentives	
1. Tax Incentive	
Corporate Tax Rate in South Korea	Ranges from 11% to 24.2% depending on the taxpayer's tax base
Tax Credit Non refundable; Unused R&D credits may be carried forward to the following five years.	Credit on either incremental or volume. However, the incremental method cannot be used in case of either (i) no R&D expense has been incurred during the previous four years or (ii) the R&D expenses of last year are less than the average of the previous four years.
a. SMEs For start up SMEs it can be carry forwarded for 10 years	• A tax credit equal to the greater of 50% of the current year R&D expenditure exceeding the average R&D expenditure for the previous four years; or 25% of the current year R&D expenditure. • A 30% tax credit computed based on current R&D expenditure related to the New Growth Engine Industry or Original Source Technology program designated by the government authority. • A tax credit equal to 10% of the purchase price of certain IP purchased by an SME from a Korean party.
b. Medium Sized Companies	• Medium-sized companies are entitled to a tax credit that is the greater of 40% of the current year's R&D expenditure exceeding the average R&D expenditure for the previous four years or 8% of the current year R&D expenditure.
c. Large Sized Companies	• Large companies are entitled to a tax credit that is the greater of 30% of the current year R&D expenditure exceeding the average R&D expenditure for the previous four years, 1%, plus an "additional rate" capped at 3% of the current year R&D expenditure. • The additional rate is 50% of the R&D expense ratio (i.e., current R&D expense divided by sales revenue).
Additional R&D tax incentives 30%; Non-refundable; Unused R&D credits may	An additional R&D tax credit is computed on qualified expenditure related to New growth engine industry

be carried forward to the following five years.	
a. **Investment tax credit for R&D equipment**	• The investment tax credit for R&D equipment is 1% of the investment in equipment used in R&D for large companies, 3% for medium-sized companies and 6% for SMEs.
b. **Tax credit for investing in facilities for energy-saving**	• The TILL provides an investment tax credit (1% for large companies, 3% for medium-sized companies, and 6% for SMEs) for the purchase of new qualifying facilities or equipment to achieve energy savings.
c. **Tax credit for investing in facilities for environmental protection**	The TILL provides an investment tax credit (3% for large companies, 5% for medium-sized companies, and 10% for SMEs) for the purchase of new qualified facilities or equipment for environmental protection, such as an air pollution prevention facility, waste water reprocessing facilities, a soil pollution prevention facility, etc.
d. **Tax incentive for foreign-invested companies**	• Foreign-invested companies that engage in certain qualified high technology businesses can apply for a five-year exemption from corporate income tax, individual income tax, acquisition tax, and property tax. • The exemption begins from the first year of profitable operations (and from the fifth year, if not there are no profits until that time). • The full exemption is followed by a two-year 50% exemption in proportion to the foreign shareholding ratio. There is a limit for the tax exemption that varies depending on the types of tax holidays
2. Patent incentives	
Patent Box	• A patent box also is available to SMEs. If a SME transfers or leases IP it developed to a Korean party, the SME is entitled to a tax exemption in the amount of 50% of the corporate income tax on capital gains arising from the transfer or 25% of the corporate income tax on rental income. • In cases where SMEs acquire a patent from a tax resident, the SME can claim 7% of the amount paid to acquire the patent. • In cases where SMEs lend a qualified patent, 25% of the related income from such lending is exempt from tax.

Source: 2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-pwc; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD

6. Singapore

Attributes	**Brief Details**
Eligible Industries and Qualifying Costs	Research tax incentives are available to all industries Eligible expenses include • wages and salaries • materials • utilities incurred directly for R&D activity Capital expenditure on plant, machinery, land, or buildings, or on alterations,

	additions, or extensions to buildings, or in the acquisition of rights arising in or arising out of R&D are specifically excluded. Non eligible activities: • Quality control or routine testing of materials, devices, or products • Research in the social sciences or the humanities • Routine data collection • Efficiency surveys or management studies • Market research or sales promotion • Routine modifications or changes to materials, devices, products, processes, or production methods • Cosmetic modifications or stylist changes to materials, devices, products, processes, or production methods
IP and jurisdictional restrictions	• Only R&D activities undertaken in Singapore qualify for the section 14DA(1) additional 50% deduction. As long as the R&D is performed in Singapore, the R&D expenditure need not be related to the entity's existing trade or business. • With respect to the Section 14D base and Section 14DA(2) PIC enhanced deductions, R&D may take place outside of Singapore but must relate to taxpayer's existing trade or business. • If R&D payments are made by a Singapore entity to a R&D organization for R&D performed outside Singapore, a claim for deduction may be allowed to such entity provided the R&D expenditure is related to the entity's existing trade or business and any benefit attributable to R&D accrues to the Singapore entity itself. • For Section 14E further deduction and the RISC/IDS grants, the R&D project must be carried out in Singapore and must receive special approval from the Minister (advance application with the Singapore Economic Development Board is required).
Technology or innovation zones	There are no technology or innovation zones providing R&D incentives in Singapore.
Role of governmental bodies in administering incentives	• The expenditure claimed is processed by the Singapore tax authorities, i.e., the Inland Revenue Authority of Singapore (IRAS), for the enhanced R&D deduction. The IRAS also monitors the activities that are claimed to ensure compliance with the R&D enhanced tax deduction regime. • The Singapore Economic Development Board (EDB) administers discretionary incentives, including cash grants and the 200% tax deduction.
Administrative requirements	• No prior approval is required to claim tax deductions under Sections 14D, 14DA(1), and 14DA(2) Companies are not required to seek Government preapproval for the enhanced R&D tax deduction. For the other discretionary tax incentives, approval must be granted by the EDB. • To be eligible for the enhanced tax deduction, a company must submit the claim in its income tax return and tax computation with the completed R&D claim form, by the annual filing deadline of 30 November. • For the R&D cash grant, companies must submit documentation in relation to making claims and reporting on the progress of the project. Claims may be made on a quarterly basis using the prescribed format as provided by the relevant authority once the R&D cash grant has been awarded. Companies are also required to submit a yearly progress report and a final report at the end of the project.

	• For the double tax deduction for R&D expenses, companies must, in the first year of assessment when a new tax incentive commences, complete and submit with their income tax return, the Evaluation Checklist for a Company Awarded with Tax Incentives(s) form
Statutory reference	Income Tax Act, Section 14D, Section 14DA, Section 14E and Section 15
R&D Incentives	
1. Tax Incentives	
Corporate Tax Rate	The headline corporate tax rate is 17% with a partial tax exemption granted for the first SGD 300K of taxable income.
Productivity and Innovation Credit (PIC) Scheme 400% When R&D expenses exceed taxable income, the excess may be carried forward and set off against future taxable profits	• This scheme offers a super deduction of up to 400% of qualifying expenditure on qualifying R&D activities conducted both in and outside Singapore so long as it can be demonstrated that the benefits of the R&D activities effectively accrued to the Singapore entity. • However, this scheme is set to expire in 2017 • R&D activities in Singapore should continue to enjoy up to a 150% or 200% tax deduction if certain conditions are satisfied or approval is granted.
Section 14D—100% base deduction When R&D expenses exceed taxable income, the excess may be carried forward and set off against future taxable profits **Section 14DA(1)—50% additional deduction**	• Section 14D provides an exception to the general rule that R&D costs are capital in nature and, hence, not currently tax deductible. • This section allows current deductions for R&D expenditure incurred by a taxpayer in the conduct of its trade or business (including payments made to R&D organizations and payments made under and R&D cost sharing agreement). • In addition to qualifying for the Section 14D base deduction, expenditure incurred with respect to R&D conducted in Singapore during tax years from 2009 to 2025 may qualify for an additional deduction of 50% of qualifying expenditure. • Expenditure incurred on R&D performed outside Singapore does not qualify for the additional deduction of 50%.
Section 14E additional deduction	• This provision allows an additional super deduction for R&D projects carried out in Singapore and approved by the Economic Development Board (EDB) before 31 March 2020. • Does not apply to expenditure for which the enhanced deduction under the PIC has been allowed.
Double tax deduction for R&D expenses	• The incentive provides a 200% tax deduction on R&D expenditure incurred on approved projects. Under the current law, no R&D projects may be approved for this incentive after 31 March 2020. Unused losses can be carried forward

Can be carried forward	indefinitely and are subject to the satisfaction of the shareholding test. Taxpayers are required to seek Government preapproval in order to obtain the incentive. • The double tax deduction for R&D expenses is applicable to future investments and, typically, approval is granted only on projects that have not yet commenced.
Pioneer Tax Incentive 5-10%	• Offers a tax holiday, development and expansion incentives that can offer a 5% or 10% preferential tax rate, together with a HQ status award, investment allowance that can be used to support projects with high CAPEX, and a global trader program that seeks to promote international trading in Singapore.
Development and Expansion Incentive (DEI) and HQ awards 5-10%	• Provides a preferential tax rate of 5% or 10% on qualifying income derived from qualifying activities and the support level depends largely on the investment plan. • The initial tax incentive period is generally from 5 to 10 years. The incentive can be renewed with additional business commitments required. The total incentive period can be up to 20 years and for very strategic project, it can be supported up to 40 years.
Approved royalties incentive	• Provides reduced or no withholding tax on royalty payments to access advanced technology and know-how.
As announced in the 2016 Singapore budget, the 400% enhanced R&D deduction and cash payout option will be allowed to expire after year of assessment 2018. Furthermore, the cash payout rate of R&D expenditure incurred from 1 August 2016 has been lowered from 60% to 40%, capped at S$100,000 qualifying expenditure per year of assessment. However, the 50% enhanced deduction (along with the 100% base deduction) for R&D activities conducted in Singapore will remain in effect up until year of assessment 2025.	
2. Funding support	
grant schemes: **Research Incentive Scheme for Companies (RISC)/Innovation Development Scheme (IDS)**	• The RISC is a Government cash grant co-fund to encourage and assist companies in setting up R&D centers in Singapore and developing their in-house R&D capabilities. • The grants have been provided selectively to large projects in certain strategic technology areas identified by the Singapore Government. • Projects awarded the cash grant are not announced nor made public. • The support level generally can be up to 30% of total project costs, with higher support for certain costs. Supportable project costs include expenditure in the following: • Manpower cost (30% to 50% support) • Equipment, materials, consumables, and software (30% support) • Singapore-based professional services (30% to 50% support) • Intellectual property rights, e.g., licensing, royalties, technology acquisition (30% support). Application for the grant is reviewed on a project basis and awarded by the Economic Development Board (EDB).
3. Patent incentives	
BEPS-compliant patent box regime: IP Development Incentive (IDI)	• The IDI would incentivize income generated from the exploitation of IP arising from R&D activities carried out by a taxpayer in Singapore or outsourced to third parties.

	• "IP income" for purposes of the IDI would encompass royalties from the licensing of IP and would also likely cover embedded royalties in the profit derived by a supply chain principal.
4. Investment	
Investment allowance	• Provides additional allowance (tax depreciation) on a percentage (can be from 30 to 100%) of approved fixed capital expenditure. This is in additional to the base allowance of 100%.

Source: 2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-pwc; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD

7. U.K.

Attributes	**Brief Details**
Eligible Industries and Qualifying Costs	Companies may claim the incentive for their expenditure on the following cost categories: • Staff costs for employees who are directly and actively engaged in carrying out R&D. • Contracted individuals working under the supervision, direction, or control of the company where their services are provided through a third-party staff provider. The costs are limited to 65% of the payments where the staff provider is unconnected and to the underlying staff costs where the staff provider is a connected entity. • SMEs can claim 65% of R&D-related subcontracting costs. Large companies can claim subcontracting costs only if they are paid to a university, health authority, charity, scientific research organization, individual, or a partnership of individuals. • Software or consumable items used in the R&D process may not be included in an R&D claim where the consumables form part of a product that is sold or otherwise transferred in the ordinary course of business. • Payments to volunteers for participating in clinical trials. Expenditure on rent, land, patents, and patent protection are not included.
IP and jurisdictional restrictions	There is no specific jurisdictional requirement on the location of intellectual property.
Technology or innovation zones	There are no technology or innovation zones providing R&D incentives in the US.
Role of governmental bodies in administering incentives	The taxing authorities may audit research credits and deductions claimed by any taxpayer after the filing for the credit or deduction. Although there is no special audit or preapproval process required, there are special procedures, such as Pre-Filing Agreements (PFAs), available to taxpayers who wish to have their federal research credit and/or deduction audited in advance of filing their tax returns.
Administrative requirements	As with any credit or deduction, a taxpayer must maintain business records to support credits and deductions claimed. There are no special procedures for research credits or deductions. No preapproval process is required for the R&D incentives.
Statutory reference	• Federal research credit: Section 41 of the Internal Revenue Code • Federal R&D deduction: Section 174 of the Internal Revenue Code • State credits and deductions: various provisions based on each state's statutory framework

R&D Incentives	
1. Tax Incentives	
The Corporate Tax Rate 20% (reduced to 19%)	Corporate tax rate is 19%
Volume-Based Super Deductions	The UK offers volume-based super deductions and credits for qualifying revenue expenditure that vary depending on the size of the taxpayer: (i) a super deduction scheme is available for companies that fall within the definition of a SME (ii) all other companies (large companies) can claim an R&D expenditure credit (RDEC) or, until 31 March 2016, a super deduction. SMEs qualify for the following expenditure-based tax incentives: • 230% super deduction (225% for revenue expenditure incurred before 1 April 2015) • Cash credits for SMEs in loss positions, up to 33.35% of qualifying expenditure (32.63% before 1 April 2015). • A cap restricts the amount of the tax benefit available to SMEs, over and above the benefit that would have been available had the company not been a SME, to EUR 7.5M per R&D project. Large companies qualify for the following expenditure-based tax incentives: • Until 31 March 2016, a 130% super deduction was available on qualifying revenue expenditure; • As from 1 April 2016, the RDEC is the only regime available for large companies and, where an accounting period straddles 1 April 2016, only the RDEC can be claimed. The RDEC currently is 11%. • The RDEC is accounted for as an “above the line” “grant” or “other” income and, therefore, is taxable. • The RDEC regime is based on the same qualifying cost categories (see below) and is more generous than the super deduction. Companies without a corporation tax liability against which the RDEC can be offset can claim a cash credit. The cash credit, however, is capped at an amount equal to the payroll taxes and social security costs associated with the employees whose costs are included in the claim. • Unused RDEC benefits may be carried forward to utilize in future periods or may be surrendered to group companies with a UK corporation tax liability in the same accounting period. • For both the SME and RDEC regimes, the cash credit is available only if the most recent financial statements of the claimant company have been prepared on a going concern basis. There is a higher rate of corporation tax for companies that earn profits from oil extraction or oil rights in the UK or UK continental shelf. The rate currently is 50%, but such companies also are able to claim a higher rate of the RDEC at 49%, resulting in a net after-tax benefit of 24.5%.
Renewable generation support	Innovative and environmentally friendly generation technologies may be eligible for support in the form of cash incentives from regulated energy utilities. In practice, this support usually is in the form of tariff payments made to the generator for each

	megawatt of qualifying renewable energy generated. A higher value tariff usually is paid for energy that is surplus to the generator's own needs.
Small scale renewable generation support	This incentive supports small scale renewable energy installations up to 5MW in size producing their own electricity. Generators are paid a tariff for the electricity units produced through qualifying generation assets (e.g., solar, wind, and hydro). The tariff varies depending on varying factors and is paid from energy suppliers.
Large-scale renewable generation support (renewables obligation)	Several tradeable certificates are available to large-scale renewable generation assets, such as "renewable obligation certificates" (ROCs) and "renewable guarantees of origin" (REGOs). Traded commercially, the value of these certificates is subject to market forces. In the case of ROCs, an annual "true-up" of the scheme usually leads to additional cash payments to participating generators.
Resources taxes recycled into local communities (funding for environmental projects and funding projects to reduce impact of extraction industry)	Environmentally driven research and smaller provincial projects can be supported by "grants" funded from certain resource taxes (Landfill Tax, Aggregates Levy).
2. Funding Support	
R&D Grants	**R&D grant (EU)** There is an extensive program of calls provided by the EU. Some permit a company to apply directly, while many require collaboration with three or more partners from three or more EU member states. EU schemes may offer a high level of assistance, but projects need to be more research-oriented and the application process is longer than that for a national R&D grant. **R&D grant (national)** Assistance can be available in response to a specific call or based on a direct application. The assistance level will depend on the nature of the work packages and whether they qualify as industrial research or experimental development. If a SME also benefits from R&D tax incentives, the company must consider that the award of the grant may reduce otherwise qualified R&D expenditure, or, if the grant constitutes state aid, exclude the whole project from the SME tax
3. Patent Incentives	
Patent box	A patent box regime introduced for profits earned on or after 1 April 2013 from patented inventions and certain other innovations enables companies to apply a lower rate of corporation tax. The relief has been phased in and effectively applies a 10% rate of corporation tax to profits generated from qualifying patents. The "new" regime requires claimant companies to track their R&D expenses and how they relate to specific patents, products, or product families, creating a much stronger link between the R&D tax relief and the patent box regime.
4. Investments	
CAPEX	This scheme encourages investment by private sector companies in medium term (three to five-year) investment plans that involve capital expenditure and the creation of net new jobs and/or the safeguarding of jobs that otherwise may be lost. For

	service sector projects, the grant may be influenced by the salary costs of net new jobs to be created. In all cases, a need for assistance must be demonstrated.

Source: *2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-pwc; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD*

8. France

Attributes	**Brief Details**
Eligible Industries and Qualifying Costs	There is no restriction on the types of entities that may qualify for incentives. Qualified activities include basic research, applied research, and development activities. To qualify, R&D activities must: • Present a significant technological, technical, or scientific advancement when compared to the current state of the art • Be associated with scientific/technological uncertainties and be uncertain with regard to the anticipated outcome • Require the use of scientific methods and/or an experimental approach. Eligible expenses generally include the following: • R&D staff expenses • General and administrative (G&A) expenses • Depreciation allowances for assets used for R&D activities in France • Patent costs • Contract research costs • Costs of technological monitoring Materials used in the research process do not qualify. The law also allows an estimate of G&A expenses. The formula for estimated G&A expenses is 50% of all R&D staff expenses and 75% of the depreciation allowance of assets used in R&D activities in France (including research equipment and facilities). The following limits apply to the amount of qualifying contract research expenses: • There is a cap on private subcontracted expenses equal to three times all other qualifying expenses, but in no event can the subcontracted R&D fees exceed EUR 12M • Qualifying contract research is limited to EUR 2M where the taxpayer and the subcontractor are related entities. • Contractors performing research on a time/materials basis can claim tax credits for their qualified research expenses because there is no "at-risk" rule under French law. • Cash grants reduce the R&D tax credit base.
IP and jurisdictional restrictions	For jurisdictional requirements, please refer to the eligibility requirements specified for each incentive.

Technology or innovation zones	There are 71 "innovation clusters" in France that are spread across the country and have been bringing together teachers, researchers and industry stakeholders to develop collaborative R&D projects — in all key technology sectors — that are eligible for state and local aid (€2 billion granted over three years through direct financial aid and tax exemptions). Based on the most recent data available, nearly 7,000 companies, including 500 foreign companies, now belong to a cluster in France.
Role of governmental bodies in administering incentives	• The R&D tax credit is managed by the French tax authorities and the French Ministry of Higher Education and Research. • No preapproval is required. An advance ruling process is available to determine eligibility for tax credits; however, it is time consuming, and taxpayers do not always receive responses during the process. As such, most taxpayers file for tax credits rather than going through the advance ruling process. • There is an automatic tax audit if a tax credit exceeds €1 million. If the credit amount exceeds this amount, the tax audit tends to be significantly scrutinized (e.g., providing supporting documentation for every project). • Tests on controls (by Government) are conducted on an average of 10% to 20% of the overall projects qualifying for the incentives, and taxpayers are advised to take consistent approaches in preparing documentation. • Documentation must be prepared in the French language. • The R&D tax credit rate has been increased from 10% to 30% since 2007.
Administrative requirements	• Detailed documentation is required for control purposes and should include detailed factual information (e.g., objective of projects, costs and calculation of the credits). The documentation also requires support on eligibility of the activity and R&D tax incentives related to the activity. This documentation has to be provided to the French tax authorities upon request, within the course of a tax audit. The company should file Form 2069 A each year with its tax return. • The requested forms (1447-M-SD/1447-C-SD and 1465-SD) should be filed with the relevant corporate tax offices within the aforementioned deadlines. The forms have to be completed as if the company did not benefit from a relief. • Therefore, all the information required by the French tax authorities to assess the territorial economic contribution should be mentioned in the forms (e.g., address, nature, size of the premise, number of employees).
Statutory reference	• R&D tax credit: Section 244 quarter B of the French Tax Code • Innovative New Company status: Section 44 sexies — 0 A of the French Tax Code • Reduced CIT treatment of revenues derived from patents: Section 39 terdecies of the French Tax Code • Territorial economic contribution relief: Section 1465 of the French Tax Code • Accelerated depreciation of equipment and tools used for research operations: Section 39 AA quinquies of the FrenchTax Code
R&D Incentives	
1. Tax Incentives	

The Corporate Tax Rate	The effective corporate income tax rate ranges from between 33.33% to 35%. Based on the 2017 Finance Act, the rate will be progressively reduced to 28% over the period 2017 to 2020.
Innovation tax credit	• R&D expenses are deductible in the year they are incurred. Additionally, France offers an R&D credit equal to 30% of the first EUR 100M of qualified R&D expenditure incurred during the tax year. • The rate is reduced to 5% for qualified R&D expenditure exceeding that amount, and the 30% rate is increased to 50% in overseas territories. An "extension" of the R&D tax credit, called the innovation tax credit, is available to SMEs for certain pilot-model and prototype developments that do not qualify for the 30% R&D credit. • The 20% innovation tax credit is an additional incentive for SMEs to encourage the completion of new/improved product/process development within France by extending the tax incentive to the late stages of development that would not qualify for R&D credit. • Specifically, this credit targets certain pilot-model and prototype developments that tend to occur after the completion of R&D, as defined under French Law, i.e., Frascati Manual definition of research.
Young innovative company (YIC) status	Specific measures apply to support new companies investing more than 15% of their spending on R&D. Eligible companies are new businesses that have existed for less than eight years, are independent, qualify as a SME,3 and have at least 15% of their total expenditure is R&D expenditure. Companies that qualify for YIC status are granted the following exemptions: • Two-year decreasing corporate income tax exemption (100% for the first profitable year and 50% for the second year) • Exemption from taxes such as the *taxe foncière, Contribution Foncière des Enterprises (CFE),* and *Contribution sur la Valeur Ajoutée des Entreprises* (CVAE) upon request for up to seven years; and A seven-year capped exemption of certain employer social security contributions for R&D staff remuneration.
2. Funding Support	
R&D grant (national and regional)	The French national and local authorities offer numerous research grants that typically are targeted towards certain industries or outcomes, such as medical research, big data, green technology, smart cities, robotics, etc. Some of the grants (particularly for SMEs) cover expenses that are outside the scope of R&D. The aid rates generally amount to around 25% for large and medium-sized companies and 40% for small companies. Such aid can be combined with the R&D tax credit. These grants generally are nonrefundable cash grants, and can also take the form a refundable grant. Refundable grants are a specific type of instrument in France which require a partial (or sometimes full) repayment of the grant proceeds if the research achieves intended goals (e.g., commercial success), as defined in the grant. R&D cash grants typically are channeled, as the case may be, via the following instruments: • Competitive project calls from certain funding bodies (e.g., *Programd'Investissements d'Avenir, Agence Nationale de la Recherche, Fonds Unique Interministériel*, or innovation clusters) • Bilateral talks with the local authorities (regional councils distribute both their own funds and ERDF funds) or with the *Banque Publique d'Investissement* (a public bank offering a number of cash grants for

	SMEs).
3. Patent Incentives	
Patent box	• Income from licensing (and the sub-licensing of eligible IP rights as from 2011) or the sale of patent or patentable technology are taxed at a maximum rate of 17%1, provided the patent/patentable technology was created by the company or acquired by the French company more than two years prior to the sale. • Moreover, for the French licensee, the royalty fee is deductible at the standard corporate income tax rate (unless the licensee does not effectively exploit the IP rights or the IP rights add no value for the licensee.) • The French patent box will be subject to a review process to check its compatibility with EU and OECD guidelines, which might lead to changes.
4. Investments	
CAPEX	• Certain R&D and industrial investments can benefit from an exceptional extra depreciation equal to 40% of the original value of eligible assets (i.e., materials and equipment involved in R&D and industrial activities) manufactured, purchased, or leased. • Assets must be eligible for accelerated (declining) depreciation and must belong to one of the following categories (some categories below only apply to certain periods of the incentive)

Source: *2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-pwc; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD*

9. Israel

Attributes	Brief Details
Eligible Industries and Qualifying Costs	• A Preferred Enterprise is an industrial company whose main activity in the relevant tax year is industrial activity that is competitive and contributes to Israel's gross domestic product (i.e., no more than 75% of total income is from sales on any one market in the year concerned, and at least 25% of total income is from sales to a market with at least 12 million residents). • A Special Preferred Enterprise meets the requirements of a Preferred Enterprise and also satisfies the following criteria: ✓ The company's total annual income in Israel is at least ILS1 billion. ✓ The combined balance sheet of the company is at least ILS10 billion. ✓ The company's business plan includes one of the following: ✓ Investment in productive equipment of at least ILS400 million in a priority area or ILS800 million in the rest of the country over a three-year period ✓ Investment in R&D of at least ILS100 million in a priority area or ILS150 million in the rest of the country or employing at least 250 employees in a priority area or 500 employees in the center of the country

IP and jurisdictional restrictions	R&D activities must be carried out in Israel and the Israeli company must incur the R&D-related expenditure. Restrictions are unique to each grant program. Under most grants, the IP must remain in Israel. However, the transfer of IP outside of Israel is possible, subject to the approval of the Innovation Authority, and may require additional payments. In some programs, the resulting IP does not have to reside within Israel, although location is considered in the granting process.
Technology or innovation zones	R&D incentives are offered through the National Cyber Arena in Be'er-Sheva (see "Employment grants" in section 2).
Role of governmental bodies in administering incentives	R&D incentives are controlled by the IIA, which is part of the Ministry of Economy and Industry. Tax incentives are controlled by the Israel Tax Authority.
Statutory reference	• Law for the Encouragement of Capital Investments, 1959 • Law for the Encouragement of Industrial Research and Development, 1984 • Income Tax Ordinance
R&D Incentives	
1. Tax Incentives	
The Corporate Tax Rate	Israel's corporate tax rate currently is 24%, and the withholding tax rate on dividends is currently 25% or 33%.
Alternative tax program	Tax benefits are granted to industrial companies (including software companies) that export more than 25% of their total turnover to a market larger than 14 million persons. A corporate tax rate of 7.5% applies to companies located in "Priority Area A," and a 16% applies to companies located in other areas. If the company pays dividends during a tax year in which the full exemption is available, the dividends are taxed at a rate of 20% and any exempted taxes become immediately payable.
Strategic program	The program is intended for multinational companies whose annual gross receipts exceed ILS 10B, whose "preferred" income exceeds ILS 1B, that invest a minimum of ILS 100M in R&D projects, and that hire at least 250 new employees. If these requirements are met, the company will benefit from a reduced tax rate of 5% in Priority Area A and 8% in other areas.
Angel's Investors	A tax benefit is granted to individuals investing in qualified Israeli R&D companies, allowing them to deduct their investment from any other source of income. The amount of the deduction is capped at ILS 5M per investor, per eligible company.
2. Funding Support	
R&D grants	Companies in any industry (e.g., pharmaceuticals and medical devices, software and hardware development, and energy and utilities) engaging in innovative R&D activities are eligible for R&D grants. Qualifying expenditure includes in-house R&D costs, materials and consumables, consultant and subcontractor costs, patent registration, application costs for regulatory approval, capital investments,

	and overhead.
R&D fund	• The main program of the Innovation Authority supports R&D projects in Israel by offering conditional grants of up to 50% of approved R&D expenditure (up to 60% in Priority Area A and up to 75% in the area surrounding the Gaza Strip). If the R&D project is successful, the company must repay the grant by making royalty payments from future related revenue. • A large corporation with over ILS 100M of annual taxable income and more than 200 R&D employees in Israel, or with an R&D budget of at least ILS 20M per year, may be entitled to a grant of up to 50% of approved R&D expenses.
Special benefits for selected areas	Israel offers special benefits for R&D undertaken in special fields, including: • Traditional industries, such as food and beverages, textiles, print, metal, and plastics • Non-traditional industries, such as cyber security, the space industry, and alternative fuels. • There also are special benefits for start-ups and new companies. • A multinational corporation (over ILS 2.5B of annual revenues) investing (money or assistance) in R&D projects may be entitled to joint ownership in IP with the Israeli company. ➢ Technological incubators may be entitled to grants of up to 85% of approved expenses for nascent companies to develop disruptive innovative technologies. ➢ The “Tnufa” program is designed to encourage and support an individual entrepreneur in the initial efforts to build a prototype, register a patent, design a business plan, etc. Grants are offered up to 85% of approved expenses up to a maximum of ILS 210K for each project. ➢ The MAGNET program sponsors innovative generic industry oriented technologies through synergetic collaboration between industrial companies and academic research groups. Binational funds and bilateral agreements enable joint R&D programs with foreign counterparts worldwide.
Horizon2020	• Israeli companies can apply for grants under the European Commission’s Eighth Framework Program—Horizon2020, which is the main instrument for funding R&D activities, and covers several disciplines including ICT, nanotechnologies, advanced materials, biotechnology, advanced manufacturing and processing, space, health, food security, energy, transport, the environment, and security. • Israel participates in the EUREKA funding platform, which is the world’s largest R&D program that promotes industrial innovation by aiding and supporting industrial R&D projects that aim to develop new products and bring them to the market. Funding is contingent on budget and funding rates outlined by the specific call for proposal (generally 70% or 100% funding, plus a 25% overhead).
Grants for expanding activity	Industrial companies located in Priority Area A that export more than 25% of their total turnover to a market larger than 14 million persons may qualify to receive grants under either of the following tracks: • Grants for investing in manufacturing facilities: 20% of the approved total investment (30% for companies located in the south of Israel) • Grants for hiring new employees: Between 20% to 27.5% of salary costs.

3. **Patent Incentives**	
Innovation box	• To be eligible for Preferred Technology Enterprise status, an Israeli company must be part of a group with global consolidated revenue below ILS10 billion. To be eligible for Special Preferred Technology Enterprise status, an Israeli company must be part of a group with global consolidated revenue over ILS10 billion. • To qualify for either status, the company must have incurred at least 7% of the last three years' turnover in R&D (or the company had ILS75 million in R&D expense per year) and meet one of the following three conditions: ✓ At least 20% of its workforce is engaged in R&D (or it has more than 200 R&D employees). ✓ Venture capital investment of at least ILS8 million was previously made in the company. ✓ It had average annual growth over three years of 25% in sales or number of employees in Israel. Companies not meeting the above conditions may still be considered as a qualified company under the IIA's discretion.

Source: *2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-pwc; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD*

10. India

Attributes	**Brief Details**
Eligible Industries and Qualifying Costs	A 100% deduction is available to all industries on revenue and capital expenditures (other than expenditures incurred for the acquisition of land) paid out or expended in scientific research related to the business. A number of requirements must be met for expenditure incurred on in-house R&D to qualify for the super deduction, including the following: • The R&D unit must be located in a separate earmarked area • The R&D unit must have its own personnel;**s1** The qualifying R&D expenses may not be deductible under any other provision of the tax code • The R&D facility may not be used exclusively for market research, sales promotion, quality control, testing, commercial production, style changes, routine data collection, or similar activities. • The company must maintain a separate account for each approved facility, which must be audited annually, and a copy of the audit must be submitted annually to the Secretary of the DSIR by 30 November. • Assets acquired with respect to the development of scientific R&D facilities may not be disposed of without the approval of the Secretary of the DSIR. Qualifying expenditure includes • Wages • Supplies • Utilities • Other expenses directly related to R&D • Expenses incurred in clinical drug trials qualify for research tax incentives only if pre-approved by the regulatory authority under a central, state, or provincial act and a patent application is filed under the Patents Act (1970) for the new drug/therapy developed through the clinical trials.

	Specifically excluded expenses include • general and administrative costs • depreciation • overhead and allocated expenditure • Non eligible items under Eleventh Schedule include beer, wine, alcoholic spirits, tobacco and tobacco preparations, cosmetics and toilet preparations, toothpaste, dental cream, tooth powder and soap, aerated waters, confectionary and chocolates, gramophones, projectors, photographic equipment and office machines, such as calculators and cash registers.
IP and jurisdictional restrictions	• R&D activities must be conducted in India. There is no location restriction with respect to IP. • IP can reside outside the country subject to ownership remaining with the Indian Company who has undertaken such R&D. Further, foreign patent filing expenditure is not allowed as a weighted deduction. Following conditions must be satisfied in order to claim the deduction: • The company must be registered in India. • The main object of the company must be scientific R&D. • The company must be approved by the Chief Commissioner of Income Tax.
Technology or innovation zones	Certain exemptions occurs in accordance to special economic zones.
Role of governmental bodies in administering incentives	Further, where any expenditure is incurred before business commences in order to pay salaries to employees engaged in scientific research or to purchase materials used in scientific research, all such expenditures as certified by the Director General of Income Tax (Exemptions) (DGIT(E)), Principal Chief Commissioner of Income Tax (CCIT) and the Department of Scientific and Industrial Research (DSIR) within three years immediately preceding the commencement would be allowed.
Administrative requirements	• Specific DSIR approval is required to take advantage of super deduction benefits. • The company will be eligible for the super deduction only if it enters into an agreement with the DSIR for cooperation in an R&D facility and for audit of the accounts maintained for that facility. • Incentives related to expenditure on scientific research, contribution sto R&D and for units set up in the northeastern states of India. • No particular forms have been prescribed under the tax laws for claiming a tax incentive. However, the assessee may claim the deduction by filing a tax return within the time prescribed for the financial year in which the expenditure is incurred.

Statutory reference	**Accelerated depreciation** • Section 35(1) of the Income-Tax Act, 1961 (the Act) **Super deductions** • Section 35 of the Act • Patent-related incentives • Section 115BBF of the Act **Tax holiday for export profits for units in an SEZ** • Section 10AA of the Act **Patent-related incentive** • Section 115BBF of the Act **Funding for R&D activities in technology** • Project Funding Guidelines issued by the Technology Development Board **Fiscal Incentives under M-SIPS and EMC schemes** • M-SIPS: DEITY Notification No. 24 (10)/2010-IPHW, dated 27 July 2012, as amended by DEITY Notification No. 27 (35)/2013-IPHW, dated 3 August 2015 • EMC: DEITY Notification No. 8(50)/2011-IPHW, dated 22 October 2012 **Customs duty exemption (related to the agrochemical sector)** • Customs Notification No. 12/2012, dated 17 March 2012 **Customs duty exemption (related to in-house research units)** • Customs Notification No. 50/1996, dated 23 July 1996 (as amended from time to time) **Concessional rate of duty (related to research institutes)** • Customs Notification No. 51/1996, dated 23 July 1996 (as amended from time to time) **Excise duty exemption (related to research institutes)** • Central Excise Notification No. 10/1997, dated 1 March 1997 (as amended from time to time)
R&D Incentives	
1. Tax Incentives	
The Corporate Tax Rate 30% (reduced to 25%)	Corporate tax rate in India is also contains a surcharge and education cess
Super Deduction for in-house R&D expenditure **(*A deduction for R&D expenditure is net of any grants/gifts, donations, payments, or gains on the sale of R&D assets*)** **If the taxpayer is in a loss situation, unused benefits may be carried**	• A 200% super deduction for in-house R&D expenditure, including capital expenditure (other than land and buildings). The super deduction is limited to taxpayers engaged in the business of biotechnology, or manufacturing or producing products (other than products on the negative list). • The R&D facility must be approved by the Department of Scientific and Industrial Research (DSIR) for a company to qualify for the super deduction. • The benefit was available till 31 March 2017; the super deduction is reduced to 150% for the period 1 April 2017 to 31 March 2020. ***200% (scrapped to 150%)*** • A super deduction was available till 31 March 2017 for specified payments made

forward for the following eight years, but cannot be carried back.	to a scientific research company/ research association/university/college/other institution for the purpose of scientific and statistical research. Such payments will be 100% deductible as from 1 April 2017. ***125% (scrapped to 100%)*** • A super deduction was available till 31 March 2017 for specified payments made to certain scientific research associations, approved universities, colleges, or other institutions. The super deduction is reduced to 150% for the period 1 April 2017 to 31 March 2020, and it will be eliminated as from 1 April 2020. ***175% (scrapped to 150% and will be eliminated after 2020)*** • A 100% deduction is available for R&D expenses (other than land) that otherwise do not qualify for the above super deductions. A deduction is available for R&D expenditure incurred before an R&D center is set up, subject to certain conditions.
Incentives related to Customs and Excise	• Customs duty exemption on goods imported for R&D and central excise duty waiver on purchases of indigenous goods for R&D to public funded and privately funded institutions registered with DSIR. • DSIR recognized in-house R&D units engaged in R&D in biotechnology and pharmaceuticals sectors can import specified equipment duty free (List 28). • In respect of R&D units with manufacturing facilities, the benefits of full customs duty exemption for specified equipment is also available for manufacturing activity to the extent of 25% of the previous years export turnover. • Central excise duty waiver for 3 years on specified goods designed and developed by a wholly owned Indian company, National laboratory, Public funded research institutions or Universities and patented in any two countries from amongst India, USA, Japan and in any one country of the European Union. The specified goods are manufactured by a wholly owned Indian Company. This exemption is available based on certification from DSIR (Notification No. 13/99-central excise dated 28th February 1999).
Tax incentives for exports	• Provided certain conditions are fulfilled, export profits earned from a new undertaking set up in an SEZ are eligible for a 100% tax exemption for the first five years, starting from the year manufacturing commences, followed by a 50% tax exemption for the following five years. • A further five-year tax exemption of 50% of the export profits then is available, subject to an equal amount of profit being retained and transferred to a special reserve. During the exemption period, the minimum alternate tax must be paid, for which a credit is available.
Tax incentive for hiring new personnel	• To encourage the hiring of new employees, a deduction of 30% of additional wages paid to new regular employees in a factory is allowed for three years. • This super deduction has been extended to taxpayers across all sectors (that are subject to tax audit) to the extent the costs are incurred on an employee with total remuneration of up to INR 25K, and the employee has been employed for at least 240 days.
Training—Tax incentives for expenditure incurred on skill development projects	• Companies engaged in manufacturing and production (other than alcoholic spirits and tobacco products) or providing specific services (such as construction, healthcare, market research, etc.) are allowed a weighted deduction of 150% of expenditure (other than expenditure incurred on land and buildings) incurred in skills development projects, provided certain conditions are fulfilled. • A 150% deduction of qualified costs incurred to develop the targeted skills is available until 31 March 2020; the deduction then reduces to 100%.
Deductions for expenditure on scientific	A weighted deduction of 200% is available for scientific research on in-house R&D expenditure as approved by the DGIT(E) and DSIR, including capital expenditures

research by manufacturing entities	(other than land and buildings) by companies engaged in manufacturing and the production of articles and things except for those articles or things specified in the Eleventh Schedule2 or for companies engaged in the biotechnology business.
2. Funding Support	
R&D Grants/Equity/Loans	Various ministries and departments under them provide R&D grants to industries. Some of them are as: • Technology Development Program (TDP)-DSIR • Technology Development Board (TDB)-DST • SBIRI, BIPP-BIRAC, DBT These schemes invests in the equity capital or gives loans to industrial concerns and research associations that are attempting development and commercial application of indigenous technology or adapting imported technology to wider domestic applications. The Board also provides grants. However, this mode of funding is not particularly popular with multinational corporations, and grants are provided by the Board only in exceptional cases. Various funding schemes under ministries/ department of Govt. of India for Technology development, upgradation and commercialization. (eg. DST, DSIR, DBT, CSIR, ICMR, ICAR, TDB, TIFAC, MNRE, MoEF, MoSteel, MoFPI)
Financial Assistance under M-SIPS and EMCs schemes	• The M-SIPS will be applicable to investments in ESDM units for expansion of capacity, modernization and diversification of existing ESDM units. • Subsidies equal to 25% of capital expenditure if the ESDM unit is in a non-SEZ and 20% of capital expenditure if the ESDM unit is within an SEZ, with capital expenditure subsidy available for investments made within 10 years from the date of approval of the project The Government offers financial assistance for the development of Greenfield and Brownfield Electronic Manufacturing Cluster (EMC). • Assistance up to 50% of the project cost is available. The incentive is subject to a ceiling of INR0.5 billion for every 100 acres of land, in the case of Greenfield EMC. • Assistance up to 75% of the project cost is available. The incentive is subject to a ceiling of INR0.5 billion, in the case of a Brownfield EMC. Implementation of the scheme is made through a Special Purpose Vehicle (SPV) that will carry out the business of developing, operating and maintaining the infrastructure, amenities and other common facilities created in the EMCs. The SPV should be a legal entity (i.e., company or society) that is duly registered. SPVs can be promoted by private companies, industry associations, financial institutions, R&D institutions, state or local governments, or their agencies and units within the EMC. The selection and location of the EMC under the scheme shall be approved by the relevant Government authorities. The scheme's sunset clause — originally 26 July 2015 — has been extended to July 2020. Such incentives may be claimed by filing the requisite documents with Department of Electronics and Information Technology (DEITY). However, DEITY has not prescribed the precise mechanism for disbursement of incentives under the scheme.

3. Patent Incentives	
Patent box	• Royalty income of an Indian resident that owns a patent developed and registered in India is taxed at a rate of 10% (plus the applicable surcharge and cess) on a gross basis. Royalty income is included in the patent box as from tax year 2016–2017. • As proposed in Budget 2017, the corporate tax rate may be reduced to 25% (plus the applicable surcharge and education cess) for: (i) Indian companies whose total sales or gross receipts do not exceed INR 500M during the tax year 2015-16; and (ii) newly incorporated (i.e., on or after 1 March 2016) manufacturing companies that do not claim any income tax incentives or exemptions. The following conditions must be satisfied in order to claim the benefit: • The patent should be developed and registered in India. • “Developed” is defined to mean “at least 75% of the expenditure incurred by the assese for invention in respect of which patent is registered.” • An eligible assessee is any person resident in India who is the true and first inventor of the invention and whose name is entered on the patent register as the patentee under Patents Act, 1970. • Eligible income is income by way of royalty from patents developed and registered in India
4. Investments	
CAPEX—Tax exemption for units in North Eastern Region of India	• Tax benefits are available for setting up undertaking/manufacturing facilities in the north eastern states of India. No area restrictions are applicable, i.e., an undertaking can be set up anywhere in the specified regions. • Undertakings located in these states that (i) begin to manufacture or produce an eligible item (ii) undertake substantial expansion (iii) commence a qualifying business between 1 April 2007 and 1 April 2017 are eligible for a 100% deduction of profits for 10 consecutive years.
CAPEX—Tax incentives for expenditure incurred on agriculture extension projects	• A deduction of 150% of expenditure incurred by a taxpayer on agricultural extension projects is allowed if certain conditions are fulfilled. The 150% deduction is available until 31 March 2020; it then reduces to 100%.
CAPEX—Other state level incentives	To encourage the industrialization of certain states, the following incentives are offered: • Stamp duty reimbursement • Land cost rebates • Land conversion cost • Power cost reimbursement • VAT reimbursement • Infrastructure development cost reimbursement.
CAPEX—Investment allowance for manufacturers	• A company engaged in manufacturing is eligible for an investment allowance of 15% of the value of investments in production-related equipment and other assets, subject to the fulfilment of certain conditions. • To qualify, the company must acquire and install new assets, and the related investment must meet a specified threshold.

CAPEX—Modified Special Incentive Package Scheme (M-SIPS)	Special incentives are designed to encourage investment in the electronics systems design and manufacturing (ESDM) sector. These incentives apply to existing manufacturers and service providers in the sector, and the investment must relate to listed products covered under M-SIPS regime. There are investment thresholds applicable to different categories and the deadline for applying for incentives is July 2020. Incentives are provided through capital subsidies. The financial incentives available under the scheme are: • Reimbursement of countervailing duties (CVD) and excise duties on capital equipment for non-SEZ units • Reimbursement of central taxes and duties (i.e., custom duties, excise duties and service tax) for 10 years in the selected high-tech units, such as fabs, semiconductor logic and memory chips, and LCD fabrication • The incentives also require minimum investment thresholds for various categories and sub-categories of eligible products. The minimum investment thresholds vary from INR10 million (for mobile phones and accessories) to INR50 billion (for memory fabrication).
CAPEX—Tax incentives for infrastructure development undertakings	A tax holiday of 100% of profits for 10 of the first 15 consecutive years is available to enterprises engaged in the business of power generation, transmission, or distribution; developing or operating and maintaining a notified infrastructure facility, industrial park, or SEZ; substantially renovating and modernizing the existing network of transmission or distribution lines (between specified periods); or laying and operating a cross-country natural gas distribution network.3 To qualify for the tax holiday, operations must commence on or before 31 March 2017. On or after 1 April 2017, a deduction of 100% of capital expenditure incurred on setting up the infrastructure facility will be available.

Source: *2017 Survey of Global Investment and Innovation Incentives-Deloitte; Worldwide R&D Incentives Reference Guide 2017-EY; Global R&D Incentives Group-pwc; Compendium of R&D Tax Incentive Schemes: OECD countries and selected economies, 2016-OECD*

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REPORT – 3: Public-Private Partnership Models for R&D (International)

(April, 2016 – July, 2017)

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Introduction

The present times are of an innovative economy, which is positioned on the pillars of knowledge, innovation, generation of and perception of novel scientific ideas, availability of ideal conditions for creating technologies, ability to implement them in the system and the different spheres of human activity (Gamidov G.S., 2003). The transition from an economy that is resource based into an innovative one needs sizeable and steady investments for modernizing the economy. However, a few constraints including the ones monetary in nature, pose problems of financial support for novel innovative projects, as well as for the mechanisms/vehicles of investment in the innovation cycle.

Public Private Partnerships (PPP) are a mode of partnerships that offer a framework mechanism for bringing together the public and private sectors to work jointly in areas that are of interests to the participating entities. Such partnerships bring together the forces of the public sector and the private sector, which heightens the quality of the service as well as the product and thereby aiding each other in reaching to the goals that are difficult to accomplish individually. Thus, the term PPP is used to indicate an alliance/union in which the resources of the associating parties are blended to achieve targets that have been set mutually. The objectives accomplished through these partnerships are beneficial to all the associating parties and therefore bolster their worth in the societal and economic spheres. With the passage of time these collaborations have gained much importance and are now well recognized. They can be defined precisely, as *"contractual agreements between the public and private sector for increased participation of the private sector into delivery of services and goods"*. In this arrangement of a legal association all the collaborators share all the benefits, rewards, risks, failures etc. Therefore, it is evident that these collaborations are not only instruments of funding research but they also act as mechanism for innovative activity, which demand dedicated efforts and commitments from all the partnering entities.

The PPP collaboration mode can be described into the following three types of arrangements -

1. Introduction of private sector ownership into state owned businesses through

means of public listings of through introduction as an equity partner.

2. Initiative of private funding – through means of awarding long-term franchises to a private-sector partner, which assumes the responsibility for constructing and maintaining the infrastructure and for providing the public service.
3. Selling of government services to private-sector partners, which can better exploit the commercial potential of public assets.

The private sector consortium usually constructs a Special Company known as the ‘Special Purpose Vehicle (SPV)’, in most of the above stated arrangements. The investments made by the government in this case are designated as and provided shares in the SPV equity.

The concept of PPP was identified as crucial ingredient of innovation by the Organization for Economic Co-operation and Development (OECD) Committee in the year 2002 for the policy of Science and Technology. This concept in the sector of innovation aims to develop scientific and technological inherent for achieving functional domestic and global markets by forming an industry that is competent enough. With time more and more countries are working towards and shifting focus for concentrating on the development of PPPs in an attempt to widen the horizon of their innovative activity and in turn the economic progress. For instance, the European Commission, for facilitating the creation of PPPs, is aiming at drawing specific legal framework. This framework shall also ensure that the responsibilities and risks associated with partnerships are shared and borne by the associating partners.

In general the objectives of PPPs are -

i. Economic growth driven by the innovative activity.
ii. Invigorating the national system of innovation.
iii. Enhancing the nation’s industrial ambitions and competitiveness
iv. Supporting and backing innovations in small and medium scale enterprises and aiding in the establishment of new high technology firms.
v. Promoting the investments of the private businesses into R&D activities.
vi. Enhancing the efficacy and efficiency of utilization of the public funds spent on R&D and innovation activities.

vii. Prudent diffusion and commercialization of public funded research outputs.

viii. Advancement in the materialization of important technologies/products/services required for fulfilling public agendas.

ix. Establishment of public infrastructure for activities of research.

x. Building networks in the innovation ecosystem

The literature and reference sources (OECD, 2004) list four major types of PPPs, as illustrated in figure 1. Nonetheless, all the types mentioned here are not exclusive and may aim at broader goals and objectives. The nature of the arrangement may also vary according to its stage/situation of implementation, time and requirements.

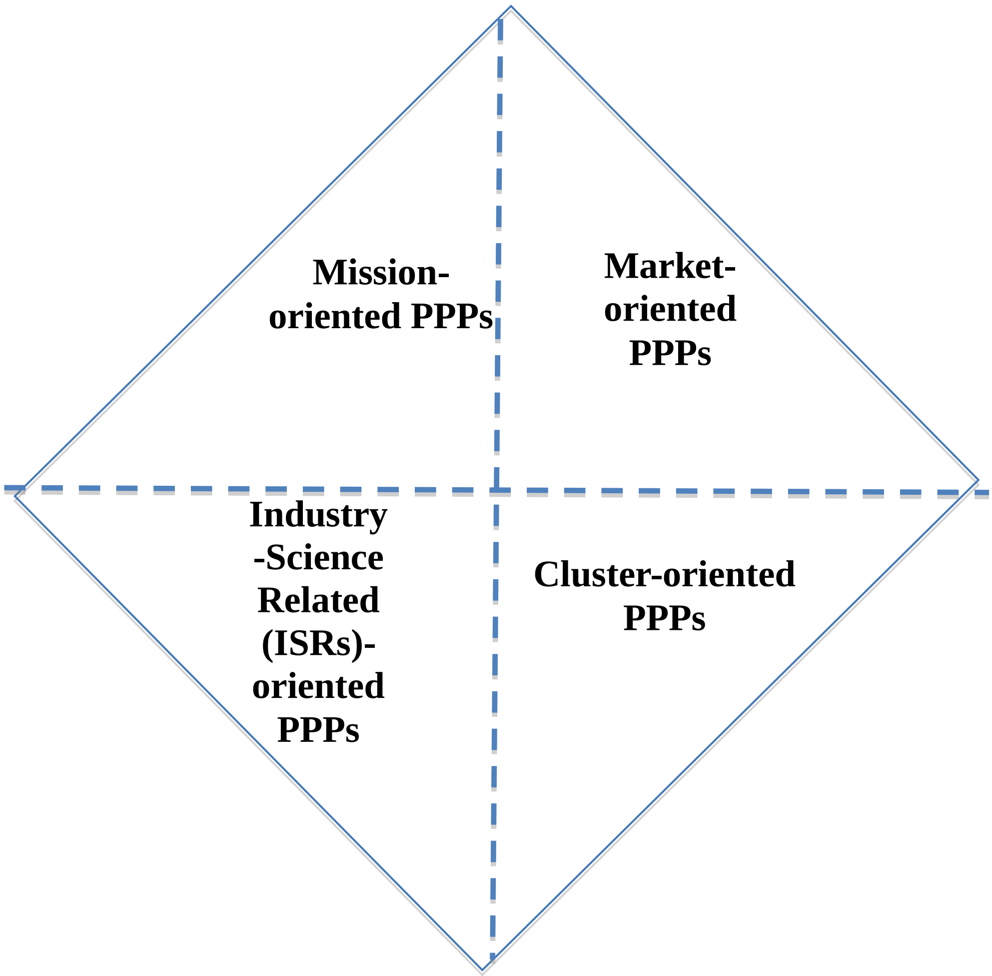


Figure 1 Types of PPPs as proposed *(adapted from OECD, 2004)*

Recent years have witnessed a steady increase in the number of PPPs world wide, which makes evident the benefits of these collaborating models towards the innovation ecosystem. The main and fundamental benefits/reasons that have lead to increase in the implementation of PPPs as innovative tool can be inferred from figure

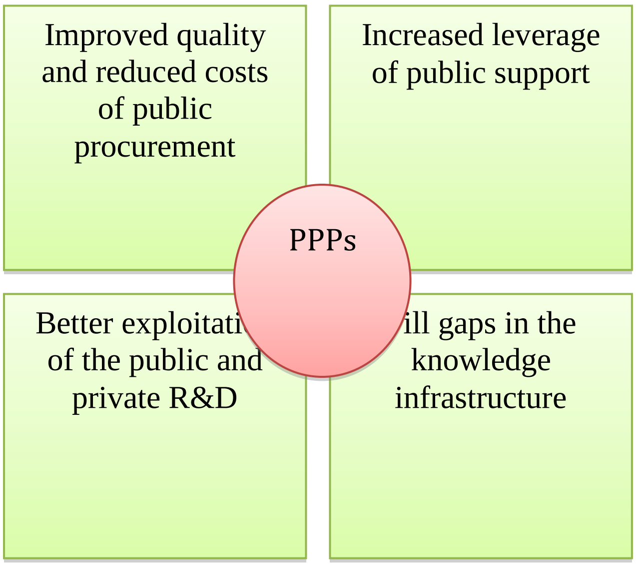


Figure 2 Benefits expected from PPPs (adapted from OECD, 2004)

Literature studies have lead to a crucial conclusion that the government of the nation needs to take a stance and be responsive towards the transformation of the process of innovation and other related strategies and market needs. The government also needs to be more receptive of the fact that heightened implementation of PPPs can enhance the efficacy and cost-effectiveness of the technologies/innovative products.

The present report is a review of the PPP programs for research and development and innovation being employed or practiced in different countries. The individual governments of different countries have taken diverse policy initiatives for increasing the intensity of R&D and efficiency of its national innovation system. One of the initiatives being, investing in and launching PPP programs. This report aims at exploring and examining the measures employed by diverse countries for encouragingcollaboration in R&D amongst the public (government, public funded research organizations, academia/universities) and the private sector (businesses, industries, enterprises, private organizations) and hence the promotion of translating the research conducted by the public domain into commercially viable entities.

The different nations that have achieved advanced innovation ecosystems, high levels of innovation and conversion of research into commercial products can be taken as a base model or template for gauging this activity. These countries have emerged as institutional contexts by incorporating collaborative R&D as a major part of the national innovation strategy of their respective country.The countries leading in innovation posses well established and well resourced innovation policies or strategies, which basically put down a roadmap and a reference point for selecting appropriate measures for achieving their specific targets. Through the use of such strategies requirements of the nation can be addressed in a more systematic and efficient approach. The division of tasks to the state governments and other agencies is also done in a better manner and minimizes duplication of tasks and overlaps amongst varied governmental levels.

Of all the countries incorporated in the present study,in a few of them the formation and implementation of *Innovation Strategies* is being taken care of by independent *Innovation Agencies* of that particular nation. These agencies work in close cooperation with the government and deliver the innovation goals of the country accordingly. India can take a cue from the successful innovation agencies like Finland's Tekes, Sweden's VINNOVA, Israel's Innovation Authority etc. as models for the Innovation Agency of India. Initiatives such as PPP for R&D and translating research must be versatile, in favor of multiple stakeholders and favorable at different working levels. Meanwhile making these initiatives a part of the National Innovation Strategy and basing them on a coherent policy set, shall help a country achieve its innovation goals.

Data Sources: The information and data presented in the present report has been deduced largely from specially commissioned country reports, reports of globally affiliated organizations, review papers, websites of the different programs/country innovation agency.

Objectives of the Study

1. Identification of countries for analyzing their R&D ecosystem viz-a-viz public-private engagements.
2. Examining the models of Public-Private Partnerships prevalent in each of the country
3. Examining the programs initiated by the government for enhancing collaborative R&D
4. Drawing experiences for the Indian scenario and develop a template model for India.
5. Evaluating the varied research policies and measures implemented in the selected countries and providing findings for India

Review

In the present day scenario, enhancing innovative activities and achieving new economic heights lie at the core of the goals set by the government for India's expansion and prosperity. Rewarding associations between R&D players, efficient translation of research being performed in the performed in the public sector, prudent utilization of intellectual property generated etc. are the methods that shall lead India to a rather vibrant innovation ecosystem. These endeavorsshall not only bestow monetary and economic gains but will also be valuable in the social and cultural aspects.

Therefore, boosting the ways in which new ideas are disseminated and applied is an important priority in a modern knowledge-based economy, requiring increased levels of collaboration between researchers, businesses, not- for-profits and the government sector. To achieve these outcomes, India can leverage the skills and knowledge in public sector research institutions through collaborative research, driving closer engagement with other parties. India is undergoing a necessary economic transformation, transitioning from high dependence on natural resources to a knowledge-based economy. This transformation needs to be driven by innovation, which relies on a number of factors, including strong engagement and collaboration between public sector researchers, business and other external counterparts.Improving this collaboration requires changes in policies and programs. Providing well targeted and funded incentives for each of the parties involved will not only increase research translation but will also bring about the cultural change necessary to make it a routine feature of research and business practice.

By comparison with other countries, India's research translation problems include:

- Low levels of collaboration between public sector researchers and business
- Most of the public sector researchers not actively seeking involvement in translation activities
- Lack of demand on the part of business, industry and other potential users who are not motivated to engage
- Lack of effective intermediaries to facilitate links between public sector

researchers and external parties.

Therefore, to draw from the experiences of other countries and develop an adaptable model for India, the following study has been conducted.

Rationale behind selection of Countries

The countries critiqued and reviewed in the present study are of relevance and purpose for different reasons, such as:

- Countries like Australia and USA, like India, possess the federal system of governance and therefore provide a platform to assess the initiatives taken at different governmental levels.
- Countries like Finland, Sweden, and Israel have built a strong culture and attitude in terms of structure and support programs to foster innovation and collaborative research.
- Countries like South Korea, China and Japan are Asian economies, like India, which have catapulted towards a status of technologically, advanced nations.

I. United States

i. Industry/University Cooperative Research Centers Program (I/UCRC)

The Industry/University Cooperative Research Center (I/UCRC) Program of USA was conscripted in 1973 and brought into action in the 1980s in order to develop and foster long-standing and deep-rooted collaboration amongst the academia, government and industry.This makes the I/UCRC Program one of the earliest and sustained one of its kind across the world. It has been operative and standing viable for close to four decades, unruffled by the changes and shifts in political scenarios and other archetypes that transpired over this long time period (Gray et al., 2015). However, the program was subjected to certain adjustments in this course of time. Also, a few of the sub-lines/modalities were introduced in between and some were later abandoned nonetheless keeping the original solicitation similar and stable since the mid-1980s (Gray et al. 2015).

This program is supported by the National Science Foundation (NSF), which is a United States government agency supporting education and research in field of science and engineering (non-medical*). NSF came into being as a result of the *National Science Foundation Act*, *1950.*NSF provides and devotes towards these partnerships for promoting research in areas of mutual interest, which shall contribute to the nation’s research base, increase the capacity of the workforce, integrate research and education and open doors for the transfer of technology(ies). NSF is a highly autonomous institution, which can be gathered from the fact that the changes in political, societal, government policy oriented factors did not affect the program, run under its aegis, notably.

Objectives of the Program

The NSF, as stated in the statement describing its mission, invests for fostering collaborations amidst the industry and university, primarily for the following rationale (https://www.nsf.gov/eng/iip/iucrc/about.jsp) -

- To promote research programs of mutual interest,
- To contribute to the nation's research infrastructure base,
- To strengthen the science workforce through the integration of research and

education, and
- To facilitate technology transfer.

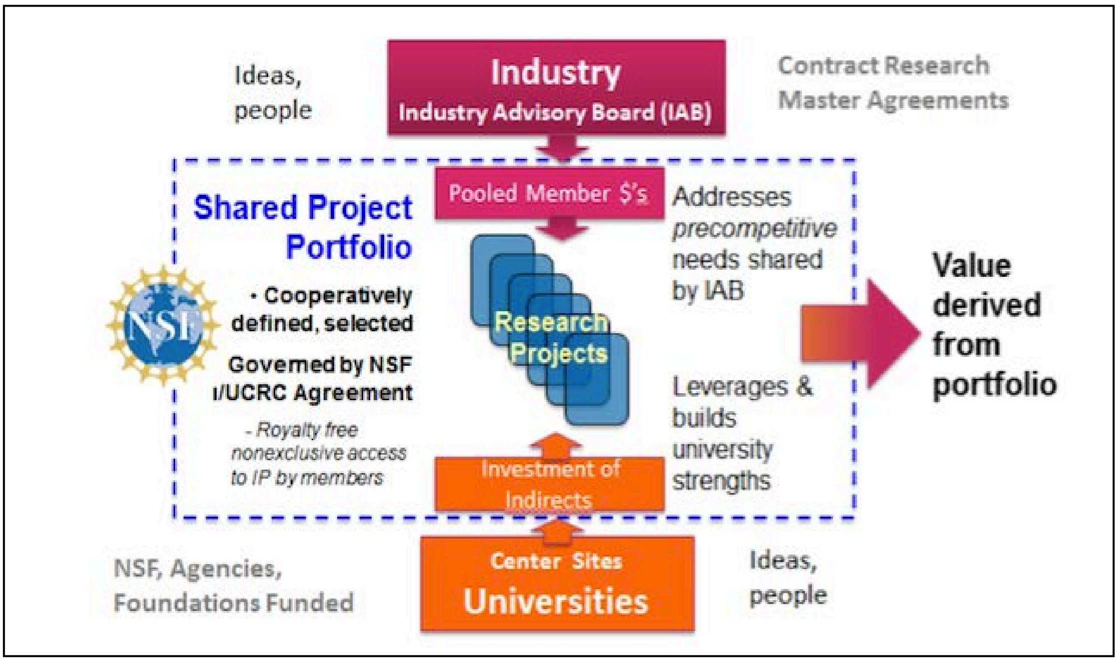
In a rather detailed account, the NSF, through the I/UCRC program aims at achieving the following goals (https://www.nsf.gov/eng/iip/iucrc/about.jsp)-

- Contributing to the U.S. research enterprise by developing long-term partnerships among industry, academia and government,
- Leveraging NSF funds with contributions from the industry to support graduate students in performing industrially relevant research,
- Expanding the innovation capacity of the U.S. competitive workforce through partnerships between industries and universities, and
- Encouraging the nation's research enterprise to remain competitive through active engagement with academic and industrial leaders throughout the world.

I/UCRC program intends to provide funds for effectuating partnerships amid the universities and businesses and grow them into long standing associations so that the parties can accomplish competitive research that will be beneficial to the participating members and will generate tangible outcomes. The I/UCRC centers are industry led research consortia based in universities and supported by the public and private sector both. Each of the Center is invested in by NSF and does not overlap with the research are of an existing I/UCRC center. Even though there are single university centers however, high emphasis is laid on the formation of multi-university centers. The benefits from multi-university centers are many including pooling of resources and generation of results. Over the time period of past three decades the I/UCRC's have not only led way for fruitful collaborations resulting in industrially relevant research, transfer of ideas from the academic sector to the private sector but have also generated a pool of talented human resource (graduates and undergraduates) possessing an industrially oriented mindset. The centers are catalyzed by NSF's supportin the creation and evolution of the centers. Along with the support of the public and the private sector, NSF assists by furnishing a scheme for membership and functions along with the other requirements derivative of the experience of other centers and their evaluation.

Each center undertakes research, vetted by an Industrial Advisory Board (IAB). This board ensures that the research being conducted is not of interest to a single company but caters to and is in alignment with the needs of all the members of the consortia. Thus, an I/UCRC provides for and adds up to the research infrastructure base of the nation and builds up the intellect in the domain of science and engineering through integrating education and research. As and when deemed pertinent, an I/UCRC also involves in associations at an international level for advancing its goals and aims. This program caters to and targets academic institutions solely. The funds are provided as seed support for establishing the center along with supporting the management of the center. The funds from NSF are not intended at covering the entire cost of activities being performed by the center. Also, the funding from NSF cannot cover the cost of a project conceptualized by the members of the center;only the members must finance it(NSF 2013a).

The program does not actually promote on-site collaborations however; it encourages the monitoring of the program by industrial monitors. The industrial monitors closely watch and regulate the research activities of the center but may or may not take part in the actual research processes. Also the program does not support the setting up of collaboratively invested infrastructure or research facilities, wherein the academic faculty, government and industry researcher can work jointly. This model aims at developing and bridging the gap between academia and industry by means of establishing cooperation between the two and enabling ‘use-inspired research’ " ('Pasteurs Quadrant') (Stokes 1997).



Source: https://www.nsf.gov/eng/iip/iucrc/industry.jsp

Figure 3 Structure and characteristics of an I/UCRC

Presently there are nearly 77 I/UCRCs in operation in the United States across 200 universities and also a few handful in Europe and Asia. Most of the existing I/UCRCs are multi-university initiatives and hence the disparity between the number of centers and universities. The Centers are granted an award for the time period of five years, which can be renewed for another five years after evaluation. Companies, both small and large, federal agencies and not for profit organizations support I/UCRCs through the means of payment of an annual membership fee for supporting the Centers research activities and other functions. Overall the program, since its inception 3 decades ago, has initiated nearly 140 I/UCRCs.

In these centers the faculty of the university works on large problems of broad discipline that will be scientifically crucial as well as relevant to the industry. In preference of working on their own predisposition, the faculty works on projects that have been developed through eloquent communication with the industry. Developing solo projects is not a prerogative and also the faculty recognizes the economical value of the research conducted thereby taking efforts to protect their research and then transferring it proactively to the private sector.

The industry, also in this arrangement, does not take university just as a convenient and cheap contractor whereas dives into long standing partnerships with the universities for backing fundamental and applied research along with teaming up with other partners of the consortia. Even though the vital objective of the industry is to commercialize knowledge and technology however the firms do take keen interest in education of the students as well as publishing their findings in due time. Therefore, it is evident that I/UCRC collaborations and other collaborations along the lines offer a win-win situation and have intensified the quality of research being conducted at the academic institutions along with enhancing the global competitiveness of the industries.

The I/UCRC model incorporates the characteristics of other mechanisms of university-industry linkages like **research units**, **industrial affiliates** and **R&D consortia**, thus it can be called a hybrid model of university-industry linkage (Fig. 4).

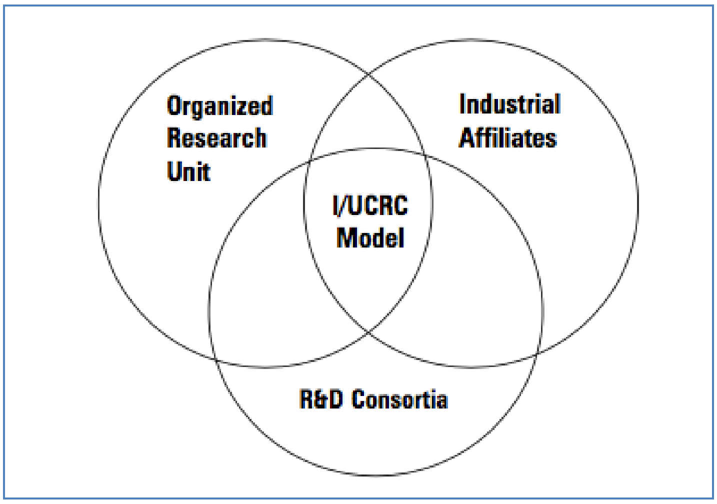


Figure 4 I/UCRC Hybrid Model [Adapted from Gray, D.O. & Walters, G.W. (1998)]

- **Research Unit –** it is an organized unit at a fundamental level i.e. a semi-autonomous organization based in a university but independent of its academic departments. It draws multi-disciplinary faculty.
- **Industrial Affiliates –** Backed and supported by number of industries. This format safeguards that research being conducted at the center shall cater to multiple firms and not just interest a single firm or department, thereby ensuring precompetitive and generic research work.
- **R&D consortia –** the research conducted is of the 'technology pull' format i.e. the requirement of the industry and not on the 'technology push' format i.e. the government's idea of industrial needs. The industry plays a vital role in the

management of the center as well hence drawing characteristics from the R&D consortia model.

This model offered hope in the regard where neither an industry or government/federal agency could afford to invest highly in associations that would not last or were highly one-sided. Therefore, the I/UCRC model catered to the cuts performed in the federal R&D, lack of fundamental research in the industries, academia's financial needs and many more requirements.

The I/UCRCs engage close to 2000 students per year and approx. 1000 graduates emerge through these centers and the member companies of the IAB hire 30% of these graduates. This is an evidence of the fact that this program is helping in building a strong work force for the nation. The I/UCRCs have also become a leading example in the model of "leveraged" funding, as the total funding by the industrial sector and other organizations amount up to 10 times the investment of NSF. This model has also been instrumental in influencing other programs of NSF and a few other federal agencies.

The results of this program speak for it. It is an amendable model, which spans over a wide range of universities, industries and, academicdepartments and is an impressive leveraging tool for sponsors' from the government and industrial sector. It entails benefits – scientific, financial, technical and social in nature. This model possesses a replicable and adaptable working framework, protocols, roles of the partners, methods of linking with the industry, and research activities.

The I/UCRC program has also been combined with other programs initiated by NSF in a manner that the R&D activities of other initiatives may either presage or accedethe activities of a Center. Other few programs that may be amalgamated with I/UCRC program are (details of the programs have been mentioned later in this report)–

- Small Business Innovation Research Program (SBIR)/ Small Business Technology Transfer Program (STTR),
- Grant Opportunities for Academic Liaison with Industry (GOALI)
- Partnerships for Innovation:Accelerating Innovation Research-Research

Alliance (PFI:AIR-RA)

Output and impact

Literature sources state that the stakeholders and participants of the I/UCRCs have benefitted in several ways. With timea few I/UCRCs have become emerged as recognized centers for innovative research. They have formed impressive indications and records for cutting edge research and sourcing novel approaches for the pressing issues of the nation. Scientific breakthroughs that are relevant industrially do not take place in silos but are a result of multi-disciplinary associations and partnerships that involve intellect and efforts of both the domains – the academia and the businesses. This program essentially creates a platform for the scientists and business minds from the two domains to work together with each other's vision and requirements thereby nurturing fruitful and lengthy partnerships. One of the strongest inkling that the centers are of value and importance is the increasing participation of firms ever since the inception of the program. The program is far-reaching and provides benefits both monetary and non-monetary in nature to the centers.

Undoubtedly, the results and outcomes of these centers have been relevant and substantial. The data compiled through means of external evaluations, self-reporting of the members demonstrates the immense benefits as well. Essentially, a large number of doctorates and graduates with a novel (university-industry) mindset have been produced as a result of these centers. Generation of generous amounts intellectual property rights (IPRs) and their constructive sharing amongst the partners associated with the respective center. In the recent years, an annual turnover of 50 patents, invention disclosures, 10 spin-offs and so on, were reported from almost all of the centers (Koschatzky et al., 2015). The program has also been bestowed with national award such as the *Technology Transfer Society of America*, for ample noteworthy technology transfers. Along with resource generation through patents, tech. transfers etc. the centers have provide d for the growth of intellect, enhancement of leadership skills, enhancement of managerial skills of ample number of professionals who have been associated with the centers over the last three decades.

The I/UCRCs have been able to generate backing from the industry and private sector close to 10 times the support offered by NSF, summarizing a notable return of the investment. Ample number of I/UCRCs have continued the generation of scientific resource, intellectual property, human capital, infrastructure, advancements in technology, financial returns, even after the NSF support had ended.

Some amount of prosperity gained and the assets accumulated through the I/UCRC program can be explained through the following points -

- *Impact on the efficiency of R&D:* It has been reported that participation in I/UCRCs has lead to the members amplifying and streamlining their research work. Working in the umbrella of a center also offers its members a cushion for performing high-end yet risky research activities.
- *Impact on generation of Intellectual Property (IP)*- Although the pre-competitive research being performed at the centers id shared amongst the members, the focus is to protect the research results through IPRs. The centers consistently indulge in protection through patents, invention disclosures, design protection, etc. and commercialization through technology transfers, licensing, assignment etc. During the most recent FY, centers reported the following IP events: 66 invention disclosures; 48 patent applications; 30 patents granted; 13 license agreements; and 9 copyright granted. Over the years, many of these inventions have been licensed to firms, including start-ups and spin outs, and resulted in commercialized products and processes.
- *Impact on resource usage* – As the centers are a platform for performing priority, high-end and risk oriented research beneficial to all the partners, the investments made towards the research allow for procuring sophisticated infrastructure and other resources, which may not be possible for an individual entity to procure, use and maintain. Therefore, the pooling of resources impacts the research in a huge manner.
- *Impact of human resource generation*– The centers have been highly instrumental in training and preparing graduates of the next generation. Industries have reported the students/graduates of I/UCRCs being rather more productive and efficient as compared to the other graduates. Nearly 30% of the graduates are absorbed by the member firms themselves. Hiring from the center saves the firm the time taken for training the student according to the requirement of that firm.
- *Self-sustenance of the centers* –The main aim of the program has been to establish long-term associations between the stakeholders for generating fruitful

research and technology breakthroughs. A few of the centers have been sustaining since the past thirty years, with NSF funding for the initial ten years only. A few like Edison Welding Institute, have also gained international eminence. Since the inception of the program approx. 70 I/UCRCs have graduated from the program and are not funded by the NSF any more.

Beginning in the year 2007, a communication entitled ‘*Compendium of Industry-Nominated Technology Breakthroughs of I/UCRCs*’ was commenced and continues. The latest, 6th edition of the compendium was published in 2016, and documents the research work undertaken by the centers in the timeframe beginning atthe onset of 2013-14 academic year (September, 2013) and terminated at the end of 2015. Each of the entry is proposed and designated in the compendium, by a member of Industrial Advisory Board (IAB) of the center. The 6th edition encompasses the work of approx. 180 universities and 775 partners from the private sector working under the ambit of nearly 77 centers. There are listed close to 50 technological findings that have resulted from the concentrated efforts of the above-mentioned partners.

A few examples derived from the compendium are:

- Berkeley Sensors and Actuators Center (BSAC) and Smart Dust: Research on “Smart Dust”, autonomous network of highly miniaturized “motes” containing microradios and microsensors, was begun at BSAC over ten years ago. This led to a $1.7 million DARPA “Smart Dust” program and eventually led to a groundswell of industrial and new venture capital investments in wireless sensor networks (WSN). Market forecasts of more than $10B/year, now seem like low estimates as the technology promises to revolutionize homeland security, environmental control, power management, and infrastructure monitoring. BSAC research has also contributed to the creation of long list of start up companies.

- Center for Process Analytical Chemistry (CPAC) and New Sampling and Sensor Initiative (NeSSI). Researchers at CPAC pioneered research on the development of devices allowing continuous analysis of chemical samples extracted from process equipment. The commercialized outcome of this work was NeSSI. It has been used for years by the petrochemical, chemical, and oil refining industries to more accurately monitor and control their production facilities. Firms have estimated tens of millions of dollars in cost savings per year.

ii. Engineering Research Center (ERC)

Aside the notable I/UCRC program, the NSF also supports other initiatives that also pursue somewhat similar goals and aims and operate along the lines of I/UCRC program. The most conspicuous other program is the *Engineering Research Center (ERC) Program*, which was set up in 1984. The ERCs are also interdisciplinary hubs set up in close association with the private sector, at universities all over the country (United States). These are university-led institutions that have been developed through the support and backing of NSF Directorate of Engineering. Each of the past three generations of ERCs have worked on the specific engineering needs of the country and have also been designed so. The ERC program is very competitive and therefore only a few of the ERCs are awarded the grant out of a large number of proposals. Each ERC aims at providing a platform for the academia to interact and collaborate with the industry for being able to pursue advancements in engineering systems and technologies. These centers have been established with a goal to realize innovations and develop technologies that posses the potential for transforming the existing products/processes/services or brace the emergence of novel industries. Thus activities undertaken at ERCs have resulted in fruitful partnerships leading to generation of novel systems along with generation of graduates in the domain of engineering graduates who posses the qualities of innovative intellect, diversified outlook, effective technology leadership and are engaged globally. The ERCs like the I/UCRCs intend to build a culture, which fosters and stimulates innovation in technology/products/services through the means of prudent associations and partnerships for performing research. This allows for exploring the space of high-risk technologies, their translation and commercialization, by involving multi-firms and thus pooled resources. Given this evolving and outward-looking program management, current and future ERCs will continue to advance transformational engineered systems and produce graduates who will be creative innovators in the global economy.

Each of the established ERC works towards the achievement of the following three missions –

Cross-disciplinary and Structured Research— The centers bring forth collectively the diverse disciplines of engineering and science for working towards issues crucial to the engineering industry and shall bolster the competitiveness of the US industry globally. The research conducted at the centers, lies at junction of two cultures i.e. the analysis-driven and innovation-driven.
Education —Each center has established a system and practices an approach wherein the graduates work in multi-disciplinary domains in association with the industry partners. The education is unified and combined with industry-driven research and industrial practices of building competence. The graduates emerging out of the ERCs posses not only fine knowledge of their domain but also posses excellent leadership plus management skills.
Private Sector Partnership and Technology Transfer— These centers are an excellent platform for collaborations between the universities and the industries. The industry is implicated in action with the ERCs at every step of the process of such as planning, collaborative research, student mentoring, and engagement in establishing proof-of-concept models, basically all the processes that would lead to strong partnerships with the industry and enhance the speeds of transfer of technology.

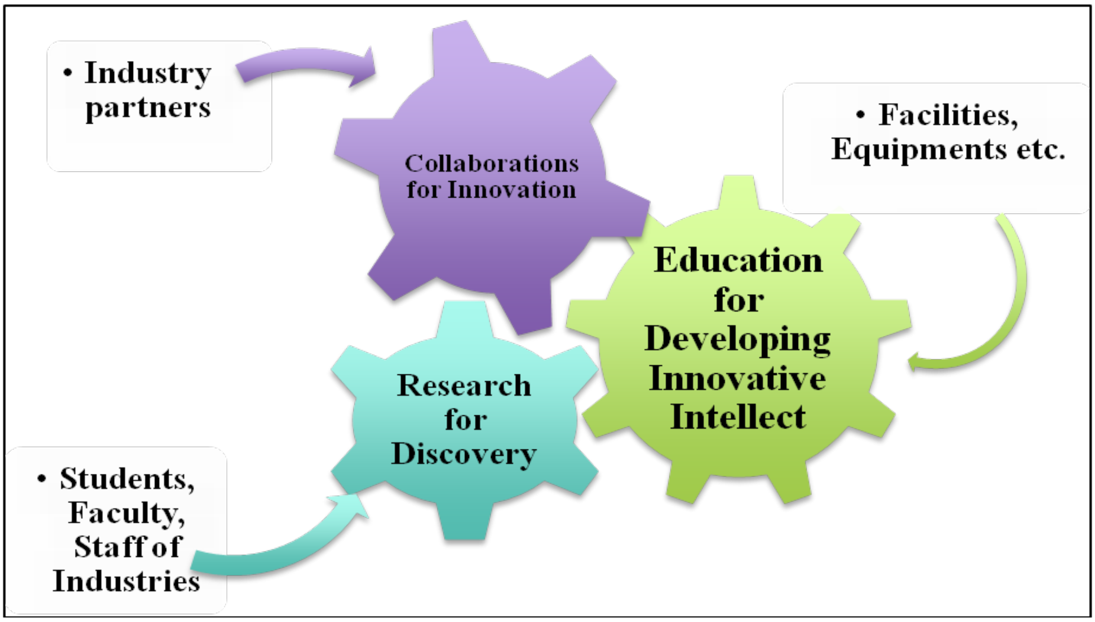


Figure 5 A complex and interdependent ERC structure

Every established center involves a tripartite partnership of the academia, NSF (state/local or other federal agency may participate) and the industry (ERC Overview Fact Sheet_2016.pdf). The NSF, according to the program provides support to each ERC for a time period of 10 years. The ERC program is also one of the longest running programs of NSF and since its inception in 1985, close to 65 ERCs have been established along with 3 Earthquake ERCs all across the United States. The number of ERCs presently in operation is 17 (ERC Overview Fact Sheet_2016.pdf) enlisted in table 1. Approx. 31 centers have gained self-sustainability as of the FY 2015 from the 38 centers that had graduated starting from 1985 up till 2014 (NSF 2013b). The annual funding for each ERC, by NSF, in FY 2016, ranged from an amount of $2.68 million (for centers in the period prior to their graduation) to $3.5 to $4.8 million per year for continuing centers. Each new ERC is elected based on its proposal, and the perceived future national needs that it proposes to cater to.

The table below enlists the ERCs along with their year of establishment. ERCs set up before 2008 are termed as second-generation ERCs and programs founded in or after 2008 are third-generation ERCs.

i. BIOTECHNOLOGY AND HEALTH CARE		
Center	**Lead Institution**	**Year Founded**
ERC for Revolutionizing Metallic Biomaterials	North Carolina A&T State University	2008
Nanosystems ERC for Advanced Self-Powered Systems of Integrated Sensors and Technologies	North Carolina State University	2012
NSF Engineering Research Center for Sensorimotor Neural Engineering	University of Washington	2011
ii. ADVANCED MANUFACTURING CENTERS		
Nanosystems ERC for Nanomanufacturing Systems for Mobile Computing and Mobile Energy Technologies (NASCENT)	University of Texas at Austin	2012
ERC for Biorenewable Chemicals	Iowa State University	2008
ERC in Compact and Efficient Fluid Power	University of Minnesota, Minneapolis	2006

Center for Structured Organic Particulate Systems	Rutgers University, New Brunswick, NJ	2006
iii. ENERGY, SUSTAINABILITY, AND INFRASTRUCTURE		
Future Renewable Electric Energy Delivery and Management (FREEDM) Systems Center	North Carolina State University	2008
Lighting Enabled Systems & Applications ERC	Rensselaer Polytechnic Institute	2008
ERC for Quantum Energy and Sustainable Solar Technologies (QESST)	Arizona State University	2011
ERC for Re-Inventing America's Urban Water Infrastructure (ReNUWIt)	Stanford University	2011
ERC for Ultra-wide Area Resilient Electric Energy Transmission Networks (CURENT)	University of Tennessee–Knoxville	2011
ERC for Bio-mediated and Bio-inspired Geotechnics	Arizona State University	2015
Nanosystems ERC for Nanotechnology Enabled Water Treatment Systems	Rice University	2015
iv. MICROELECTRONICS, SENSING, AND IT		
ERC for Power Optimization for Electro-Thermal Systems (POETS)	University of Illinois at Urbana-Champaign / University of Arkansas / Stanford University / Howard University	2015
ERC for Collaborative Adaptive Sensing of the Atmosphere (CASA)	University of Massachusetts Amherst	2003
ERC for Extreme Ultraviolet Science and Technology (EUV ERC)	Colorado State University / University of Colorado at Boulder / University of California at Berkeley / Lawrence Berkeley National Laboratory	2003

ERC on Mid-Infrared Technologies for Health and the Environment (MIRTHE)	Princeton University	2006
Center for Integrated Access Networks (CIAN)	University of Arizona	2008
Nanosystems ERC for Translational Applications of NanoscaleMultiferroic Systems	University of California, Los Angeles	2012

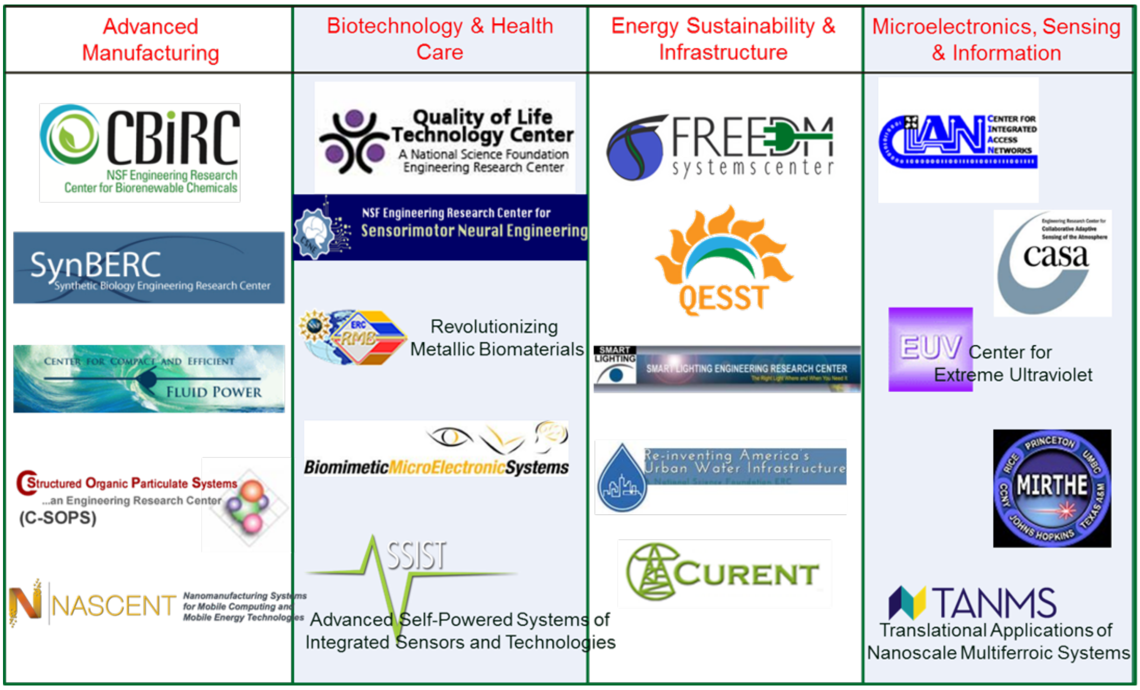


Figure 6 ERCs in operation (https://www.cbirc.iastate.edu/overview/erc/)

The solicitation of the programs makes it evident that the stipulations for attaining an ERC are rather more demanding than that of I/UCRCs. A few points included in the compulsory stipulations are, - A proposal for an ERC must comprise of multi-institutions, with one lead institute and a maximum of four domestics partner institutions,minimum three faculty members should be part of the ERC proposals along with three students, the lead university should be the one that caters to a large number of students, ERC should provide an opportunity for the domestic faculty and studentsto collaborate globally, Firm and/or industry members (with membership fees) are required, ERC must incorporate guidance from the scientific advisory board/industrial advisory board etc.

In comparison to the I/UCRC grants, the ERC grants are difficult to achieve, as there is a higher requirement with respect to research, teaching, multi-institutional, and other diversity factors. The proposal for the grant of a Center needs to lay out in detail a system, research focus, work plan, dedicated research program, education program, the configuration as envisioned, list of collaborators and affiliated institutes and a pre-college education scheme. Along with all the above stated information the proposals need to chalk out the details of the innovation environment of the proposed ERC i.e. the advisory boards. Details about the Industrial or Practitioner Advisory Board(I/PAB) are required to be submitted in the proposal, also including the terms of agreement of membership, collaborations with other universities, or other promoters (state/local government) of entrepreneurship, translational research associations, infrastructure present with the university, human resources (directors, managers), technical facilities etc. The outright spread of these requirements and details of activities impedes certain small universities to apply for the grant as lead institutes. However associating with larger and more resourceful universities strengthens the research base of such universities and also helps them in building a reputation.

iii. National Network for Manufacturing Innovation (NNMI)

Another important of the federal government in the domain of partnerships between the public and the private sector is the National Network for Manufacturing Innovation (NNMI). The NNMI program is also called as ‘Manufacturing USA’, entails a grid of research institutions in the country. The main focus are of this network is to developand commercialize manufacturing technologies through means of PPP between the federal government, U.S. industry and universities. This program has been modeled on the lines of Germany's Fraunhofer Institutes and consists of 14 institutes as of 2017 (https://www.manufacturingusa.com). Each of the institute is a PPP model with a main aim of promoting strong and long standingresearch and development in the field of manufacturing, enhancing to specificities in advanced manufacturing spheres. The program provides for enhanced and high end infrastructure that is required for the academia and the industry to work together for resolving problems that are pertinent to the industry, hold relevance in the manufacturing sector, transfer of technologies from the universities to the businesses, training of the work force/development of human capital and education (https://www.manufacturingusa.com). These institutes, which are placed in different states of the country, along with federal support also receive substantial amounts of backing from the state agencies and therefore are a part of the regional innovation strategies (NIST 2015; Molnar 2014).

AFFOA (Advanced Functional Fabrics of America)	**AIM Photonics (American Institute for Manufacturing Integrated Photonics)**	**NIIMBL (National Institute for Innovation in Manufacturing Biopharmaceuticals)**
ARM (Advanced Robotics Manufacturing)	**ARMI (Advanced Regenerative Manufacturing Institute)**	**CESMII (Clean Energy Smart Manufacturing Innovation Institute)**
DMDII (The Digital Manufacturing and Design Innovation Institute)	**IACMI (The Institute for Advanced Composites Manufacturing Innovation)**	**LIFT (Lightweight Innovations For Tomorrow)**
NextFlex	**America Makes**	**Power America**
RAPID (Rapid Advancement in Process Intensification Deployment Institute)	**REMADE (Reducing EMbodied-energy And Decreasing Emissions)**	

According to the mission statement of the administration an IMI, will be backed by and co-funded by the partners along with the federal and non-federal organizations.

It is expected that institutes will typically receive $ 70-120 million in total funds, over a 5-7 year timeframe it is envisioned the total capitalization of an institute over this period will be $ 140 to 240 million" (NIST 2015; Molnar 2014). The first IMI set up in Ohio ("America Makes") indeed received $ 30 million of federal investment matched by $ 40 million of industry, state and local funds (Ratcliffe 2014).

According to a recent key report on Advanced Manufacturing activities of IMIs should include:

- Applied research, development and demonstration projects that reduce the cost and risk of developing and implementing new technologies in advanced manufacturing,
- Engagement with education and training at all levels,
- Development of innovative methodologies and practices to increase the capabilities and capacity for supply chain expansion and integration,
- Engagement with small and medium-sized manufacturing enterprises, as well as large Original Equipment Manufacturers (OEMs), and
- Provision of access to shared facility infrastructure, with the goal of scaling up production from laboratory demonstrations and making technologies ready for manufacture.

iv. Grant Opportunities for Academic Liaison with Industry (GOALI)

Grant Opportunities for Academic Liaison with Industry (GOALI) promotes university-industry partnerships by making project funds or fellowships/traineeships available to support an eclectic mix of industry-university linkages. Special interest is focused on affording the opportunity for:

- Faculty, postdoctoral fellows, and students to conduct research and gain experience in an industrial setting;
- Industrial scientists and engineers to bring industry's perspective and integrative skills to academe; and
- Interdisciplinary university-industry teams to conduct research projects.

This solicitation targets high-risk/high-gain research with a focus on fundamental research, new approaches to solving generic problems, development of innovative collaborative industry-university educational programs, and direct transfer of new knowledge between academe and industry. GOALI seeks to fund transformative research that lies beyond that which industry would normally fund.

Funding is provided to develop creative modes of collaborative interactions with industry through individual or small group projects, and for industry-based fellowships for graduate students and postdoctoral fellows. Examples of GOALI mechanisms include the following:

- extended faculty visits to industry (three to 12 months) to foster long-term industry/university collaboration;
- faculty visits to industry (two to six months) at the beginning of a three-year university-based research project with the intention of transferring results to industry by the project's end;
- university-based support for cooperative university and industry engineers and/or scientists on research projects of mutual interest;
- support for interdisciplinary research/educational projects for two or three faculty from different academic units to interact with one or more industrial partners in a "virtual industry/university group"; and
- visits to universities by leading industrial engineers, scientists and managers to catalyze collaborative research and/or teach and develop curricula.

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II. AUSTRIA

In the recent years the Austrian government has taken a variety of policy initiatives to increase both the R&D intensity of the economy and the efficiency of the National Innovation System (NIS), including measures to stimulate R&D in the business enterprise sector (e.g., a substantial extension of fiscal support). But fostering linkages in the national innovation system has become the major policy focus, and public private partnerships, the major policy instrument.

The Kplus program of the Ministry of Transport, Innovation and Technology, and the Kind/Knet programs of the Ministry of Economic and Labour are emblematic examples of this reorientation of the technology and innovation policy of Austria. In addition to the above, the Competence Center Program of Austria also had an important positive impact on the science and technology ecosystem of Austria. Even though Austria had succeeded in raising its GERD/GDP ratio to the European average, but it still lagged behind certain other European countries. There are a significant number of firms, many of them SMEs, operating in the market niches where they enjoy strong competitive positions. However, only a small number of research-intensive firms have the capability for 'breakthrough' technological innovation.

The Austrian government realized that only increasing investment in R&D was necessary but not sufficientachieving high long- run economic performance. Additional investment in both public and private R&D needs to generate sufficiently high returns. This requires enhancing the overall efficiency of the innovation system. In this respect, there are three priority complementary objectives:

- Encouraging existing firms to engage in more radical types of innovation.
- Promoting technology-based start-ups.
- Increasing the role of the Higher Education sector in providing a research base to be utilized co-operatively with industry and as a breeding ground for start-up companies.

Alleviating the weaknesses identified in industry-science relationships is a prerequisite for achieving these objectives.

In this context, PP/Ps for research and innovation came to play an important role. PP/Ps have the potential to increase the flexibility of the system of funding science and technology and its responsiveness to new needs. In the late 1990s several developments led to the implementation of new policy initiatives based on a PP/P approach. The *Expert Draft for a Technology Policy Concept of the Austrian Federal Government 1996* provided a rationale for these initiatives. In addition, Austria's participation in the EU framework program increased the readiness to start new multi-firm, multi-actor programs for research and technological development. Since public support schemes and institutions in place at that time were not sufficiently geared to take up this task, it was perceived as necessary to set up new institutions to manage these new types of programs.

Project-based, non-targeted support for science, technology and innovation had long been dominating the system of public support to R&D. In recent years there has been a move towards program-based support targeting clearly identified weaknesses in the Austrian innovation system, in particular in the area of Industry-Science Relationships (ISRs), complemented by regulatory reforms in the public research sector, especially universities.

The Kplus and the Kind/Knet programs are the most representative examples of this shift in emphasis in Austrian science and technology policy. Launched in the late 1990s, they encourage and organize the collaboration between enterprises and research institutions (universities, government research labs, etc.) in pre-competitive research with a high potential for commercial application. They create centers or networks of competence that may serve several purposes such as increasing the efficiency of the production and distribution of knowledge, creating clusters of competence and critical masses, facilitating technology transfer, fostering linkages with international R&D programs and networks, and developing human resources.

Establishment of Christian Doppler Laboratories (CDL) is another example of a recent PP/P program for enhancing science-industry linkages. Unlike Kplus and Kind/Knet, CDL does not create medium to large-scale competence centers but fosters co-operation between business enterprises and small public research teams in a more direct manner. The comparatively low scale of individual CDL and simple procedures make the program easily accessible. In some cases CDL form a nucleus of future competence centers.

The basic characteristics of the three programs mentioned above have been listed in Table –

Table 1 Initiatives of the Austrian Government

Initiative/Program Name	**Year of Establishment**	**Characteristics**
Kplus Program	1998	The Kplus competence center program aims to build long-term co-operative research initiatives between public institutions and private companies. Selected in a competitive process according to specific quality criteria and established for a specified time-span (4+3 years).
Kind/Knet Program	1999	This program serves the development and strengthening of internationally competitive technology clusters by supporting competence centers with the purpose to develop and transfer application-oriented technological knowledge, jointly run by business enterprises and universities/public science and research enterprises on a long-term basis (4+3 years).
Christian Doppler Laboratories (The ***Christian Doppler Research Association*** was founded in 1988 to bridge the gap between universities & industry research)	1989 (old form) 1995 (new form)	Christian Doppler Laboratories (CDL) performs application-oriented basic research on topics of interest to member companies. They provide member firms of the *Christian Doppler Research Association* with early and direct access to new scientific and technical knowledge. The latter invest on a long-term basis in specific basic research fields and participate in the labs. A total of 72 CD laboratories with nearly 830 employees are active as of 2016. 69 CDLs are

		based at 16 Austrian universities and research institutions and 3 are situated internationally. The scientific output of the CD Laboratory manifests itself in scientific publications, presentations and patents: In 2016, this includes 479 publications (of which 366 publications in scientific periodicals with peer review), 1,040 presentations at conferences and 11 granted patents.

i. The Kplus program

The present Ministry of Transport, Innovation and Technology (BMVIT) developed the Kplus program. Based on a policy paper prepared in 1997, program guidelines were issued in 1998. These guidelines in turn provided the basis of the program's notification according to EU competition rules. They were complemented by a series of manuals for reviewers, applicants, evaluators, etc.

This program was designed by taking into account relevant experience of other countries such as Canada, Sweden and Australia –their programs and practices.

The management of Kplus was handed over to the newly established Technologie Impulse Gesellschaft (TIG), a limited company owned by the Republic of Austria represented by BMVIT. A block grant of ~EUR 50 million was received by TIG for funding the first two calls of the Kplus program.

Kplus is aimed at improving cooperation between scientific institutions and industry in Austria. It funds collaborative research facilities (jointly run by business enterprises and research institutions (universities, government research laboratories etc.) with a specified life time, set up to carry out top-quality, long-term and internationally competitive research and technological development (RTD) projects at a pre-competitive stage. The goal is to perform research that is highly relevant for both the academic world and industry and to develop human capital in areas that are either multi-disciplinary or which are relevant for a number of sectors/companies.

Kplus competence centers are established for a period of four years, with the possibility of extension for another three years, depending on the results of an interim evaluation in the fourth year of operation. Thus the time-horizon is much longer than that of standard R&D projects funded by the traditional schemes of public support in Austria.

Characteristics of Kplus competence centers are the following:

- Long-term participation of research institutes and (at least five) companies each to guarantee multi-firm projects and pre-competitive research; on the other hand prevent dependency of center on one big industrial partner.
- Existence of a scientific core. This is a vital criterion – mere networks do not qualify as Kplus competence centers. This does not preclude that centers have more than one location.
- The annual budget of a center is typically in the range of EUR 2 to 4.5 million (up to 35% federal funds through TIG, a maximum 25% from other public sources, and a minimum 40%from industry).

The main objective of the program is to establish long-term co-operative relations between business enterprises and scientific institutions and the pooling of resources to form “critical masses”. Given the long-term goals of the program, the main focus is on building trust and a shared knowledge base.

ii. The Kind/Knet program

The ideation of the Kind/Knet programwas initiated in 1997, when the Minister for Economic Affairs announced a plan to foster co-operation between enterprises and science institutions. It has the goal to lay the ground for cluster formation by providing a durable framework for cooperation, and the building of trust and of a shared knowledge base. The program was launched in May 1999.

The Kind/Knet program is one consisting of two lines of action:

Kind	**Knet**
Creates industrial competence centers mostly to enhance the existing network of organizations with similar R&D interests. For concentrating the R&D activities of a number of enterprises and research institutions (universities, government research labs, etc.) working in the same field, with the aim of building up and developing application-oriented technical expertise and promoting its dissemination in existing and new companies.	Supports networks, which create synergies between different competence nodes situated at various locations. The prerequisite is that the individual nodes complement one another in terms of their thematic orientation within the framework of an overall concept: existing regional R&D institutions (e.g. university institutes, CD laboratories, polytechnic colleges, joint venture research institutes) are expected to be included as partners.

The target groups are industrial enterprises with their own R&D department and public research institutions. SMEs without their own R&D can participate as "associate" partners at the level of individual projects. Technology transfer activities are encouraged.

Both the above-mentioned programs were initiated around the same time and are examples of PPPs for R&D, aimed at enhancing the cooperation between the industry and the academia. They offer fixed funding for a specific time period and were set up with the goal of increasing the R&D expenditure, speed up innovation, and share risks of intensive R&D. Other similar characteristics of the programs –

- They do not "target" specific fields of technology or industries. The definition of the topics takes place through a self-organizing, "bottom-up" process.
- They encourage or demand some formal organizational structure or minimum standards. However, a high degree of flexibility is offered to the participants

The differences between the programs are not with respect to their main goals but with respect to their research emphasis and procedures of implementation, such as selection process, role of evaluation etc.

- The Kplus centers are knowledge-driven and the Kind/Knet centers are industry-driven.
- Kind/Knet has the stimulation of private R&D as a major goal, while Kplus puts stronger emphasis on addition of knowledge in both the private and public sectors.
- Kplus seeks to promote excellence in research, while the Kind/Knet program puts more emphasis on the combination of (existing) capacities and technology transfer.
- Kind/Knet includes virtual centers/networks, while the Kplus program requires that the majority of researchers are assembled at one physical location.
- A major goal of Kind/Knet is the creation and establishment of industrial/technological clusters. In this context Kind/Knet takes regional or local conditions into account. Kind/Knet has therefore a stronger regional dimension than Kplus.

The above-mentioned initiatives and programs were put in place since 1998 as the central research competencies in the field of science-industry cooperation.

The COMET-Program is the next step in the innovative further development of the previous Kplus, K_ind, and K_net programs.

The chief motivation for COMET is:

- Provision of a framework for further innovative development of expertise already established,
- Development of new expertise, bundling of existing competences, and the development of research of outstanding quality via international orientation, and the
- Stabilization of the number of centersin line with Austrian research capacities through structural adjustments and permanent quality assurance.

The distinct new element of the program is the ambitious orientation towards excellence, the involvement of international research expertise, and the development and assurance of technological leadership of companies to strengthen Austria as a research location. Scientific-technological development and innovation are to be promoted, thus increasing the intensity of research and innovative capability of companies. Research carried out in competence centersranges from medium- to long-term and meets high standards of quality. The applied orientation of the research and actual use to industry are priorities. With its focus on top-level research, COMET constitutes an element of the Austrian strategy of excellence and has been considered in the federal strategy for research, technology and innovation (RTI- Strategy).

iii. COMET

COMET is designed as a program on the national level. The program is owned by the Austrian Ministry for Transport, Innovation and Technology (BMVIT) and the Ministry of Science, Research and Economy (BMWFW). The program is managed by the Austrian Research Promotion Agency, FFG. The Austrian federal states also support COMET with their own additional funds and can strengthen their own regional technology policy objectives in this way. The central government offers the federal states different cooperation options that are formally agreed to bilaterally and in writing. If regional funds are granted based on the current program document, the federal states can influence the selection of centers and projects in several ways:

- The federal states take part in the selection procedure.
- The federal states have the opportunity to formulate an opinion to the expert evaluators.

COMET plays a key role in the Austrian innovation funding architecture and is the "flagship" in the field of industry-science cooperation. For instance, about half of all funding grants approved by the Austrian Research Promotion Agency FFG, which is responsible for managing COMET, are for the COMET program. With an annual state budget of 50 million euros for COMET, about 10% of all FFG funds flow into the COMET centers (for comparison: about 40% of total FFG funds go to cooperation projects).

COMET is made up of three program lines: K projects, K1 centers and K2 centers. The projects and centers of all program lines are characterized by high research competence and close ties to science with simultaneous high relevance for implementation in the business sector. These are also the main evaluation criteria.

K projects aim to initiate high quality research in science-industry cooperation with medium-term perspectives and clearly defined topics that have future development potential. The idea is to increase the program's flexibility and also give research subjects and consortia a chance to participate that do not have sufficient potential for a K1 center. K projects integrate science and industry and have a "multi-firm" character (a minimum of 3 company partners). The projects are strategic in the sense that a sustainable profile is the objective in the medium term. Re-application is a possibility. K projects can be used by new consortia for new research projects with the potential to evolve into a K1 or K2 center in the future. Financing is not available for purely networking or initiation activities, only for joint research, although accompanying activities (such as initiation activities, awareness, network development and platforms) are possible to a reasonable extent.

K1 centers pursue the goal of initiating high quality science-industry cooperative re- search with a medium- to long-term perspective. K1 centers conduct advanced re- search and focus on science-technology developments and innovations with a view to relevant future markets. The defining features of K1 centers are a joint research pro- gram with at least five companies and an interim evaluation in the fourth year of the program. Where possible and reasonable, existing structures and focal points of excel- lent research should be combined or new ones created. Re-application is possible.

Regular calls should ensure the renewal of all centers.

The objective of *K2 centers* is to pool existing national expertise in the long term and cooperation with the world's leading researchers, scientific partners and company partners in joint strategic research programs at the highest level. The intention is to strengthen and significantly increase the attractiveness of Austria as an international research location in the long term. The defining features of K2 centers are a particularly ambitious research program and associated high risks in development and implementation. They have particularly high international visibility and are integrated in international networks. K2 centers have a clear commitment to institutionalization, the development of expertise and long-term work: They are initially de- signed to run for 10 years. There is an interim evaluation in the fifth year, and the center is only continued if the results are positive. The centers are encouraged to reapply for continued funding even after 10 years, provided that a second evaluation is also positive.

The following figure illustrates the differences between the criteria of the three program lines:

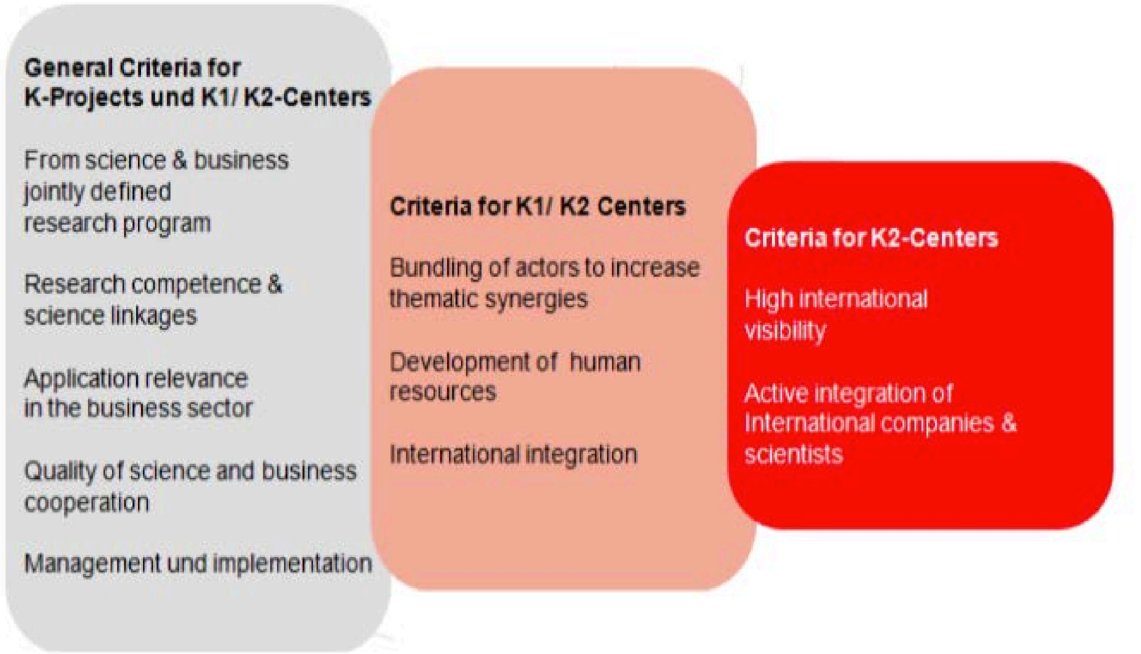

Figure 7 Criterion of the three program lines

Source: FFG: COMET – Competence Centers for Excellent Technologies

Table 2 Key features of the three lines of COMET program

	K projects	K1 centers	K2 centers
Number (across all calls) / employees	46 approved	26 approved	5 approved
Public funding (max. state & federal state)	45%	55%	55%
Funding intensity industry partner (min.)	50%	45%	40%

Funding intensity science partner (min.)	5%	5%	5%
Amount of funding from state	Max. €0.45 mill. /year	Max. €1.7 mill. / year	Max. €5.0 mill. / year
Duration	3-4 years	8 years (4+4)	10 years (5+5)
Partner structure	Min. 1 sc. partner & 3 companies	Min. 1 sc. partner & 5 companies	Min. 1 sc. partner & 5 companies

Source: Pichler, M. (2015): Das österreichischeKompetenzzentrenprogramm COMET; FFG: COMET – Competence Centers for Excellent Technologies

Evaluation protocol of the competence centers has been described in the image (figure 8) below:

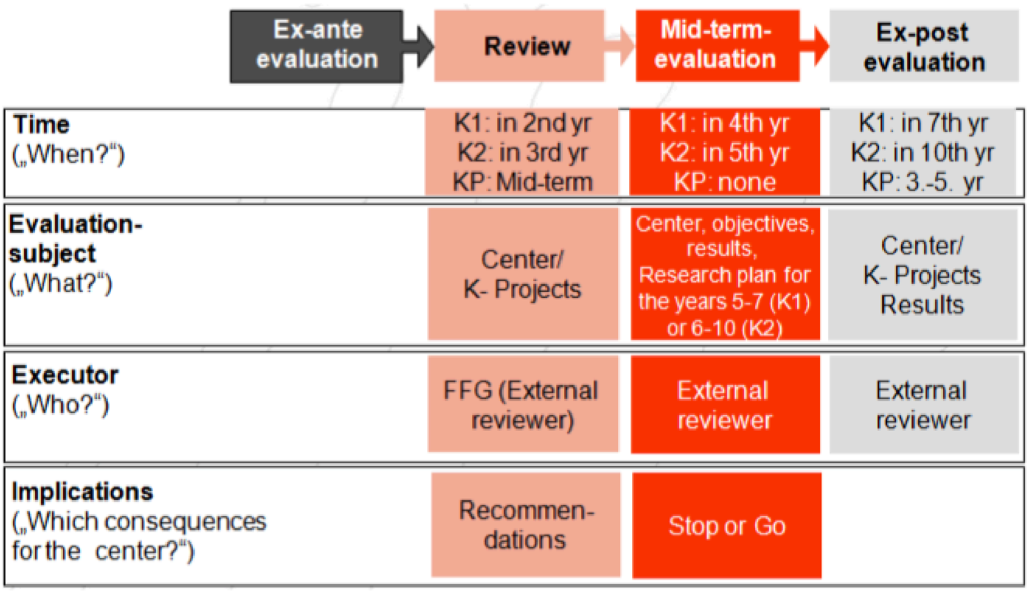

Figure 8 Evaluation stages of the K Centers/K Projects

The success factors and the lessons learnt from the COMET program have been enlisted below. Based on the analysis of COMET the following success factors can be named that have emerged since the program began:

- High level of trust between science and industry,
- Long-term commitment on the part of science,
- Long-term commitment on the part of the companies,
- Research manager at the centers,
- Openness to international environment,

- Research program as a "living" construct: constant modifications and adaptations as well as the ability of the committees in the centers to deal with them,
- Competitive components from the regular calls and the "predetermined breaking points",
- Thematic openness: priorities are not forced; the selection is not done based on pre- determined topics (e.g. societal challenges).

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III. AUSTRALIA

Subsequent to the early 1990s the economy of Australia grew and emerged as one of the finest performers. This change could be attributed to the changes, modifications and structural reforms that were carried out over a widespread horizon. Included in the reforms were also initiatives taken for reforming science and innovation policy, which aimed at broadening the base for growth of the country in terms of economic heights, by shifting the base from resource-based economy to a one based on knowledge. The following characteristics define the science and innovation scenario of Australia -

- Valuable and acceptable scientific performance.
- Advanced skill base i.e. strong university-level education.
- Heightened use of advanced technology i.e. ICT and novel software's for achieving the desired changes.
- Heightened government backing for research and development.
- Low level of business R&D expenditure

For achieving increased levels of private sector research and development and for bolstering the links/associations between the players of the innovation system, the government of Australia undertook steps for modifying and reforming the policy instruments in the 1980s. These modifications included competitive grants for enhancing private sector R&D, tax concessions, programs for boosting corporate firms to establish research infrastructure and base, measures for establishing contacts/linkages/partnerships between the public, private and governmental sectors. The latter causereached a stage of high priority in the 1990s.

Since then the Australian government has introduced a range of schemes and initiatives for harboring collaborations amongst the university and the industry and facilitating PPPs for innovative solutions. Few of the Australian government's initiatives for promoting PPP in R&D have been listed in the table 4 -

Table 3 PPP Programs in Australia

Initiative	Description	Period
CRC Program	The most important and notable initiative – the Cooperative	1990 -

	Research Centers (CRC) program focuses on long standing collaborations for performing research in order to advance the development of industry and private firms by the means of transferring knowledge from the public domain to the private sector leading to commercialization and economic growth. The funds available in this program are from combined public and private sources.	present
Rural Research and Development Corporations (RRDCs)	RRDCs are a model of association amongst the government, including Public Research Organizations (PROs) and rural industries. This scheme comprises of many short term and long-term projects for advancing technology and building of capacity. The RRDCs are characterized by strong involvement and close cooperation of an industry participant in the projects of that particular sector.	1990 - present
Innovation Investment Fund (IIF)	The IIF was set up for providing access of the equity capital to the small, high technology companies to enhance and refine the commercialization scenario in Australia. The funds in IIF are a combination of the funds provided by both the private and the public sources. The IIF has funded nearly 65 companies till date and majority are working in high-technology areas such as internet commercialization, healthcare technologies, IT systems etc.	1998 - present
ARC Linkage Grants	‘Australian Research Council’ has set into place a provision for funding strategic research undertaken jointly by higher education institutes and industry. The linkage grants also include funds for infrastructure, industry fellowships etc.	1999 - present
PreSeed Fund	Pre-Seed Fund is also an investment based scheme, which is looked after by fund managers from the private sector and aims at encouraging development of business from the stage of early research of public universities and PROs. Funding again is a mixture of backing from both the public and private sectors.	2002 - present

Source: Department of Industry, Tourism and Resources

Of all the programs/schemes/initiatives enlisted in the portfolio above, the most substantial and successful has been Cooperative Research Centres (CRC) Program. This initiative has been in place for close to 27 years since its inception in the 1990s. The CRC Program has witnessed the establishment of nearly 100 centers since its initiation, and approximately 70 centers are functioning currently.

i. Cooperative Research Centers Program

This initiative was put into place by the Australian government in the 1990s and the functioning started in 1991. The main aim of CRCs, according to the guidelines of the program, was to "link and build on outstanding research activities in the public and private sectors. Emphasis will be placed on enhanced research cooperation achieved through concentrating research activities in one location, or through effective methods of networking; strengthening research training; and on the economic and social benefits of research" (CRC Program: Guidelines for Applicants 1990; cited in Australian Government 2014a).

The literature derivatives and other sources concede to the fact that it is likely that initiatives of foreign countries like the FraunhoferGesellschaft, Network of Centers of Canada, Catapult Centers of UK may have been the plausible trendsetters for the idea of setting up a portfolio of CRCs (Australian Government 2014a). The Ministry of Department of Industry and Science is the main agency responsible for administering the program and looking into its modalities. It is responsible for providing secretarial backing and support to the CRC committee and the experts thereby aiding in administrative functioning of the centers. It is the duty of the Committee to feed in suggestions and recommendations to the Ministry concerned regarding functioning, sustenance, funding, planning, monitoring and evaluation of CRC program in whole.

The primary and the most notable aim of the program is "to deliver significant economic, environmental and social benefits to Australia by supporting end-user driven research partnerships between publicly funded researchers and end-users to address clearly articulated, major challenges that require medium to long-term collaboration efforts" (Australian Government 2013a).

In the above mentioned aim statement the end users are referred to as the public or private systems that possess the capacity to deploy the results and outputs of research in order for delivering significant benefits – social, environmental and most importantly economic in nature.

Objectives of the CRC Program

The Australian government drew out the objectives of the CRC initiative in a fashion that they enhance/bolster the overall innovation ecosystem of Australia

- The *Program* aims to improve the competitiveness, productivity and sustainability of Australian industries, especially where Australia has a competitive strength, and in line with *Government Priorities*.
- The *Program*aims to foster high quality research to solve industry-identified problems through industry-led and outcome-focused collaborative research partnerships between *Industry Entities* and *Research Organizations*.
- The *Program* aims to encourage and facilitate *Small and Medium Enterprise (SME)* participation in collaborative research.
- Collaboration amongst the researchers, between the researchers and industry or other users, and to improve efficiency in the use of intellectual and other research resources.

The main agenda of establishing the CRCs was to fulfill the framework laid by the above stated objectives. The CRCs carry the onus of bringing at a single platform the researchers/research groups from public universities, research organizations, R&D units, federal/state and territorial laboratories, and the private business sector for carrying out innovative research. These Centers create strong networks of research and provide the researchers with an area of concentration thereby making sure that the national resources are utilized to their maximum capacity and judiciously.

This initiative fulfills an important role in the innovation system of Australia, working in the domains of:

- Collaboration between researchers and research users;
- Education of graduate researchers in an outcome oriented context;
- Excellence in long-term strategic research; and

- The transfer of research outputs into commercial or other outcomes of economic, environmental or social benefit to Australia.

The fundamental objective of Australia's CRC program is similar to Austria's Forschungscampus, essentially with respect to the benefits that it generates economically, for the environment and for the society. Also it caters to address major obstacles and challenges that need medium to long-term attention.

The CRC Program essentially consists of two types of funding streams:

a) Cooperative Research Centers (CRCs) for supporting medium to long term industry-driven collaborations; and
b) Cooperative Research Center Projects (CRC-Ps) for supporting short term, industry-led collaborative research.

The users eligible for funding may either be from the private sector, public sector, universities or a research organization affiliated to a university. Of all the participants one must essentially be an Australian for the group to source funding. Also it is necessary for the essential participating members to contribute to the CRC resources.

Funding is granted for a period of up to five years. The legal basis is the public good funding mechanism. In case of satisfactory performance, further five years of funding may be granted. Under exceptional circumstances, an application for up to five additional years is possible (upper limit of funding is 15 years; according to the recommendations of the recent program evaluation the maximum funding period should be 10 years). Exceptional circumstances can be the evidence of the CRC's success, the need for continued public support, outcomes of the most recent rigorous performance review, the identification of research programs, which are significant to Australia. Under these circumstances, the CRC Committee will either recommend the extension of an existing CRC or the establishment of a new CRC to the Minister.

CRCs can be established as an incorporated or unincorporated entity. It is open to the applicants which legal form they choose. The only limitation is that they need to ensure that they have fully considered the legal and taxation implications of the structure proposed in their application and that it deals effectively with the ownership and management of IP (Australian Government 2013a).

According to the program guidelines, all CRCs must employ a governance model, which demonstrates good practice in design (for the application) and good practice in execution (for the operation of the CRC). It must also be demonstrated why the governance arrangements are the most suitable for the proposed/intended results.

The program guidelines include eight governance principles as recommendations for the CRC. These governance principles were developed by the Australian Stock Exchange Corporate Governance Council and adapted to the needs of the CRCs.

The Cooperative Research Centre Association (CRCA) was established on 1 December 1994, to promote the CRC program while also acting a conduit for information sharing and learning between CRCs. Over time the role has evolved to the extent that today the CRCA is also recognized as the principal non-Government advocate of the CRC Program.

Success Stories:

The CRCs have been performing excellent research and producing effective outputs, which have not only enhanced the innovation index of Australia but have also significantly affected the society for the good. A few examples of the same are enlisted below-

- *Tooth Mousse Plus Product*, produced by CRC for Oral Health Science. This product re-mineralises tooth enamel thereby reducing tooth decay.The product is now sold in over 50 countries.
- *Cochlear Hybrid System*, produced by Hearing CRC has aided in restoring the hearing of close to 1,40,000 children and adults worldwide.
- The Vision CRC through means of their developed product the O2Optix and Night & Day contact lenses is earning royalties nearing $10 million per year.
- A RT genetic diagnostic test kit, developed by Australian Biosecurity CRC has been used for equine influenza. The development of this test has led to a monumental result, i.e. eradication of equine influenza.

ii. Rural Research and Development Corporations

The rural industries and producers of Australia have to go through a wide range of unique challenges, which may be societal, biophysical or environmental in nature, along with facing extreme global competitions. A main object of response towards the solution of these challenges is a strong and effective rural innovation system, and one of the pillars of this system is the unique partnership between the industry-government, which is being delivered through the means of Rural Research and Development Corporations (RRDCs). The funding of the RRDCs is a contribution of financial support from the industry and the support from the government of Australia. The industry contribution is usually raised through levies on production. The government support is for R&D activities of the program, adoption work and other basic operations that are required to back the investment program. All the other modalities are supported by means funds received through the industry.

Presently there are 15 RRDCs in Australia working in the domain of fisheries, agriculture and forest industries. Each of the RRDC has been accorded with the responsibility of dispensing tangible and prudent solutions for the community and for their respective industries and aid in improving the productivity, enhancing the profitability and sustenance. The corporations achieve these objectives by devising strategic plans and through focused investments towards decisive partnerships for R&D, market access, development and promotion (http://www.ruralrdc.com.au/about-the-rrdcs/). Of the 15 corporations only 5 are statutory corporations, which are owned and retained by the Commonwealth of Australia and are set up vide the legislation, all the others are retained and owned by the industries and are established as *not-for-profit* companies. The industry owned RRDCs have been set up in conformity with the Corporation Law of Australia and have also been declared through a regulation as 'the service providers to industry for specific activities'. Excise/duty payees can eventually be the members/shareholders of the RRDCs and can participate in the decision making process.

iii. ARC Linkage Grants

The scheme of Australian Research Council (ARC) Linkage Grant came into being for promoting associations and collaborations between the players of research and innovation ecosystem. These players include a plethora of stakeholders from the higher education institutes (HEIs), R&D organizations/units, government agencies, private firms, industries, and business and community end-users. All R&D activities are undertaken for applying advanced knowledge to varied issues and problems;

amass new expertise for attaining economical and related benefits from research.

To stand by its most fundamental aim of fruitful collaborations between the institutes of higher education and other elements of the national innovation ecosystem, the solicitation of ARG Linkage projects facilitate submission of project proposals all throughout the year and the outcomes are declared within six months.

Funding is administered to the proposals of the eligible organizations, for supporting the R&D activities, which are:

- Collaboration between researcher of HEIs and other stakeholders.
- Performed for attaining and amassing new expertise & proficiency, and
- Innovative activities involving high risk.

The proposal sent for evaluation, for receiving funding vide the scheme of Linkage Projects must have mandatorily one ‘Partner Organization’ (in the least). This partner organization should provide a contribution in the form of cash/orkind, towards the project. Also the total fund requested from ARC should match the total contributions of all the partner organizations.

The fundamental objectives of the scheme of Linkage Projects (http://www.arc.gov.au/linkage-projects), are to:

- support the initiation and/or development of long-term strategic research alliances between higher education organizations and other organizations, including industry and other research end-users, in order to apply advanced knowledge to problems and/or to provide opportunities to obtain national economic, commercial, social or cultural benefits
- provide opportunities for internationally competitive research projects to be conducted in collaboration with organizations outside the higher education sector, targeting those who have demonstrated a clear commitment to high-quality research
- encourage growth of a national pool of world-class researchers to meet the needs of the broader Australian innovation system
- build the scale and focus of research in the national Science and Research Priorities.

The amount of funding provided by the scheme is $50,000 to $300,000 each year, for a time period of two-five years. The funding of the project can be utilized for a wide variety of uses such as (http://www.arc.gov.au/linkage-projects)-

a) personnel i.e. research associates/assistants/technicians
b) emoluments for higher degree education by the research students
c) teaching assistance relief
d) access to all facilities (research and infrastructure) and technical workshop services
e) field activities
f) outsourcing expert services
g) materials, consumables and other equipment
h) dissemination of research results via publications,
i) special computer software's
j) travel costs
k) web development
l) essential support costs for researchers (who are care takers or themselves require care).

Observations

The initiatives of the Commonwealth of Australia have been pioneering and innovative and have tremendously consolidated as well as broadened the base of economic advancement. These initiatives aimed at transitioning the economy from a resource based economy to a knowledge driven one and have achieved it majorly. The most persuasive one being the CRC Program that brought about evolving and gradual reforms in the research culture of the country and its public and private sectors. The program has lead to enhanced associations and partnerships between the researchers of HEIs/public institutes, R&D units and private firms and bolstered the translation of research into commercial entities. The results of translated research have improved the innovation scenario of the country and bestowed many social, economic and environmental assets. Many characteristics of the CRC Program have granted it the eminence and progress that it has achieved. These aspects of the program are:

- A reasonable concept of PPP for remedying the innovation system of the country.
- A wide portfolio of the technology domains in which the CRCs operate. These areas were identified for weak linkages between the researchers and firms and an

institutional structure was put into place for bridging the gaps.

- Long-standing, yet open-ended commitment from the Government’s side.
- Including the objective of higher education, which aimed at generating a talented pool of trained workforce.
- The program stresses equally on all its four objectives: collaborations, research, higher education and applications of the research results.
- It emphasizes on all the partnering organizations to make a contractual and formal bond for the period of contract (approx. 7 years).
- A specific management system providing the Chief Executive Officer (CEO), complete authority over the resources of CRC.

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IV. NETHERLANDS

The Netherlands has been struggling for some time with what is now known as the "European paradox": high-quality scientific research coupled with trailing application of public knowledge in actual innovations, despite the existence of a relatively large applied research infrastructure. The Dutch government faces the following main challenges in the field of science and technology policy:

- Increasing the incentives and improving the institutional frameworks for co-operation between public and private actors of innovation.
- Improving the attractiveness of the Netherlands as a top location for researchers as well as R&D and other innovative activities.
- Streamlining and improving the public support schemes for innovation and a complex innovation governance system.
- Improving interdepartmental co-ordination.

  Public-private partnerships for innovation (PP/Ps) are an important part of the answer to such challenges. Different models of PP/Ps are already key components of the Dutch innovation policy tool kit.

PPP in research requires new forms of coordination. Traditionally, research councils and national academies have coordinated academic research, but PPP raises new coordination challenges, partly due to the participation of a more heterogeneous set of actors with diverging interests and competencies. Consequently, many governments have by- passed these traditional intermediary organizations and introduced novel coordination structures. Typical examples of this new category of coordination organizations are centres of excellence and cooperative research centres in which (consortia of) public and private actors coordinate strategic research programs.

The Ministry of Education, Culture and Science is responsible for science policy and the Ministry of Economic Affairs has responsibility for policy on innovation and ICT. Other ministries, such as the Ministry of Public Health, Welfare and Sport; the Ministry of Transport, Public Works and Water Management; and the Ministry of

Agriculture, Nature Management and Fisheries each have their own science and technology budgets, focusing on their own fields. The total 2003 S&T budget amounts to € 3,590.6 million.

The 1979 Innovation White Paper already noted this problem and introduced the Innovation Oriented Research Program (IOP) and the STW's scheme to stimulate fundamental research in response to industry needs. The Knowledge in Action Memorandum published in 1996 marked a further turnaround in policy concepts and announced various measures:

1) The creation of four Leading Technology Institutes (LTIs) focusing on business-relevant fundamental and strategic research of an excellent international level in an institutional partnership between the public research infrastructure and the private sector;
2) Introduction of co-financing for part of the funding of TNO (Netherlands Organization for Scientific Research) and the LTIs (Large Technological Institutes) in order to make these institutes more responsive to private sector demand; and
3) Creation of two schemes designed to stimulate project-based technological partnerships between companies and research institutes, and between companies: the Economy, Ecology and Technology (EET) scheme and the Business-Oriented Technological Partnership scheme (BTS).

Since then promoting interaction between public research and industry has remained a top priority of the Dutch innovation policy. A number of new programs (Table 5) have been started in recent years, such as the Netherlands Genomics Initiative and the Platform ACTS, aimed at catalysis research. PP/Ps now play a key role in the Dutch innovation policy, far more importantly than would suggest their rather modest share in the overall Science & Technology budget.

Table 4 Public-private partnership programs in the Netherlands

Initiative	Characteristics
STW Technology Foundation	Via the STW Technology Foundation, the Ministry of Economic Affairs stimulates the development of excellent demand-driven technical and scientific research at Dutch university research centers. Three aspects play a key role here: user involvement in the research, utilization and the research yield.
Innovation-Oriented Research Programs (IOPs)	The aim of the IOPs is to strengthen strategic research at Dutch universities and research institutes in relation to private sector innovation needs, via a programmed approach. IOPs are currently running in the following technology fields: image processing, genomics, industrial proteins, man-machine interaction, environmental technology/heavy metals, surface technology, precision technology and power electronics. The resources for each program are made available for research and knowledge diffusion.
Leading Technology Institutes (LTIs)	With the LTIs the Ministries of Economic Affairs aims to increase the innovative capacity and competitiveness of Dutch companies in a number of selected fields. This takes place through company-relevant fundamental and strategic research of an excellent international standard, in institutional partnerships between the public research infrastructure and the private sector. The fields involved are telematics, food, polymers and metals.
Technological Partnership (TS) scheme	Through the TS scheme, subsidies can be provided for technological projects by corporate alliances or partnerships between companies and between companies and research institutes, aimed at fundamental/ industrial research or pre-competitive development.
Economy, Ecology and Technology (EET) Program	Through the EET program, subsidies are provided for major research projects conducted by corporate alliances or partnerships between companies and research institutes, which can lead to substantial advances in both ecological and economic terms through technological innovations. This contributes to improved economic sustainability.

i. Leading Technology Institutes (LTIs)

Leading Technology Institutes (LTIs) represent one of the purest forms of PP/P, both in their rationale and organisation. The review of LTI program leads to the conclusion that it is a proven good practice in mobilizing public and private research towards common objectives of high importance for the economy and society. The initiative of LTIs was launched in 1996 in order to 'strengthen the innovation potential and competitive position of Dutch Industry'. A Technological Top Institute (TTI) or LTI is a special type of research institute at a Dutch research university. A TTI carries out scientific research in areas that -

- have been designated to be of key importance to the Netherlands by the Dutch government; and that
- is subject to such industry interest that it can be funded by public–private partnership agreements.

The concept of the TTI was first developed when the Ministry of Economic Affairs was empowered by the Dutch government to identify key areas of national, economic interest and set up funding programs to stimulate those areas, improve Dutch knowledge of them and establish and/or maintain a leading, international position in them.

The LTI instrument does not have a legal document that describes its objectives and modalities. The 1996 government memorandum 'Towards Leading Technology Institutes'4 lists the key characteristics of an LTI:

- A recognizable institute led from one position and, if required, physicallyconcentrated;
- The LTI focuses on one coherent scientific area of fundamental-strategic research
- This area is chosen in close consultation with knowledge intensive enterprises;
- The LTI harbors researchers and equipment of global excellence;
- This excellence forms an attraction for knowledge intensive firms and international top-talent;

- The LTI has a training component through PhD and designer courses;
- Enterprises should have a strong commitment to the LTI.

LTIs fill a gap in the Dutch NIS, which was widening because of the evolution of large firms' research strategies, the insufficient responsiveness of university research to emerging opportunities, and the applied focus of industry-relevant research in most public laboratories. Large companies in the Netherlands have reduced or abolished their central research facilities. This has entailed a shift to more short-term and development-related work and the decline of business-performed basic research, making firms more dependent on the results of fundamental and long-term research performed in the public sector. But universities have the responsibility to carry out curiosity-driven fundamental research that cannot be oriented towards industry's needs through traditional research contracts. On the other side of the spectrum, a large fraction of the activities of TNO and DLO institutes is in the form of assignments from individual companies.

In the Netherlands, the role of LTIs was seen as performing 'strategic-fundamental research' positioned in between one the one had academic research, which can be characterized as basic research or 'blue sky', and on the other hand applied research, which would typically be performed by contract research organizations such as TNO

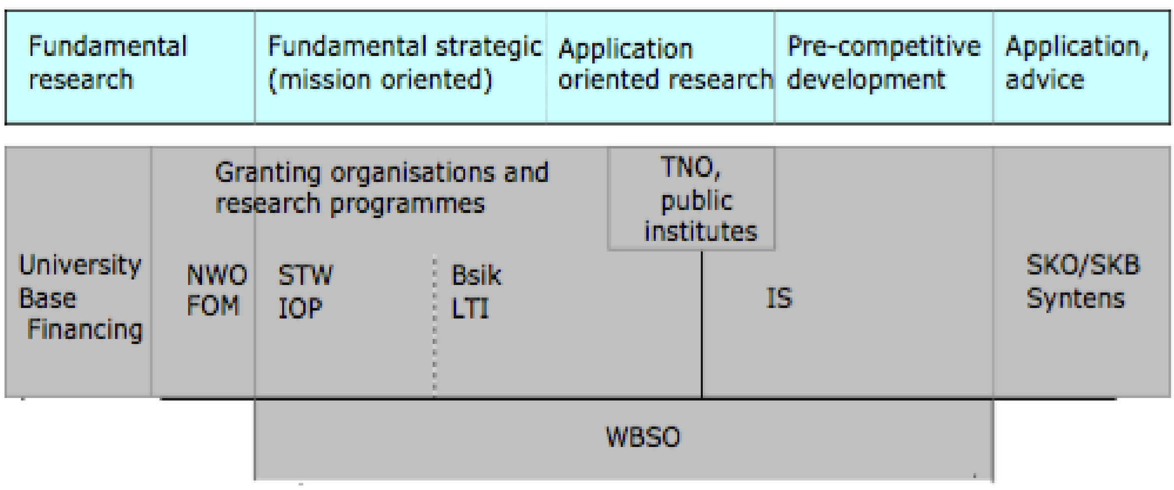

Figure 9 Positioning of the LTI in Netherlands Innovation System

LTIs operate at the interface between academic research and industry. The industrial partners have a leading role in defining the research program, thus ensuring that the program is in line with the long-term needs of the industry and creating the favourable conditions for transfer of new knowledge from the academic environment to industry. On the other hand, the participation of competing companies in each consortium and the fact that the knowledge generated is available to each of them, ensure a wide diffusion of the research results, and thus the maximization of the longer-term socio-economic benefits of the research programs.

Organization, governance and management

The government was very active in the initiation of LTIs but left each of them free to decide on their organizational set-up. The government imposed only minimum requirements: scientific excellence and industrial appropriateness. The organizational form of each LTI is specific. DPI and WCFS are purely virtual organizations, with a lean organization at the core and research being done at the participating research institutes, whereas NIMR and TI do much research at their core and thus have a mixed form between the virtual and the central organization. Each organizational mode has advantages and disadvantages, which have been stated in the table 6 below-

Table 5 Organizational set up of LTIs

	Central Institute	**Virtual Institute**
Advantages	• Easy integration • More corporate culture	• Researchers can work in their natural habitat • Flexible personnel policy
Disadvantages	• Pulls out researchers from universities • Can become isolated	• Difficult to organize • Double loyalty of researchers

ii. Technology Foundation STW

Technology Foundation STW was officially established in 1981 as a foundation to serve the entire spectrum of technical sciences. Since then the foundation's objective has been to realise knowledge transfer from excellent technical scientific research.The NWO Domain Applied and Engineering Sciences (TTW, previously Technology Foundation STW) facilitates the transfer of knowledge between the technical sciences and users. In this process it is important that a responsible approach is taken with regard to research results in general, and patentable inventions and discoveries in particular. TTW aims to exploit and publish the results of research as widely as possible, whilst retaining the possibility to establish IP rights and to subsequently commercialize these rights and, secondly, to stimulate collaboration between researchers and various external companies. TTW adheres to a set of rules concerning Intellectual Property (IP) that supports this mission. This policy is in line with the IP policy adopted by the Netherlands Organisation for Scientific Research [*Nederlandse Organisatievoor Wetenschappelijk Onderzoek*, NWO] and with the '*Rules of Play for public-private collaboration*' as presented to the Lower House of the Dutch Parliament on 25 June 2013.

TTW also offers knowledge institutions the opportunity to make their own IP and Publication (IP&P) arrangements with the parties with which they cooperate. In this way, we can respond even better to the wishes of the researchers and co-funders who are involved in the research projects

If knowledge institutions prefer to make their own arrangements, they must make this known – with the approval of the other project partners concerned – at the time the application is submitted, and have concluded the arrangements within three (3) months of receiving TTW's approval for the project. The knowledge institution has the lead in making these arrangements. The arrangements will subsequently be reviewed by TTW to ensure they are compatible with four criteria that reflect the task and mission of TTW.

iii. Innovation-Oriented Research Program

The Innovation-oriented Research Programs (IOPs) were initiated in the 1980s and were funded by the ministry of Economic Affairs, which delegated the administration to its agency SenterNovem (later called NL Agency). Later the IOP became part of the 'programmatic approach' of the ministry of Economic

Affairs (Van *et al.*, 1998).

Observations:

The launching and operation of the Dutch LTIs are an undeniable success, as assessed by the interim evaluation report and confirmed by the interviews of the main stakeholders in Dutch science, technology and innovation policy during the OECD mission. These government-sponsored partnerships currently meet the expectations of the main stakeholders. The main factors of success appear to be the following:

- Fluctuating governmental support and variable policies inhibit the accumulation of knowledge, competences and social capital with regard to the coordination of public- private research.
- National governments are responsible for ensuring that there is sufficient learning capability about the coordination of research in public-private partnerships.
- *Sound economic rationale* - LTIs are founded on a sound PP/P concept of how to remedy well- identified systemic failures in the Dutch innovation system.
- *Customized implementation* - This concept has been applied in a flexible manner, with different organizational arrangements (from pure virtual networks to more hybrid arrangements involving both distributed and centralised research capabilities, as in the case of Telematica) to suit different the specific needs of different technological fields, taking into account the peculiarities of the Dutch innovation system in each of these fields.
- *Legitimacy*- They were launched as part of a broader movement to PP/P and network-based approaches to innovation policy, reflecting a new consensus between public and private actors regarding the best way to identify and achieve common strategic goals.
- *Quality* - They emerged from a stringent bottom-up selection process where proposals had to compete, based on the quality of their scientific content, their industrial relevance and the soundness of their business plan.
- *Leverage and long-term commitment* - The cost-sharing arrangements ensure high reciprocal leverage. This is the key in ensuring sustained commitment from both public and private partners.
- *Leadership* - They include all leading enterprises and public research centers in each field, and their managers are well-known/respected figures that have a broad

experience and good links with both academia and industry.

- *International openness* - Not only have LTIs opened up to foreign firms, but also to foreign knowledge institutes.
- *Learning hubs* - LTIs are platforms for learning about good practices in managing PP/Ps for actors that are well-positioned to diffuse the lessons throughout the Dutch NIS. The participation of TNO in all four LTIs is key in that regard.
- *Visibility* - The institutionalization of the research networks in the form of “institutes” helps them acquire visibility in the Netherlands as well as internationally. This helps them attract competent partners, position themselves within international networks, and creates continuous “peer pressure” for improvement from “competing” forms of public-private relations.

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V. ISRAEL

Israel’s R&D sector is based on three pillars: scientific research performed primarily in academia, research conducted in government institutes, and research conducted by civil-industrial partnerships led by the Ministry of Finance. Israel’s R&D is private- sector oriented and is becoming more so over time. In 2000, government funds accounted for 24% of total spending on civil-industrial R&D development. In 2006, they accounted for only 15.9%, and in 2009 further reductions brought public investment down to 14.5%, far below the European median of 37.3%. In contrast, in 2006 private-sector investments were above the European median by more than 20%. Consequently, although government funding has declined over the years, total R&D investment as a percentage of GDP is high in comparison to many European countries. 42% of non-governmental funding for R&D is attributed to foreign investment – the highest rate among OECD countries.

In 2013 the Ministry of Science and Technology submitted a report urging the government to allocate more public funds to R&D, arguing that private funding dominance prevents long-term and high-risk exploration. The report also pointed to the continued erosion in funding of R&D at universities. This decline is exhibited both in the declining share of contributions by universities to R&D activity over the years as well as in the reduced number of scientific publications per person compared to the 1990s.

A large portion of Israeli R&D policy is directed toward international cooperation. In 2011, Israel was engaged in 30 different international cooperative research ventures with a variety of European countries and organizations. These resulted in 250 grant applications and projects with a total budget of €250 million. The Ministry of Science and Technology secured 14 bilateral agreements with various countries including Russia, Germany and France. Israel is also a signatory to some 29 bilateral R&D agreements and is involved in five EU programs, including Eureka, Eurostars, the Competitive and Innovation Program – Enterprise Europe Network (CIP-EEN), Galileo, and Sesar. In terms of both policy and budgets, the most significant international involvement is in the Framework Programs, such as Horizon 2020, which are managed by the Israel-Europe R&D Directorate (ISERD).

The Israeli policy shifted from horizontal towards thematic R&D support, with specific domains and sectors under its scope. The commercialization of Key Enabling Technologies (KETs) is promoted mainly by the Ministry of Industry, Trade and Labor, and even more specifically by the Office of the Chief Scientist (OCS). A main feature is the strong linkage between the academia and the industry, which is heavily supported by the governmental programs.

Such government programs have been enlisted in the table below -

i. Kamin Program

The Kamin Program forms a bridge between basic research and applied research. The Program is supported from the Ministry of Trade and Industry and involves the Office of the Chief Scientist.The Kamin Program funds public sector research groups to continue a research project into an applied phase, where it is no longer eligible for support from competitive funds intended to promote basic research and where no Israeli firm is yet willing to co-fund the work. Universities or their commercialization companies lodge applications. There appears to be two rounds of applications called each year. The principal investigator’s salary cannot be paid from a Kamin grant, although it may be supplemented from another source. The funding available for individual projects is generous.

Proposals must:

- Be technologically innovative,
- Exhibit the potential to evolve into an industrial research program,
- Show commercial and economic potential, and

- Display the availability of supporting infrastructure at the university/institute and the commitment of the principal investigator (Yeda, 2015).

The Program aims to extract the potential of public sector research for the benefit of Israeli industry. Consultants are used to evaluate the business feasibility of the project (potentialfor take-up by business in Israel, competing products in the market, potential applications, economic feasibility, comparative advantage resulting from development of the technology etc.)The Program allows for the transfer of the knowledge, which will be created to companies (including to a start-up company) for further development of the technology and for developing products for the global market.

ii. Magneton Program

Israel'sMagneton Program is an example of direct, generous support for research translation. Magneton grants support collaborative research projects involving industry and universities. The project is managed by the industry partner, which receives the grant and pays the university research team. The Magneton Program, administered by the Office of the Chief Scientist, aims to encourage technology transfer from research institutes to industry through research collaboration. Magneton aims to maximisecommercialisation of the technological capability in universities for the benefit of Israeli industry.

Magneton funding is provided for joint R&D projects. Part of the project is undertaken by the research institute and part by the industry partner. Upon project completion, the industry partner is expected to complete product development using the technology developed.To qualify for Magneton funding:

- The research institution must own the technological knowledge to be transferred
- There must be significant technological uncertainty that needs to be resolved before industry can make a decision on commencing a product development

process

- The industry partner must have suitably qualified personnel
- There should be no business connections between the research group and the industrial corporation
- The technology must not already exist elsewhere and has not been developed by another company in Israel
- The industry partner must have the capability to realise the commercial potential of the product arising from the project.

Eligible projects receive grants of up to 66 per cent of the approved budget. The project duration is 12 to 24 months. Companies cannot fund more than one third of their R&D through Magneton. The industry partner, who manages the project and pays the university research team from, submits project grant requeststhe grant. Industry partners are exempt from paying royalties on IP arising from the project.

Evaluation of the Magneton Program found that around 80 per cent of Magneton Programprojects involved a high level of innovation and achieved breakthroughs or new knowledge. Projects in communications, life sciences, optics and electronics had high success rates. Total annual funding for this Program is not known but is believed to be substantial.

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VI. JAPAN

The first *Science and Technology Basic Plan*was launched in 1996, and was based on Science and Technology Basic Law established in 1995. The basic plan aimed to construct new systems for R&D to cope with the new era, including a cooperation and exchange system beyond public and private sectors.

Following this policy, Japan arranged its legal system for public-private partnership through leadership of Ministry of Economy, Trade and Industry(METI) and Ministry of Education, Culture, Sports, Science and Technology (MEXT). The **TLO Act** (Act on the Promotion of Technology Transfer from Universities to Private Business Operators) was established in 1998, where METI and MEXT promoted the TLO (Technology Licensing Office) to provide subsidies etc. Moreover, Act on Special Measures Concerning Revitalization of Industry and Innovation in Industrial Activities, which included the Bayh-Dole clause, was established in 1999. This clause permits universities or public research institute to license their patents invented in R&D using public funds. However, partnerships between university and industry didn't progress very much with little mutual credibility in 1990's.

In 2001, a Council for Science and Technology Policy (CSTP) was established in Cabinet Office of Japan's Government as a part of the reorganization of Japan's central government ministries and agencies.The second*Science and Technology Basic Plan*was also decided in 2001. That plan stressed the necessity of "restoration of R&D results to society through industrial activity", and the importance of public-private partnership as well as the first plan. The CSTP was responsible for disseminating the importance of public-private partnership to the universities and the private business sector. An important initiative by CSTP was organization of an exhibition '*Innovation Japan*' that showcased the research results of the universities. Through these efforts, credibility between industry and university was gradually enhanced, and partnership has progressed thereafter.

Several additional measures were also taken. MEXT carried out the program promoting universities to establish offices for the intellectual property, which manage the intellectual properties from the research of the universities. In 2004, national universities, which were part of MEXT's organizations in the past, gained legally independent status as the national university corporations, increasing flexibility for partnership with industry. Additionally, MEXT amended the *Basic Act on Education* in 2006, and decided social contribution as the third role of university adding to education and research. Other measures were also carried out by MEXT, METI and ministries for technology transfer and collaboration between universities and companies. For example, METI provided subsidy to universities for building facilities to carry out joint research with companies under one roof. As a result, the number and amount of technology transfer and collaboration increased after 2001.

The number of patents which universities possess increased 10 times for domestic patents and 7 times for overseas patents from 2005 to 2013. University income from licensing or transferring patents was 2.2 billion yen in 2013. This amount is 3.5 times that of the income in 2005 (6.4 billion yen). The income from joint research is 51.7 billion yen including 39.0 billion yen from joint research with companies. This has increased from 32.3 billion yen in total, with 24.9 billion yen in joint research with companies in 2005.

All the forthcoming S&T Plans of the Japanese Government focussed on building technologically advanced nation with PPP as an integral part of the plan. The present Fifth *Science and Technology Basic Plan*, which was launched in 2016,also focuses on developing systems for promoting inclusive innovations and expanding the partnerships between industry, academia, and government.

The *Japan Revitalization Strategy 2016* was also launched in 2016 with a clear policy & target toward university reform for full-scale Industry-Academia-Government collaboration.

Another initiative is a Keidanren (Japan Business Federation) report titled "*Towards Strengthening of Industry-Academia-Government Joint Researches*" which was released in February 2016. The stated report describes the need for promotion of full-scale, top-level industry-academia-government collaboration along with reform of domestic universities and research institutes.

Funding Programs for PPP:

1. **A-STEP Program by JST**

Universities use a large percentage of government expenditure for R&D promotion, and its research results are needed to contribute to society, through industry-university partnership. Therefore, Japan Science and Technology Agency (JST) implements the *A-STEP(Adaptable and Seamless Technology Transfer Program through Target-Driven R&D)* program used for the practical application of university research output. A-STEP supports industry- academia collaborative R&D across a range of phases to develop commercial applications of research output generated by basic research in Japanese universities. A-STEP provides ten types of support for collaborative university- industry R&D across different phases of technology development. The JST determines the appropriate A-STEP funding for each phase.Depending on the R&D phase and the objectives of each particular project, A-STEP determines the optimal R&D funding and R&D period to enable the seamless pursuit of medium- to long-term R&D. Through this approach, the program aims to bridge the gaps between academic research results and industrial needs to realize highly effective and efficient innovation.

A-STEP consists of three stages, Stage I, Stage II, and Stage III. It covers a broad range of R&D phases, from the potential verification of technological seeds to development for practical application.

Stage I: Stage I has two support types. One is the “Strategic theme-focused type” and the other is the “Industrial needs response type.”

- The mission of the “Strategic theme-focused type” is to return outstanding achievements of JST’s basic research programs to society and to create the foundations of new industries. For this type, the R&D themes are selected based on notable research achievements of JST’s basic research programs. JST selects one or two R&D themes every year, holds open calls for proposals, and adopts about five projects for each theme. Applicants should be joint teams consisting of researchers both from academia and industry.
- The “Industry needs response type” aims to bolster Japanese industrial competitiveness by contributing to the solution of technical issues common in

industry. JST selects the R&D themes for this type, based on requests from industry groups, rather than respective companies. Again, JST selects one or two R&D themes every year and adopts about 10 projects for each theme. Applicants should only be academic researchers, but JST organizes meetings once or twice a year for each theme so that people from industry can exchange opinions with academic researchers.

Stage II: Stage II has one support type, the "Seeds development type." The aim of this type is to lower the technical risks of research outcomes of academia and to establish the core competencies of private companies by using academia's technology seeds. Stage II differs from Stage I in that it doesn't set any specific R&D themes, but targets all science and technology fields except for the medical and pharmaceutical fields.

With this type of funding, researchers from both academia and industry can spend the funds from JST, but the companies involved are required to share some portion of the total R&D cost. They have to provide an amount equal to one forth to one half of the funding JST provides (matching funds). The percentage, which the companies need to contribute, is determined according to their capital size.

Stage III: Stage III is the R&D phase close to the market. The main players in this stage are private companies. Depending on the R&D scale and its period, as well as the company size, two types of funding are offered in Stage III, "NexTEP-A type" and "NexTEP-B type."

- *NexTEP-A type* is like an interest-free loan, which is designed for private companies that will take on the challenge of carrying out the practical application of academic research despite the high risk of R&D. The companies supported by this type have a repayment obligation if they succeed in achieving a technological goal that they and JST have set together in advance. If they fail to achieve the pre-set goal, however, they only need to repay 10% of the total R&D cost and 90% is exempt from repayment. In addition, successful companies also have an obligation to pay to JST some portion of their sales resulting from the R&D supported by JST.

- *NexTEP-B type* is a funding type only for small and medium sized enterprises (SMEs) who work on relatively small-scale development research. SMEs supported by this type don't have a repayment obligation, but they are required to share half of the total R&D cost during their R&D period (matching funds). In addition to this, these companies have an obligation to pay to JST some portion of their revenue resulting from the R&D supported by JST, for a period of up to 10 years.

A summary of the support offered by the program to various applicants at different stages of R&D has been depicted in Table 7.

Table 6 Support offered by the A-STEP Program

	Stage I		Stage II	Stage III	
Support Type	**Industrial needs response type**	**Strategic theme-focused type**	**Seeds development type**	**NexTEP-B type**	**NexTEP-A type**
Objectives	Bolster Japanese industrial competitiveness by contributing to the solution of technical issues common in industry	Return outstanding achievements of JST's basic research programs to society and create the foundations of new industries	Lower the technical risks of research outcomes of academia and establish core competency of private companies by utilizing academia's technology seeds	Support private companies who carry out high-risk development which uses research achievements of academia. (NexTEP-B is available only for small and medium-sized enterprises whose capital is 1 billion yen or less.)	
R&D Fields	Specific R&D themes*1		Broad area*2		
Applicants' Affiliation*3	Academia	Academia and Industry	Academia and Industry	Industry	
IP	Not required		Required		
R&D Expenses (supplied by JST)	up to \ 25 million per year	up to \ 50 million per year	\ 20 million ~500 million per R&D period	Up to \ 300 million per R&D period	Up to \ 1.5 billion per R&D period
	Grant		Matching funds	Matching funds plus payment of royalties	Quasi-loan plus payment of royalties
R&D Period	2～5 years	Up to 6 years	2～6 years	up to 5 years	Up to 10 years

Source:https://www.jst.go.jp/tt/EN/univ-ip/a-step.html#supportContent

Example of products/technologies developed through the A-STEP Program

a) *Product Name: Autologous Cultured Cartilage "JACC" Development*
Company: Japan Tissue Engineering Co., Ltd. (J-TEC)
Academic Institute: Hiroshima University

J-TEC's autologous cultured cartilage JACC also received the government approval in July 2012, and is listed as an item covered by the national insurance since April 2013. Professor Mitsuo Ochi of Hiroshima University established the therapeutic technique of autologous cultured cartilage transplantation, and the technique was transferred to J-TEC. A small amount of cartilage is taken from the patient's knee, and cultured after having been mixed with atelocollagen gel and shaped into a three-dimensional form.

b) *Product Name: Clearforest*
Company: Japan Aroma Laboratory Inc.
Academic/Research Institute: Forestry and Forest Products Research Institute

Japan Aroma Laboratory Inc." together with Forestry and Forest Products Research Institute have developed the new distillation method for the air purifying essential oil from the thinned out coniferous trees and branches abandoned in forests. These distillated natural products are able to eliminate the pollutant like nitrogen dioxide, just by spraying it in the air. Moreover it can widely be useful for other applications. The microwave vacuum controlled extraction apparatus- Clearforest, enabled the extraction of more useful components for air purification.

To promote the commercial development of advanced technology seeds created and nurtured by universities and other public research institutions, JST supports the development of human resources required for industry-academia collaboration as well as a range of technology transfer activities relating to the output from academic research, including patent acquisition and licensing. JST undertakes such support while utilizing the respective R&D potential of universities and private-sector enterprises.

Other initiatives (table 8) of JST for enhancing collaborative R&D include:

Table 8 Initiatives of JST

Initiative	Characteristics
J-STORE (JST Science and Technology Research Result Database for Enterprise Development)	J-STORE is a database open to the general public free of charge, comprising patents and unpublished patentsheld by universities, JST and other parties,which are available for licensing to companies.
Innovation Japan: University Technology Exhibitions	To promote the practical application of research output from universities and public research institutions, JST organizes national-scale university knowledge fairs with the aim of matching high-quality technology seeds with the needs of industry.
New Technology Presentation Meetings	Inventors present their own perspectives on the potential for commercial applications for their new technologies to companies. In addition, opportunities are provided for direct dialogue with individual inventors. Companies may ask questions relating to presentation themes and discuss requests relating to joint research and the adoption of technologies. Approximately 60 New Technology Presentation Meetings are held each year.
Open Innovation Seminars	Companies communicate their research-related needs to universities, including issues that require short-term solutions and issues on which companies wish to conduct collaborative research. The main objective of Open Innovation Seminars is to facilitate the generation of new technology.
Portal Site for Industry-Academia-Government (IAG) Collaboration	The Industry-Academia-Government Guidepost Website provides a wide range of

	information relating to IAG collaboration for all interested parties to meet their information needs. The site is open to the general public for free.

Industry-Academia-Government collaboration support database	Online database that has a wide range of available information to support the parties involved in IAG collaboration
	
	• Program and project database
	  ➢ R&D support programs conducted by public institutions like national and regional government agencies
	  ➢ Financial assistance programs operated by foundations and other bodies
	  ➢ Venture capital
	
	• Database of experts involved in coordination and promotion of IAG collaboration
	• Database of events related to IAG collaboration

2. National R&D projects by New Energy and Industrial Technology Development Organisation (NEDO)

NEDO is one of Japan's three main R&D funding organisations. NEDO provides funds to business enterprises for projects that are undertaken in partnership with universities and/or Advanced Industrial Science and Technology (AIST). These projects explore future technology ideas as well as mid- to long-term industrial technology development. NEDO is funded by the Ministry for Economy, Trade and Industry (METI) with a 2015 budget of ¥131.9 billion (approximately $A1.4 billion).

NEDO currently funds and manages around 64 national R&D projects to support the development of important technologies that are high risk and would not be developed by private companies on their own. The projects run for 5–10 years. NEDO supports the employment of new graduates from universities or graduate schools, and also mid-career engineers from companies. Research funded by NEDO may result in academic papers and patents. Research results are expected to be commercialized by companies participating in the R&D projects. NEDO has a 30 per cent of target rate for commercialisation of R&D. The 2015 budget for the 64 national projects is ¥121.5 billion (approximately $A1.4 billion).

3. Promotion of start –ups from universities: START Program by JST

a) Start-ups from universities in Japan

In 2001, METI announced the plan to establish 1000 start-ups within 3 years. This target was achieved in 2004, by efforts of ministries, universities and private sector, for example, METI provided subsidy to R&D by start-ups. The University of Tokyo established its VC named UTEC (University of Tokyo Edge Capital), and promoted start-ups. Half of the start-ups were in an early stage and were developing the products before commercialization. As of 2008, the number of start-ups from universities increased to 1,800. The policy to promote start-ups from universities was in the middle way from the view-point of the social use of research results of universities. From 2008 to 2013, METI supported establishment of facilities of potential strongholds, in major regions, where Industry-Academia-Government get together "under one roof" in order to bridge leading technologies in the region for practical development (subsidy up to 2/3 of the facility cost).

b) START program

The START Program (Program for creating start-ups from advanced research and technology) was initiated by MEXT in 2012 and transferred to JST in 2015. The Program aims to develop business/IP strategy and commercialise technology 'seeds' in universities that are risky but have great potential. START works by combining government funding and private sector commercialization knowledge at the time that a start-up is founded. A researcher and an entrepreneur with a team of experts jointly formulate an R&D and business development plan. Milestones are determined on the basis of market needs. The Program consists of two sub-programs:

- “Project promotor support” sub-program calls for application and chooses business promoters from capable persons who have commercialization know-how and who want to promote R&D and business building integrally. This sub-program provides the business promotors with expenditure for the activities to discover the promising technological seeds and to provide hands-on support with using their human network and know-how. Thus this sub-program aims at the inducement of the private fund within 3-5 years.
- The “project support” sub-program calls for application of good technological seeds from universities or public research institutes firstly. Secondly technological seeds in the applications are evaluated and due diligences are carried out by the approved business promoters. Thirdly, universities and business promoters submit joint applications of projects to bring promising seeds to market and fourthly, JST examines these applications. Approved projects can gain expenditure for R&D from JST. And the approved universities etc. support the R&D managed by the business promoters. 56 business promotors in 13 units and 58 projects have been approved including finished projects under this program, uptill 2014.

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VII. SOUTH KOREA

Korea has transformed itself from a stagnant agrarian society into one of the most dynamic industrial economies of the world within the past five decades. As an economy develops toward an advanced level, technological competence becomes a critical factor. To build up the competence, it is required to nurture high-caliber scientists and engineers who are capable of dealing with the developments at scientific and technological frontiers. In other words, advanced education in science and technology should come first in preparing for entrance into a developed world. In the case of Korea, education and industrialization helped each other in sustaining and accelerating mutual development.Korea's industrialization evolved from imitation to innovation and together, the public and private sectors of Korea focused strategically on competitiveness through increased technological self-sufficiency and identificationof new sources of technology. The Korean globalization strategy takes advantage of all opportunities to improve its technological infrastructure and global competitiveness.

The 5thBasic Plan for Technology Transfer and Commercialisation Promotionis being implemented by the Ministry of Technology, Industry and Energy. Key contents of the plan include: Targets and strategies of technology transfer &commercialisation, matters related to budgets for the implementation of the plans, activities and infrastructure to promote technology transfer, ways to strengthen technical evaluation, and financial support to stimulate technology commercialisation.

Earlier plans have been considered successful; the number of technology transfers had doubled and royalty income in 2012 increased 1.6 times compared to those of 2007. The Plan sets targets for increases in the technology transfer rate and research productivity of public research institutes, and outlines strategies to achieve them, such as to stabilise the operation of the technology trade market, enhance the technology marketing capabilities of public research institutes, supply technologies with high potential for commercialisation, and foster an environment favourable to the growth of companies at the early commercialisation phase.

Korean technological advances have relied on cooperation and collaboration to a surprising degree, since the late 1980s. Example of technological advancement as a result of successful collaboration was the designation of CDMA technology as a national project. A government-led consortium of private firms and the Electronics and Telecommunications Research Institute (ETRI) chose to develop the core technology through an alliance with the US company Qualcomm. CDMA, now the global standard behind 3G, was rolled out first in Korea in 1996, and since then Korean telecoms companies have continued to drive up mobile phone penetrationrates with the offering of 3G CDMA services, CDMA wireless data services and wireless mobile internet services.D-RAM development is another example.

As a part of its globalization strategy, the Korean government developed a plan to select and develop strategic industrial technology requiring nationwide R&D investment. This plan, called the highly advanced national (HAN) projects, develops and assimilates core technologies in strategic areas where Korea will have the capacity and capability to compete on the level of more advanced countries by 2001. Korea cannot upgrade its capacity in every industry to the level of all highly advanced nations, but it intends to build and maintain its competitiveness in selected industries by concentrating its limited R&D resources.

A HAN project is a large-scale R&D project carried out through joint investment by the government and the chaebols under a long-term project management system, which is supported by inter-ministerial cooperation and coordination. Various R&D actors such as universities, industries, and government-supported research institutes participate in each project. For the areas where domestic R&D capacity is lacking, international cooperation is actively pursued.

However, this project has been discontinued/was not renewed.

i. Centers of Excellence (SRCs/ ERCs)

In 1989, Korea Science and Engineering Foundation (KOSEF), a government-supported non-profit organization, initiated a program to support university research and create collaborations between universities and industries. It was aimed at fostering university research potentials and building university-industry research relationships. The result was the Centers of Excellence. There are major Centers of Excellence (COE) in Korea, namely: Science Research Centers (SRCs), Engineering Research Centers (ERCs), and Regional Research Centers (RRCs). These COEs were put up to implement programs that encourage basic research in major universities. The SRCs and ERCs, founded, in May 1989, focus on the creative and innovative research in basic sciences and new technologies, while the RRCs, which started in 1995, emphasize cooperative research between regional universities and industries. SRCs and ERCs were selected on the basis of creativity and research capability. In the selection of RRCs, both research capability and contribution to the regional economy and community are important factors. Once the centers are selected, they receive government's funding for nine years provided that the interim evaluation done every three years shows good progress.

The SRC/ERC program plays a vital role in upgrading our science and technology by carrying out the following functions and activities.

- To do cross-disciplinary research - The most important function of the centers is not to perform cooperative research in traditional areas such as machinery, electricity, physics, chemistry, etc., but to perform horizontal cooperative research. Professors, graduate and undergraduate students are needed to join in cooperative research in both industry and government related research institutes (GRRIs), together utilizing the laboratories and equipment of these institutes.
- To give science and engineering education - The centers train graduate and undergraduate students to synthesize, integrate and control engineering systems in areas whereindustrial personnel are needed. The centers utilize cross- disciplinary research approaches.
- To provide a continuing education program for industry - They give continuing education to provide engineers, from industry and GRRIs, with new knowledge.

- To cooperate with industries and GRRIs - The centers carry out exchanges and joint research programs by sending professors and university students to industries and GRRIs and vice versa. They maintain the membership system through membership fees from industries and GRRIs. Universities cooperate with them by distributing periodicals to their members.

ii. Korean Industrial Research Council

The project aims to increase the internal capability of Technology Liaison Offices (TLOs) and spread research outcomes by providing effective programs on IP management and technology transfer/commercialisation. It aims to improve the IP management capabilities of government-funded research institutes' TLOs. The project is divided into three programs listed below with specific objectives:

1. To resolve common issues faced by government-funded research institutes in an aim to improve quality of the support program and achieve work efficiency.
2. To provide dedicated support to late starter TLOs.
3. To provide customised support to strengthen the capabilities of individual government-funded research institutes with weak IP management capabilities.

iii. Science Town

One of the initiatives of the government was developing Government-led Institutions for Active Support of the Private Sector for Information, R&D and Financing. The Korean government set up a R&D cluster in the town of Daedok, in the year 1973. This was when the science park development, in Korea, began to gain momentum. The Daedok Science Town (DaedokInnopolis, since 2005) was created intentionally created as an engine of enhancing the national competitiveness of high technology and economic prosperity through the agglomeration of research institutes, universities and private enterprises (Oh and Yeom, 2012).Presently it houses close to 30 government research institutes (GRIs),42 private research institutes (PRIs), 5 universities, 8 support agencies, over 400 corporate R&D centres and more than 1200 high-technology companies (SMEs). Most of these companies are spin-offs from GRIs and PRIs.

The main functional features of the science park have been illustrated in the figure 10 below.

Function	Main Features	Key Role
R&D	- HEIs that lead advanced science technology R&D. - Government affiliated research institutes : In order to increase national science and technology capacity, major R&D projects were supported by the government. (government affiliated institutes)	HEIs, National R&D Center
Business	- Firms that originated from research institutes in advanced science fields. - Venture firms that originated from labs in HEIs or research institutes (research centered HEIs).	Spin-offs of R&D labs
Infrastructure	- Management departments in HEIs or research institutes. - A special management institute, which is established by the central government, managed and operated the Science Park. → An independent management institute is established. - The Science Park should be managed, designed, and developed by the central government.	Administration and Management of on science park development

Figure 10 Functional features of Science Park

Source: Oh and Yeom, 2012

The active components of the science town can be characterised by the following features-

Industry: In DaedeokInnopolis, with its high concentration of R&D functions, technology-intensive venture firms achieve rapid growth and new technologies find active world application through start-ups. DaedeokInnopolis serves as both cradle and stronghold for thousands of high-tech venture companies, a place where state- of-the-art technologies and the finest entrepreneurship in the world come together.

Academia: Some 15% of all PhD level engineering and science researchers in Korea are concentrated in DaedeokInnopolis, giving it the greatest capacity for R&D in the nation. By nurturing world-class scientists and research professionals, Daedeok plays a crucial role in the cultivation of world leaders.

Research: In DaedeokInnopolis, state-funded research institutes and corporate research centers with proven records of technological innovation in such fields as IT and aerospace engineering are working ceaselessly to produce the world's best achievements in R&D. In particular, high-qualified innovation manpower are also the driving force behind the technological creativity and cultural diversity characterizing DaedeokInnopolis.

The generous investments and support of central and local governments, continue to serve as Daedeok’s facilitator, patron, and partner, DaedeokInnopolis is rapidly transforming into a shining hub of global innovation of high- tech sectors including technology commercialization.

iv. Private Universities

Private universities and colleges make up a very large proportion of the Republic of Korea’s education institutions. The government funds higher education institutions through indirect measures such as competition grants and performance funding. As a result of this approach, high-performing universities have received more subsidies. One of these universities is Pohang University of Science and Technology (POSTECH). It is unique due to its position as a private university that was able to achieve, over just the past 2 decades, world-class status. The Pohang Iron and Steel Company (POSCO) established the university in 1986 for the purpose of managing the research institute, as well as for providing advanced education for budding engineers and laying the groundwork for future technology development. To continuously produce high-impact research outcomes, POSTECH has been reinforcing strategic resource allocation, collaborative research, and international research partnerships. POSTECH has expanded research collaboration with companies other than POSCO and, at the same time, has actively participated in government-funded projects. Nevertheless, POSCO’s research fund still accounts for the largest portion of research revenue, about 50% (World Bank, 2011).

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VIII. CHINA

Scientific and technological cooperation between the industry and the universities/academia began in China in the 1950s and was mostly a result of the governments order. However the present scenario of U-I collaborations and partnerships between the public and private sectors is rather mutual. Over the past two decades China has made immense progress in S&T and at the same time the higher education system of China has developed at an unprecedented scale in terms of capacity, level and R&D competence. Collaborations have aided the R&D activities in the country, have enhanced the capacities of enterprises, and generated novel products/technologies. These partnerships have benefitted the academic sector also by helping the universities renew their curriculum, adapting new teaching programs, update their R&D infrastructures, uptake of skilled workforce etc.

In China the government has initiated most of the R&D programs and therefore the U-I collaborations too are usually accompanied with the government's involvement. Hence *University-Industry-Government* collaboration is also referred to as *University-Industry* collaboration.

Ministry of Science and Technology (MOST), is a central government agency under the State Council and it is responsible for the nation's science and technology activities.Departments of Science and Technology of various ministries and administrative agencies are responsible for its science and technology activities.

Science and Technology Departments or Bureaus in the local governments are responsible for its science and technology activities.

There are six main R&D resources in China:

- Chinese Academy of Sciences
- R&D institutions under the various ministries and administrative agencies
- Industrial enterprises
- Universities and colleges
- Local R&D institutions
- R&D institutions affiliated to defense

The national mid-long-term frameworks for Science and Technology Development, and Education Reform and Development support the translation and industrialization of research achievements and various laws have been enacted from promoting research collaborations and transfer of technologies.

However the Chinese government, for promoting the Triple Helix of industry-academia-government has initiated a few programs –

1) The Torch Program

The Torch Program was designed to develop the strength and potential of Chinese S&T and facilitate the commercialisation of high-tech achievements, the industrialisation of high-tech products, and the internationalisation of high-tech industries. Through this Program, the government creates an environment that helps knowledge and S&T talent enter the market as essential productive factors, and establish a corresponding mechanism. The Program also creates an innovative environment for high-tech enterprises, and supports the uptake of technologies and the integration of firms in supply chains.

One of the main goals of the Torch Program is to support enterprises' independent innovation. The Program enables private enterprises to compete for government-funded S&T projects, allowing private technology companies to use stock options to encourage innovation and entrepreneurship. In particular, the Program promotes entrepreneurship and development of

S&T enterprises by nurturing business incubators. The Torch Program also contributes to the multi-level capital market, and promotes the construction of an investment and financing system that provides solutions to the financing difficulties encountered by technology companies.

Key tasks of the Torch Program include:

- building high-tech industrial development zones
- building technology business incubators
- building the national software industrial base
- implementing projects aimed at the development and industrialization of high-tech products with economic benefits and strong potential.

2) **Blue Flame Program**

Launched in 2008 by the Science & Technology Development Centre of the Ministry of Education, the Blue Flame Program is designed to facilitate targeted collaboration among HEIs and local governments and organisations, using the advantages of HEIs in talent and S&T, to integrate regional economic and industrial characteristics and needs closely. The main objectives of the Blue Flame Program:

- Organise for research staff to communicate with enterprises, understand the technical difficulties they encounter, and promote the translation of universities' research outputs, and solve practical problems experienced by enterprise;
- Establish a long-term mechanism for collaboration between HEIs and industries, and to introduce a market mechanism to build a policy conducive to transforming research achievements. The Program also plans to build specialised and standardised large-scale technology transfer centres in universities, and foster a number of high quality S&T service teams; and
- Build a system for collaboration between HEIs and industries. The Program is designed to build a network and platform for collaboration between HEIs and industries, making technology transfer and the mobility of talent and knowledge between HEIs and enterprises operate more smoothly.

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IX. SINGAPORE

Singapore abides being a dynamic science & technology hub, alongside the R&D

activities, which conferred significantly towards the building of a knowledge-driven/intensive and entrepreneurial economy. Under the aegis of the Prime Minister's Office, the National Research Foundation of Singapore (NRF) was established in January 2006. NRF aims at setting a national direction for R&D by drafting policies, strategies, and plans of action for research, innovation and entrepreneurial activities. It has taken the onus of honing and nurturing research by funding well planned initiatives and building R&D capacities. With these pursuits, NRF aims to transmogrify the country into a dynamic and tenacious R&D hub, which will provide for a knowledge-intensive and enterprising economy, thereby effecting Singapore into an appealing destination for S&T and innovation.

The NRF works on the following 'Mission' statement (https://www.nrf.gov.sg/about-nrf/national-research-foundation-singapore):

- Developing policies, plans and strategies for research, innovation and enterprise;
- Funding initiatives that strengthen research and scientific capabilities, and achieve economic and national impact;
- Building up R&D capabilities and capacities through nurturing our people and attracting foreign researchers and scientists; and
- Coordinating the research agenda of different agencies to transform Singapore into a knowledge-intensive, innovative and entrepreneurial economy.

Four pillars of thrust undermine the plan of action to evolve the economy of Singapore. The transformation of the economy into an innovative and enterprising one has been realized through building the innovation ecosystem on these very four pillars, which are-

- Strengthening foundational capabilities;
- Developing talent;
- Driving research excellence through competition; and
- Ensuring impact through public-private collaborations, industry-oriented R&D, and commercialization.

The Research, Innovation and Enterprise (RIE) scenario in Singapore is composed of different ministries, R&D funding agencies and R&D analysts/performers (figure 11).

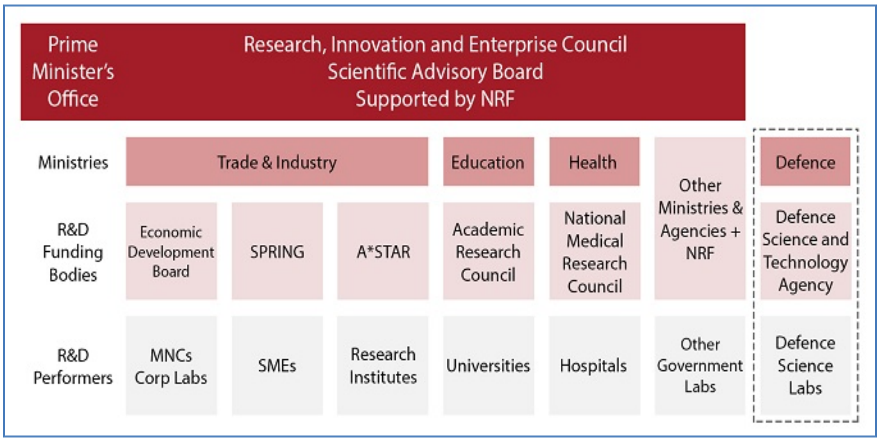

Figure 11 The Research, Innovation and Enterprise (RIE) system in Singapore (https://www.nrf.gov.sg/about-nrf/rie-ecosystem)

The Research, Innovation and Enterprise Council (RIEC), is supervised and regulated by the Prime Minister and is responsible for overseeing the long term strategic plans with respect to science, technology and innovation. The NRF also supports RIEC, which draws out five-year plans and policies in accordance with the national issues and challenges.

The various programs/initiatives and schemes operating in the PPP mode in Singapore are as follows -

i. National Research Foundation (NRF): Corporate Laboratory@ University

The scheme ofCorporate Laboratory@University was put into motion by NRF in 2013, for securing the foundation of laboratory set up of key industries in the universities. Through this kind of initiative this scheme seeks to strengthen the innovation scenario by reassuring the collaboration of public (universities) and private (companies) sector for R&D. This scheme caters to establishing laboratories of domestic as well as international companies in autonomous universities for performing industry-driven and relevant research activities. This arrangement ensures that the academic institutions bring about conclusive impacts by working on effective solutions for the issues faced by the industries, with whom they have collaborated. The environment created by this sort of collaboration ensured that the researchers from the public domain as well as private domain work alongside on mutually selected areas and generating outputs that possess relevance to the private firms. This initiative has lead to marginal increase in the effective translation of public research into commercial entities and services. Apart from this there are multiple benefits brought about by the laboratory set up of an industry in a university. The research activities being undertaken are geared for supporting growth of companies and for spawning financial benefits. The scholars at the universities advantage from the industrial involvement and emerge as better prepared for employment in the industrial sector. The partners from the industries gain complete access to the intelligentsia of the university and can effectively utilize the scientific and technological expertise of the faculty/mentors.

Beginning from 2013, nine such laboratories have been set up at various universities of Singapore (https://www.nrf.gov.sg/programmes/corporate-laboratory@university-scheme). The table 9 below enlists the collaborating partners of the Corporate Labs set up till date:

Table 9 List of Corporate laboratories set up at different Universities in Singapore

Name of the Corporate Lab	Industrial Partner	Academic Partner	Year of Establishment
Rolls-Royce@NTUCorporate Lab	Rolls-Royce	Nanyang Technological University (NTU)	2013
Keppel-NUS Corporate Laboratory	Keppel Corporation	National University of Singapore (NUS)	2013
Urban Computing and Engineering Centre of Excellence	Fujitsu Limited	Singapore Management University (SMU)	2014
ST Engineering-NTU Corporate Laboratory	ST Engineering	Nanyang Technological University (NTU)	2015
Sembcorp-NUS Corporate Laboratory	Sembcorp Industries	National University of Singapore	2016
ST Electronics-SUTD Cyber Security Laboratory	Singapore Technologies Electronics Limited (ST Electronics)	Singapore University of Technology and Design (SUTD)	2016
SMRT-NTU Smart Urban Rail Corporate Laboratory	SMRT Corporation Ltd.	Nanyang Technological University (NTU)	2016
Delta-NTU Corporate Laboratory for Cyber-	Delta Electronics	Nanyang Technological	2016

Physical Systems		University (NTU)	
NUS-Singtel Cyber Security Lab	Singapore Telecommunications Ltd. (Singtel)	National University of Singapore (NUS)	2016

ii. **Central Gap Fund**

This program also aims at advocating and backing the translation of R&D outputs into commercial entities, which along with generating wealth also provide societal as well as environmental benefits. The initiative is applicable on a national platform and strongly encourages the collaborative participation of performers of public domain and that of the private domain, for undertaking resourceful and impactful projects. The proposals submitted for the grant must aim at developing early on technologies into working models/prototypes, which are functionally closer to the market needs and also clearly demonstrate their place/position in the demand supply chain. This characteristic is helpful in ensuring investments from the private sector and even receptacles of commercialization. Research projects that involve fundamental and basic research or general academic research are not covered under the ambit of this scheme and hence are not suitable for submission. All public-funded researchers (from PRIs) and government-linked corporate entities are eligible to apply for Central Gap Fund. The team applying for the project must mandatorily consist of a 'business development resource', for providing the much-required expertise for arriving onto the commercial outputs of the project. This is crucial as one of the objectives of Central Gap is to imbue the commercialization of outcomes of R&D activities into suitable practical applications. The projects are awarded for a period of two years and the time period may be extended for another 12 months. Considering the not very long time period of support, it is imperative that the project proposal is well thought out and certain specifications be met beforehand. Few points that need to addressed before submitting the proposals include:

- Selection of possible collaborators - Even though the requirement of collaboration is not strict however, the grant prefers collaborative projects. Therefore, the project team is firstly recommended to scan for analogous or complimentary projects within the surrounding industrial landscape and approach them, if found. The lead of the project is required to justify the efforts made in this direction and also provide reasons for no collaboration/lack of suitable collaborators.

- Undertake an intellectual property (IP)/technology study- The team submitting the proposal is also mandated to perform a study for identifying related technology of IPs that may affect the intermediary or final products of research project. This also gives the teams a heads up with regards to the areas where their proposed technology can be exploited.
- Development of a preliminary business plan – An initial assessment of the market and industry scenario along with identification of a protocol for commercialization of the outputs is also a task that the team needs to perform beforehand. The endorsements from probable investors/end-users are taken in a positive light and make the award of grant promising. However, no specific template for a business plan applies to all and the teams are free to approach a mentor for the development of the same. The teams may also undergo training and special courses on entrepreneurship. There are specific boot camps operating for the purpose and the example of one such program is the Lean LaunchPad Program (http://leanlaunchpad.nus.edu.sg)*.

Lean LaunchPad – It is the first entrepreneurial program, piloted by National University of Singapore in Singapore. This program is for helping researchers and engineers transform their inventive activities into commercial products/services and viable ventures of business. This program was initiated in 2013 and is modeled on the US National Science Foundation I-Corps program. However, the program has been adapted to suit the context of Singapore.

iii. Technology Consortia

NRF along with Institutes of Higher Learning (IHLs) worked for setting up of Technology Consortia (https://www.nrf.gov.sg/programmes/technology-consortia). NRF also through its schemes like ‘Competitive Research Programme’ (CRP) cultivates the creation of multi-disciplinary groups/crewfor conductinghigh expertise and high-risk (cutting-edge) research activities that are relevant to the country and society. Under this scheme, the research being undertaken is inclusive, and coordinated and the initiative also brings together complementary researchers under an aegis for undertaking high impact research and innovation. Through the measures of CRP, capacities and expert groups in specific technology domains have formed in Singapore. The Technology Consortia has been structured around the pockets developed through CRP and works on individual domains for generating outcomes in a specific technology area.

The basis of each consortium is partaking of knowledge and transferring technology by means of effective university-industry partnerships. The benefits accrued through this initiative are almost similar to the ones bestowed by other PPP initiatives.

The consortia seek to invigorate user-encouragedstudies, translation of know-how, instructing and training manpower, and generate awareness in the specified technology domain. All these purposes are accomplished through nurturing and upholding research dialogues amongst academia, business and government organizations.

The IHLs streamline their agendas according to the private sector and develop protocols, which are more affiliated to the prerequisites of the industries. Enterprises also receive opportunities to formbasis on the knowledge findings of the IHLs for strengthening their technical capabilities, join forexpertise seminars prearranged by the researchers for learning about the latest findings of research, and engageinvestigators for their intramural R&D exertions. The members of the industry and the academia can also obtain other grants and support from the authoritative agencies through formulation a new collaborative project.

As of present, the NRF has established five technology consortia –

1. Singapore Spintronics Consortium (http://sg-spin.nus.edu.sg)

   The first of the Technology Consortia to be established was the Singapore Spintronics Consortium (SG-SPIN). It was founded in December 2014 through the joint efforts of National University of Singapore (NUS), Nanyang Technological University (NTU), and National Research Foundation (NRF). The main task of the syndicate is to cultivate interactions and promote further alliances amid academia and business R&D groups in the general zones of spintronics and magnetics.

   The instituting affiliates of SG-SPIN are NUS, NTU (academia), Applied Materials, Inc., Delta Electronics and GLOBALFOUNDRIES (industry members). The Industry Liaison Office (ILO) of NUS, seized the opportunity to lead in compelling and motivating this association, reinforced by NRF and NTU's NTUitive*.

*NTUitive - NTUitivePte Ltd (NTUitive; http://www.ntuitive.sg/about-us) is the NTU's 'innovation and enterprise company'. NTUitivewas created to support the task of the university mission to advance groundbreaking ecosystem to inculcaterevolutionary innovations, further entrepreneurship and expedite the commercialization of universities research outputs.

2. LUX Photonics Consortium (http://luxphotonicsconsortium-sg.org)

The LUX Photonics Consortium leaped across in September, 2015 and was founded in association with NTU, NUS, the Agency for Science, Technology and Research (A*STAR) and Technolite (industry partner).

3. Singapore Cybersecurity Consortium (http://luxphotonicsconsortium-sg.org)

This consortium is affixed at NUS and was set up in 2016. It serves as a platform for cross-section interactions between the public agencies, industries, academia and the National Cyber-security (NCR) R&D program. Presently there are 26 member industries, six government agencies (apart from NRF) and ten IHLs including NUS, in the consortium.

4. Singapore Consortium for Synthetic Biology (SINERGY), has been established by the efforts of significant partners i.e. NUS, NTU, A*STAR and Temasek Life Sciences Laboratory, with the backing from NRF. Close to S$34 millionhave been invested in eight research projects in the domain of synthetic biology by NRF, vide the grant of Biological Design Tools and Applications (BDTA) and CRP. The group will leverage from the R&Dactivities undertaken by the above-mentioned projects and look for opportunities to translate the research outputs. The consortium has more than 10 industries as its member partners.

5. Singapore Data Science Consortium was established for intensifying Singapore's prevailing assets in the field of data science and analytics. SDSC like other consortia, aims at strengthening linkages amid IHLs, Research Institutes and Industries. This shall facilitate industry'sacceptance of the latest advances in data science and analytics technologies. The Consortium, set up by NRF in alliance NUS, NTU, SMU and A*STAR, will operate in association with the Economic Development Board (EDB) and the Infocomm Media Development Authority (IMDA). The EBD and IMDA would involve businesses in six different economic sectors, i.e.healthcare; finance; manufacturing; customer and retail; logistics; and transport.

iv. Test-Bedding and Demonstration of Innovative Research

The 'Test-Bedding and Demonstration of Innovative Research' initiative targets at making use of the efforts in direction laid by the Government for demonstrating probability of pioneering technologies and foster adoption by the private enterprises. The projects approved for funding encompass partnerships with indigenous industries, which certifies commercialization of solution obtained through dedicated research efforts. Examples of a technology industrialized through this initiative.

- QuicaBot (short for Quality Inspection and Assessment Robot), is a technology that can move around independently and examine/scan a room within a very short time period. It employs cameras of latest technology and laser scanners to identify defects such as uneven surfaces, cracks etc. The researchers from NTU in association with JTC CORPORATION and a local start-up called Ctrl Works invented this technology.

v. A-STAR

The Agency for Science, Technology and Research (A*STAR) energies pecific research that aims at advancing science discovery and innovation. The agency plays a crucial position in cultivating and nurturing the capacity for research organizations, and industries. The agency has devised different models for associating with industries, public sector organizations and the broader communities of research.

These models have been structures depending on the research requirements and capacity domains. The four engagement models are:

a) *Many to Many* – This model entails the existence of multiple Research Institutes (RIs) and industries for creating an efficient platform of collaboration between the private and the public sector, to work on special themes and bolstering the research capabilities. An example of the same is the 'EpiGen Global Research Consortium' that engages the Singapore Institute of Clinical Sciences (SICS) [an international research organization with 5 member parties in 3 different countries]
b) *Many to One* – This model entails the participation of numerous public researchers while engaging with one partner for materializing long-term planned partnerships. Through this model the scientific expertise of different disciplines are integrated for delivering impactful solutions. The collaborative lab established through the joint efforts of Applied Materials, Inc. (American corporation), Institute of Microelectronics (IME), Institute of Materials Research and Engineering (IMRE) and the Institute of High Performance Computing (IHPC) is an example of the model. The lab makes use of the cross-disciplinary R&D capacities, thereby catalyzing the advancement of novel techniques/protocols for developing the fabrication methodology of semiconductor devices.
c) *One to Many* – In this model several companies come together with one RI to develop a consortium, which focuses on the strength of the RI. Example – 'Nanoimprint Foundry' anchored by the Institute of Materials Research and Engineering (IMRE) collaborates with industries like Toshiba Machine, Micro Resist Technology and Kyodo International for working on the applications of nano-imprint technology.
d) *One to One* –this model includes work on an individual research project and formation of a joint laboratory for the same. The Institute of Bioengineering and Nanotechnology (IBN) and Delta Electronics, cooperatively created a diagnostics laboratory for focusing on emerging know-hows for better infectious disease recognition and custom-made medication.

The 'Industry Consortia Programs' of A-STAR takes advantage of the wide base of the technical proficiency existing at the Science and Engineering Research Council (SERC) Research Institutes for aiding the indigenous industries in developing new technologies and move ahead. These programs also give an opportunity to the small local industries to work in association with the SERC research institutes as well as big multinational corporations by means of research partnerships and membership initiatives. These Joint-Research Programs are essentially one-to-one research partnerships between a firm and A*STAR research institutes (RIs).

Novel breakthrough technologies are essential for evolution and development of new processes/products etc. and the research has to be supported by both the industry as well as the academia. In light of this the A*STAR research organizations have made associations with prominent industry players. Examples of such partnerships include the Singapore Bio-imaging Consortium (SBIC) – Nikon Imaging Centre, and the Clinical Imaging Research Centre – a joint venture between NUS and A*STAR with industry partner, Siemens.

This sort of an association has the capacity to serve as a platform for the industry to learn new insights from researchers thereby facilitating advancement of technology and the devising of novel methodologies and techniques.

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- https://www.nrf.gov.sg/about-nrf/national-research-foundation-singapore
- http://leanlaunchpad.nus.edu.sg
- https://www.nrf.gov.sg/programmes/technology-consortia
- http://www.ntuitive.sg/about-us
- http://luxphotonicsconsortium-sg.org

X. SWEDEN

Sweden has enjoyed strong economic growth in recent years. The present government aims to make growth more sustainable, inclusive and green, which will depend in part on Sweden's future research and innovation performance. The government's 2012 Research and Innovation Bill (for the period 2013-16) established a more selective, quality-based funding approach, and increased public expenditure on STI over this period by USD 445 million PPP (SEK 4 billion) – or by 15% compared to 2012, which followed a substantial increase of USD 625 million PPP (SEK 5 billion) during 2009–12. In connection to this target was set for for GERD to reach 4% of GDP by 2020. The Bill for 2017–20 was published on November 28 2016, setting the orientation of research and innovation policy and the funding frame for the coming four years (2017-20) and with a perspective towards 2026.

i. VINN Excellence Center Program

The program VINN Excellence Center offers a completely new generation of competence centers in Sweden, which strengthen the link between science and industry by creating an excellent academic research environment. Industrial enterprises participate actively to generate long-term benefits. Their mission is to strengthen the important link between academic research groups and industrial research and development (R&D) in the Swedish innovation system in the long term. The participation of industry means that research is focused on those areas, which are interesting for industry and present a challenge for academia. The purpose of this approach is to create new knowledge and new technologies, which result in new products, processes and services.

The creation of competence centers in the university landscape has already had a long tradition in Sweden. Even in the early 90s NUTEK (National Board for Technical and Industrial Development), VINNOVA's (Swedish Agency for Innovation Systems) predecessor, started the first generation of such centers (Competence Research Centers CRCs) in Sweden. Between 1995 and 2005 the Swedish industry, the government (NUTEK/VINNOVA) and universities together invested €550m (4.9 BSEK) in research co-operations of the 30 selected CRCs which were all affiliated to a total of eight Swedish universities. Sweden was therefore one of the first countries in Europe which supported this type of competence center (Lidgard and Lundberg 2010).

The reason to initiate the CRCs was the Swedish market failure, which was primarily caused by insufficient production of knowledge relevant to industry. The reason NUTEK gave for the implementation of the predecessor program CRC was that Swedish scientists only had very weak contacts to other areas of society and that universities made relatively low investments in industry-related research. In order to resolve this situation NUTEK saw the need for a new organization, which would coordinate research and industry.

The objective of these competence centers was to achieve increased interaction between science and industry in order to improve the NIS (Arnold, Clark and Bussillet 2004). This should be done by systematically integrating industry into long-term multi-disciplinary academic research to sustainably increase the international competitive- ness of the Swedish industry. According to NUTEK, the increasing complexity of technologies made it necessary that industry does not only conduct its own research, but also opens up to external knowledge. The universities, on the other hand, would have to meet societal requirements for relevant knowledge and make R&D efforts more efficient (Hjorth 2000).

The VINN Excellence Centers are not focused on research in specific areas or disciplines, although they focus more on the strategic aim of sustainable growth than their predecessor program the competence centers. The VINN Excellence Centers deal with basic research and applied research and they collaborate in order to ensure that new insights and new technological developments result in new products, processes and services. Overall, they can be regarded as the secondphase of the Swedish predecessor program of the competence centers and with that also pursues the fundamental objectives, which this program itself has pursued. Naturally in the new program of the VINN Excellence Center the emphasis is particularly placed on,

- Advancing the development of academic excellence centers which actively involve enterprises and research groups and conduct joint research,
- Supporting the introduction and implementation of new technologies and

sustainably expanding and strengthen the technical competence of the Swedish industry.

Additional priorities are the funding of R&D co-operations, strengthening excellence, relevance of research management at universities as well as training researchers and others who are involved in the innovation process. Attaining these objectives is to contribute to sustainable growth in Sweden.

The VINN Excellence Center Programs focuses on groups of researchers, industries involved in R&D and actors of the public sector. Universities as well as researchers can initiate such a center although the center itself always has to be at a university. All those involved in a center have two basic tasks, financial and active involvement in the research process. Currently VINNOVA supports 18 VINN Excellence Centers financially where a total of nine universities collaborate with over a hundred enterprises and public research facilities. The 18 centers are financed in four phases for a maximum often years. Before every new phase an international evaluation of its activities as a whole is carried out for each center (Anaya-Carlsson/Lundberg 2014 und Lundberg 2011).

VINNOVA makes no stipulations regarding the organizational form and governance. A managing director and a board manage the centers. The participants can decide on the research direction. Members of the enterprises and the public are the majority (ERAWATCH 2014). Regarding the creation of effective and efficient organizational structures, the first evaluation (2009) advises VINNOVA to analyze best practice structures and guidelines and thereby offer the Centers support (Reeve et al. 2009).

There were no explicit stipulations in the call for tenders regarding the spatial relationship, which has to exist between the persons involved in a VINN Excellence Center. Nevertheless, it was required that the Centers must be located at a university, which stipulated the spatial component. In addition the spatial dimension was a significant success criterion in the first evaluation. The "geographical programs" for which the majority of work was done directly at the university were evaluated as particularly positive as they achieved a "minimum degree" of interaction between research and education (Reeve et al. 2009).

Regarding the management of IPR (eye level principle), VINNOVA has in principle no binding stipulations regarding the collaboration of actors from science and industry. In principle, many individual agreements about IPR are therefore possible (Runesson 2006). However, over time VINNOVA commissioned a model agreement as it transpired relatively quickly that this issue in particular was difficult to clarify. All partners were constantly in contact while this model agreement was drawn up. In the beginning the lawyer VINNOVA commissioned received approximately 300,000 ideas, which he needed to examine. After six months, a contract was drawn up and all three parties (industry, university and public sector) came to a so-called 70% agreement. The model agreement is applied everywhere. The model agreement consists of the following regulations regarding research results:

- All parties of the center can make use of the results for future research free of charge.
- All parties of a project can make use of the results for commercial purposes.
- Parties of the Center may not refer to their background knowledge to prevent another party form using the results free of charge.
- Enterprises that participate in a project and are not competitors can sign own contracts on the right to commercialize the results. These contracts do not affect the usufruct of the universities
- The usufruct of the results for the project parties also includes the right to give a license to a third party after an agreement has been reached with the other parties.
- When a project party has made a claim to exclusively make use of a result the other parties can forbid that competing enterprises receive licenses.
- The other parties always have to give permission to license results if the results are part of an R&D background which the party pursues with another party from the Center or pursues jointly with a third party or was commissioned by a third party.
- Enterprises that are involved in a Center can always grant licenses for the results to companies for which they alone have control or to enterprises that have control over the party.
- The university can transfer its usufruct to the involved enterprises.
- Agreed restrictions of the usufruct are only to be applied so the usufruct is based on the sole intellectual ownership or constitutes commercial law.

- Agreed restrictions of the usufruct are to be restricted to a maximum of seven years as of the EU market introduction of the products. Agreed restrictions of the usufruct can expire earlier or become invalid if the total market share of the enterprises exceeds a certain thresh- old and when agreed thresholds are considered a barrier to competition.

In principle, this model proposal treats all parties of a Center as equals and pays particular attention to enterprises which are involved are not disadvantaged when other enterprises make use of licenses or third parties are granted licenses.

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Future Work

National Scenario
• The data presented from each of the organization/institution under the ambit of three different categories will be sent for verification to the corresponding organization/institution. • The ministries of GoI and other departments dealing with R&D activities shall be contacted for updating data regarding PPP initiatives/schemes of the respective ministry.

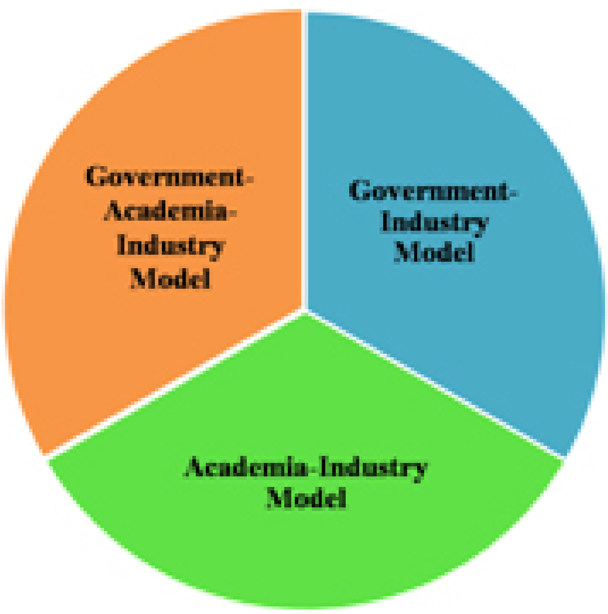
International Scenario
• The data presented for each of the country will be vetted after contacting the concerned personnel in the consulate/embassy (in India) or the Consulate/Embassy of India in the respective countries. • The officials in-charge of the programmes/initiatives discussed shall be contacted for validating the information and providing further information. • Analysis of other countries including U.K., Germany etc. would be carried out. • Relevant inferences shall be drawn from the collected information.

Appendix I

DST-Centre for Policy Research at PU, Chd.
(DST/PRC/CPR-03/2013)

Existing Models of R&D under Public Private Partnership (PPP) Mode

(May, 2015 –Aug., 2016)



Department of Science & Technology
Govt. of India

DST-Centre for Policy Research at PU, Chd.

(DST/PRC/CPR-03/2013)

REPORT – 4

(April, 2016 – July, 2017)

Compilation of Reports on Strengthening R&D in Universities

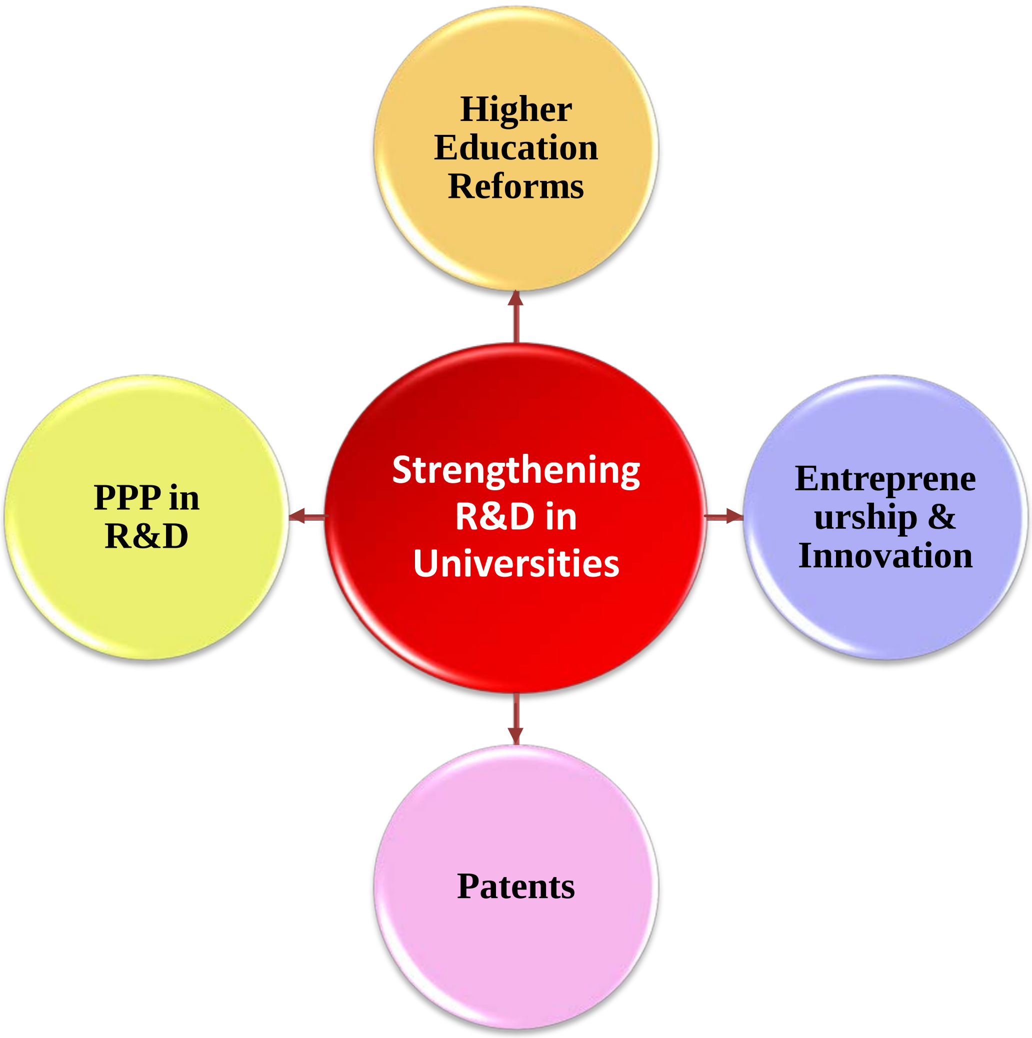


Table of Contents

Introduction

Science, Technology and Innovation have emerged as the major drivers of national development globally. India is also seriously pursuing sustainable and inclusive development through the applications of Science and Technology. Working in this direction, the Ministry of the Science and Technology, Government of India (GoI) released STI Policy, 2013 during 100^{th} Indian Science Congress held in Kolkata. This policy has laid special emphasis on promoting innovative research and R&D outputs for commercial and societal gains. The STI-2013 has been drafted with a vision of realizing the dreams of an aspiring India by accelerating the pace of discovery of Science- led solutions for faster, sustainable and inclusive growth.

The STI, 2013 policy strongly advocates the strengthening of Industry-Academia (I-A) interactions in India which will in turn lead to promotion of private sector investments in R&D and stimulate translation of knowledge into commercial solutions for the economic growth of the country. Therefore in this present scenario, the strengthening of I-A interaction regarding R&D activities is vital for all ministries that are related to Science and Technology in India. In the last decade many ministries have constituted committees for making recommendations for enhancing I-A interactions in R&D of Higher Education Institutes (HEIs) . The following table enumerates the 28 reports that were found relevant from the perspective of I-A interaction.

Table: List of Reports compiled for the study

S. No.	Name of the Report	Ministry/Department	Year of Publication
1.	India Science Report	National Council of Applied Economic Research	2005
2.	Report of the working group on CSIR, Eleventh Five Year Plan 2007-2012	CSIR	2006
3.	Report of the working group for eleventh five year plan	DSIR	2006
4.	NKC Compilation of Recommendations on Education	National Knowledge Commission	2007
5.	Innovation in India		2007
6.	Towards a knowledge Society		2008
7.	Entrepreneurship		2008
8.	More quality Ph. Ds		2008
9.	Creative (Technopreneur Promotion Programme (TePP)	DSIR	2010

10.	Consolidated Working Group Report of the Dept. of Higher Education for 12 year plan on higher education, technical education & private sector participation including PPP in higher education	MHRD	2011
11.	Report of the Working Group on Higher Education for the 12 five year plan	MHRD	2011
12.	Inclusive and Qualitative Expansion of Higher Education 12th five year plan, 2012-17	UGC	2011
13.	Report of the Working Group On Science & Technology Human Resource Development For 12th Five Year Plan (2012-17)	DST	2011
14.	Cross Flow of Technology, Report Of The Working Group for The Twelfth Five Year Plan	MHRD	2011
15.	CSIR@80: Vision & Strategy 2022	CSIR	2011
16.	Committee Report on Corporate Participation in Higher Education (Narayana Murthy Committee Report)	Planning Commission	2012
17.	Rashtriya Uchchatar Shiksha Abhiyan (RUSA): National Higher Education Mission	MHRD	2013
18.	Select case Studies of A-I collaboration	CII+MHRD	2013
19.	Workshop on A-I collaboration	MHRD	2013
20.	National Biotechnology Development Strategy	DBT	2014
21.	Report of the Expert Committee on Innovation and Entrepreneurship	Niti Aayog	2015
22.	National Biotechnology Development Strategy 2015-2020	DBT	2015
23.	International Comparative Performance of India’s Research Base (2009-14)	DST	2015

24.	Recommendations of CII -National Committee on Higher Education on New Education Policy	CII	2015
25.	Knowledge Economy	CII	2015
26.	National Policy on Education, 2016	MHRD	2016
27.	All India Survey on Higher Education (2014-2015)	MHRD	2016
28.	Education Statistics at a Glance	MHRD	2016

We have endeavoured to compile the recommendations arising out of the above mentioned reports. Our main purpose was to consolidate the activities carried out by the relevant ministries for the purpose of enhancing I-A interactions. The report has been organised into four major headings i.e., 1) Higher Education Reforms, 2) Entrepreneurship & Innovations, 3) Patents and 4) PPP in R&D. Under these major headings recommendation have been compiled from the above mentioned reports as well as from the various I-A interactions and studies conducted by our Centre.

1. Higher Education Reforms

Indian Higher Education is a mammoth system comprising of 803 Universities out of which there are 365 State Universities, 122 Deemed to be Universities, 47 Central Universities and 269 Private Universities (UGC, as of June 2017), 39071 colleges and 11923 Stand Alone Institutions. The total enrolment of students in the higher education sector has been estimated to be around 34.2 million. In the graduation level, the highest numbers of students are enrolled in B.A programmes followed by B.Com and B.Sc programmes. Around 79.4% of the total enrolled students are under undergraduate level and an estimated 0.34% students which amounts to 1,17,301 students are enrolled in PhD programmes (2014-2015). It is further estimated that a total number of 14,73,255 teachers are working in the higher education sector (All India Survey on Higher Education, 2016).

With the onset of the knowledge economy, the role of the higher education system is gradually being seen as a driver of economic growth and sustainability. This new functionality of higher education sector necessitates close ties with the industrial sector, particularly through strengthening Industry- Academia linkages. On top of that due to fast paced globalisation, our society has also realised the need of securing global reputation for our higher education institutions. In order to realise these expectations, it has become imperative to urgently reform our higher education system. Higher education reforms can be discussed under the various sub –heads mentioned below.

A: Infrastructure

Higher education sector is facing acute shortage of adequate infrastructure. The infrastructural shortage consists of glaring gaps in physical infrastructure, research facilities, knowledge clusters, science parks etc. This is a stumbling block in the endeavors of the government towards expansion of higher education Measures taken to effectively improve the infrastructural framework of the higher education sector have the potential to significantly alter the knowledge economy over the medium and long term.

The following recommendations can be considered to enlarge and enhance the infrastructural framework of the higher education sector in India.

- **Setting up theme based Research/Innovation universities under PPP mode**: In order to be at par with global R&D instuitions, it is essential to have at least 100 world class research/innovation institutions, which can be established at a typical investment of Rs. 500-600 crores per institution and spread over all states of India which might be covered in a span of 8-10 years. National Universities can be established by the government, or by a private sponsoring body by setting up a society, charitable trust or Section 25 company or under PPP mode. Industries having R&D investment of over Rs. 1000 crores (TATA, RIL, Mohindras and Mohindras etc.) may be invited for establishing theme based instituions.

- **Consolidating and improving the capacity and quality of the existing institutions.** The concept of Meta University aimed at collaborative and multi-disciplinary learning that redefines knowledge-creation and knowledge-sharing in the twenty-first century, should be explored. The strategy of converting universities into Research Universities, on the pattern of China (e.g. Peking University, Tsinghua University, University of Science and Technology of China, etc.) may also be adopted in India.

- **Inter University Centres:** The few inter university centres that have been set up have proved the concept to be a successful and viable one. Such centres need to be multiplied in different fields to enable a wider cross section of university researchers access advanced research facilities and equipment which are otherwise not available in university environments.
- **Creation of Industrial Zones in Universities**: In universities engaged in applied-research, Govt. may set up 'Industrial Zones' which cater to entrepreneurship programmes, business management programmes, space for incubates/ start-up companies. This facility may be created under PPP mode.

- **Research-Building Funds**: In India, the funding agencies provide grants for R&D projects and refurbishing of laboratories. However, there is no provision of funds for the construction of buildings for housing R&D facilities like Entrepreneurship Centre, Incubation Centres, Centres of Excellence, I-A Cell, IPR Cell, Technology Transfer Cell, Laboratory Animal Facility, Bio-safety level-III facility, Test- Beds, Workshops and so on. To give impetus to applied research it is suggested that MHRD along with UGC and AICTE should earmark dedicated funds for the construction of buildings for R&D related activities. The presence of such facilities will definitely encourage university scientists to orient their research towards translational R&D.
- **Establishment of Translational Research Centre (TRC):** The study carried out by our Centre suggests that HEIs excelling in translational research have strong IPR and Tech Transfer set ups. In order to promote the spirit of patenting in the universities, it is felt that each university should have a TRC having a vibrant Patent Cell, managed by a professional/s competent enough to assist/guide young researchers and teaching-faculty in patent search/filing and technology transfer (if possible). Each TRC should lay down robust policies of IPR and Tech Transfer. Industries are reluctant to forge R&D collaborations if these policies are not in place.

- **Setting up of Business & Marketing Entities in Universities** : Generally, the administrative ecosystem of the universities is not conducive for smooth functioning of patenting and Tech Transfer processes. Red tapism and ambiguous rules/regulations hampers the scientists to tread this path. To promote the culture of patenting and Tech. development/transfer, it is recommended that universities be permitted and encouraged to establish a legally distinct non-profit entity such as Society, Trust, Foundation or Section 25 Company to exploit/ market its knowledge base, products, databases etc. *Evidence:* Foundation for Innovation in Technology Transfer (FITT) in IIT-Delhi is an autonomous body, set up by Govt. of India, and is dedicated for promoting Industry-Academia interactions and converting academic knowledge of IIT-D into commercial products. FITT is financially self sufficient, well connected with private sector and has a hefty bank balance (around 30 crores). During last one decade it has licensed ~33 technologies and incubation of > 46 Start ups.

- **Setting up of IPR Academies:** It is suggested that in each state, one university is adopted for the setting up of IPR Academy, which runs dedicated IPR programmes/workshops for researchers and scientists throughout the year. The main objective of the IPR Academy will be to generate at least two resource persons for each university. The IPR Academy will act as mentor for the universities associated with it. The IPR Academies may be financed by DIPP/CIPAM for its administration and for running IPR programmes.

- **Creation of 'Industry Academia Web Portal':** Though, Indian academic sector is engaged in applied research of industrial relevance, but the private sector finds it difficult to access the expertise and facilities existing in the academic institutes. It is suggested that 'Web Portals' caterings to the expectations of industry from academia be created at university level, state level and national level, displaying the following parameters existing in universities: Scientific expertise (field wise), b) Centres of Excellence, c) Infrastructure facilities such as sophisticated instruments, test beds, animal facility, library, workshops, fermentation facility etc., d) Patents (filed/granted Technologies (transferred, available & under process), e) IPR and Tech Transfer policies of the institute, f) Entrepreneurship and Incubator programmes of institute.The institutes may use CRIKC I-A web portal as a template. The information collected from all the institutes should be collated to construct a 'National I-A Web Portal'. The responsibility of maintaining and updating the 'National I-A Web Portal' may be delegated to MHRD or DST or DIPP.

B: Faculty Development

There must be a conscious effort to attract and retain talented faculty members. This is necessary because talented students who are potential faculty members have choices that are far more attractive in other professions in India or in the academic profession outside India. It is necessary to provide working conditions in the form of office space and research support combined with housing. But it may not be sufficient. This must be combined with some incentives and rewards for performance. There is, however, another dimension to the problem. Universities do not always choose the best in part because of native-son/daughter policies which leave them to select their own former students. This tends to lower quality and foster parochialization in universities. Therefore, cross-pollination between universities should be encouraged. It may be worth introducing a ceiling, say one-half or even one third, on the proportion of faculty members than can be hired from within the university. This would almost certainly engender greater competition and more transparency in faculty appointments. The following recommendations may be considered:

- **Faculty Fellowships for Indian Academics:** Academicians should be encouraged to to be stakeholders/partners of the entrepreneurial and incubation eco-systems in universities by offering “faculty entrepreneurial fellowships”.
- **Employing retired employees from corporations:** Retired employees from reputed Corporates with relevant experience may be encouraged to undertake a second-career in teaching in higher education institutions, after completion of a short training/orientation course.
- **Industrial training for academic leaders:** Industry could help train the academic leaders like Vice-chancellors, finance officers, administrators, principals and head of departments on leadership skills.
- Introduction of crash-courses on IPR, Entrepreneurship and Business Management for science faculty.
- **Mobility of R&D professionals of public sector to private sector and vice versa**, with full pay and job protection should be encouraged. Provisions of sabbatical leave for the faculty members engaged in applied research to spend time in industry to understand industrial environment should be made.
- Incentives should be given to academicians/scientists having industry tie ups for pursuing collaborative I-A R&D. Similarly, industries having research tie ups with universities or R&D institutes should be incentivized.

C: Central level and State level

The formulation and implementation of policies, programmes and projects that emanates from the various central ministries and funding agencies relevant to scientific research in India invariably influences the quality of research in the country. The following points may be pondered upon for quality enhancement at the central, funding agency and state level:

- **Dedicated R&D Funds for State Universities by the Funding Agencies:** If India has to progress in the domain of scientific research, patents and technologies, the R&D ecosystem of state universities needs to be improved. These universities need to be empowered with R&D infrastructure and Translational Research Ecosystem. It is strongly recommended that central government, through its funding agencies, creates a special R&D fund for State governed universities. State universities, having potential of good R&D, should be mentored by an experienced faculty member of central universities/autonomous institutes. To begin with, top ten percent of the universities showing promising research, as evidenced from their research publications, patents and technology transfers, may be provided special funding for R&D.

- **Special Fund under Maintenance Grant:** The funding agencies are quite liberal in granting money for creating R&D facilities including purchase of equipments. However, it is difficult to maintain the equipments after the warranty period is over. Almost each institute is facing this problem. It is suggested that funding agencies should create a separate fund under Maintenance Grant, to be utilized by a scientist/institute.
- **Creation of Talent Retention Grant**: A fresh Ph.D pass out finds it difficult to get absorbed immediately once his/her Ph.D *viva voce* has been conducted. It might take an year, may be more, before he/she gets a job or post doctoral fellowship. In order to utilize the services of these highly talented scholars, it is recommended that funding agencies may initiate 'Talent Retention Scheme' (TRG), under which a fresh Ph.D pass out can continue working in the laboratory for at least an year. This time period can be utilized by the candidate (or his/her Ph.D guide) to continue working on interesting leads found during Ph.D research work or channelize his/her innovative research into generation of patent/technology. A candidate may apply for TRG, six months prior to the submission of Ph.D thesis, so that he/her gets the grant immediately after the Ph.D *viva voce* has been conducted.
- **I-A Activities as an Important Criterion in National Assessment and Accreditation Council (NAAC) Evaluation of Universities:** NAAC, an autonomous body of UGC, is an organization that assesses and accredits institutions of higher education. One of the NAAC evaluation criteria is 'Consultancy' by the faculty of the university/college. By replacing 'Consultancy' category with 'I-A Activities' category (consultancy, industry sponsored activities like, R&D projects, industry chairs, centre of excellence and I-A fares/symposia/workshops) and allotting more weightage for the same, the universities will be bound to promote I-A activities.
- **Creation of UGC-IP Fund:** Public sector R&D funding agencies like CSIR, DRDO, ICAR etc. take care of the charges involved in patents (filing and maintenance) generated by their scientists. Unfortunately, UGC has no such provision. It is the discretion of the university to set aside funds for patenting. In reality, universities are not in a position to create IP Fund due to financial constraints, thereby creating a bottle neck in stimulating IP ecosystem in the universities. It is suggested that UGC-IP Fund be created as is prevalent in CSIR/DRDO/ICAR.
- **Linking of Universities, R&D laboratories and Industries:** Our nation has a mammoth strength of public funded R&D laboratories (over 500), > 1700 DSIR certified private R&D labs. and hundreds of HEIs (institutes of national importance + NAAC 'A' accredited universities) excelling in research.

However, each sector has its own strengths and limitations. Universities are rich in intelligentsia and man power, but have limited availability of sophisticated instruments and knowledge of R&D problems of the private sector i.e. industries. Public funded R&D labs have ample sophisticated instruments but are limited in manpower and understanding of R&D bottle necks of the industries. Private sector is well aware of the needs of the society that can be addressed by developing innovative products but have limited R&D manpower and research facilities. The limitations of each body can be overcome by developing meaningful linkages with other two bodies. And the net result would be improvement in the area of applied research resulting into increased number of patents, products and technologies. Government would be the biggest beneficiary of these alliances, as it does not have to spend even a single additional penny, but the quotient of research publications, patents, technologies will increase.

D: Reform Existing Universities

The endeavour to transform higher education must be initiated by reforming existing institutions. There are several institutional as well as procedural gaps that are hindering the fast and efficient functioning of most of the higher education institutions in India.

A mechanism needs to be devised to support the State's endeavour to create Research Universities by improving its infrastructure, creating enabling governance structures which would help achieve academic excellence, attract high quality talent, forge linkages with industry, peer institutions, the academia and other stakeholders and facilitate resource mobilisation for continued enhanced research activities.

The Research University should be supported with complete autonomy in matters of administration, academics and finances for development of a vision for the future. The Governing and Academic Council should be broad-based to include representatives from industry, globally renowned institutions and peer academic institutions.

The following steps can be considered for the reformation of existing universities:

- **Appointment of R&D oriented Vice-Chancellors:** Universities having a track record of excellent scientific research should be headed by a reputed scientist. It has been observed that, if a Vice- Chancellor of a university is from arts/languages/social-sciences/law/music background, he/she may find difficult to understand the importance of scientific research/fervour and thus may not be promoting scientific research to a level it should be. Hence, it is recommended that science-oriented universities may be headed by a reputed scientist having good administrative skills.

- A serious re-look is needed on the academic syllabi of science subjects. Syllabi should be in tune with the requirements of the industries. Dedicated courses on entrepreneurship development, IPRs and business management programmes should be introduced.
- **Reforms in Promotion Criteria for Teaching Faculty:** A Promotion criterion for universities faculty is heavily tilted towards research publications. Due weightage to scientists working on industry related projects should be given.
- For the promotions of Asstt. Professor to Assoc. Professor and Assoc. Professor, to full Professor, a condition for having successfully completed at least one industry activity i.e. consultation, tenure (period: at least 6 months) in industry, technology transfer, patent, member/expert in governing body of industry/industry association etc. should be mandated.

E: Research Focus

We attempted to create stand-alone research institutions, pampered with resources, in the belief that research should be moved out of universities. In the process, we forgot an essential principle. There are synergies between teaching and research that enrich each other. And it is universities which are the natural home for research. What is more, for universities, research is essential in the pursuit of academic excellence. It is time to reverse what happened in the past and make universities the hub of research once again. This would need changes in resource-allocation, reward-systems and mindsets. Substantial grants should be allocated for research. The provisions of these grants should be competitive and the criteria for these grants should be different from the usual criteria for non-plan and plan grants.

For India's higher education institutions to be truly world-class, research should be fostered in addition to teaching. This is also a huge opportunity for the corporate sector to participate in research by supporting doctoral programs and providing funding for research. They can also directly collaborate on joint research.

- **'The Indian Corporate R&D Fund'** should be set up with a corpus of Rs. 5,000 crores on the lines of National Science Foundation in the United States of America. This should be funded by the central government and the corporate operating in India. Such a fund operating with a transparent and merit based funding mechanism can act as a huge fillip for R&D in all Indian universities and higher education institutions.
- Tax exemption to corporate to the extent of 300% of their contribution should be provided by the government

- To recognize the local priorities, local enterprise partnerships between Small and Medium Enterprises (SME) and universities should be promoted. Through these partnerships, the SMEs can leverage the facilities of the universities in the region.
- A flexible public-private partnership (PPP) developmental framework should be defined to build local synergies and to leverage existing resources/capabilities to their full potential
- Two percent of the budgeted allocation of each Ministry /Department should be exclusively earmarked for research will reap a lot of benefits and go a long way in creating an enabling climate of research.
- Transparent centrally implementable **Performance Related Incentive Scheme (PRIS)** based on past and proven track record in research, should be put in place to enable grant based investments in such performers. For R&D leading to technology development and knowledge services, the criteria would, however, be institution specific. Centrally instituted incentives to public-funded R&D centres for outcomes leading to public and strategic goods could be introduced.
- Industry should be involved from the very beginning of the university research projects having industrial implications. Using this approach, the project will be more focussed and shorten the time for commercialization of the technology developed.

F: Funding Access for Students

To bring in competitiveness and upgrade the quality of the institutions, students should be empowered in their choice of institutions. Students should be free to pursue education in institutions of their choice without worries of finance and have easy access to inexpensive loans. Therefore, there is a need to provide funding not only to educational institutions but also to students. This will provide more opportunities for students to pursue higher education in institutions of their choice.

- **Industry-Academia Scholarship/Fellowship Schemes:** DST (GoI) has introduced 'PM's Fellowship Scheme for Doctoral Research' It is recommended that in order to stimulate I-A collaborative R&D, higher education bodies i.e. UGC and AICTE should initiate similar schemes for Ph.D and post-doctorate research work
- A scholarship to be named **"The Indian Corporate Higher Education Scholarship"** should be set up with a corpus of Rs.1,000 crores contributed by the top 1000 corporations of the country. This should be run by an eminent independent board. This scheme should be encouraged by the government by providing full matching grants as well as providing tax exemption of up to 300% for all contributions.

2. Entrepreneurship & Innovation

Entrepreneurship and Innovation has the potential to create much required economic growth in India coupled with employment opportunities. Entrepreneurship gives young people an opportunity to work on their own skills and interests and in the process, creating their own and additional employment. Encouraging entrepreneurship in young people is an important way of harnessing their enthusiasm, energy and ambition to contribute to economic development. According to the World Bank's World Development Report, 2013, around 600 million new jobs will be required in the next 15 years to support a growing workforce. It is important to note that in most emerging economies, 9 out of 10 jobs are created by the private sector, which is the foundation of any thriving economy.

Entrepreneurship and Innovation are so closely linked together since innovation is of utmost importance for the long-term success and survival of any enterprise. In the absence of new and innovative ideas, enterprises find it difficult to grow and struggle to sustain their business. Innovation is not only about designing a new product or service but can also be new ideas which can improve efficiency, cut down on waste and increase profits. There are several reasons why innovation is critical to business success. Innovation help to discover what opportunities exist now or will appear in future. It will help an enterprise to stay ahead of its competitors. If a company doesn't adapt to its changing environment by constant reinvention of its products & processes, it will soon be surpassed by its competitors.

If we take a glance at India's recent history of successful entrepreneurs, the names that have etched into public memory are Bharti's Airtel, Karsanbhai's Nirma, Dhirubhai's Reliance, Kiran Shaw's Biocon, Iyengar's TVS group, Munjal's Hero, among the inexhaustible list of Indians who have carved a niche in the entrepreneurial hall of fame. This knowledge enforces the thought that Indians are adept entrepreneurs. However, in the Indian system we also need targeted training and assistance with access to funding, recognition of their contribution and social tolerance for failure along with a streamlined tax and regulatory system in order to harness the potential of our budding entrepreneurs.

The following listed recommendations are especially relevant for promoting Entrepreneurship and Innovation in India.

A: What the Government Can Do

The government can encourage a sustainable and conducive business environment by ensuring simplified processes for establishing startups, reducing bureaucratic regimes and corruption, addressing the specific and peculiar needs of start-ups such as the provision of seed funds, reduction of risk and harnessing support from corporate players to provide both mentorship and funding, improving governance regulations and norms,.

I. **Creating an enabling entrepreneurial ecosystem.** The following are some important points that can contribute towards creation of an enabling entrepreneurial ecosystem:

- The wide publicity of information related to entrepreneurship and innovation including various promotional schemes and policies through creation of regularly updated information sources catering to the needs for start-up and entrepreneurs in the form of web portals, books and periodicals.
- Introduce a Single Unique Company Number to be used by new businesses for company, social security and tax registrations.
- Creation of dedicated commercial courts for speedy enforcement of contracts and dispute resolution.
- Bankruptcy laws needs to be reformed in order to ease the process of closing down businesses.
- Innovative PPP mechanisms should be explored for setting up a Public Fund for new entrepreneurs.
- A comprehensive and effective Incubation Policy at the national level needs to be developed; this will increase scale of innovation, enhance quality and increase access to financing.
- Explore crucial incentive structures in Incubation such as land schemes (given the level of infrastructure problems that start-ups face), tax sops, banking policies, micro funds, innovative financial schemes, outcome measurement and delivery mechanisms.
- Explore possibilities of PPP as well as private incubation centres as a way to increase the number of incubation centres in the country and thereby providing wider access to incubation opportunity for new entrepreneurs.
- Government should set up a Global Technology Acquisition Fund in Intellectual Property (IP), which can enable crucial technology acquisition across the world, especially for SMEs. Funds could be placed with a financial institution or a special purpose vehicle

(SPV) could be created to manage the fund, with members of industry and government invited on the board. Relevant financial instruments, including support in the form of loans and equity could be evolved for such technology intensive acquisition.

- Enact legislation that creates a legal framework for public funded research. Such legislation would give universities and research institutions ownership and patent rights and create an enabling environment for them to commercialize such inventions through licensing arrangements where the inventors would also receive a share of royalties.
- Frame appropriate polices to encourage innovation among smaller institutions and companies and encourage transition among R&D/educational institutions.
- Give high priority to Vocational Education and Training (VET) policy and bring about a transformation in the sector through innovative delivery models, re-branding, improving certification and monitoring as well as increasing flexibility of VET with the higher education stream.
- Explore performance-based models in VET policy that links incentives to outcomes. Incentivize State Council for Vocational Training (SCVT) and states; assess the entry stage requirements of each trainee; align financial incentives to teaching of requisite English language skills as well as to a transparent industry-backed certification system for each trainee. Encourage learning by doing earning; connect financing to performance based outcomes through nationwide publication and dissemination of learning outcomes in the form of a Vocational Skill Primer, that measures each VET institution; publication of performance based outcomes becomes therefore the first step in developing a transparent, independent rating system in VET.
- Develop recognition and reward systems for Entrepreneurship, at the local, state as well as national levels (such as those instituted by MSME at the national level).
- Implement far reaching changes in higher education policy to enhance quality, quantity and inclusiveness.
- Modernize and make transparent and accessible IPR infrastructure.
- Explore the possibility of innovative social security for entrepreneurs to encourage ability to take risks.

II. **Fostering a National Entrepreneurship & Innovation Movement:** Celebrating and recognizing entrepreneurship at the national level could go a long way in raising the profile of entrepreneurs, shedding light on their role and importance in society, and encouraging more young people to consider entrepreneurship as a career. The following recommendations may be considered:

- **Institute a 'National Entrepreneurs' Day:** The committee recommends instituting a National Entrepreneurs' Day during which entrepreneurial success from different entrepreneurship programs is celebrated. On this day, winners of competitions such as those between entrepreneurs from different state initiatives, or business plan competitions run by incubators, could be honored. **In the USA, National Entrepreneurs' Day** is held on the third November every year since 2010. It is observed to celebrate the contributions of the American men and women who promote entrepreneurship, business, innovation, and creation of new jobs.
- **National Action Brigade:** Setting up a platform called National Action Brigade to get youth and others interested and involved in multiple ways. The Action Brigade could be a network of volunteers helping with the "back-end" of setting up online entrepreneurial platforms, volunteering for events such as the National Entrepreneurs' Day, and helping build other assets for the Atal Innovation Mission. One could think along the lines of the National Cadet Corps (NCC).
- **National Knowledge Infrastructure:** Developing powerful knowledge infrastructure is just as crucial as building world-class institutions and organizations. Without highly-skilled intellectuals, academics, managers and leaders, even the most progressive physical infrastructure and facilities will remain under-utilized. The country needs to invest and nurture its talent from academia and industry, as well as tap into the network of accomplished Indians globally. The Indian diaspora have attained much professional and personal acclaim in several countries around the world. For example, the Indian-American community is among the most educated and affluent in the US. Roughly a third of new ventures in Silicon Valley are promoted by entrepreneurs of Indian origin. This massive knowledge pool of NRIs, from all over the world covers all the major advanced technology sectors and could be harnessed quickly. China, with a laser-like focus on tapping into its own diaspora, has shown the way over the past three decades. Members of the diaspora could be offered time-bound assignments, opportunities to attend/conduct seminars, teach short or long-term courses at universities and more.

III. Improving the Ease of Doing Business:

- **Digitization of government permits:** The central government must require all government departments to have all registrations, permissions, and licenses to be online within two years. States must be given incentives and ranked based on electronic, single window compliance within a deadline. The process for name, approval, and company incorporation needs to move completely online. There could be a deadline of three days free, and one day with payment of expedited services. All new laws should be mandatorily born digitally native. Automation of as many government processes should take place, and discretion of government officials should be reduced as much as possible, to reduce red-tape. Innovation in governance is critical. Without this, even well-intentioned policies are doomed to fail.

- **Create a Central ID for enterprises:** Every enterprise in India, whether company or not, is assigned multiple numbers. A single number for enterprises is a key ease of doing business initiative and the basis for the "online" portal for enterprises proposed above. The AIM should set up a committee to chart a 1-year roadmap for all enterprise numbers to converge on the Central ID.

Among the Multiple Identities Issued to Indian companies are:

- Corporate Identity Number (21 digit alphanumeric) from ROC
- Tax Payer Identification Number for Commercial Taxes (11 digit numeric)
- Service Tax Number (15 digit alphanumeric)
- PAN Number (10 digit alphanumeric)
- Central Excise (PAN Number +2 characters)
- Provident Fund Number (11 digit alphanumeric)
- Profession Tax Registration Certificate (9 digit numeric)
- Profession Tax Enrollment Certificate (9 digit numeric)
- Tax Deduction and Calculation Number (10 digit alphanumeric)
- ESIC number (17 digit numeric)
- Labour Department Registration Number (13 digit alphanumeric but varies from state to state)
- Importer Exporter Code (10 digit numeric)
- Shops and Establishments Act Registration (20+ digits alphanumeric)
- CLRA Registration (15+ digits alphanumeric)
- Labour Welfare Board (5 digit numeric)

- **Creating an enabling environment for social enterprise**: Creating the relevant infrastructure to promote social enterprise is important. Though we have several successes in this space, efforts need to be scaled up to have an impact at the macro level. In the following box, we discuss what can be done to promote social entrepreneurship.

Encouraging Social Enterprise: Social entrepreneurship is the recognition of a social problem and the uses of entrepreneurial principles to organize create and manage a social venture to achieve a desired social change. Social entrepreneurs are commonly associated with the voluntary and not-for-profit sectors, but this need not preclude making a profit. Social entrepreneurship has progressed significantly in India over the last decade. Companies like Narayan Hospitals, Arvind Eye Hospitals, and Vaatsalya Healthcare are well-known and recognized for improving access to affordable healthcare. Pratham and Aakanksha are well-recognized for improving access to education amongst the underprivileged. Several enterprises have been set up to deliver high-quality affordable solar solutions for families living off-grid. Of late, many SMEs have been set up to encourage rural craftsmanship. Impact investing is becoming increasingly better established in India, with over $1.6 billion invested in over 220 enterprises since 2000.

However, there is still a long way to go. Though several ventures are creating impact on a local/ regional basis, the impact at the macro level appears small. Furthermore, 60% of all impact investment was channelled to just 15 out of the 220 enterprises, and 70% of investment was directed towards microfinance and financial inclusion. Areas like water and sanitation, affordable housing, energy, education, and healthcare need funding and attention. Much can be done to encourage these ventures.

Some measures that would encourage social enterprise are:

A. Involving the corporate sector to fund social enterprise: The corporate sector could have much to gain from partnering with social entrepreneurs. This includes reaching untapped markets through entrepreneurs who have spent decades refining innovation means of bringing excluded groups into the marketplace. It also includes attracting more " millennials" , for whom social impact is a key component of job satisfaction. The 2% CSR "tax" (estimated to amount to $2.5 billion per year) on corporate presents a significant pool of domestic funds that could be used to fund social enterprise. To be effective, funds need to be utilized efficiently. Improved transparency on CSR spend is much required. This could be achieved through collation of company-level CSR information on an e-platform. This could help firms augment each others' CSR efforts, rather than duplicate them. Coordination of CSR can be done by industry bodies. A common fund to pool CSR resources to make sure the corpus is spent intelligently could also be useful. One option is for firms to aggregate CSR funds and channel them to Impact Investors (like Aavishkaar, Acumen, and Elevar Equity), as these organizations have the skill and expertise to generate and monitor impact.

B. Encouraging the setting up of business incubators for social impact: UnLtd, Dasra, and Khosla Labs, are amongst the most prominent incubators for social enterprise. Many more such incubators are needed to provide expertise, technical help, and financial support for social enterprise. A quick way to achieve impact is to set up virtual incubators i.e. curated sites to provide social entrepreneurs with access to advisors, mentors, and experts, remotely.

C. Promoting a culture of "giving back": The government should encourage philanthropy amongst high net-worth individuals to increase funding. One way is to provide tax credits to HNIs that invest in early stage VCs or to incubators and angel investors. Involve students in finding solutions to practical problems could promote a culture of innovation and may increase the number of professionals working in the social impact space.

IV. **Government to support venture capital institutions:**

The private sector needs to assume a greater role in promoting Innovation in the country. The budding innovators should be catalyzed through venture capital institutions, who would ensure critical assessment of the funding required by the budding innovator. Government may co-invest along with the venture capital institutions to the extent of 50% and also refinance the Venture Capitalists through a Fund. This support should be extended in key priority areas where the country wishes to be a leader in the world.

It may be noted here that, in a small way, the Technology Development Board (TDB) under DST provides soft loan @ 5% for commercialization of technologies and products. It also provides equity support to companies through venture capital funds.

V. "**Idea to Production" time to be minimized**:

The budding innovators should be enabled to productionize their ideas at the earliest so that their enthusiasm is not killed in the time consuming start-up procedure which takes nearly two years. For this purpose, the Government should set up readymade factory sheds which can be rented to the innovators for a limited period. In this connection, it may be worthwhile to note that Cooperation Research Centres (CRCs) have been promoted in Australia as engines of innovation since its establishment in 1990. The CRC programme links researchers with industry and government with a focus towards research application. CRC provides grants for medium to long term Industry led collaborations for up-to ten years and for short term collaborations for up to three years. At least one Australian university and one private sector participant is mandatory for these collaborations. National Science Foundation (NSF) has also sponsored Engineering Research Centres (ERCs) in the US which have industry – university partnership with NSF acting as a catalyst since its foundation during 1984. The commercialisation of academic research is one of the primary goals of ERCs. ERCs are initially funded by the NSF and they are expected to be self-sustaining within 10 years of their foundation. These research centres are equipped with all the facilities required for transforming an innovative idea into a model / prototype followed by up-scaling to pilot plant level and thereafter, commercialization. India may study these centres and adopt them suitably.

VI. **Product commercialization:**

Many Indian Companies insist that their intending suppliers must have a "Proven Track Record" while offering their products. This raises a question, how will the products based on indigenous R&D get a market? There is therefore a need to consider risk mitigation measures to facilitate acceptance of such products based on indigenous R&D. Insurance Companies should be encouraged to offer an insurance cover to the users/suppliers and 50% of the premium charged by the insurance companies should be subsidized by the Government.

Here again, it may be noted here that, in a small way, the Technology Development Board (TDB) under DST provides soft loan @ 5% for commercialization of technologies and products.

VII. **Technology transfer to be made mandatory:**

In order to enhance the technology depth of our industry, technology transfer should be made mandatory in approvals for foreign direct investment into the country.

VIII. **Mobile exhibition of innovations**:

To capture and disseminate frugal innovations, e.g. the database of more than 200,000 ideas (technological ideas, innovations and traditional knowledge practices) maintained by the National Innovation Foundation, it is recommended that a mobile exhibition depicting these innovations may be taken around the country to create awareness among people and attract some entrepreneurs among the audience to take up commercial development of innovations of interest to them. In the next phase, the agency which is engaged in dissemination of innovations must identify the dealers, suppliers and vendors to convert the innovations into marketable products.

IX. Establish/strengthen/encourage domain specific 'Innovation Accelerators' and 'Translational Accelerators' accessible to public- institutions and SMEs to successfully incubate discoveries, and take them through the validation stage, and package them for transfer and licensing. Funding agencies such as BIRAC create and sustain 'Translational accelerators' in key locations..

- Over 150 Technology Transfer Organizations (TTO) to be set up, spread across the country in research institutes and universities.
- Establishment of Rural Technological Innovation & Application Center
- New scheme to be launched 'Encouraging development and commercialization of inventions and innovations' for scientists of HEI and R&D Institutes to explore entrepreneurship.

X. Support for business incubation infrastructure, technology validation and scale-up infrastructure

- Science and technology park (STP) environment with distributed investment made in 5 zones of the country (North, South, West, East and Central)

- The five clusters may require creation of 40 technology incubators, with average of 8 incubators in each of these clusters providing technology incubation, validation and scale up support to enterprises located within these clusters

XI. Technology Management Professional development and licensing of technologies for accelerated commercialization Institutional level capacity creation

- Over 150 Technology Transfer Organizations (TTO) to be spread across the country with 10 professionals per institution, the need for minimum of 1500 professionals to be developed in the span of next 10 years
- Provide support to TTOs with adequate funding
- Reward and recognition mechanisms for inventor and technology management professionals.

XII. Creation of a Technology repository

Funding agencies to create a centralized repository for technology emanated from research. The repository could be used for depositing technologies developed indigenously and for global acquisitions. The access transaction to be structured by trained professionals for affordable solutions. The repository to include broad spectrum of intellectual assets- biomaterials, patents, data, copyrights and business methods.

B: How can Chambers of Commerce/Industrial Associations/Other Networks Help?

- Chambers need to take active steps to give prominence to regular entrepreneurial meetings, discussions and networking.
- Chambers need to go beyond mid-size and large companies to reach out to young entrepreneurs.
- Scale up current initiatives on Entrepreneurship; coordinate across associations and networks, and beyond metropolitan cities and top educational institutions.
- Create networks of Entrepreneurship initiatives that are being undertaken across the country.
- Strengthen mentoring programmes for upcoming entrepreneurs and actively leverage networks with successful entrepreneurs.
- Provide platforms for discussing entrepreneurial best practices and experiences by holding nation wide workshops.

- Create forums for partnerships with and mentoring by financial institutions.

C: Role of Educational Institutions/R&D Centres

There is a need to assign simple but practical innovative projects to the engineering students as a part of their B.Tech./B.E. degree program. The teaching institutions should be equipped with innovation labs, which may be set-up using government funding, e.g. under the FIST (Funding for Infrastructure in S&T) scheme of DST.

- Develop content, learning methods, pedagogy, examination systems and curricula that encourage critical and lateral thinking; incorporate case studies of real life situations in the curriculum so that students are able to get a ‘concrete feel’ of the outside world; introduce manuals in school curricula on ‘How Things Work’ on various practical aspects of everyday living; explore ideas for flexibility of vocational education with mainstream education for greater linkages between theory and practice.
- Make Entrepreneurship a core subject in business schools, including topics relating to business ethics, early enterprise management, relevant aspects of scaling-up, Indian corporate law and relevant international laws in curricula, explore possibilities of establishing entrepreneurship schools at the undergraduate and post graduate levels such as the one envisaged at IIT Kharagpur, with possible alumni and NRI involvement.
- Encourage student-led entrepreneurial activities in campus with active stakeholder participation; encourage initiatives such as business plan contests (with angel/VC/private sector assistance by holding ‘Enterprise Melas.’ Encourage activities that deal with the basic practicalities of Entrepreneurship and platforms to interact with various entrepreneurs, the financial community (especially VCs and angels) and relevant networks.
- Set up Enterprise Centres in major educational and research centres, with industry linkages, partnerships and supporting incubation activities.
- Create greater linkages with industry; provide flexible options and supporting environment for those with PhD degrees to translate high tech innovations into wealth generating ideas and entrepreneurial ventures; enable researchers to set up commercial entities while in professional employment with research organizations; facilitate mobility and flexibility; encourage universities/ research organizations to establish commercial enterprises based on their new inventions.

- Enable research organizations to invest through knowledge, positioning inventions and innovations as equity in the new enterprises.

D: Business Incubation Centres

I. Improving the Efficiency of Incubators:

- **Increasing the Amount of Funding Going into Business Incubators:** The total amount of funding going into business incubators is miniscule in relation to demand for financing. A target of up to INR 200 crore per year should be set for public investment in incubators in the initial years. Efforts should also be made to rope in private sector funding. CSR funds, for instance, could be at least partially directed to incubators. Apart from the need for more funding, there is also a need to monitor efficiency of spending and impact. We discuss this in more detail in the following points.
- **Creating Virtual Incubators:** Curated sites should be set up to provide entrepreneurs with access to advisors, mentors, and experts. These sites should also include information on how to access funding, how to navigate the regulatory landscape, and e-education. The purpose is to raise the odds that even those in remote/ inaccessible areas to launch their own businesses.
- **Keep Incubators Up to Date:** Incubators must be able to provide services and facilities most in demand with current market and business conditions. Key decision-makers and managers must routinely study and survey the needs of the entrepreneurs, as these are constantly evolving, and offer the best they can to help the incubated ventures succeed. For example, while a few years ago, high-level guidance was most sought after by entrepreneurs, at present, young startups are increasingly seeking specific, actionable assistance and skill development, such as creating sales proposals, hiring strategy, introduction to influencers and investors. One way to kick-start these linkages would be to connect incubators with pre-existing networks of entrepreneurs – for example, through TiE or NASSCOM – so as to exchange ideas and build partnerships.
- **Link Funding with an Institutionalized Annual Ranking:** Incubators must be ranked every year according to a set of stringent guidelines, whilst offering space for failure and risk-taking. Increased funds and resources help incubators provide better facilities. However, greater resource commitment must be linked to performance, which could be identified through annual rankings recommended here.

- **Exit Non-Performing Incubators:** Incubators that perform poorly beyond a certain timeframe must be shut down to channel resources that enable relatively successful incubators to do even better. A formal ranking process and annual reviews will help identify these non-performers.

- **Introduce Specialized Sector-based Incubation Services:** Since different sectors throw up unique challenges, the one-size-fits-all approach does not work when it comes to incubation. For example, currently, e-commerce ventures receive greater interest and funding offers. Therefore incubators focused on e-commerce must strive to improve the quality and mortality of these start-ups. On the other hand, sectors like social inclusion, healthcare, education and clean technology do not attract sufficient attention and incubators should work on increasing awareness, and getting more entrepreneurs & investors involved, which will also boost innovation across these crucial sectors. Separate incubators are required to help the manufacturing SME sector innovate.
- **Mould a Supportive Incubation System to Encourage Disruptive Innovation:** Incubators must strike a balance between offering stable environments for incremental innovations but also permitting creative and disruptive innovation. To encourage this, rules and procedures must be minimal, while offering a supportive and empathetic system.
- **Strengthening Links between the Corporate Sector and Incubators:** Currently, incubators operate in silos rather than within an overall ecosystem. This dilutes impact. To maximise impact, links between incubators and the corporate sector need to be strengthened. The corporate sector should be encouraged to provide more finance and support for start-ups, via incubators. This money could partially come from corporate venture capital funds. This could serve a dual purpose. Start-ups would get access to much needed funding and mentoring, while corporates would implicitly be supporting ventures that could later add value to their own business. For example, Indian pharmaceutical companies could have an interest in supporting drug discovery firms. This system is well established in the US, where corporate buy-outs present an important source of funding for technology/products generated by incubators.

II. SETU Funds Should Be Used to Upgrade Incubators and Set-Up Tinkering Labs:

In his budget speech (FY 2015-16), the Hon'ble finance minister allocated Rs. 1000 crores for Self Employed and Talent Utilization (SETU). This is a one-time allocation, intended to jump-start skilling for the better utilization of talent. Half of the Rs. 1000 crores should be spent in upgrading the system of incubators already in place in the country. A system can be created to survey and rate the incubators on objective criteria. At AIM' s discretion, though always transparently, criteria should be spelled out to codify this rating function, and then to award the majority of the Rs. 500 crores to the best ten incubators, publicly or privately funded, with the proviso that they will be held accountable for the efficacy with which the funds are spent. Subsequent years' allocation of AIM funds should similarly be used to continue to rate the incubators and to reward those producing exemplary results. The remaining Rs. 500 crores SETU money should be used to set up Tinkering Labs. These centers will permit aspiring entrepreneurs to experiment to create products that address local problems. A number of so-called Tinkering Labs could be based in engineering colleges, with the state and the academic institute sharing responsibility for maintenance. They should be equipped with basic engineering design equipment and with a 3D printer, as well as staffed with appropriate technical personnel. They will need young leaders who have strong hands-on experience in technology problem solving. while designing training programmes for the convenors of these Tinkering Labs, inspiration could be sought from organisations like JED-I (The Joy of Engineering, Design and Innovation), focused on quality in engineering. Some experimentation is needed to decide the format and associated economics of the Tinkering Labs. For example, it's quite clear that such a lab will not exist in a vacuum. It will have to be part of the local societal fabric. Further, we envisage that the labs will develop differing sectoral expertise depending on their local contextual circumstances.

- Make incubation a core business proposition to trigger Entrepreneurship.
- Develop feasible business models at the incubation stage which align incentive structures towards measurable performance outcomes and provide stake in the outcomes (through knowledge equity, etc.).
- Emphasize the financial and commercialization aspects of incubation (i.e. on the feasibility of taking an idea to market, understanding risk mitigation-measurement-strategy, cash flows, analysis of business failures, ethics etc and not only technical feasibility) where the financial community can play a significant role.
- Actively involve industry (other successful entrepreneurs, angels, VCs, banks, chambers of commerce, associations etc) as part of the social networks for mentoring, thereby supplementing the efforts of academics within the educational institutions.
- Develop formal and informal systems of active, regular mentoring by successful entrepreneurs, platforms for networking and peer recognition, and honour successful emerging entrepreneurs at regular intervals.

- Widen incubation and mentoring beyond technology related ventures, alumni and centres of excellence in metropolitan centres.
- Widen the incubation horizon beyond the start-up stage to also include scaling up.
- Hold national and state level incubation seminars and workshops.

E: Role of the Financial Community

- Banks must consider Entrepreneurship as a major business opportunity.
- Explore innovative options such as venture debt, soft loans etc for start-ups.
- Encourage current efforts on development of systematic risk management systems [Small and Medium Enterprise Rating Agency (SMERA), Credit Information Bureau (India) Limited (CIBIL)-information disclosures, Credit Appraisal and Rating Tools (CART), Risk Assessment Models (RAM) etc] as ways to increase risk appetite.
- Incentivize entrepreneurs to undertake ratings and information disclosures by linking cost of credit to ratings (where more holistic ideas of risk can be evolved).
- Encourage the setting up of special industrial and management consultancy departments in banks to address functional inadequacies and market gaps, as well as develop multi-dimensional skills and increased information flows to encourage entrepreneurial funding.
- Actively assist entrepreneurs to develop multiple skills necessary for scaling up.
- Implement significant policy initiatives, including relevant RBI recommendations which facilitate ease of credit flow to small entrepreneurs.
- Banks need to reduce information asymmetries at various levels and disseminate information on various relevant issues (ratings, policies, schemes, consultancies etc).
- Banks could explore ways to monetize aspects of the knowledge industry (including Intellectual Property in the form of licenses etc as assets) with a view to better finance for such sectors.
- Realize the enormous potential for greater involvement of angels and VCs at the seed stage, especially in the newer, high growth sectors of the economy.
- Increase awareness on the activities of angel/VC financing through greater involvement with educational and research institutions, incubation centres etc.
- Scale up and publicize best practices in financial innovations for Entrepreneurship.

F. Improving the Innovation Ecosystem

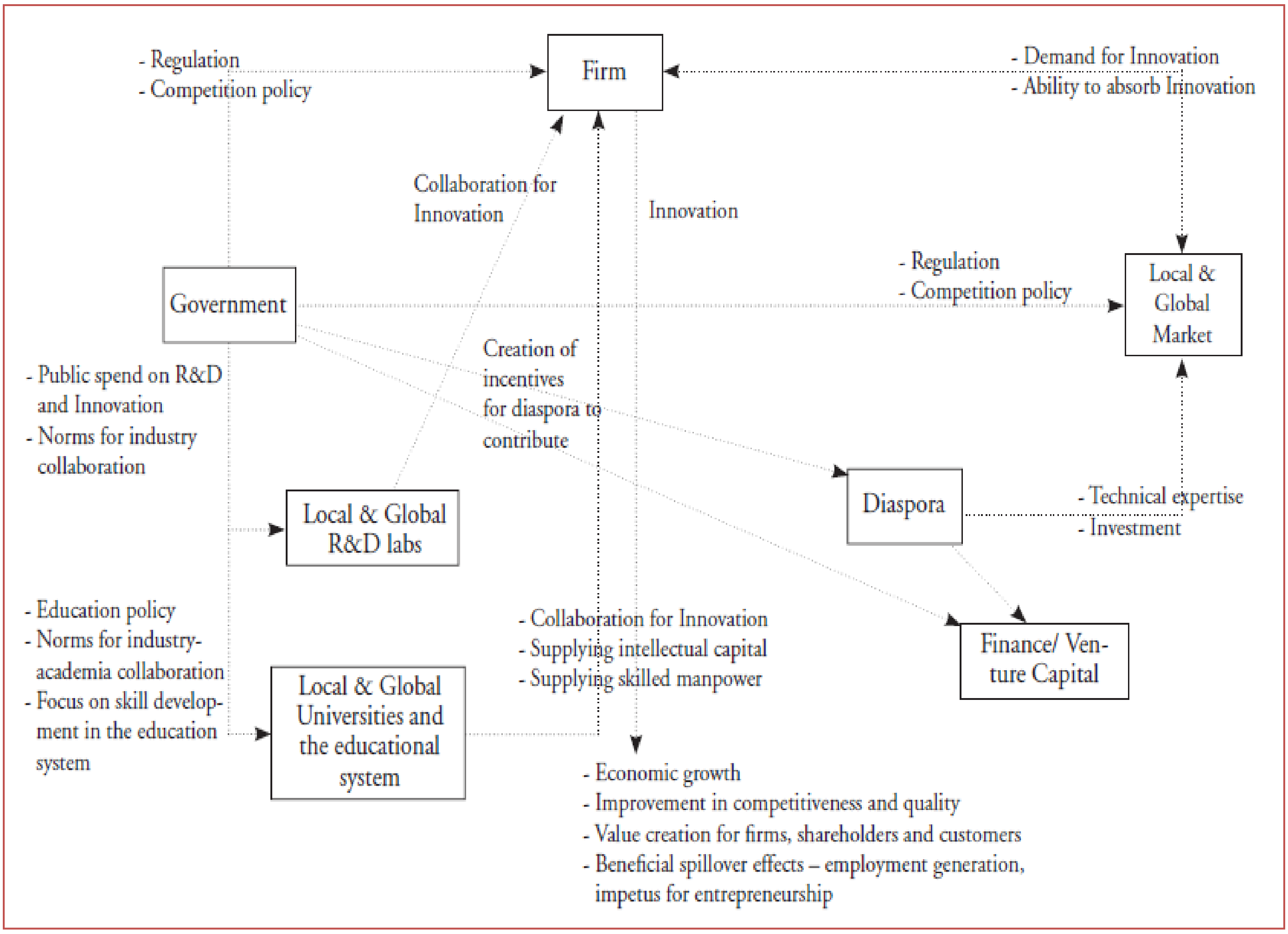
I. R&D Collaboration

An important external barrier as perceived by large firms is the lack of effective collaboration between industry with research conducted in universities and R&D institutions. In fact, more than half of the large firms and SMEs claim that the lack of co-operation with universities and R&D labs is an important barrier to Innovation. Conversely, there is a clear indication that collaboration with universities and R&D labs does enhance firm innovativeness. Innovation Intensity is higher for firms that collaborate, and the proportion of Highly Innovative firms is also higher. In order to create more incentives for R&D, the enactment of legislation for government funded research in the country is recommended, this will enable the following: give universities and research institutions ownership and patent rights over inventions arising out of government funded research; create an enabling environment for universities and research institutions to commercialize such inventions through licensing arrangements/partnerships where inventors would also be allowed to receive a share of the royalty; and also thereby generally facilitate more collaborative efforts with industry. There are precedents for such legislation such as the American enactment entitled the Patent and Trademark Law Amendments Act, enacted in 1980 and commonly known as the Bayh-Dole Act. Introduction of legislation generally along the lines of the Bayh-Dole Act, while keeping in mind India's specific interests, is necessary to help scientific research develop far reaching Innovations, generate employment and function as a vehicle of significant economic growth.

II. Systemic Reforms

Innovation is an effort that requires the synergistic use of cumulative energies of the industry, the government, the educational system, the R&D environment and the consumer. The Innovation Ecosystem, as seen from Figure 1 below, is a complex environment that requires the coordinated functioning of a number of diverse factors in order to function effectively. Innovation also needs to become as wide spread as possible, spreading across the entire economy, from the grassroots to the large firm level. As already noted above, crucial to the goal of increasing Innovation led growth is the need to bring about reforms in the education system, especially in respect of higher education and skill based marketable vocational education. Therefore, the mandate of the NKC, which is to guide policy and direct reforms to allow India to effectively use and create knowledge capital, is critical and extremely relevant to furthering the cause of Innovation and entrepreneurship in the Indian economy. It is felt that a comprehensive effort to address these issues would act as a critical enabling factor for India to be amongst the global leaders in Innovation.

Figure 1: The Innovation Ecosystem



3. Patents

As a fast growing economy, India will have to establish that it is serious about rewarding and fostering innovation in every sphere. A strong and robust IP ecosystem will not just boost India’ s image globally but also help in harnessing more Foreign Direct Investments (FDI). A strong and effective IP ecosystem will also spur domestic innovation and investment in R&D. A culture of patenting innovations needs to be nurtured. It was observed that industrial firms where innovations are patented have higher innovation intensity and are also more likely to be highly innovative. Firms that have filed more than 20 patents in the last five years have higher innovation intensity than those with less than 10 filings. Further, firms that use IPR consultants have higher innovation intensity. At the same time, there is potential for increased scope of patentability, use of licensing as well as a greater translation of IP awareness into concrete revenue generation and asset creation.

Developing countries like India are associated with much lower standard of intellectual property rights (IPR) protection than developed countries. Comparison of India with some developed Asian countries like Singapore, Japan, S. Korea and China shows that India is far behind S. Korea, Japan and China. As per WIPO Report 2016, India is ranked 10 and 14 in the indicators of IPR filing (residents) and IPR filing (residents and abroad) respectively. China, Japan and S. Korea have been ranked ahead of India and are amongst the top five nations. It is clear from the above observations that India has lot of scope for improvement in the field of IPR. Effective policy interventions are required to boost up the patent ecosystem in India.

The following recommendations have the potential to address the gaps in the Indian IP ecosystem:

A. Strengthening education in Intellectual Property Rights (IPR): Under the scheme of Intellectual Property Education, Research and Public Outreach (IPERPO) has so far set up 20 IPR Chairs in various universities and institutes considering their potential for development and growth of IPR Education, Research and Training. Given the rising global significance in the domain of IP, capacity building and strengthening IPR education has assumed great importance. Developing appropriate academic programmes and curriculum in keeping with World Intellectual Property Organisation

(WIPO) guidelines is an emerging need. Universities must be encouraged to frame academic programmes which can, initially be of Certificate and Diploma levels. The existing Chairs can be infused and rejuvenated to become more active in their respective knowledge domains. A few of the existing Chairs can be converted as Nodal/ Regional bodies to facilitate and coordinate the education of IPR within their jurisdiction. They could function as lead institutions and play the role of mentoring other institutions engaged in IPR education. Capacity building in IPR is essential as presently most of the individuals/ institutions which innovate and develop new patents and IPR are unable to derive their dues and rights.

B. Setting up an Indian Institute of Intellectual Property Rights Studies.

The scheme envisages ten Ph.D scholarships to students from different streams. The vision is of the Institute is to promote IPR studies by way of interdisciplinary research**.** The main objectives of IIIRPS will be:

i. Provide for collecting and storing materials to help scholars from different disciplines to acquire information on IPR.
ii. Offer postgraduate courses in the area of IP and development in association with Universities in India and abroad.
iii. Undertake research and development activities in the field of IPR and development.
iv. Undertake studies and consultancy services for State and Central Governments, public and private sectors.
v. Conduct lectures, seminars, study groups, workshops etc. in the area of IP.
vi. Institute and maintain libraries.
vii. Institute Chairs, Fellowships and award them to deserving scholars and persons of professional attainments.
viii. Publish research papers, treatises, books and periodicals and other literature relating to IP and development.
ix. Design and develop trainer modules for teaching IPR in Engineering/Science Colleges and other educational institutions.
x. Encourage taking up projects which will motivate young researchers for undertaking research linking IP to economic and social development.
xi. Develop training modules and to undertake training in the area of IP to professionals in the field of law industry, R&D institutions and other educational institutions.

xii. Do all such other things as may be incidental or conductive to the attainments of the above objectives.

xiii. Without prejudice to the generality of the above and for the effective carrying out of those objects, the Institute shall have the power to acquire, hold and receive property of any kind, including securities and negotiable instruments, to construct and maintain buildings, including the right to alter and improve them and to equip them suitably, to manage, sell, transfer any kind belonging to the Centre, to enter into contracts for and in connection with any of the purposes of the Centre and on its behalf to raise moneys and funds in such manner as may be deemed fit for and on behalf of the Centre.

Various activities of the Institute are proposed to be organized under three major Centres. They are:

1. Centre for Policy Research;
2. Centre for Teaching and Training; and
3. Centre for IPR Facilitation

While the Policy Research Centre will focus on research activities along with M.Phil and Ph.D programmes the Centre for Teaching and Training will concentrate on teaching various degree, diploma and certificate courses and training programme for various stake holders in the area of IPR. The main activity of the IPR Facilitation Centre is to look at the practical aspects of IP and help researchers and Industry in the commercial exploitation of IP.

C. IP Landscaping

- Run awareness program on IPRs to raise awareness about their benefits and value to both right holders and public: making scientists and researchers aware of the need to protect to their inventions.
- Build an atmosphere that leads to generation of IPs and their protection, to further stimulate innovation.
- Facilitate commercialization of IPRs by promoting collaborations between R&D institutes, industries, academia and funding agencies.
- Promote exchange between IP offices and scientists.

D. Enhanced Enforcement: IP Laws in India are compliant with Trade-Related Aspects of Intellectual Property Rights (TRIPS) administered by the World Trade

Organization (WTO). However, the laws are poorly enforced, as innovation and protection of IP are not prioritized adequately by enforcement officials. An important first step is spreading awareness and sensitizing all the relevant authorities involved in enforcing laws, including the police and the judiciary. Further, specialized training must be provided to members of the judiciary on Intellectual Property and innovation, given the complexity of the cases involved.

E. **Dedicated IP Courts:** Due to the limited jurisdictional reach of the Intellectual Property Appellate Board and the rise in the number of patent litigations, India needs dedicated IP courts to manage specialized IP cases, as well as to improve the efficiency and speed in IP judgment. The IP courts must be stipulated to give their judgments within 2 years, with no more than 3 adjournments between hearings, and no more than 10 adjournments in total throughout the trial.

F. **National Virtual IP Platform:** Academia-Industry Model (AIM) could oversee the establishment of a National Virtual IP Platform that offers a forum for the stakeholders and all those interested in Intellectual Property Law to discuss, innovate and collaborate. Further, the Virtual IP Platform could contain a database of all the resolved IP cases in India, as well as details of those under litigation. Over time, an electronic case management system can be integrated into the Virtual IP Platform for quick resolution of IP-related disputes and issues.

G. **Increase Number of Patent Examiners:** New innovations are often time-sensitive and a large number of pending patent applications severely dampens the spirit of innovation in the country. The shortage and attrition of patent examiners at the Patent Office must be addressed to resolve the issue of pending applications. There should be a concerted effort to introduce a large number of high-quality patent examiners, with a ten-fold increase from the current number of examiners by 2020 being a reasonable goal.

4. PPP in R&D

In the knowledge economy, universities as a source of knowledge have become far more important than in the past. In recent years, universities have acquired a crucial “Third Mission” of contributing to economic development after teaching and research. Among the developed countries, the United States is feted for offering entrepreneurs many structural advantages, among them close linkages with universities is of vital importance. Many universities have incubators, technology parks, and venture funds within their sprawling campuses. Similarly, in Cambridge, UK, engagement of the faculty with industry has spawned many “millionaire dons” among its academics. The private sector can be tapped to fund research and development at universities.

It might be possible to leverage public funding, especially in the form of land grants, to attract more (not-for-profit) private investment. In principle, it should be possible to set up new institutions in higher education, not just more IITs and IIMs but also more universities, as public-private partnerships where the government provides the land and the private sector provides the finances. Such public-private partnerships which promote university- industry interface would also strengthen teaching and research.

“Risks” are an integral part of a vibrant innovation system. Risk sharing by the government will significantly increase private sector investment in R&D and technology development. New financing mechanisms for investing in enterprises without fear of failure and options for foreclosing unsuccessful ventures are essential part of an enabling innovations ecosystem. A public procurement policy that favors first of its kind products developed through indigenous innovations and measures to promote such products globally are necessary.

BIRAC, an industrial arm of DBT is a perfect example of a successful PPP in R&D. It is a not for profit section 25 company. Its research activities involve funds from both government and the private partner. BIRAC is a new industry academia interface and implements its mandate through a wide range of impact initiatives, be it providing access to risk capital through targeted funding, technology transfer, IP management and handholding schemes that help bring innovation excellence to the biotech firms and make them globally competitive. BIRAC has initiated several schemes, networks and platforms that help to bridge the existing gaps in the industry-academia innovation research and facilitate novel, high quality affordable products development through cutting edge technologies. Some of the on-going programmes include Biotech ignition grant scheme (BIG), Small business innovation research initiative (SBIRI), Biotech industry partnership programme (BIPP), contract research scheme (CRS), Bio-incubators support scheme (BISS), Grand challenge-India, University innovation cluster among others. The following recommendations can be considered for promoting PPP in University R&D.

A. **Streamlining Creation of New Universities & Higher Education Institutions:** The process for establishing public, private and PPP universities and higher education institutions under both the central and state governments should be quick and hassle-free. Approval for fully autonomous institutions should be granted by simplifying norms and establishing clear, transparent, and time bound approval process.

B. **Setting up of new facilities by corporate in existing universities and higher education institutions**

Models for corporate sector participation should be explicitly laid out for engaging with the top-75 existing institutions with a focus on Institutions of National Importance (INIs), central universities, deemed universities, state universities and established private universities.

To facilitate good governance of such relationships, an advisory board should be set up with adequate representation from corporates, educational institutions, and eminent people from the society, at each school/center of excellence/training & learning center,

- To enable this, the higher education institutions should be allowed by government to lease land on perpetual lease to corporates (including corporate consortia and industry associations) to set up a corporate R&D ecosystem in the form of research laboratories and technology parks. These facilities should be accessible to the students and the faculty of the sponsoring educational institution.
- Opportunities to the faculty for collaborative research and to publish research papers with the corporates should be made available.
- In addition to land provided by the educational institution, up to one-third of the funding required for these centers should be funded by the government as grants. More opportunities to create intellectual property with adequate royalty sharing among the government, corporate and the innovator (e.g. IIT Madras Research Park) should be allowed.

- It will be worthwhile to invite well-known universities abroad to engage with existing institutions in creating new campuses. Recent experiments such as New York City conducting a contest and selecting Cornell University and Technion Israel Institute of Technology to set up a new engineering campus should be further explored. In this case, New York City provided the institutions with a grant of land in Roosevelt Island and $100 million for infrastructure improvements.
- Companies which already run large corporate training programs should be encouraged to set up new universities.
- Large corporations which have an R&D establishment should be encouraged to set up full-fledged institutions inside the vast campuses (in excess of 100 acres) to leverage existing infrastructure and benefit from existing laboratories. Globally, individuals have played a key role in building higher education institutions. India has over 30 companies with annual revenues of over $5 billion and 48 billionaires (US$). Hence, while considering corporate participation in setting up new educational institutions, it is important to look at high net worth individuals who have the necessary resources to contribute to this sector. In this context, the definition of corporates should be expanded to include individuals. This will encourage philanthropic corporate founders, entrepreneurs and individuals to start new institutions or contribute to existing higher education institutions.
- To send out a strong signal that such contributions are welcome, the Committee recommends that a personal invitation from the Prime Minister of India should be sent to 25 Indian corporate and 25 eminent, high net worth individuals to start a university on meeting a minimum set of conditions and a commitment from the corporate / individual for the institution to be in the top 250 in the world, over a 15 year period.
- In return, complete autonomy, free land, and central-university status, should be provided by the government for such educational institutions. If an individual or a corporate is unable to set up a full-fledged university, such entities can set up a center of excellence within an existing institution of their choice.
- The top-75 existing institutions should be allowed to set up technology parks on their campuses to foster research and innovation.

C. Harnessing Corporate Funds to Finance R&D: The following Recommendations will be helpful in harnessing Corporate funds to finance R&D:

- Facilitating private sector investment in R&D centres in India and overseas. Promoting establishment of large R&D facilities in PPP mode with provisions for benefit sharing.
- Treating R&D in the private sector at par with public institutions for availing public funds.
- Bench marking of R&D funding mechanisms and patterns globally.
- Modifying IPR policy to provide for marching rights for social good when supported by public funds and for co-sharing IPRs generated under PPP.
- Launching newer mechanisms for nurturing Technology Business Incubators (TBIs) and science-led entrepreneurship.
- Providing incentives for commercialization of innovations with focus on green manufacturing.
- 1% of corporate profit could be directed towards research labs in universities and/ or industry-university collaborative research. The government could provide some tax benefits against this. Monitoring of this rule should focus not only on the absolute amount channelled into universities, but also on the efficiency of spending, that is, it needs to be output-rather than input-oriented. The idea here is that universities become the breeding ground for new technology/ ideas that can be used by the corporate sector. Firms would implicitly be outsourcing R&D—financing development of products/ services that can be bought by them. In that sense, this financing would be perceived as absolutely core and fundamental to a firm's operations, rather than as a CSR-related activity. Though the actual development of R&D may take some time, beginning the involvement of the corporate sector in the financing of universities could be achieved relatively quickly.
- Encouraging top Indian firms to set-up research and education wings at universities
- Introducing a "Make in Universities" program which would involve setting up 500 tinkering labs with one 3D printer per institute.
- A percentage of corporate profit could be directed towards corporate venture capital funds, for the purposes of investment in start-ups and/or incubators. The government could offer tax credits against this.
- All contracts with foreign defence companies above $5B should include a clause for 5% of contract value to be directed to establish research centric universities with strong emphasis on its core product areas in particular and broadly focused on the related areas in general. Aggregated contracts with companies below $5B should include a clause for 5% of the contract value to be directed to establish a research centre associated with a

university, focused on the corresponding product space. In order for such a scheme to be implemented effectively in India, the responsibility of setting-up, staffing, and managing these institutes should also be that of the company for at least 10 years. This would allow India to develop a number of top-class research institutes with high-quality faculty within a few years, and would kick start the process of industry-university collaboration in a meaningful way. Companies should also clearly define ex-ante how these funds should be used, and guidelines should be as specific as possible to prevent misuse of funds. The practice of encouraging foreign investors to partake in local R&D development is not entirely new. Over the past two decades, for example, western multinationals operating in China have come under increased pressure to undertake technology transfer to local personnel as a quid pro quo for accessing their domestic market. In India, Bosch's Rs. 140 crores investments in a research centre at the Indian Institute of Science is an example (though it is not a defence company). The purpose of this investment is to promote applied research in a range of new-age areas, including but not limited to cyber security, mobility solutions, renewable energy, and the like.

सत्यमेव जयते

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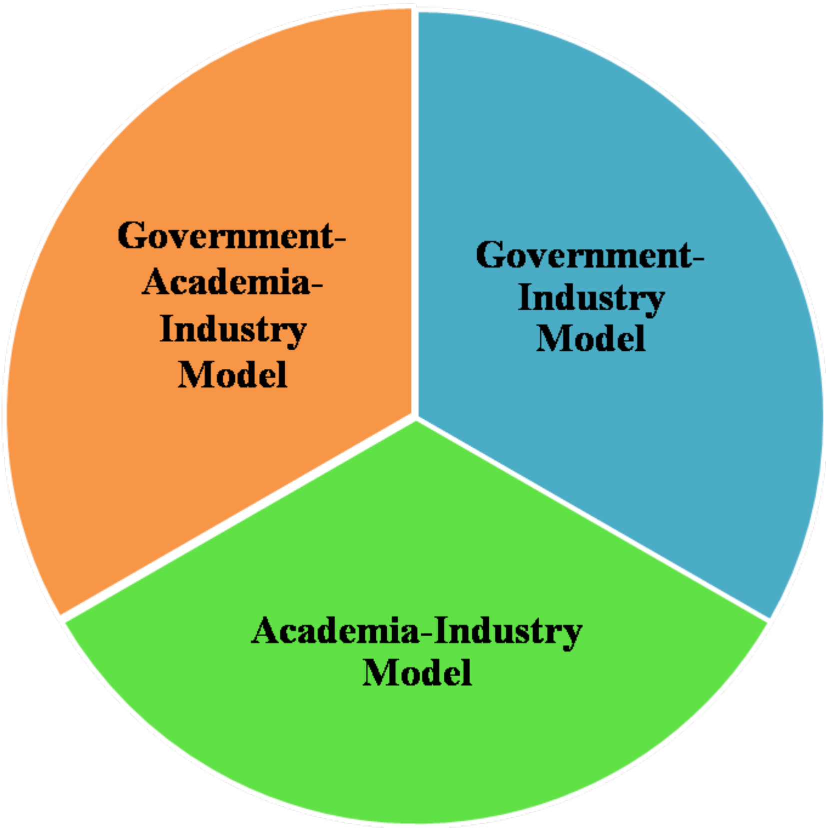
Existing Models of R&D under Public Private Partnership (PPP) Mode

(May, 2015 – Aug., 2016)



Introduction

In this era of competitiveness, national economic growth needs to compete with rest of the world by means of creating strong and powerful national innovation system. A robust innovation system is essential for wealth creation, economic and societal development of the country. Since the beginning of the 21st century, the emphasis of the Indian government has been to develop national infrastructure under PPP mode. The emergence of India as a major global economic power calls for high levels of technological freedom but unfortunately the growth of technology has remained disunited and unlinked. This is due to the fact that the R&D activities of both the public and the private sector have remained disconnected from each other thereby creating a large gap in technology development and technology deployment. Synergies between academic basic research and industrial applied research have to be established to generate mutual added worth. To achieve this synergy it is imperative to create a PPP framework engaging both the public and the private sectors leading to multivariate use of knowledge, innovations, technologies and value creation of R&D activities. Government of India has instituted various R&D schemes at national level to promote innovations leading to technology development and utilization. But on the other hand, private sector role in R&D has remained superficial. Government is making continuous efforts for adoption of Public Private Partnership (PPP) by launching various innovation and technology development support programmes. Government efforts have catalyzed creation of robust interface between public owned research and academic institution and industry. Indian private sector needs to be incentivized to invest in R&D activities. In present Indian scenario, public funded research institutes and higher educational institutes are skewed towards basic and fundamental research rather than applied research. To attract the industry to drive PPP in R&D domain, research should be equally focussed for fundamental and applied areas. Innovations result of Industry-Academia interface can lead to knowledge creativity and productivity that will lead to socio-economic benefits.

In this decade of innovation (2010-20), government's thrust relies on PPPs to foster innovative ecosystem in India and PPPs are acting as one of the effective measures for industry to contribute to national innovation system. Keeping in mind the importance of PPPs in R&D, it is imperative to study existing models of PPP in R&D and associated PPP programmes of government funding agencies to present a successful examples of R&D under

PPP that can be replicated and promoted at different levels such as state and central universities, public owned research institutes and government funding agencies.

In the present chapter, detail overview of existing PPP models for promoting R&D activities is presented. Figure 1 presently the overlay of the chapter. Under each category, existing PPP mechanisms are elaborated. PPP models are discussed under three categories which are:

- Government-Academia-Industry Model (GAIM)
- Government-Industry Model (GIM)
- Academia-Industry Model (AIM)

Existing PPP Models of R&D in India

1. Government-Academia-Industry Model (GAIM)

- A. Autonomous Institutes
- B. Creation of Dedicated Agencies
- C. Government Funding Schemes/Programmes and Government Initiatives

2. Government-Industry Model (GIM)

- A. Autonomous Institutes
- B. Industry Oriented Programmes of Funding Agencies
- C. Incentivization of Private Sector by DSIR

3. Academia-Industry Model (AIM)

- A. Industrial Set Ups in Academic
- B. Scholarships/Fellowships/ Industrial Chairs/ Scientist
- C. Industry Supported I-A Cells

Government-Academia-Industry Model (GAIM)

In the first category of PPP, three sectors government academia and industry come together in a partnership in the form of the triple helix model. The various models are discussed below in 4 sections.

A. Autonomous Academic Institutions

Autonomous academic institutions, such as Bombay College of Pharmacy and Institute of Chemical Technology were created on industry demands by getting support from government and industry. These institutes are working in close collaboration with industries and have significantly contributed to the industrial growth. These institutes are explained in following section.

Bombay College of Pharmacy, Mumbai

www.bcpindia.org

Bombay College of Pharmacy (BCP) affiliated to University of Mumbai, is one of the premier pharmacy colleges in India, imparting quality pharmacy education and research. It was established in 1957 by the Indian Pharmaceutical Association-Maharashtra State Branch (IPA-MSB) with financial assistance from several pharmaceutical conglomerates and Government of Maharashtra to address the needs of pharma industry. Within few years of its establishment, number of graduate, master and doctorate programmes were started in particular branches of pharmaceutical sciences. Since its inception, BCP has grown in stature, and has generated more than 3500 pharmacists, ~700 M. Pharma and ~100 Ph.D. graduates.

BCP is providing master's and Ph.D. programmes through which research in various domains such as Pharmaceutics, Pharmacology and Toxicology, Pharmaceutical Chemistry, Pharmacognosy and Pharmaceutical Analysis is carried out. BCP has formed the research society which is recognized by DSIR, GoI. It has established world class facilities, state of the art instruments and equipments. Research is highly promoted in the college, faculty members have received number of research grants worth ₹100 million from Government funding agencies (DST, DBT, ICMR, UGC and AICTE) and ~₹10 million from private sector. Number of Industry-Academia (I-A) collaborative projects are undertaken in BCP. Till date, More than 300 industry sponsored projects have been successfully completed by BCP. The college has built up effective interface with the industrial sector in term of industrial trainings, industry sponsored projects, consultancy and faculty exchange.

BCP has been accredited with the “Best Industry-Linked Institution in Pharmacy” according tp the national survey carried out by AICTE in collaboration with CII, consecutively from past three years (2013 onwards). Details of BCP are given in Annexure I.

Institute of Chemical Technology, Mumbai

www.ictmumbai.edu.in

The Institute of Chemical Technology (ICT), Mumbai was established in 1933 with active industrial participation, as University Department of Chemical Technology (UDCT) under University of Mumbai, with the noble intention of enhancing India's knowledge base in chemical science and technology. Based on its continuous progress in academics and translational research, UDCT was upgraded to Deemed-to-be-University and renamed as Institute of Chemical Technology in 2008. Recently (2016), ICT-Mumbai has been ranked as number 2 university, under the National Institutional Ranking Framework (NIRF) of MHRD, (GoI). Details of ICT Mumbai are given in Annexure II.

B. Creation of Dedicated Agencies Promoting PPP

Government has created specialized agencies for promoting investments in R&D from both industrial and academic sector in PPP mode. One of such agency is BIRAC which was established by DBT, GoI with a mandate of strengthening Indian Biotech Sector by bringing industry and academia together and enhancing entrepreneurship in biotech field. On the other hand, CSIR supported the creation of CSIR Tech as a commercialization arm for various academic institutions including R&D institutions and universities by collaborating with potential industries.

Biotechnology Industry Research Assistance Council (BIRAC)

www.birac.nic.in

BIRAC is a not-for-profit Section-8, schedule B, public sector enterprise registered under Indian Companies Act 1956 and was established in 2012 by Department of Biotechnology, GoI, (DBT; http://www.dbtindia.nic.in/). DBT created BIRAC as an I-A interface agency to stimulate emerging biotech enterprises in India by supporting R&D activities addressing the national societal needs to make the biotech sector globally competitive. Details of BIRAc have been presented in Annexure III. Various schemes of BIRAC promoting I-A interface are presented in table 1.

Table 1: Industry-Academia Programmes Offered by BIRAC

S. No.	Programmes	Brief details
1	**Small Business Innovation Research Initiative (SBIRI)** http://www.birac.nic.in/desc_new.php?id=75	Scheme was started to boost PPP functioning in the country by facilitating innovations, risk taking ability by small and medium companies and bringing together the industries, public institutions and the government under one roof to promote research in the Indian biotech sector.
2	**Biotechnology Industry Partnership Programme (BIPP)** http://www.birac.nic.in/desc_new.php?id=76	BIPP promotes government partnership with industrial sector for supporting path-breaking research in futuristic technological areas along with societal importance.
3	**Contract Research Scheme (CRS)** http://www.birac.nic.in/desc_new.php?id=104	It aims to enable promotion of academia research having commercial potential to engage the Contract Research and Manufacturing Systems (CRAMS) industry for validating a process or a prototype.
4	**Biotechnology Ignition Grant Scheme (BIG)** http://www.birac.nic.in/desc_new.php?id=83	BIG is made available to scientist entrepreneurs working in research institutes, academia to initiate their own start-ups.
5	**BIRAC University Innovation Cluster: (UIC)** http://www.birac.nic.in/desc_new.php?id=95	Five universities possess Cluster Innovation. **These centres are working to promote entrepreneurial cultures and pursue industry oriented research having commercial importance.**
6	**BIRAC Regional Innovation Centre (BRIC) at IKP Knowledge Park** http://www.birac.nic.in/desc_new.php?id=94	It is working for mapping regional innovation ecosystem for Southern India to bring out technologies of commercial importance.
7	**Bio-Incubator Support** http://www.birac.nic.in/desc_new.php?id=92	Bio-incubation support is harnessing entrepreneurial potential of start-ups and is providing access to well-developed infrastructure networking platforms. **Till now BIRAC has extended support to15 Bio incubators.**
8	**BIRAC-SRISTI (Society for Research and Initiatives for Sustainable Technologies and Institutions)** http://www.birac.nic.in/desc_new.php?id=98	This scheme is promoting indigenous and grassroot innovations. For example: • Development of **Honey Bee Network** (HBN; http://www.sristi.org/hbnew/index.php) for extracting, protecting and promoting innovative ideas from all over the country. • Creation of **Techpedia** (http://techpedia.sristi.org/) as a platform to put problems of small and medium

		enterprises and locate solutions for them. Academicians, industries, researchers, students and entrepreneurs can register and draw services that come under techpedia. • Creation of **Social Innovation Fund** (http://sif.sristi.org/) for providing mentoring, financial and fabrication support to academicians, industries and budding entrepreneurs to carry forward their innovations.
9	**BIRAC AcE Fund - Accelerating Entrepreneurs** http://www.birac.nic.in/desc_new.php?id=99	This scheme provides access to equity based fund for budding entrepreneurs.

Source: *www.birac.nic.in*

C. Programmes of Funding Agencies

Government funding agencies and various industrial associations have instituted various programmes and schemes for bringing government, industry and academia together. Moreover, funding agencies have taken impactful initiatives such as creation of Centre of Excellence, TBIs and S&T parks for enhancing MSMEs growth and entrepreneurship in India.

Table 2: Programmes for Stimulating Industry-Academia Linkages

S. No.	**Programme/Scheme/initiative**	**Government Funding Agency**
1.	Schemes for Funding Industry Relevant R&D (Under SERB) http://www.serb.gov.in/home.php	DST
2.	International S&T Co-operation http://www.dst.gov.in/international-st-cooperation	GITA
3.	Advanced Composites Programme http://tifac.org.in/index.php?option=com	TIFAC
4.	Collaborated Automobile R&D Core-Group ifac.org.in/index.php?option=com_content&view=article&id=68&Itemid=99	TIFAC
5.	Promoting Innovations in Individuals, Start-ups and MSMEs (PRISM) http://www.dsir.gov.in/12plan/prism/prism.htm	DSIR
6.	Consultancy Promotion Programme (CPP) http://www.dsir.gov.in/tpdup/cpp/cpp.htm	DSIR
7.	New Millennium Indian Technology Leadership Initiative' (NMITLI) http://www.csir.res.in/external/heads/collaborations/nmitli.htm	CSIR
8.	Small Business Innovation Research Initiative (SBIRI)	BIRAC

	http://www.birac.nic.in/desc_new.php?id=75	
9.	Contract Research Scheme (CRS) http://www.birac.nic.in/desc_new.php?id=104	BIRAC
10.	BARC Entrepreneur's Corner- Technology Transfer and Consultancy & Scientific Services http://www.barc.gov.in/	DAE
11.	Visvesvaraya Ph.D. Scheme for Electronics and IT http://deity.gov.in/content/schemes-projects	MeitY
12.	**Scheme for Financial Assistance to Select States/UTs for Skill Development in Electronics System Design and Manufacturing (ESDM) sector** http://deity.gov.in/content/schemes-projects	MeitY
13.	Scheme of Financial Assistance for Setting Up of Electronics and ICT Academies http://deity.gov.in/content/scheme-financial-assistance-setting-electronics-and-ict-academies	MeitY
14.	Council for Industry Higher Education Cooperation (CIHEC) http://mhrd.gov.in/collaboration	MHRD
15.	Technical Education Quality Improvement Programme (TEQIP) http://mhrd.gov.in/technical-education-12	MHRD
16.	Global Initiative for Academic Network (GIAN) http://www.sici.org/programmes/details/global-initiative-for-academic-network-gian-programme/	MHRD
17.	Kaushal Kendras http://mhrd.gov.in/sites/upload_files/mhrd/files/lu3667.pdf	MHRD
18.	University-Industry Inter Linkage (UIL) Centres www.ugc.ac.in	UGC
19.	Industry Institute Partnership Cell (IIPC) http://www.aicte-india.org/schiipc.php	AICTE
20.	AICTE – Indian National Academy of Engineering (INAE) Distinguished Visiting Professorship (DVP) http://inae.in/aicte-inae-distinguished-visiting-professorship-scheme/	AICTE
	Industry Association	
21.	National Knowledge Functional Hub http://ficci-nkfh.com/	FICCI
22.	I-A-Research/ Government Interface (IARGI) http://www.ficcifwi.com/ppts/rnd2.pdf	FICCI

D. Government Initiatives (Centre of Excellence, Technology Business Incubators, S&T Parks and Accelerators)

In order to promote R&D activities in HEIs, government has undertaken initiatives, such as creation of Centre of Excellence, Technology Business Incubators, S&T Parks and

Accelerators where industries, academicians, government and budding entrepreneurs are placed under single roof. Other than these, various specific scholarships/fellowships and industrial chairs were promoted to bring academia and industry close to each other. These initiatives taken for promotion of R&D to bring industry and academia together are briefed below.

- **Centres of Excellence (CoEs)**

CoEs are the organizational set ups for pursuing high standards of research addressing number of socio-economic objectives. Creation of such CoEs in HEIs and research institutes has contributed to the stimulation of technological innovations in different sector. Government introduced various schemes for established of CoEs. One such CoEs working under PPP mode is Telecom Centres of Excellence (TCOEs). These are the perfect examples of academia, industry and government working together to achieve excellence in field of R&D. They were created with an objective to promote generation of IPRs, development of new technologies, incubating innovations and entrepreneurship in telecom sector. TCOEs were conceptualized in 2007 and came into existence in 2008. Various telecom industries became sponsors for establishing TCOE in premier institutes in India such as IIT and IISc (Table 3).

Table 3: Telecom Centres of Excellence in India

S. No.	TCOE	Research Focus Area
a.	Aircel TCOE at IISc Bangalore	Information security and Disaster Management of Telecom Infrastructure
b.	Bharat Sanchar Nigam Ltd. (BSNL) TCOE at IIT, Kanpur	Multimedia and Telecom, Cognitive Radio and Computational Mathematics
c.	Bharti Airtel TCOE at IIT Delhi	Telecom Technology and Management
d.	Idea Cellular TCOE at IIM Ahmedabad	Telecom Policy, Regulation, Customer care
e.	Reliance Communications TCOE at IIT Madras	Telecom Infrastructure (Active and Passive) and Energ
f.	Tata Teleservices TCOE at IIT Bombay	Rural Telecom Technology
g.	Vodafone Essar TCOE at IIT Kharagpur	Next Generation Networks and Technology
h.	RailTel TCOE at IIT Roorkee	ICT and Broadband Applications

Numbers of CoEs were created by government funding agencies with an objective to develop a dedicated facility in particular research domain to promote innovation and technology development in association with industry. One such centre created by DBT is the Centre for

Cellular and Molecular Platforms (C-CAMP). C-CAMP is acting as technology platform for industry interaction/collaboration, innovations and incubations. They provide number of services for research, technology development and entrepreneurship to various stakeholders such as academia, other research institutes and industries. MHRD has also created CoEs under the scheme of 'Training and Research in Frontier Areas of Science and Technology' (FAST). These centres possess world class infrastructure and facilities and are pursuing research as per industrial needs. 36 centres of excellence were created by MHRD in different parts of India. MHRD also established 30 CoEs under the scheme 'Technical Education Quality Improvement Programme' (TEQIP). Government has also announced setting up of more CoEs, to be run under PPP mode for adoption of industry oriented technologies. For instance, announcement for creation of CoE in lot technology in association with NASSCOM, MeitY and Education and Research Network (ERNET), which was announced by government in 2016.

There are some of the industrial units who have also established CoEs for technology upgradation. They strive for technological solution from government and academia. Examples of such CoE are 150 IBM Software CoEs, created in 20 different locations in India to create generations of IT innovators.

- **Technology Business Incubators (TBIs)**

National Science and Technology Entrepreneurship Development Board (NSTEDB) under the aegis of DST , New Delhi has taken impactful"Institution Mechanisms Building Initiative" by building Technology Business Incubators (TBIs) all over India to incubate indigenous technology for creating technology based new enterprises, facilitating transfer of technologies and entrepreneurship development. NSTEDB has established 66 TBIs (http://www.nstedb.com/institutional/tbi.htm) in different parts of India in collaboration with host institute and DST. Each TBI has dedicated thrust areas and are working with mandate to build efficient technologies in their respective domains. Each TBI are acting as a role model for enhancing industrial involvement in academic research, hence leading to PPP R&D. Other then NSTEDB under DST, New Delhi, there are some other agencies which support establishment of Incubators and support technology incubation at various educational institutes and R&D organizations. For instance, BIRAC has initiated a programme of Bio-Incubators with an aim to harnesses technology generation and entrepreneurial potential of start ups by giving access to them for proper infrastructure and mentoring. Till date, BIRAC has strengthened the existing fifteen incubation facilities in the country to develop world class bio-incubation facilities. Under Atal Innovation Mission at NITI Ayog, scheme for creating Atal Incubation Centres (AICs) at different educational institutes in order to promote incubation and entrepreneurship culture has been announced. Ministry of Electronics and Information Technology (MeitY) has also established an incubation centre at Patna and Cochin, Kerala for development of Product and IP creation.

Table 4 lists of notable TBIs in different parts of India working for technology enhancement and simultaneously addressing the gap in PPP.

Table 4: Technology Business Incubators (TBI) working for PPP

S. No.	**TBI**	**Brief Details**
1.	**IKP Knowledge Park-Life Science Incubator** www.ikpknowledgepark.com	It was established with an aim to boost technological advancements in field of life science, pharmaceutical and biotech areas and addressing needs of industries in these respective areas.
2.	**Technology Business Incubator at Shriram Institute of Industrial Research (SRI-TBI)** www.shriraminstitute.org	SRI-TBI is acting as unique networking and technology resource centre which is equipped with latest facilities and is supported by highly skilled knowledge providers.
3.	**Society for Innovation and Entrepreneurship (SINE) at IIT Bombay** http://sineiitb.org/sine/home	Initiated with the support of IIT-Bombay alumni, SINE is a platform for promotion of entrepreneurship and administers business incubator that supports technology based entrepreneurship and industrial growth.
4.	**Venture Centre, Pune** www.venturecenter.co.in	Dedicated towards technology start-ups and generating products and services by exploiting scientific expertise in the fields of materials, chemicals and biological sciences and engineering. It is a collective initiative of NSTEDB, CSIR and TDB and is a not–for-profit company which is hosted by National Chemical Laboratory (NCL), India, through which support to technological enterprises is provided by leveraging scientific competencies of the institutions in the Pune region.
5.	**Kalinga Institute of Industrial Technology Business Incubator (KIITTBI), Bhubaneswar** www.kiitincubator.in	KIITTBI is an initiative of KIIT University with support of NSTEDB and it offers incubation facilities and enables the incubatees to work in a secure, innovative and entrepreneurial environment as they progress through various stages of entrepreneurial development.

➢ Science, Technology and Innovations Park

Science, Technology and Entrepreneurship parks (STEP) were instituted by NSTEDB with a mandate of creating an environment for entrepreneurship and innovation. NSTEDB has established 15 such STEP at different locations in India in different HEIs (Table 5).The major objectives of STEP are to forge linkages among academic and R&D institutions on one hand and the industry on the other and also promote innovative enterprise through S&T persons. The department has so far catalysed 15 STEPs in different parts of the country, which have promoted nearly 788 units generating annual turnover of around ₹ 130 crores and employment for 5000 persons. More than 100 new products and technologies have been developed in by the STEPs/STEP promoted entrepreneurs and industrial collaborators. In addition, over 11000 persons have been trained through various skill development programmes conducted by STEPs.

Table 5: List of STEPs created by NSTEDB

S. No.	STEPs	Technology Thrust Area
1.	STEP-Birla Institute of Technology, Ranchi	Mechanical engineering
2.	JSS Technical Institutions Campus, Mysore	Electronics and IT
3.	National Institute of Technology, Surathkal	IT
4.	Science & Technology Entrepreneurs Park (BEC-STEP), Bagalkot	Food processing, textiles and building technology
5.	Science and Technology Park, Pune	IT and innovative technologies
6.	Maulana Azad National Institute of Technology, Bhopal	IT and innovative technologies
7.	Thapar University, Patiala	Agribiotechnology, biofertilizer, food biotechnology, tissue culture
8.	Guru Nanak Dev College of Engineering, Ludhiana	Mechanical and IT
9.	TREC-STEP, NIT Campus, Tiruchirappalli	Mechanical and IT
10.	PSG-STEP, Coimbatore	Mechanical and IT
11.	Harcourt Butler Technological Institute, Kanpur	Paints, chemical and IT
12.	Indian Institute of Technology , Roorkee	Environment, Materials and IT
13.	Indian Institute of Technology Kharagpur	ICT, big data analytics, advanced manufacturing, agriproducts and machinery, healthcare devices , bioprocess

		and bioproducts
14.	NSIC Technical Services Centre, Rajkot	Energy and pumps
15.	National Small Industries Corporation Limited, New Delhi	Energy and pumps

Apart from NSTEDB, there are other organizations [Ministry of Communications and Information Technology (Software Technology Parks of India), ASSOCHAM (Mega Food Parks); Reliance ADA Group (Dhirubhai Ambani Knowledge City)] that have created number of science and innovation parks. These science, technology and innovation parks via their R&D activities are bridging the gap between industry and academia. Table 6 lists down some of the science, technology and innovations park which are actively involved in PPP.

Table 6: Science, Technology and Innovation Parks under PPP mode in India

S. No.	Park	Brief Details
1.	**Science and Technology Park, Pune** www.scitechpark.org.in	It was established by NSTEDB with an objective to create wealth from innovation and R&D activities. It has various linkages with European union and DST for skill enhancement, USAID-India and UNEP. It has various industry association as its members like Indo-Japan Business Council to promote industry, trade and commerce; Indian Green Building Council.
2.	**Science and Technology Entrepreneur's Park (STEP) at IIT Kharagpur** http://www.step-iit.org/	STEP was established in IIT Kharagpur with support from Government of West Bengal, DST and financial assistance from IDBI, IFCI, ICICI. It is working in harmony with other incubation programmes of IIT Kharagpur such as technology Business Incubator, Technology Incubation and Entrepreneurship Training Society (TIETS) to facilitate technology transfer to the industrial segment.
3.	**Indian Science and Technology Entrepreneurship Parks and Business Incubator Association (ISBA), Noida, UP, India** www.isba.in	ISBA is the only pan India network of Business Incubators and has an abundance of expertise and knowledge base in technology business Incubation. A unique feature is its diversity, with member organisations coming from academic institutions / universities of repute such as IIM-A, IIT Bombay, IIT Kanpur, University of Pune, NIT Trichy, NIT Surathkal, NID, VIT University, PSG etc., R&D organisations such as NCL, ICRISAT, NDRI etc. and other technology parks such as ICICI Knowledge Park, technopark etc.
4.	**IKP Knowledge Park,**	It is ICICI Knowledge Park and is India's premier

	Hyderabad www.ikpknowledgepark.com	science park, facilitating business driven R&D for over a decade now. IKP Knowledge Park has promoted 65 companies so far, and is currently associated with 47 of them. It has also facilitates technology transfer between Indian research organizations and local and global industries. Moreover, it educates local industries, entrepreneurs for IP rights and technology licensing.

- **Accelerators**

Accelerators are the entrepreneurship grooming organizations that promote indigenous start-up culture. It is comparatively new concept that India is following. Setting up of accelerators has aided in enhancing start-up culture in India. Some of the accelerators instituted in India are as follows:

Table 7: Accelerators in India

S. No.	Accelerator	Brief Details
1.	**Times Internet Limited Labs (Tlabs), New Delhi and Bengaluru** http://tlabs.in/about-us/	• It aims to develop entrepreneur's ideas to their potential and bridge the gap between entrepreneur and investor community. • It provides access to more than 100 experts to mentor entrepreneurial idea. It also provides seed capital fund to develop the idea into reality. • The programmes occurs in phases which start with hypothesis development, deep validation, strategic direction and business planning and financing to make an individual or group of individuals ready to set up a venture
2.	**GSF Global Accelerator, Gurgaon, Bengaluru and Chennai** http://www.gsfindia.com /accelerator/	• It composes of 13 weeks programme in order to foster innovation and start up culture in country in area of digital economy. It was designed to support product-oriented start-ups. • This Accelerator invests around $50k at 7-8% equity into product oriented start-ups which are inducted into the Accelerator program.
3.	**Microsoft Accelerator, Bengaluru** https://www.microsoftaccelerator.com/locations/bangalore	• It is 4-6 months programme where Microsoft representatives and associated partners provide tools, resource, connection and knowledge expertise to budding start-up to get converted into successful company.

4.	**Startup Village, Kochi** https://www.sv.co/?redirect_from=startupvillage.in	• It is run by Indian government to support start ups in field of agriculture. • It mentors the start-ups till the end when they start earning revenues and provides them start-up village angel fund • It is working impressively with portfolio of launching ~1000 companies in last 10 years
5.	**iAccelerator, Ahmedabad** http://www.ciie.co/	• It is an initiative of IIM, Ahmedabad for promoting innovation in field of internet and mobile technologies. • Expertise support in areas of technology development, product development and management, marketing and customer acquisition is provided along with seed fund to develop idea into reality.

These accelerators give good exposure the network of angel investors in India, budding ventures and number of industry services and support mechanisms for emerging R&D start-ups. These accelerators provide hand holding services for formation of company at any critical point of their growth. More of such accelerators should come up which can be run by either government agencies or industry representatives/venture capitalist or under PPP mode. Such accelerators are quite common in Israel where they have contributed to the development of R&D Based MSMEs.

Government-Industry Model (GIM)

A. Research Institutes (Public and Private)

- **Research Institutes Established by Government and Industrial Sector**

  First category focuses on PPP models instituted by government and industry together leading to initiation of industry oriented research institutes, such as Indian Plywood Industries Research and Training Institute (IPIRTI); Bengaluru (www.ipirti.gov.in) and Automotive Research Association of India (ARAI), Pune (www.araiindia.com) which are discussed in the coming sections. These institutes were established by Government with an aim to provide technological support to industries and are now working in close association with industrial associations.

Indian Plywood Industries Research and Training Institute (IPIRTI); Bengaluru; *www.ipirti.gov.in*

IPIRTI is an autonomous body established in 1962, under the Ministry of Environment, Forests and Climate Change (MoEFCC), GoI. The Institute is a co-operative research association of the Plywood Industry and the Council of Scientific and Industrial Research (CSIR), and has evolved into a dynamic and creative organization dedicated in developing new environment friendly technologies for wood based industry. IPIRTI has been closely associated with the development of wood panel industry in the country and is also instrumental in its growth from its infant stage to the technical competence for producing high level of plywood. It has become industry driven organization. IPIRTI formulates projects based on the needs of the plywood industries. Funding support for projects is provided by various industries, national agencies like DST, NRDC, Bureau of Indian Standards (BIS), Building Materials and Technology Promotion Council (BMTPC) and international agencies like *International Tropical Timber Organization* (ITTO), International network for Bamboo and Rattan (INBAR), Department for International Development (DFID)/Timber Research and Development Association (TRADA). It has established field station/centre in Kolkata in year 1963 and Mohali in 2008 to meet the needs of industry in these regions.

IPIRTI is working with a mandate of carrying out a) R&D activities; b) education and training; c) testing and standardization services and d) extension services such as technical consultancy to academia and industries in field of wood and panel products such as lignocelluloses and agro residues. IPIRTI is recognized by BIS for testing and licensing/certification programme of wood and related products. IPIRTI has created a notable intellectual property profile. IPRTI is credited with 5 granted patents and 9 filed patents (Table 8). It has carried out 28 in house projects, 13 sponsored projects and 3 consultancy projects. It has successfully transferred 18 technologies to various organizations (Table 9).

Table 8: List of Patents Granted to IPIRTI and Filed by IPIRTI

S. No.	Title	Status
1.	Development of Matchstick from Bamboo	Granted
2.	Bamboo Mat Corrugated Roofing Sheets	Granted
3.	Nn improved process for the preparation of water impermissible resings	Granted

4.	Improvements in relating to a process for making composite boards from rice husk	Granted
5.	An adhesive based on natural polyphenols	Granted
6.	Earthquake resistant Bamboo Housing System	Filed
7.	Improved method of manufacture of Bamboo Mat Board [BMB], and Bamboo Mat Veneer Composite [BMVC]	Filed
8.	Method of manufacture of Bamboo Mat Trays and Coir trays	Filed
9.	A process for manufacture of Cardanol Phenol Formaldehyde Resin	Filed
10.	Development of mechanized E-Tester	Filed
11.	Compregs from Bamboo Mats/Veneers of Plantation Timber or a combination and a process for the preparation thereof	Filed
12.	A process for the manufacture of Bamboo mat moulded skin board doors from Bamboo mats	Filed
13.	A process for the manufacture of Bamboo mat Ridge Cap roofing with Bamboo Mat Corrugated Sheets	Filed
14.	A process for gluing preservative treated veneer with improved Phenol Formaldehyde Resin	Filed

Table 9: Technologies Transferred from IPIRTI

S. No.	Technology	Transferred to
	Industries	
1.	Development of 50mm Compreg using Gurjan species	Indeustch International, Noida
2.	Manufacture of High Density Bamboo Mat Board	Divine Industries, Maharastra
3.	Manufacture of Bamboo Mat Corrugated Sheet	Brahmaputra Forest Industries, Lakhimpur, Assam
4.	Instru-ments for Peeling Lathe adjust-ments	Kalyan Industries, Haryana
5.	Finger Jointing Machine	Lakshmi Industries, Ahmedabad
6.	Light coloured PF	Shivhari Plywood, Nanital
7.	Shuttering grade plywood	TATA Coffee Ltd., Mysore
8.	Bamboo technology (BMT)	Natura Pvt. Ltd., Bangalore
9.	Bamboo technology (BMB and BMCS)	Timpack Pvt. Ltd., Meghalaya
10.	Bamboo technology (BMB)	Supernatural Plywood, Chandapur
11.	Bamboo technology (BMB & BMVC)	Cosmicraft Industries, Meghalaya
	Government organizations	
12.	Bamboo technology (BMB & BMVC)	Kerala State Bamboo Corpn. Angamally, Kerala
13.	Bamboo technology (BMB)	Gramvikas, Berhmapur
14.	Bamboo technology (BMT)	BAIF, Pune

15.	Coir Tray	Coir Board, Bangalore
16.	Pine Needle Particle Board	Himachal Pradesh Forest Development Corpn. H.P.
17.	Establishment of Bamboo Composite Centre	Rain Forest Research Institute, Jorhat, Assam
International		
18.	Manufacture of Bamboo Mat Corrugated Sheet	Habitat for Humanity International, Nepal

Till date major technological achievements of the Institute are listed below:

- Development of processes for various resin systems
- Development of layered composites
- Development of Non-wood products
- Development in Solid Wood Products
- Protection and Enhancement of service life of wood and panel products
- Development of instruments, accessories and equipments

Moreover, for proper functioning of IPIRTI in terms of its IP profile, it has designed set of rules and regulations for IPR, technology transfer and consultancy (http://ipirti.gov.in/Rule_for_%20Patenting.pdf).

IPIRTI has also started various academic programmes in association with government agencies and industries to provide education and training in field of wood and panel industry. Various courses instituted in year 2014-15 are presented in table 10.

Table 10: Short Term Courses Conducted by IPIRTI in 2014-15

S. No.	Name of the course	Duration and no. of candidates	Sponsored by
IPIRTI, Bangalore			
1.	The Post Graduate Diploma Course in Wood and Panel Products Technology	1 year, 25	IPIRTI
2.	Plywood Manufacturing Technology-II	5 days, 9	Plywood industry
3.	Testing of plywood and bloack boards as per internationals tandards	5 days, 1	Plywood industry
4.	IFS Training Course: Contribution of forests plantation in livelihood support and industrial production	2 days, 10	MoEF&CC, RT Division, New Delhi

5.	Special Training: Sawmilling & Saw-doctoring and Wood working and wood finishing	10 days, 8	Kannur University
6.	International Nepal's Training course: Plywood Manufacturing Technology-I	3 days, 3	Ganpati & Shikhar Plywood, Nepal
7.	International Nepal's Training course: Plywood Manufacturing Technology-II	3 days, 3	Ganpati & Shikhar Plywood, Nepal
8.	IPIRTI-NID Bamboo Training	4 days, 45	IPIRTI & NID, Bangalore
IPIRTI Field Station, Kolkata			
9.	Plywood manufacturing Technology	1 month, 7	Plywood industry
10.	Low cost and special Resin for manufacture of plywood	4 days, 6	Plywood industry
11.	Testing of Plywood Block board and Flush Door	4 days, 8	Plywood industry
12.	Plywood Manufacturing Technology	1 month, 5	Plywood industry
IPIRTI Centre, Mohali			
13.	Testing of block board and flush door As per IS: 1659& IS:2202and Resin manufacturing conventional PF & UF resin	10 days, 1	Plywood industry

Source: *IPIRTI Annual Report (2014-15)*

IPIRTI is the only institute in India dealing with wood and panel industry. There are number of member industries of IPIRTI who are availing services offered by IPIRTI as mentioned in table 11.

Table 11: IPIRTI Services to its Member Industries

S. No.	Service
1.	Providing trained man power industries through one year post graduate diploma course and different short term vocational training course sponsored by industries and MoEFCC.
2.	Providing solutions to common problems of the industries and their needs through regional workshops/meetings.
3.	Extending technical support services related to processing and production of plywood
4.	Formulating specifications for the new products developed by the industry and issue of draft amendments to existing standards.

Source: *www.ipirti.gov.in*

Till date, sixty eight industries have attained IPIRTI membership. Some of the notable member industries are:

ARCL Organics Ltd., Kolkata; Aditya Industries., Navsari; Century Plyboards (I) Ltd., West Bengal; Fine Wood Products Pvt. Ltd., Tamil Nadu; Greenply Industries Ltd., West Bengal; Hero Plywoods & Boards, Kerala; Indian Timber Products (P) Ltd., Hyderabad; The Indian Plywood Manufacturing Company Pvt. Ltd., Mumbai; Kanara Wood & Plywood Industries Ltd., Mangalore; Kaziranga Wood Products Pvt. Ltd., Guwahati; Madras Chipboard Ltd., Rajapalayam; Plystone Plywoods Pvt. Ltd., Ernakulam; The Western India Plywoods Ltd., Kannur.

Automotive Research Association of India (ARAI), Pune

www.araiindia.com

ARAI, a Pune based co-operative industrial research unit, was established by the automotive industry in association with the Ministry of Industries (GoI) in 1966. ARAI is playing an essential role in designing less polluting, safe and more efficient vehicles. It provides technical assistance in domains of R&D along with testing, homologation, framing and certification of vehicle regulations. ARAI is known for its finest services and it is accredited with ISO 9001, ISO 14001, Occupational Health and Safety Management (OHSAS) 18001 and National Accreditation Board for Testing and Calibration Laboratories (NABL). Various kinds of services provided by ARAI are listed in table 12.

Table 12: Services Offered by ARAI

S. No.	Service	Brief Details
1.	**R&D Services**	Pursuing research in fields, such as: • Power Train • Structural Dynamics • Safety • Electronics • Materials • Noise, Vibration and Harshness • Computer aided engineering ARAI has successfully developed indigenous LPG and CNG conversion kits, especially for two and three wheelers to meet EURO IV emission norms. ARIA through its research activities in field of powertrain and electronics has generated key products of industrial importance, some of the key products are listed below:

		• EURO - 4 CRDI Diesel Development • CNG HCV For Bus Application • LPG Passenger Car For OEM Application • In-vehicle Duty Cycle and Operation Pattern Recorder • Conversion of legacy sensors data to CAN messages
2.	**Education and Training**	ARAI has built ARAI Academy to develop world-class eco-friendly education institute for masters, doctoral and professional improvement courses in automotive engineering in collaboration with National and International Universities. • VIT University, Vellore • VELTEC University, Chennai • College of Engineering Pune • University of Alabama, Birmingham • Braunschweig University, Germany
3.	**Forging Industry Division (FID)**	With its world class testing and validation laboratories for metallurgical and fatigue testing, product and process simulation and computer aided engineering, ARAI – FID is all set to make Indian forging a strong "Made in India" brand. ARAI – FID understands training requirements of the industry very well and has developed full-fledged advanced training facility. FID is supported and promoted by Ministry of Heavy Industries &Public Enterprises, Government of India, ARAI and Association of Indian Forging Industry (AIFI)
4.	**Certification**	ARAI provides certification for vehicles, engines, safety components, genset, agricultural equipments, construction equipments, bus body builders, Population Check Equipment (PUC) equipment, CNG Retro fitment, LPG Retro fitment, Conformity of Production (COP), export homologation, *Central Motor Vehicles Rules* (CMVR) Test Approval (TA) status.
5.	**Testing and Calibration**	Under testing and calibration service, ARAI offers testing services to the auto component, auto electronics, embedded and IT industry in the following areas: • Electromagnetic interference (EMI)/ Electromagnetic compatibility (EMC) • Material; Chemical; Environment testing; Swirl testing Drop testing; Security product testing; Engine durability
6.	**Standard Formulation**	Standard formulation are designed by ARAI under: • Automotive Industry Standards Committee (AISC) set up under Central Motor Vehicles Rules-Technical Standing Committee (CMVR - TSC) by Ministry of Road Transport & Highways,(Dept. of Road Transport & Highways) (MoRT&H and DoRT&H) in the year 1997 to review the safety in the design, construction, operation and maintenance of motor vehicles. • United Nations Economic Commission for Europe (UN-

		ECE) is an international body having its headquarters at Geneva, Switzerland. Under the Inland Transport Committee (ITC) of UN-ECE, there are several groups which deal with transport related technical and administrative matters. The group WP.29 (World Forum for Harmonization of Vehicle Regulations) deals with the subject of worldwide harmonization of automotive regulations. • CMVR TAP
7.	**Web based services**	ARAI provides web based services in field of homologation and regulations for DELTA application and TA certification. Along with this they provide expert advice in field of homologation.

Source*: www.araiindia.com*

ARAI has completed its 50 years of establishment. In these years, ARAI has progressed in terms of total income generated. In the year 2013-14, ARAI's total income was reported to be ₹19014 Lakhs. Figure 1 represents the total income of ARAI from 2008-2014. In these 7 years ARAI has revealed continuous growth in its income profiles. ARAI is credited with 12.8% growth in its operational income and 55% of its operational income comes from non-certification business which mainly lies on its R&D activities. Year 2012 onwards, learning and training centre also contributed to the operational income of ARIA. Figure 2 depicts the breakup of ARAI's operational income in 4 sections a) sponsored projects (government and industry funded); b) certification and routine testing; c) development testing and d) learning and training centre.

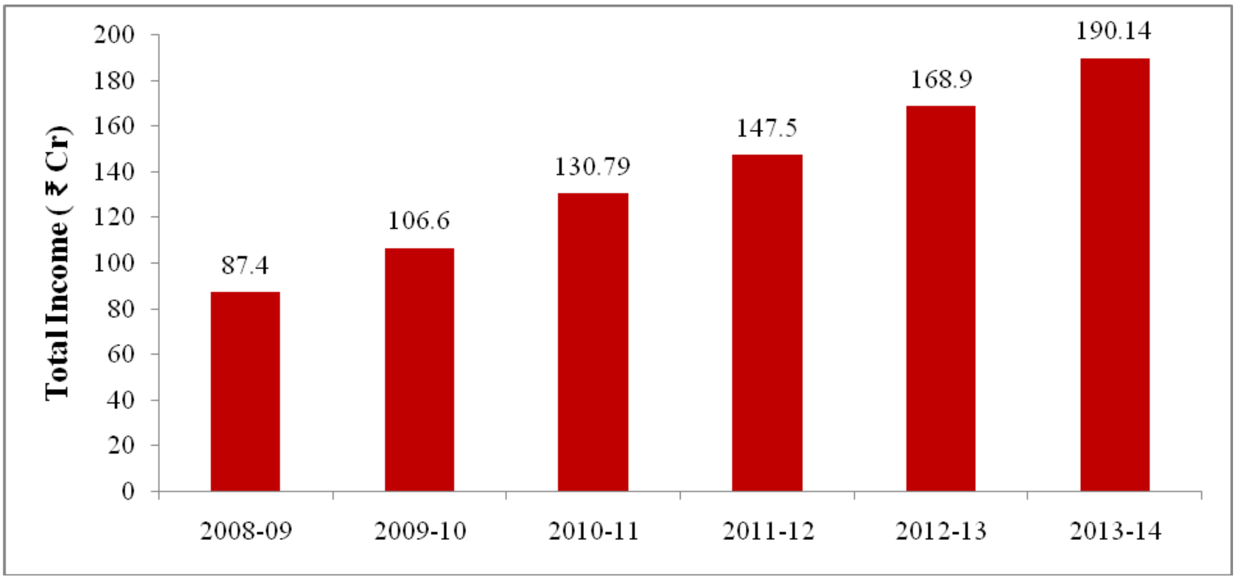


Figure 1: Total Income Profile of ARAI from 2004-2014.

Source*: 44th Annual Report of ARAI (2013-14)*

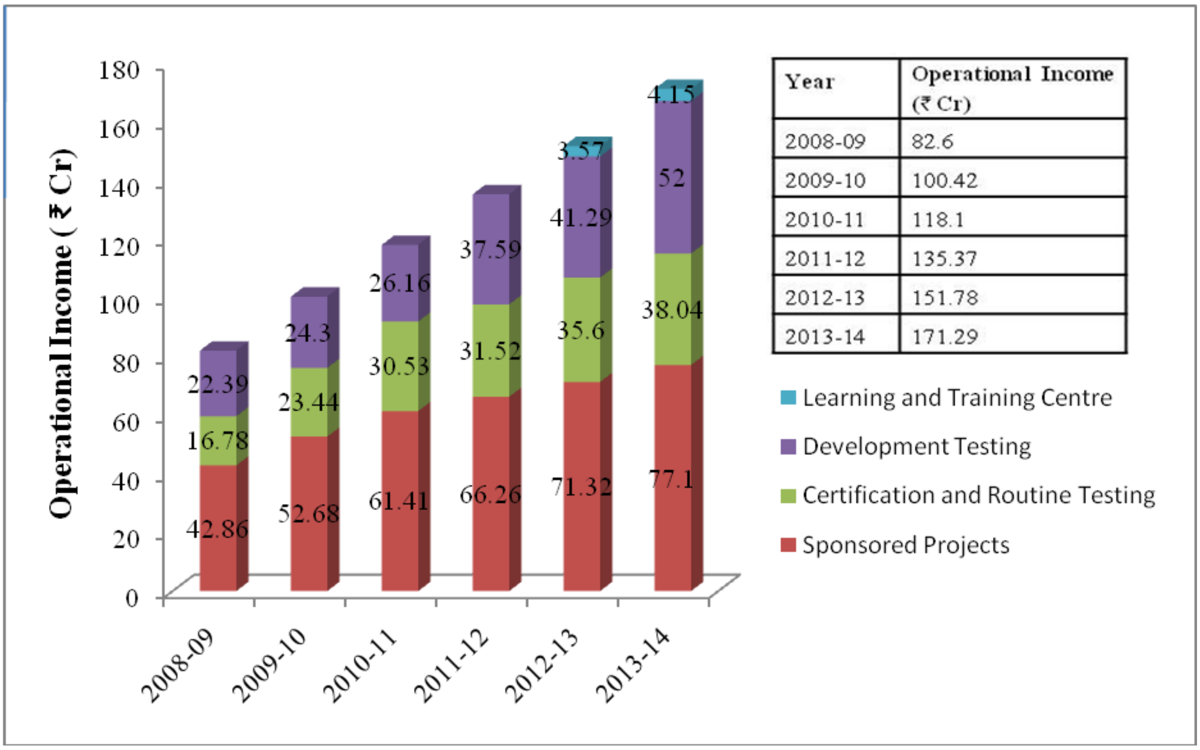


Figure 2: Operational Income of ARAI from 2008-2014

Source*: 44th Annual Report of ARAI (2013-14)*

ARAI has strong industrial linkages. It has 73 member industries who are availing different services offered by ARAI. List of important member companies is presented below:

Ashok Leyland Ltd., Bajaj Auto Ltd., Bharat Forge Ltd., Bosch Ltd., Cummins Technologies India Pvt. Ltd., Delphi-TVS Diesel Systems Ltd., Eicher Motors Ltd., Fiat India Automobiles Pvt. Ltd., Ford India Pvt. Ltd., General Motors India Pvt. Ltd., Greaves Cotton Ltd., Hero Electric Vehicles Pvt. Ltd., Honda Cars India Ltd., Hyundai Motor India Ltd., Kirloskar Oil Engines Ltd., Lombardini India Pvt. Ltd., Mahindra & Mahindra Ltd., Maruti Suzuki India Ltd., Mercedes-Benz India Pvt. Ltd., Piaggio Vehicles Pvt. Ltd., Power Electronics, Skoda Auto India Pvt. Ltd., Tata Cummins Pvt. Ltd., Tata Motors Ltd., Toyota Kirloskar Motor Pvt. Ltd., TVS Motor Co. Ltd., Volkswagen India Pvt. Ltd., Volvo India Pvt. Ltd.

ARAI has successfully utilized its state-of-art laboratories, developed technologies and skilled manpower for generation of engineers to meet the demands of automotive industry. It has stretched it arms in industry as well as academia and has drawn immense benefits for the automobile industry in India.

Government Supported Organization for Industrial Development

Many other organization/institutes have been established by GoI for assisting industrialization of MSMEs (Table 13).

Table 13: Organizations/Institutes established by GoI for Assisting Industrialization of MSMEs

S. No.	Institute	Brief Details
1.	**Mahatma Gandhi Institute for Rural Industrialization, Wardha, Maharashtra** *A National Institute under the Ministry of Micro Small & Medium Enterprises, GoI* http://www.mgiri.org/	The institute is working with an aim of developing novel technologies for rural industries, entrepreneurs and enterprises to bring industrialization and technology up-gradation. It provides S&T support and R&D guidance to enterprises to compete globally.
2.	**National Institute for Micro, Small and Medium Enterprises** *An organization under Ministry of Micro Small & Medium Enterprises, GoI* http://nimsme.org/	It is ISO 9001:2008 certified organization promoting advancement of MSMEs. Through its expertise in field of entrepreneurship development, technology development and management and informative services it has contributed to the promotion of MSMEs in India. It provides services, such as consultancy, research, training and extension to enterprises. It has carried out 885 research and consultancy projects. It is pursuing intellectual facilitation services to MSMEs via schools of excellence which are: • School of Enterprise Development (SED) • School of Enterprise Extension (SEE) • School of Enterprise Information and Communication (SEIC) • School of Enterprise Management (SEM)
3.	**National Small Industries Corporation** *Facilitating growth of small enterprises* *GoI enterprise under Ministry of Micro, Small and Medium Enterprise* http://www.nsic.co.in/SCHSERV.ASP	It is an ISO 9001:2008 certified government enterprise. It is working with an aim to promote growth of MSMEs. It provides marketing support, credit support, technology support and consultancy services for MSMEs. They have established 106 training cum incubation centres all over India for assisting technology growth of MSMEs.

4.	**Central Manufacturing Technology Institute (CMTI)** http://cmti-india.net/	CMTI is an R&D organization supported by DIPP is focusing its efforts mainly on harnessing know-how in the manufacturing technology sector to practical purposes and assisting technological growth in the country. CMTI has the role of being a Catalyst and a Key Player in manufacturing technology growth in the country.
5.	**Central Pulp & Paper Research Institute (CPPRI)** http://www.cppri.org.in/	The institute was established as a autonomous body under administrative control of DIPP, GoI, to promote R&D in the field of pulp & paper.
6.	**National Council for Cement and Building Materials (NCB)** http://www.ncbindia.com/	NCB is the premier body under the administrative control of Ministry of Commerce and Industry, Govt. of India, for technology development, transfer, continuing education and industrial services for cement and construction industries.

B. Industry Oriented Programmes of Funding Agencies

Various funding agencies have initiated number of programmes/schemes to support R&D in industries. Industrial association and GoI has together created a dedicated agency such as GITA (http://gita.org.in/), a joint initiative of DST, GoI and CII, for promoting industrial development globally by providing funding support and capacity building for industrial R&D. Industrial association FICCI and DIPP, GoI created a joint initiative ‘Invest India’ (http://www.investindia.gov.in/) for facilitating investments in R&D. Industry and DST also joined hands for starting a unique fellowship programme ‘Prime Minister Fellowship Programme’ for researchers pursuing industrial R&D, where industry and SERB, DST contributes equally for fellowship.

Table 14 lists down the programmes/schemes initiated by government funding agencies for promotion of industrial R&D contributing to the growth of Indian industry.

Table 14: Industry Oriented Programmes of Government Funding Agencies

S. No.	Programme/Scheme	Government Funding Agency
1.	Technology Development Board (TDB) http://tdb.gov.in/	DST

2.	Drugs and Pharmaceutical Research Programme http://www.dst.gov.in/drugs-pharmaceutical-research	DST
3.	Patent Acquisition and Collaborative Research and Technology Development (PACE) http://www.dsir.gov.in/12plan/pace/pace.htm	DSIR
4.	Promoting Innovations in Individuals, Start-ups and MSMEs (PRISM) http://www.dsir.gov.in/12plan/prism/prism.htm	DSIR
5.	Access to Knowledge for Technology Development and Dissemination (A2K+) http://www.dsir.gov.in/12plan/a2k+/a2k+s.htm	DSIR
6.	Technology Development and Demonstration Program (TDDP) http://www.dsir.gov.in/tpdup/tddp/tddp.htm	DSIR
7.	Technology Management Programme (TMP) http://www.dsir.gov.in/tpdup/tmp/tmp.htm	DSIR
8.	International Technology Transfer Programme (ITTP) http://www.dsir.gov.in/tpdup/ittp/ittp.htm	DSIR
9.	National Agricultural Technology Project (NATP) http://www.agriinfo.in/default.aspx?page=topic&superid=7&topicid=1472	ICAR
10.	The DRDO-FICCI ATAC Programme http://drdoficciatac.com/	DRDO
11.	Extramural Research (ER) and Grant-in-aid Schemes http://drdo.gov.in/drdo/English/index.jsp?pg=grantinaid.jsp	DRDO
12.	Industrial Corridor Projects http://dipp.nic.in/English/default.aspx	DIPP
13.	Modified Industrial Infrastructure Upgradation Scheme (MIIUS) http://dipp.nic.in/English/Schemes/IIUS.aspx	DIPP
14.	Antrix Corporation Limited http://www.antrix.gov.in/	ISRO
15.	Biotechnology Industry Partnership Programme (BIPP) http://www.birac.nic.in/desc_new.php?id=76	BIRAC
16.	Technology Upgradation Fund Scheme for the Textile Industries (TUFS) http://www.sidbi.com/?q=government-subsidy-schemes	SIDBI
17.	Technology and Quality upgradation Support to Micro, Small & Medium Enterprises (TEQUP) http://www.sidbi.com/?q=government-subsidy-schemes	SIDBI
18.	Credit Linked Capital Subsidy Scheme (CLCSS) http://www.sidbi.com/?q=government-subsidy-schemes	SIDBI
19.	Integrated Development of Leather Sector Scheme (IDLSS) http://www.sidbi.com/?q=government-subsidy-schemes	SIDBI
20.	Scheme for Food Processing Industries http://www.sidbi.com/?q=government-subsidy-schemes	SIDBI

C. Incentivization of Private Sector by DSIR

DSIR, nodal agency under Ministry of Science and Technology, New Delhi which is working with a mandate of promoting industrial research, supporting indigenous technology development and faster commercialization. DSIR has taken an initiative of "***Building***

Industrial R&D and Common Research Facilities (BIRD-crf)". Under this initiative, DSIR has commenced granting recognition to **In-House R&D Units** established by corporate companies and Scientific and Industrial Research Organizations (SIRO). Recognition of In-House R&D Units (RDI) is the solitary scheme in the entire Government sector for benchmarking R&D pursued by industrial sector. Through this DSIR recognition, industries pursuing research and innovation practices can avail fiscal incentives from the government sector which are categorized as a) Funding for R&D from Government Agencies and b) Tax Rebate and Customs /Excise Duty Waiver on Inputs for R&D.

<u>Incentives provided to private sector by GOI, as on Nov. 2015</u>

- **Incentives based on direct taxes (Income-tax Act, 1961)**

- 100% write off of revenue expenditure on R&D; (Section 35(1)(i) of IT Act).
- 100% write off of capital expenditure on R&D in the year the expenditure is incurred; (Section 35(1)(iv) of IT Act).
- Weighted tax deduction @175% (to the sponsor) for payments made to approved national laboratories, universities and IITs or a specified person, with a specific direction that the said sum shall be used for scientific research under a programme. (Section 35(2AA) of the IT Act).
- Weighted tax deduction @200% on expenditure (other than land & buildings) incurred on approved in-house R&D facilities of companies engaged in the business of biotechnology or in any business of manufacture or production of any article or thing, not being an article or thing specified in the list of the Eleventh Schedule. [Expenditure on scientific research in relation to drugs and pharmaceuticals, includes expenditure incurred on clinical drug trials, obtaining approvals from any regulatory authority under any Central, State or Provincial Act and filing an application for a patent under the Patents Act, 1970 (39 of 1970). (Section 35(2AB) of the IT Act.)]
- Accelerated depreciation allowance for investment on plant and machinery, made on the basis of indigenous technology (Rule 5(2) of IT Rules, 1962).

- **Incentives based on indirect taxes**

- Customs duty exemption to in-house R&D units established by corporate companies, other than a Hospital for capital equipment and consumables needed for R&D.

(Notification No.24/2007-customs, dated 01 March, 2007 as amended from time to time).

- Central excise duty exemption to in-house R&D units established by corporate companies, other than a Hospital for capital equipment and consumables needed for R&D. (Notification No.16/2007-central excise, dated 01 March, 2007 as amended from time to time).
- Central excise duty waiver for 3 years on goods designed and developed by a wholly owned Indian company and patented in any two countries out of: India, USA, Japan and any one country of European Union (Notification No.15/96-CE dated July 23, 1996, amended vide Notification No.13/99-CE dated 28 February, 1999).
- Exemption from customs duty on imports made for R&D projects funded by Government in industry. (Notification No. 50/96-Customs dated 23 July 1996).
- Goods specified in List-28 (comprising of analytical and specialty equipment) for use in pharmaceutical and biotechnology sector allowed to be imported duty free {notification No. 26/2003-Customs dated 1 March 2003 (entry substituted at S. No. 248 of the table in the said notification)} Subject to conditions mentioned in the notifications.

Academia- Industry Model (AIM)

Academic institutions are the store house of the R&D activities. They possess handsome amount of resources that can lead to generation of novel technologies that can be readily commercialized contributing to economic and societal benefits. Whereas, industrial sector in order to progress and compete globally need to bring innovation in their existing systems. Therefore, it is imperative for academia and industry to come in close collaboration in order to pursue directed research that can be successfully transferred to industries.

In this category, successful industry-academia initiatives are briefed in following sections:

A. Industrial Setups (Research Laboratories) in Academic Sector

Industries are coming forward to collaborate with academic sector to pursue collaborative research. Various industries have set up specialized laboratories/units in academic institutions where industry personals and academicians (faculty and researchers) together carry out industry oriented research activities. Table 15 represents some of the notable industrial sets ups in different academic institutes where academia and industry in partnership are pursing R&D activities.

Table 15: Laboratories Set Up by Industry in Academic Sector

Industrial Set up	Academic Institution
• M. K. Rangnekar Memorial Laboratory • Ramesh Banatwala Memorial Industrial Pharmacy Laboratory • E- Merck Laboratory and Chemistry Laboratory • Nihchal Israni Microbiological Laboratory	BCP Mumbai
• Xilinx FPGA Laboratory • The Tata Infotech Laboratory • Intel Microelectronics Laboratory • Laboratory for Intelligent Internet Research • Tata Consultancy Services Laboratory for VLSI Design and Device Characterisation • Texas Instruments Digital Signal Processing (TI-DSP) Laboratory • Wadhwani Electronics Laboratory • Cummins Engine Research Laboratory • Applied Materials Nano manufacturing Laboratory • VLSI Design Consortium	IIT Bombay
• Intel set up a Planet Labs in E&C Dept. • Cisco set up equipment for a Telephony and Security Lab in E&C Dept.	IIT Roorkee
• Bharti School Of Telecommunication Technology And Management	IIT Delhi
• General Motors-IIT Kharagpur Collaborative Research Laboratory on Electronics, Controls and Software	IIT Kharagpur
• Autodesk, Microsoft and Intel have established Centres of Excellence and sponsored research laboratories in the campus.	IIT Madras
• Ricoh Company- Centre for Design and Innovation at the Institute. • Analog Teaching Lab and C2000 Micro Controller Lab Setup by Cranes Software International Limited	IIT Gandhinagar

B. Scholarships/Fellowships/Industrial Chairs

Industry-Academia has collaborated for pursuing R&D and for this industry has come up with the grant of special fellowships and scholarships for researchers doing industrial research. List of some of the notable fellowships from industry to researchers for pursuing I-A collaborative projects is presented in table 16 below:

Table 16: Fellowships/Scholarships Sponsored by Industry

Fellowship/Scholarship
Prime Minister Fellowship Scheme- Industry and government funding agency to pay equal amount of fellowship to the researcher pursuing industrial research
Industry oriented fellowships in IITs IIT Kharagpur: • Google India Fellowship • Aditya Birla Fellowship • TCS Research Scholarship • Singapore Technologies Engineering Scholarships IIT Bombay: • Infosys fellowship • Intel India Fellowship • TCS Research Scholarship IIT Madras • Aditya Birla Fellowship • Nissan Scholarship • TCS Research Scholarship • Singapore Technologies Engineering Scholarships
ICT Mumbai • Pidilite Industries Ltd, Visiting fellow in Dyestuff Science & Technology • Marico Industries Visiting Fellowship • ICT - Lupin Visiting Fellowship for Bioprocess Technology • CIPLA Distinguished Visiting Fellowship in Pharmaceutical Sciences

Various industries are in collaboration with academia in sponsoring industry chair through which they support scientist pursuing industrial research. Table 17 lists some of the notable industrial chairs in HEIs.

Table 17: Industrial chairs in HEIs in India

S. No.	Industrial Chair	Academic Institution
1.	TATA Chair	IIT Bombay
2.	Praj Industries Chair	IIT Bombay
3.	Forbes Marshall Chair	IIT Bombay
4.	Bajaj Group Chair	IIT Bombay
5.	USV Chair	IIT Kanpur
6.	ABB Chair	IIT Delhi
7.	Microsoft Chair	IIT Delhi
8.	Henry Ford Chair	IIT Delhi
9.	Bharti Airtel Chair	IIT Delhi
10.	Reliance Chair	IIT Bhubaneswar
11.	Bharat Petroleum Distinguished Professor of Chemical Engineering	ICT Mumbai
12.	V.V. Mariwala Chair in Chemical Engineering	ICT Mumbai
13.	J.G. Kane Chair of Oil Technology	ICT Mumbai
14.	R. A. Mashelkar Chair of Chemical Engineering	ICT Mumbai

On individual basis faculty/scientist of the HEIs also collaborates with industries to carry out collaborative research projects.

C. Industry supported I-A cells

Various industries have supported academic institution for creation of dedicated Industry-Academia cells. One such I-A cell is Pfizer-Foundation for Innovation and Technology Transfer (FITT). Details of FITT as a successful model of academia industry initiative for PPP is given below.

Pfizer-Foundation for Innovation and Technology Transfer (FITT)

http://fitt-iitd.in/

GoI established FITT in 1995 in the campus of Indian Institute of Technology, Delhi (IIT-D), a premier engineering institute of India by GoI as the first I-A interface (FITT Annual Report, 1994-95). The GoI at that time provided an amount of ₹ 16.2 million as an aggregated fund to IIT-D for initiation and build up of FITT. The centre was set up as an autonomous and self governing body, to act as a single window utility to the industrial sector with complete professionalism and function as a marketing arm for the IIT-D developed technologies (Sengupta, 2009).

The broad organizational structure is composed of a) Governing Council and b) Research Council. The governing council consists of representatives from industries; industrial associations and nominee from MHRD, selected nominated members from IIT-D senate and its board of governors. On the other hand, research council is composed of selected faculty members of IIT-D having experience in I-A collaborations. The management is vested with the managing director of the organization, guided by governing council and research council. Details are given in Annexure IV

3. Summary

The emergence of India as a major global economic power calls for high levels of technological freedom but unfortunately the growth of technology has remained disunited and unlinked. This is due to the fact that the R&D activities of both the public and the private sector have remained disconnected from each other thereby creating a large gap in technology development and technology deployment. Synergies between academic basic research and industrial applied research have to be established to generate mutual added worth. To achieve this synergy it is imperative to create a PPP framework engaging both the public and the private sectors leading to multivariate use of knowledge, innovations, technologies and value creation of R&D activities.

Present chapter focuses on different PPP models existing in India, under three broad categories as:

1. **Government-Academia-Industry Model (GAIM): Triple Helix Model**
2. **Government-Industry Model (GIM)**
3. **Industry-Academia Model (AIM)**

Existing PPP models were studied under the category of Government-Academia-Industry Models that comes under Triple Helix Model. Under this section, creation of autonomous academic institutes by government on demands of industry and their support are reviewed. For example, Bombay College of Pharmacy (BCP), Mumbai and Institute of Chemical Technology (ICT), Mumbai was established on demands of industries and central and state government supported the creation of these institutes. Bothe these institutes are ranked top in Industry-Academia linkages in pharma and chemical sector by survey carried out by AICTE-

CII. BCP has established dedicated Industry Institute Interaction Cell that coordinates with industries getting associated with BCP. Industry representatives are part of governing body and curriculum design committee of BCP and have resulted in functioning and course structure of BCP is in accordance with industry needs. BCP has delivered more than 300 industrial R&D projects. In last four years (2012 onwards), BCP has carried out 81 industrial projects worth ₹ 1 Cr. Revenue generated from industrial sponsored and consultancy projects are utilized for faculty salary and institute development. Strong industrial collaborations of BCP have resulted into establishment of various laboratories in BCP by industrial units. On the other hand, ICT-Mumbai is a premier institute of India which has been ranked number 2 under the National Institutional Ranking Framework (NIRF) as declared by MHRD, GoI during April 2016. Since inception it has generated more than 500 entrepreneurs. It has successfully completed around 320 government sponsored projects and 318 industry sponsored projects. The number of Industry consultancies conducted till date is around 269 and many of the scientists actually earn their salaries through the consultation fees paid by the collaborating industry. During the last 10 years, ICT-Mumbai has filed a total of 310 patents and in the year 2014-15, ICT-Mumbai with faculty strength of 82 published 382 international publications. ICT-Mumbai enjoys various industry sponsored faculty positions and industry endowments. Under the Government-Academia-Industry Partnerships, creation of dedicated agencies by government, such as 'Biotechnology Industry Research Assistance Council' BIRAC and CSIR-Tech are also briefed. These organizations are effectively bringing industry and academia together for R&D activities and boosting entrepreneurship culture. BIRAC provides funding support in form of grants to SMEs in order to stimulate R&D activities and promoting innovation amongst SMEs (funds were created involving ₹1300 Cr from BIRAC and ₹750 Cr from Industry). BIRAC has also promoted I-A collaborations to explore innovations in biotech sector to be identified and commercialized for generating affordable products of social relevance [BIRAC through its schemes (SBIRI, BIPP and CRS) has led to 121 collaborative projects, out of which 108 I-A collaborative projects and 13 Industry-Industry collaborative projects]. CSIR-Tech is Pune based private Limited company established in 2011. The major partners of CSIR-Tech are CSIR (a conglomerate of public funded R&D labs), State Bank of India (a public funded financial services company) and Venture Centre (a technology business incubator). CSIR-Tech works for the commercialization of Intellectual Property (IP), know-how and technology emerging from public and private R&D labs as well as academic institutions. CSIR-Tech provides services like, Technology Venturing, India Science Venture Fund, Technology

Commercialization, Market Insights and Consultancy. CSIR-Tech is associated with CSIR labs, IITs, DAE, ICAR, Industry Association and universities (public & private) to aid them to encourage academic entrepreneurs who want to get involved in knowledge intensive ventures. Government funding agencies have also commenced various programmes for supporting Industry-Academia collaborative research such as 'New Millennium Indian Technology Leadership Initiative' (NMITLI) sponsored by CSIR, 'Schemes for Funding Industry Relevant R&D' (Under SERB) by DST and 'Advanced Composite Programme' by TIFAC and many more. Moreover, initiatives taken by government and private sector for establishing Technology Business Incubators, Centre of Excellences, S&T Parks and Accelerators have catalysed the Government-Academia-Industry Partnership in promoting R&D activities and technology development.

Under the second model Government-Industry Model, initiatives taken by government and industry for mutual benefits are presented. Research institutes, such as 'Indian Plywood Industries Research and Training Institute' (IPIRTI), Bengaluru and 'Automobile Research Association of India' (ARAI), Pune were created collaboratively by industry and government organizations and are working exclusively for enhancing industrial sector in their respective domains. IPIRTI was created by Ministry of Environment, Forests and Climate Change in association with plywood industries. The institute carries out R&D activities, training, testing and standardization services for industries. It has carried out 28 in house projects for collaborated industries, 13 sponsored projects and 3 consultancy projects of industries. It is in fact the only research institute dealing with plywood industries. ARAI was established as co-operative industrial research unit by automobile industry and Ministry of Industries, GoI. It is dealing with R&D activities in field of automobiles. ARAI is advancing in its income profile. In the year 2013-14, ARAI's income was of total worth ₹ 19014 lakhs and major chunk of its income comes from R&D activities carried out for industries. Many government organizations have created dedicated institutes that are working for industrial growth. Examples of such institutes, such as Ministry of Micro, Small and Medium Sized Enterprises (MSMEs) established institutes like 'Mahatma Gandhi institute for Rural Industrialization', 'National Institute for Micro, Small and Medium Enterprises' and 'National Small Industries Corporation' for assisting development of MSMEs in India. On the other hand, Department of Industry Policy and Promotion, GoI, has supported various autonomous institution, such as 'Central Pulp and Paper Research Institute' (CPPRI), 'Central Manufacturing Technology Institute' (CMTI) and 'National Council for Cement and Building Materials' (NCCBM) for assisting industrial research in respective domains. Under government-industry initiatives, number of programmes floated by government agencies for strengthening industrial sector is presented. Few of such schemes are ‘Technology Development Board’ instituted by Department of Science and Technology, New Delhi; ‘Promoting Innovations in Individuals, start-ups and MSMEs’ (PRISM) AND Technology Development and Demonstration Programme’(TDDP) initiated by Department of Scientific and Industrial Research (DSIR); ‘DRDO-FICCI-ATAC’ Programme of Department of Research and Development Organization (DRDO) and many more. Other government-industry initiatives include the incentivization of private sector which are recognized by DSIR to avail government benefits in form of tax rebate and custom/excise duty waiver on R&D inputs of industries. Moreover, government organizations like Department of Atomic Energy (DAE) have also established exclusive industrial units to supply hazardous and radioactive material to industries for R&D.

The final category of PPP includes Industry-Academia Initiatives. Under this category, industrial role in academia is reviewed. Industries have set up close collaboration with academia in terms of R&D activities. For example, industries have set up laboratories and dedicated units in academia, introduced number of scholarships and fellowships and sponsored chairs in academia. These steps undertaken by industries are one of the successful models of Industry-Academia Partnerships. Industry has also supported creation of specific cells in academia for assisting R&D activities and technology development and deployment from the academia to the industry along with enhancing entrepreneurship culture. Amongst Higher education institutes, IITs are leading in above mentioned Industry-Academia Initiatives. On the other hand, academia has also created I-A enablers, such as I-A cells which deal with Sponsored Research And Industrial Consultancy Cells, Entrepreneurship and innovation Cells for stimulating entrepreneurship and Technology Development and Intellectual Property Cells.

Annexure I

Bombay College of Pharmacy, Mumbai
www.bcpindia.org

Bombay College of Pharmacy (BCP) affiliated to University of Mumbai, is one of the premier pharmacy colleges in India, imparting quality pharmacy education and research. It was established in 1957 by the Indian Pharmaceutical Association-Maharashtra State Branch (IPA-MSB) with financial assistance from several pharmaceutical conglomerates and Government of Maharashtra to address the needs of pharma industry. Within few years of its establishment, number of graduate, master and doctorate programmes were started in particular branches of pharmaceutical sciences. Since its inception, BCP has grown in stature, and has generated more than 3500 pharmacists, ~700 M. Pharma and ~100 Ph.D. graduates.

BCP is providing master's and Ph.D. programmes through which research in various domains such as Pharmaceutics, Pharmacology and Toxicology, Pharmaceutical Chemistry, Pharmacognosy and Pharmaceutical Analysis is carried out. BCP has formed the research society which is recognized by DSIR, GoI. It has established world class facilities, state of the art instruments and equipments. Research is highly promoted in the college, faculty members have received number of research grants worth ₹100 million from Government funding agencies (DST, DBT, ICMR, UGC and AICTE) and ~₹10 million from private sector. Number of Industry-Academia (I-A) collaborative projects are undertaken in BCP. Till date, More than 300 industry sponsored projects have been successfully completed by BCP. The college has built up effective interface with the industrial sector in term of industrial trainings, industry sponsored projects, consultancy and faculty exchange.

BCP has been accredited with the "Best Industry-Linked Institution in Pharmacy" according tp the national survey carried out by AICTE in collaboration with CII, consecutively from past three years (2013 onwards).

<u>Industry-Academia Interface</u>

BCP has developed strong industrial linkages and is documented as one of the successful I-A linked institute of the country. BCP was constituted on the demand of industry which led to the full fledged functioning of BCP and it is providing continuous support to Indian pharma industry. In return, faculty receives incentives from their industrial collaborations. 20% of total project cost for research projects and 67% of total consultancy cost for individual consultancy is paid to the faculty, who is carrying out the research project consultancy.

Dedicated Industrial Cell

BCP has dedicated Industry Institute Interaction Cell (IIIC) whose main objective is to act as a liaison between industries and the college. Following are the major activities of the IIIC:

- Maintenance, coordination and promotion of consultancy services
- Distribution of funds that are obtained from industrial consultancy services for strengthening college's infrastructure and resources.
- Encouraging industry to start "Industry Study Tour Programme (ISTP) internship programme" and enhancing student's placement.
- Assist industries in obtaining tax incentives from Government by collaborating with them for R&D activities.
- Training of industry personnel.
- Exchange of personnel between the industries and BCP (such as industry personnel in delivering lectures on the latest technological development; development of curricula as per industrial needs and evaluation of projects).

BCP has also constituted '***Research Society***' in association with Indian Pharmaceutical Association which is recognized by DSIR. This society manages and co-ordinates various industrial research collaborations for related industries.

Industrial Linkages

- **Governing Body and Executive Curriculum Committee**

BCP has developed close linkages with industries, through which industries have become an important component of the Executive Curriculum Committee and play essential role in curriculum and course structure designing. Eighteen industrialists from notable pharma industries are presently part of BCP's Governing Body.

- **Industrial Representatives as Faculty Members**

In BCP, there are notable industry representatives as faculty of BCP. They share their valuable knowledge, experiences and industry challenges with the students. They also make the students aware of the industry needs. A few of the eminent industrialists in the faculty of BCP are listed in table 1.

Table 1: Industrial Representatives as Faculty Members of BCP

S. No	Faculty Member	Present Designation in the Industry

1.	Dr. Rao VSVV	Vice President, Nektar Therapeutics India Pvt. Ltd.
2.	Dr. Arun Bhatt	President, ClinInvent Research Pvt. Ltd.
3.	Dr. C.N. Potkar	Director, Clinical Research and Regulatory Affairs, Pfizer India Ltd.
4.	Dr. Chitra Lele	Executive Vice President, Sciformix Technologies, India
5.	Dr. Shekhar S Dawkar	Clinical Operations Manager, Amgen Technology Pvt. Ltd.
6.	Dr. Viraj Rajadhyaksha	Senior Medical Advisor, Pfizer India Ltd.
7.	Dr. Aakash Ganju	Director Clinical Operations, Johnson and Johnson, India
8.	Ms. Aditi Andrade	GCQA Specialist, Asia Pacific Global Clinical Quality Assurance, Johnson & Johnson Pharma Res.
9.	Dr. Anupama Ramkumar	Director, Arkus Clinical Trial Support Solutions, Ahmedabad
10.	Dr. Arun Nanivadekar	Medical Research Consultant, Mumbai

Moreover, numbers of guest lectures are arranged from the industry side as well. Students pursuing their final year of B. Pharma course are readily taken up by industries for internship programme where they get associated with industrial requirements and in return industry gets access to the manpower.

➢ **Industry Participation in R&D**

- **R&D Collaborative Projects**: Many R&D projects at the college are funded by pharma industry. BCP has successfully completed over 300 industrial projects. Each department of BCP has collaborations with the industry (Table 2).

Table 2: Industrial Collaborations in Each Department of BCP

Department	Industrial Collaborators	Details
Pharmacology and Toxicology	Shreya Lifesciences; Yasham P2D; Marico Ltd; ACTREC; Haffkin Institute; PCP (BDVU)	Faculty Member: 2; Patents: 3 Consultancy Services *(In Last 5 Years)*: ~7
Pharmaceutics	Unichem Labs. Bayer (I) Ltd; Bombay Drug House; Novartis; Bristol Maver Squibb; SPDS Lab India; USV Ltd; Abott India Ltd; Hanschen Probiotics; Famy Care; Glenmark Ltd; Getz Pharma; Cipla Ltd.	Faculty Member: 6; Patents: 15 Consultancy Services *(In Last 5 Years)*: ~8
Pharmaceutical Chemistry	Astrazeneca Research Foundation; Bristal Mayer Squib; Biocon Ltd; Alchemy Research Centre; Ciba Speciality Chemicals Ltd; Unichem Labs.	Faculty Member: 4; Patents: 6 Consultancy Services *(In Last 5 Years)*: ~2
Pharmacognosy	Omniactiv; Anazeal; Marico Ltd.	Faculty Member: 2; Patents: 1 Consultancy Services *(In Last 5 Years)*: ~3
Pharmaceutical Analysis	Marico Ltd; Spring Bank Pharmaceuticals Inc.	Faculty Member: 3; Patents: 3 Consultancy Services *(In Last 5 Years)*: ~2

- **Industry Initiated Laboratories**: BCP in association with pharma industries has set up number of laboratories and dedicated research centres such as Drug Testing Centre, Bio-

Availability Centre and Clinical Excellence Academy (Table 3). Industries have also promoted Research Fellowships e.g., Amrut Mody Research Fund (AMRF) was created at BCP out of donation from Unichem Laboratories Ltd. The main objective of this fund is to recognize and encourage research carried out in the field of pharmaceutical and allied science in the BCP and some other pharmaceutical institution in India.

Table 3: Research Laboratories Created in BCP in Association with Industry

Research Laboratory	Inaugurated year
The Vividhlaxi Audyogik Samshodhan Vikas Kendra (VASVIK) Research Wing	1987
M. K. Rangnekar Memorial Laboratory	1988
Bioavailability Centre	1990
Ramesh Banatwala Memorial Industrial Pharmacy Laboratory	1995
E- Merck Laboratory and Chemistry Laboratory	1996
Academy for Clinical Excellence (ACE) in Collaboration with Pfizer Global Research	2002
Nihchal Israni Microbiological Laboratory	2005

In addition, AMRF has also supported BCP for payment of faculty salary (Table 4).

Table 4: Contribution of AMRF to Payment of Salaries to Faculty

S. No.	Amount of Salary (₹)	Year
1.	9,78,215	2012-13
2.	12,55,571	2013-14
3.	11,63,716	2014-15
4.	13,04,798	2015-16
Total Amount 47,02,300/-		

- **Industrial Partners:** BCP has signed MoUs with many industries for providing education, training, consultancy and research projects. Table 5 represents the name of industrial collaborators of BCP in last four years.

Table 5: Industrial Collaborators of BCP, 2012 Onwards

S. No.	Industrial Collaborator	Year
1.	Anazeal Analytical Pvt. Ltd., Omni Active Health Technologies Ltd., Marico Ltd., Shreya Life Sciences Pvt. Ltd., IPCA Laboratories Ltd., Omniactives Health Technologies Pune, Enem Nostrum Remedies Pvt. Ltd., Zytex Biotech Pvt. Ltd., Bristol Myers Squibb, Ambernath Organics Pvt. Ltd., Glenmark	2012-13

	Pharmaceuticals Ltd., Evonik Degussa India Pvt. Ltd., Piramal Life Science Ltd., Gattefosse India Pvt. Ltd., Panacea Biotech Ltd., USV Ltd., Franco-Indian Pharmaceutical Pvt. ltd., Cymbiotics Biopharma Pvt. Ltd., Bharat Serums and Vaccines Ltd., Abbott India Pvt. Ltd.,Getz Pharma Research Pvt. Ltd., Glenmark Ltd., Famy Care Ltd., Getz Pharma Ltd. **(25)**	
2.	Marico Ltd., Getz Pharma Research Pvt. Ltd., Cipla Ltd., Bajaj Healthcare Ltd., Evonik Degussa India Pvt.Ltd., Neon Labs, Piramal Life Science Ltd., Enem Nostrum Remedies Pvt. Ltd., Ankum Drugs and Pharmaceuticals Ltd., Bharat Serums and Vaccines Ltd., Piramal Enterprises Ltd., Ipca Laboratories Ltd., Ambernath Organics Pvt. Ltd., BASF SE, Germany. **(17)**	2013-14
3.	Getz Pharma Research Pvt. Ltd., J M B Pharmaceuticals, Piramal Healthcare Ltd., Gattefosse India Pvt. Ltd., Enem Nostrum Remedies Pvt. Ltd., Panacea Biotech Ltd., Marico Ltd., Bharat Serum Vaccines Pvt. Ltd., Vinayak Ingredient India Pvt. Ltd., Naprod Life Science Pvt. Ltd., Anazeal Analytical & Research Pvt. Ltd., Vaidya Patankar Pharmacy Pvt. Ltd., Sandu Pharmaceutical Ltd., Ambernath Organics Pvt Ltd., BASF SE, Germany **(15)**	2014-15
4.	Gattefosse India Pvt. Ltd., Fusion Scientific Laboratories Pvt. Ltd., Pioma Chemicals, Naprod life Sciences Pvt. Ltd., Vinayak Ingradient India Pvt. Ltd., Bharat Serums Vaccines Pvt. Ltd., Marico Ltd., Fusion Scientific Laboratories Pvt. Ltd., Gutam Exports, Anazeal Analytical & Research Pvt. Ltd., Sandu Pharmaceutical Ltd., Ambernath Organics, Spring Bank Pharmaceuticals , BASF SE, Germany **(14)**	2015-16

Several industries as mentioned below are partner with BCP for curriculum design and academic teaching along with pursuing collaborative research:

Pfizer Ltd., Mumbai; Bhavan’s SPARC, Mumbai; ClinInvent Research, Mumbai; Fulford India Ltd., Mumbai; Dr. Reddy’s Laboratories Ltd., Hyderabad; Goldsheild Services, Mumbai; Lambda Therapeutic Research Pv.t Ltd., Mumbai; Neeman Medical International Asia Ltd., Delhi;Novartis India Ltd., Mumbai; Quintiles Spectral India Ltd., Mumbai; Ranbaxy Research Laboratories, Gurgaon; Sanofi-Aventis Pharma Ltd., Mumbai; Spectra Clinical Research Center, Hyderabad; SIRO Clinpharm Pvt. Ltd., Mumbai; SRL Ranbaxy, Mumbai; Wockhardt Ltd., Mumbai; Wyeth Lederle Ltd., Mumbai and Zydus Byk Healthcare Ltd., Mumbai.

- **Role of Industry in Institute Development and Revenue Generation:** Industry is actively contributing to the growth of BCP by providing finances for faculty salary, institute development and revenue generation. Figure 1 represents the amount of revenue generated from industries, 2012 onwards and table 6 lists the revenue generated from individual project and its corresponding collaborator. Department wise distribution of institutional share from industrial projects is presented in table 7.

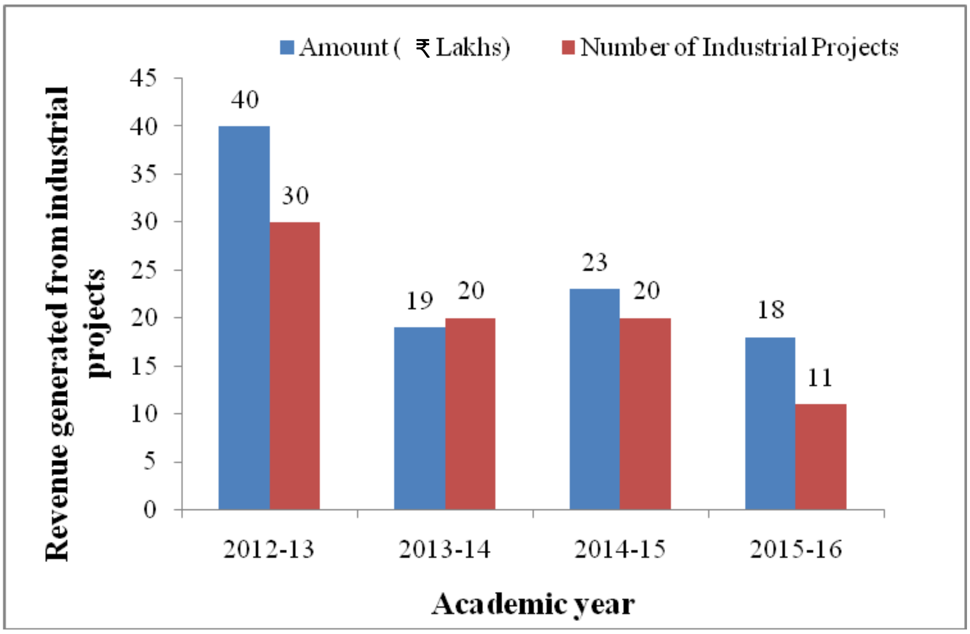


Figure 1: Revenue Generated from Industrial Projects in BCP since 2012.

Table 6: Revenue Generation from Industrial Collaborations (≥ ₹ 1 Lakh)

S. No.	Project Title	Industry	Amount Received (₹)
	Academic year (2012-13)		
1.	Comparison of Dry Powder Inhalation Devices	Glenmark Pharmaceuticals Ltd	4,10,000
2.	Fellowship/Manpower towards project entitled " Novel formulation stratagies for New Chemical Entities	Piramal Life Science Ltd	2,80,000
3.	"Extension of SR Project "	Gattefosse India Pvt Ltd	1,00,000
4.	BAE Project of Gelucires Part I		2,65,000
5.	Particle size and Zeta Potential Analysis of formulations	Panacea Biotech Ltd	1,00,000
6.	BMS-Fellowship	Bristol Myers Squibb	4,59,000
7.	Evaluation of Gardcef-1500 Injection for Anaphylactic Reaction Potential	IPCA Laboratories Ltd	1,02,600
8.	Pharmacological evaluation of drugs using	Enem Nostrum	1,65,000

	carrageenan induced paw edema and croton oil/Oxazolone induced ear edema method	Remedies Pvt Ltd	
9.	Preclinical studies of Nattokinase	Zytex Biotech Pvt Ltd	1,81,500
10.	Use of SOTAX USP type IV- Apparatus (Single cell unit) for Dexamethasone and Tobramyein Ophthalmic suspension.	Getz Pharma Research Pvt. Ltd	3,70,000
11.	Three way, three period, cross over bioequivalence study of single oral dose of three brands of 300 mg phenytoin sodium tablets marketed in India, on healthy volunteers.	Abbott India Ltd	5,04,250
12.	Use of SOTAX USP type IV- Apparatus (Tablets)	Glenmark Ltd	2,00,000
13.	Dissolution studies using SOTAX USP Type IV apparatus	Famy Care Ltd	3,00,000
14.	Use of USP type IV- Flow through Cell Dissolution Apparatus 2nd Extension Feb 2012 to April 2012	USV Ltd	1,00,000
Academic Year (2013-14)			
15.	In-silico Resistance Estimation - Assessment and development of computational methods for predicting which amino acids in a target protein binding-site are most likely to mutate in order to generate resistance against specific crop protection agents	BASF SE, GERMANY	6,07,925
16.	Effect of some NCEs on Aspirin induced ulcers in rats	Ipca Laboratories Ltd.	4,06,000
17.	Particle size and zeta potential analysis	Bharat Serum and Vaccines Ltd.	1,37,000
18.	Use of SOTAX USP type IV- Apparatus (Single cell unit) for Betoxolol hydrochloride Opthalmic suspension.	Getz Pharma Research Pvt. Ltd.	3,03,000
Academic Year (2014-15)			
19.	In-silico Resistance Estimation - Assessment and development of computational methods for predicting which amino acids in a target protein binding-site are most likely to mutate in order to generate resistance against specific crop protection agents	BASF SE, GERMANY	6,07,925
20.	In vitro studies of Bilagyl, Berbenterone tablets and Berbenterone paediatric suspension for antiamoebic, antibacterial and antifungal activity for proof of concept in infectious diarrhoea therapy	Sandu Pharmaceuticals Ltd	1,53,302
21.	Bioanalysis of Disulfiram and its metabolites by HPLC	Nerlikar Hospital	2,00,000

22.	Stability studies of Doctor Mom Herbal Cough Lozenges	Anazeal Analytical Pvt Ltd	2,00,000
23.	BAE Project of Gelucires Part I	Gattefosse India Pvt Ltd	1,00,000
24.	Design of lipsomal formulations	Panacea Biotech Ltd	2,21,000
25.	Particle size and zeta potential analysis	Bharat Serum and Vaccines Ltd	1,40,500
		Marico Ltd	1,38,000
26.	Particle size and Zeta Potential Analysis of formulations	Panacea Biotech Ltd	1,00,000
27.	Use of SOTAX USP type IV- Apparatus (Single cell unit) for Dexamethasone and Tobramyein Ophthalmic suspension.	Getz Pharma Research Pvt. Ltd	2,30,000
	Academic Year (2015-16)		
28.	In-silico Resistance Estimation - Assessment and development of computational methods for predicting which amino acids in a target protein binding-site are most likely to mutate in order to generate resistance against specific crop protection agents	BASF SE, GERMANY	6,08,925
29.	Expression, Purification and X-ray structure determination of plasmid RIG-1	Spring Bank Pharmaceuticals, Inc., MA 07157, USA	6,37,800
30.	Bioanalysis of Disulfiram and its metabolites by HPLC	Nerlikar Hospital	2,28,000
31.	BAE Project of Gelucires Part I	Gattefosse India Pvt Ltd	2,65,000

Table 7: Institutional Share from Industrial Projects

S. No.	**Name of the Department**	**Amount (₹)**				
		2012-13	**2013-14**	**2014-15**	**2015-16**	**Total**
1	Pharmaceutics Department	6,25,270	2,52,726	3,34,277	1,54,850	13, 67,123
2	Pharmaceutical Chemistry	-	83,000	83,000	-	1,66,000
3	Pharmacognocy	18,000	7,850	18,875	21,550	66,275
4	Pharmacology	1,10,320	81,200	24,244	65,738	2,81,502
5	Pharmaceutical Analysis	12,000	22,100	58,200	58,500	1,50,800
	Total Amount (₹)	**7,65,590**	**4,46,876**	**5,18,596**	**3,00,638**	**20,31,700**

It is clearly highlighted that BCP is having close collaboration with pharma industries for collaborative research projects and consultancy, which has largely contributed to institution growth for example revenue generated from industries are utilized for providing salary component of the faculty, instrumentation purchase and institute infrastructure development. Hence, collaborated pharma industries have led to the overall growth of BCP as the pioneer institute in field of pharmacy.

Annexure II

Institute of Chemical Technology, Mumbai

www.ictmumbai.edu.in

The Institute of Chemical Technology (ICT), Mumbai was established in 1933 with active industrial participation, as University Department of Chemical Technology (UDCT) under University of Mumbai, with the noble intention of enhancing India's knowledge base in chemical science and technology. Based on its continuous progress in academics and translational research, UDCT was upgraded to Deemed-to-be-University and renamed as Institute of Chemical Technology in 2008. Recently (2016), ICT-Mumbai has been ranked as number 2 university, under the National Institutional Ranking Framework (NIRF) of MHRD, (GoI).

Table 1: Brief Profile of ICT-Mumbai

Attributes	Details
Status of University	Deemed University (University under Section 3 of UGC)
Source of funding	State government
Date of establishment of university	12th September, 2008
Elite status by Government of Maharashtra	12th April 2012
University departments: Undergraduate Postgraduate (including Ph.D.) Research centres on the campus (PG)	 7 (983*) 11 (1015*) 2 (72*)
Academic programmes UG courses PG courses Ph.D. courses Integrated Ph.D.	 9 20 29 29
Faculty Strength	82
Faculty involved with industrial consultancy	80%
Patents (in last 10 years) Filed	 310
Research paper in international journal (2011-15) Average papers per faculty	2806 4.5
Industrial collaborators (MoUs signed)	~56
Government sponsored projects (Completed)	~320
Industry sponsored projects (Completed)	~318
Industrial consultancy	~269
Entrepreneurs generated (till date)	>500

**number of students*

Source: *www.ictmumbai.edu.in*

Centres of Excellence

Three Centres of Excellence related to R&D have been established in ICT- Mumbai to promote quality education and research through the support of central agencies. These are:

1. **DBT-ICT-Centre for Energy Biosciences:**

   The Centre's main focus is on developing biofuels from renewable resources to reduce India's rising dependence on petroleum fuels. The team of faculty working under this Centre comprises of Professor (1), Assistant Professors (2), Research Scientists (6) and Research Associates (8). Currently the Centre has more than 50 research scholars. The total grants received by this Centre from various sources amounts to ₹ 49 crores (approx). This Centre also has a dedicated unit for IP management and commercialization.

Table 2: List of Select Research Projects Sponsored by Public and Private Sectors

S. No.	Title	Funding Agency	Amount (₹) in Lacs	Duration
Public Funded Projects				
1	Green enzymatic fat splitting technology for production of fatty acids and acyl glycerols	DST, India	847.53	2014-2016
2	Improved production of Biogas and Bio-CNG from lignocellulosic biomas	MNRE, India	515.61	2013-2015
3	Centre for energy biosciences: New and extension proposals	DBT, India	1800.00	2013-2018
4	Transnational approaches to resolving biological bottlenecks in macroalgal biofuel production	DBT-BBSRC (Joint Indo-UK Scheme)	471.02	2013-2016
5	Integrated technologies for economically sustainable bio- based Energy	AISRF Indo-Australia Grand Challenge Program, DST, India	444.00	2013-2016
Private Funded Projects				
6	Microbial biotransformation for aromatic chemicals	Nagar Haveli Perfumes & Aromatics, Mumbai	15.00	2014-2015
7	Generation of purified phytoene from yeast cell mass	Wacker Chemie AG, Mumbai	14.49	2014-2015
8	Mass cultivation of algae for aqua feed	Godrej Agrovet Ltd, Mumbai	115.00	2014-2016

Table 3: Inter Institutional Collaborative Projects

S. No.	Title	Collaboration	Grant (₹) in Lacs
International			
1	Design of selective nanoporous membrane bioreactor for efficient production of biobutanol from lignocellulosic sugars	• Fraunhofer Institute for Ceramic Technologies & Systems, Hermsdorf, Germany	115.40
2	Transnational approaches to resolving biological bottlenecks in macroalgal biofuel production	• Durham Energy Institute, Durham University, UK • Centre for Advanced Research in International Agricultural Development (CARIAD), Bangor University, UK • Institute of Biological, Environmental and Rural Sciences. Aberystwyth University, UK	471.02
3	Engineering enzymes, bacteria and bioconversion processes for advanced biofuels from waste grain straw	• Clostridia Research Group/ Life Sciences, University of Nottingham, UK • Centre for Novel Agricultural Products, Department of Biology, University of York, UK • Institute for Cell and Molecular Bioscience, Newcastle University, UK • Faculty Health & life Sciences, Oxford Brookes University, UK	272.08
4	Integrated technologies for economically sustainable bio-based Energy	• Centre for Tropical Crops and Biocommodities, Queensland University of Technology, Australia • The Centre for Energy, The University of Western Australia, Australia • Department of Chemical Engineering, Curtin University, Australia	444.00
National			
5	Green enzymatic fat splitting technology for production of fatty acids and acyl glycerols	Acme Synthetic Chemicals, Mumbai	362.66 (Industry Contribution) 850.60 (DST Contribution)
6	Pilot scale translational facility for value added chemicals from	Privi Biotechnologies (P) Ltd, Mumbai	395.00 (Industry

	biomass		Contribution), 390.00 (BIRAC, DBT Contribution to company as loan), 50.00 (BIRAC, DBT Contribution to ICT as grant)
7	Lignocellulosic ethanol pilot plant to integrated continuous pilot plant	• India Glycols Limited, Noida, UP	862.50 (Industry Contribution), 862.50 (BIRAC, DBT contribution to company as loan)

Table 4: Some Prominent Patents from the Centre for Energy Biosciences

S. No.	Title	Patent No.	Status
1	Enzymatic process for fat and oil hydrolysis	SG11201404463P	Patent granted; Pilot plant being constructed for demonstration with DST support Total project cost (₹) = 850.60 L+362.50L = 1213.10L
2	Method for production of fermentable sugars from biomass	•US8709763 (USDIV-I); 2009 • US8338139; 2009 •US8673596 (USDIV-II); 2009 • BD1005172; 2009 • PK141809; 2009 •ZA2011/09250; 2012 •AU2010252547; 2015	Patent granted; Pilot plant being constructed for demonstration with BIRAC, DBT support Total project cost (₹) = 862.50L+862.50L = 1725.00L
3	Process for fractionation of biomass	•JP2013-513816;2015 •ZA2013/00133; 2010	Patent granted; Pilot plant being constructed for demonstration with BIRAC, DBT support Total project cost (₹) = 862.50L+862.50L = 1725.00L
4	Enzymatic production Of	1583/MUM/ 2014	Patent filed; Pilot plant being

	monoacylglycerol from oil		constructed for demonstration with DST support Total project cost (₹) = 850.60 L+362.50L = 1213.10L
5	A process for fractionation of oligosaccharides from cereal Bran	155/MUM/ 2014; PCT/IB2015/ 000030	Patent filed; Pilot plant being constructed for demonstration with BIRAC, DBT support (₹) 395.00 (Industry Contribution), (₹) 390.00 (BIRAC, DBT contribution to company as loan) (₹) 50.00

Table 5: Industry Consultancy and Income Generated in the year 2014-2015

S. No.	Name of the Company	Period	Amount (₹) in Lakhs
1	M/s. Warden International (Agencies) Pvt. Ltd, Mumbai	3 months	9.00
2	M/s. Kanoria Chemicals & Industries Ltd, Kolkata	1 year	25.00
3	M/s. Catapro Technologies, Nasik	7 months	8.00

2. **ICT-DAE Centre for Chemical Engineering Education and Research**:
This Centre was established as a joint effort of ICT-Mumbai and the Department of Atomic Energy (DAE) for conducting Ph.D. programmes in Chemical Engineering to carry out R&D projects.This Centre is working in close association with the DAE research institutions such as BARC, Mumbai and IGCAR, Kalpakkam, Tamil Nadu.The research objective is focused on generation of nuclear power production, use of radioisotopes in industry, health and agriculture.

Table 6: List of Important Sponsored Projects Related to the Centre for Chemical Engineering Education and Research

S. No.	Project title	Amount (₹) in Lakhs	Sponsoring agency
1	Design of solvent and extractant by molecular modelling for heavy metals	84.40	DAE
2	Experimental determination of H_2-I_2- HI-H_2SO_4 vapor-liquid equilibria	48.40	DAE
3	Studies on steam pyrolysis of a CHON amide as a waste solvent management method	24.70	IGCAR
4	Polysaccharide based nanocarriers for improved therapy of systemic fungal infections	16.90	DAE
5	Passive decay heat removal system of AHWR	221.00	DAE
6	Thermal hydraulic studies related to coolants for	80.00	DAE

	new generation reactors		
7	Characterization of cavitation phenomena and its applications in solid liquid mass transfer operations	88.90	DAE
8	Design of sodium cold-trap	23.80	IGCAR
9	Preparation of mono disperse MOX	23.80	IGCAR
10	Role of cavitation and its prevention in sodium pump	24.80	IGCAR
11	Scale up of MOX precipitation	21.50	IGCAR
12	Characterization of the regeneration process for liquid sodium cold trap in secondary system	38.00	IGCAR
13	Transport of actinides and fission products across hollow fibre supported liquid membranes	72.40	DAE
14	Thermal mixer design	24.20	IGCAR
15	Flow distribution in inlet plenum of steam generators	24.90	IGCAR
16	Removal of dissolved TBP for aqueous stream	24.50	IGCAR
17	Self assembly of tethered nanoparticles :Macromolecule' for tailored nanomaterials	95.00	DAE
18	Knowledge based engineering : Improvements in reactor design, heavy water production efficiency, nuclear waste management and development of novel	150.00	DAE
19	Chemical engineering, education and research	7500.00	DAE

3. **Centre for Green Technology:**

   Synthetic chemicals are routinely used to make virtually every man-made product. However, when the production and use of chemicals are not managed responsibly it can also have enormous impact on human health and the environment. Alternative means of chemical production which have benign or reduced adverse impact are required and new robust technologies in this direction need to be developed. In recognition of this urgent need, Centre for Green Technology was established in order to promote research in green chemistry with ₹ 30 crores sanctioned by UGC. The Centre is jointly owned by ICT-Mumbai and University of Mumbai.

National and International Accolades

- The Melinda and Bill Gates Foundation, USA, has awarded four grants to ICT-Mumbai recently which speak volumes of ICT's standing internationally.
- During 2014-15, ICT-Mumbai with faculty strength of 82, published 382 research papers in international journals which is a record in India.

- There are around 340 UG scholarships which have been created through funds generated from endowments, philanthropists, donations, trusts etc.
- Many of the scientists actually earn their salaries through the consultation fees paid by the collaborating industry.

Technology Enhancement in ICT-Mumbai

ICT-Mumbai has established various dedicated units that promote technology development and commercialization. A couple of these units are as follows:

1. An entrepreneurship cell (E-Cell) was launched in April 2013 with the primary goal of accelerating the entrepreneurial culture of ICT-Mumbai.
2. The Technological Association (TA) is the student body of ICT-Mumbai that conducts various extra-curricular and co-curricular activities throughout each academic year. The in-house technical journal, Bombay Technologist is also run by the TA and actively promotes scientific writing among students.

The following Centres of Excellence are included in the future expansion plans of ICT-Mumbai:

1. Centre for Infectious Disease Control and Prevention
2. Centre for Process Intensification and Innovation
3. Centre for Product Engineering
4. Centre for Undergraduate Research In Engineering (CURIE)
5. Creation of Visiting Professorships endowments
6. Entrepreneurship resource centre
7. Group consultations: Adoption of sick industries.
8. Increasing international collaborations (Joint projects with leading institutes and Joint degrees , UG exchange, PG exchange)
9. Interactive student services portal
10. Technology Incubation Centre
11. Technology Transfer Cell

Promotion of Research

- The culture of research among faculty and students is actively being promoted by facilitating participation in research projects and by providing resources and other facilities. Even UG students are engaged in active research in ICT-Mumbai. The institution facilitates its faculty by providing research funds as seed money. There are funds organized under Golden Jubilee Endowment through which seed money is provided to young faculty.

- ICT-Mumbai utilizes dedicated funds from agencies (BIRAC, RGSTC etc) for Tech Transfers.
- Teaching work load remission is provided to the faculty members in order to devote time to Research activities and for attending conferences etc. A 2 hour concession is given to Heads, Deans and other senior administrators (Controller of examination, Registrar, TEQIP Coordinator, and Course Coordinators).
- Faculties who did not have a Ph.D were encouraged to do Ph.D. Three faculty members took up the chance offered to them and completed their Ph. D during 2014-15. They have now started supervising Ph.D students.
- Sabbatical leave for higher research within the country and abroad can be availed and a good percentage of faculties have utilized this facility.
- New research areas such as computational chemistry, nanotechnology, material science, process control among many others has been initiated by young faculty, and is bound to bring laurels in future. All facilities and provisions such as duty leave and training expenses were made available for the same.
- Many endowment chairs have been created to invite eminent person from academic and industry. All efforts are made to appoint distinguished scientists and faculty through industry endowments. List of some industry endowments is given below:
    1. R.T. Mody Professor of Chemical Technology
    2. Sir Dorabji Tata Reader in Pharmaceutical Chemistry
    3. Darbari Seth Professor of Inorganic Chemical Technology
    4. Bharat Petroleum Distinguished Professor of Chemical Engineering
    5. V.V. Mariwala Chair in Chemical Engineering
    6. J.G. Kane Chair of Oil Technology
    7. M. M. Sharma Distinguished Professor of Chemical Engineering
    8. R. A. Mashelkar Chair of Chemical Engineering
    9. Gunavati Kapoor Chair in Pharmaceutical Technology
    10. Dr. B. P. Godrej Distinguished Professor of Green Chemistry and Sustainability Engineering
    11. Pidilite Industries Ltd, Visiting fellow in Dyestuff Science & Technology

12. Marico Industries Visiting Fellowship
13. ICT - Lupin Visiting Fellowship for Bioprocess Technology
14. CIPLA Distinguished Visiting Fellowship in Pharmaceutical Sciences

For details please see NAAC Self Study Report, ICT-Mumbai,2015 (http://www.ictmumbai.edu.in/uploaded_files/NAAC-Self_Study_Report_2016.pdf)

- The institute receives only salary grants from the state government and the government does not provide any other type of block grant to the institute. As such, institute does not earmark any budget head as a separate research fund in its annual budget. However, institute is supported by central government institutes such as UGC through its Career Advancement Scheme (CAS) programme, DST, CSIR, AICTE and Government and Industrial projects for the research work carried out in the institute.
- The instruments/equipments of ICT-Mumbai are available to research scholars 24X7, for performing their research work.

Mode of Publicizing the Consultancy Expertise of the University:

- The consultancy expertise available is publicized by the Institution through the Annual Reports and prospectus and through several conferences and workshops showcasing the capability of individual faculty member.
- Details of all faculty, their expertise and current consultancies, the projects under supervision as well other relevant details are published in the annual reports which are circulated to industries and also uploaded on the website. Industries approach the faculty directly or through the officials in the VC’s office for appointing faculty as consultants.
- As long as the terms and conditions of consultancy are in line with the institute’s policy, all faculty members are permitted to take consultancy without compromising on their academic work.

Areas of Consultancy: The areas of consultancy provided by ICT-Mumbai may be broadly classified into Pharmaceuticals (drug formulation, purification, delivery systems etc) Food industry (process, additives, formulation etc) Cosmeticeuticals, Nutraceuticals, Microbial biotransformation and Bio-based chemicals, Organic chemical synthesis and Natural product purification.

Outcomes of Research in ICT-Mumbai

1. **Publications**: Details of the publications by the faculty from 2011-15 are provided below:

- Number of papers (national / international)published in peer reviewed journals - 2806
- Chapters in Books – 29
- Books with ISBN with details of publishers - 8
- Books edited - 25
- Monographs - 6
- Number of publications listed in International Database (For e.g. Web of Science, Scopus, Humanities International Complete and EBSCO host) - 2037
- Citation Index – 26,498
- H-index – 63

2. **Patenting and Licensing**: ICT-Mumbai has filed/acquired 310 patents in last 10 years of which 189 are during the last 5 years. Two patents have been licensed during the year 2012-13. Trend in patenting in ICT-Mumbai in last 3 years is illustrated in figure 1.

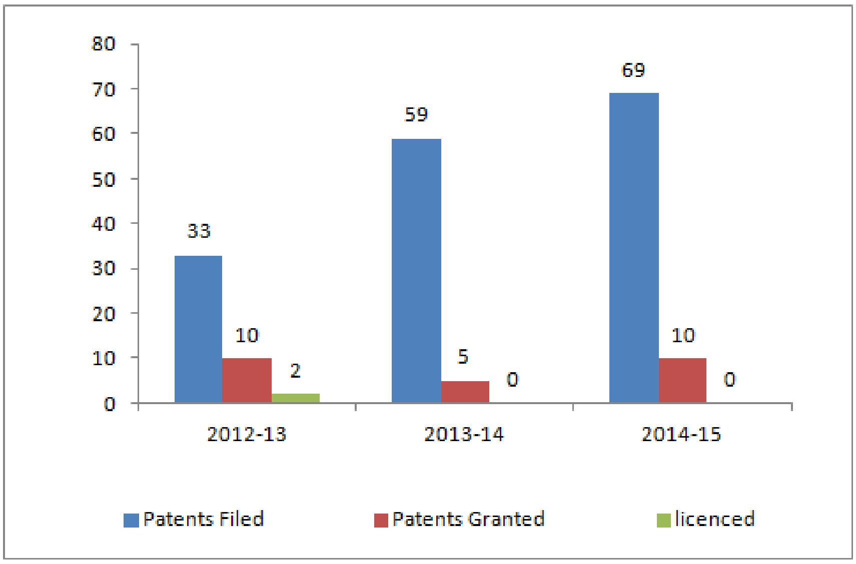


Figure 1: Patents Filed, Granted and Licensed in ICT-Mumbai from 2012 Onwards

Source*: NAAC A Self Study Report, ICT-Mumbai, 2015*

3. **Industry Sponsored Projects**: Around 232 industry/corporate houses sponsored projects are undertaken by ICT-Mumbai worth ₹ 84.7 crores. The list of industrial projects along with the funds involved is given below.

Table 7: Prominent Industry/Corporate Houses Sponsoring Research Projects at ICT-Mumbai

Industry/Corporate Houses	Principle Investigator	Amount (₹)
Abbott Healthcare Pvt. Ltd	Prof. P.V. Devrajan	603800.00
Asian Paints Ltd	Prof . R.N. Jagtap	*
BASF Ltd	Prof. R.V. Adivarekar	*
Bill Gates Foundation.	Prof. B.N. Thorat	*
Bio-Rad Lab	Prof. A.M. Lali	198987.00
BIRAC	Dr P.R. Namade	54656.00
Cadbury India	Prof. Rekha S. Singhal	*
DSM India	P.R Gogate/V.K. Rathod	34500.00
General Mills-III	Prof. A.M. Lali	*
Glenmark Pharma Ltd	Dr. S.S. Sathaye	*
Godrej Agrovet Ltd	Prof. A.M. Lali	8595540.00
Himedia Laboratories Pvt Ltd	Prof. U.S. Annapure	*
Hindustan Unilever Ltd	Prof. P.A. Mahanwar	301962.00
India Glycols Ltd	Prof. A.M. Lali	*
IPCA Lab Pvt Ltd	Prof. S.S. Bhagwat	*
Nicholas Piramal	Prof. K.G. Akamanchi	*
Pepsico	Prof. A.M. Lali	*
Pidilite	Prof. R.N. Jagtap	50000.00
Reliance Industries	Prof. G.D. Yadav	*
Tata Chemicals Ltd	Prof. U.S. Annapure	126405.00
Unilever India Pvt Ltd	Prof. A.W. Patwardhan	161270.00

* Project amount not available

Source: *NAAC Self Study Report, ICT-Mumbai, 2015*

4. **Mutual Benefits Accrued due to Consultancy:** The faculties of the institute get an understanding of the industry requirements and an opportunity to solve real life problems. Financial remuneration is another added advantage. Institutional resources in the form of equipments, endowments etc are generated through consultancy. Industry gets expert advice in the shortest possible time which saves their resources (time, energy, money). Figure 2 presents the worth of industrial consultancy carried out in ICT-Mumbai

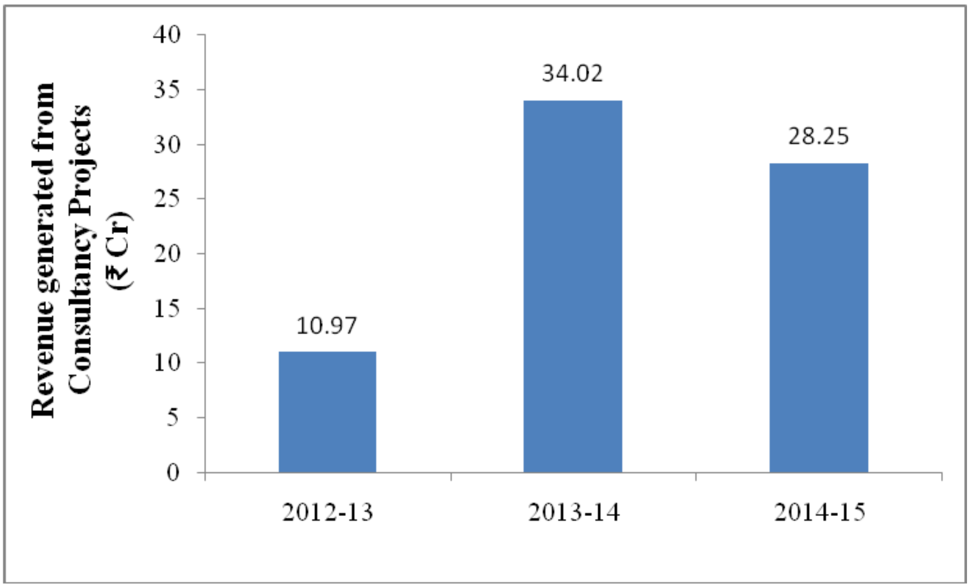


Figure 2: Revenue Generated from Industrial Consultancy Projects

Source: *NAAC Self Study Report, ICT- Mumbai, 2015*

5. **Industrial Collaborations:** ICT-Mumbai has close working relations with both foreign and Indian institutes and industries. In order to facilitate faculty and student exchange, research programmes and joint projects and symposia a large number of MoUs has been signed. We have listed some important MoUs in the following table.

Table 8: Important MoUs of ICT-Mumbai with National and International Industries

S. No.	National Industry/ Corporate Houses	Year of Collaboration
1	Bharat Petroleum Corp. Ltd (BPCL)	2000, 2015
2	Reliance Industries Ltd	2007
3	Hindustan Petroleum Corporation Ltd.	2010
4	General Mills Operations LLC	2010
5	Tata Chemicals Limited	2010
6	Biotech Consortium India Limited	2010
7	Bayer Crop Science Ltd	2011
8	Bio-Rad Laboratories India Pvt. Ltd	2012
9	GlaxoSmithKline Consumer HealthCare Ltd	2012
10	India Glycols Ltd	2012
11	Unilever Industries Pvt. Ltd	2013
12	Tata Chemical Ltd	2013
13	Kirloskar Integrated Technologies Ltd	2013
14	L'oreal India Pvt. Ltd	2013
15	Glenmark Research Centre(Non Disclosure Agreement)	2014
16	Reliance Technology Group (Non Disclosure Agreement)	2014

17	Agilent Technologies	2014
18	lndian Oil Corporation Ltd	2015
19	Asian Paints Ltd	2015
20	Godrej industries Ltd	2015
21	Siemens Ltd	2015
International Industry/ corporate houses		
22	Microsoft Corporation	2010
23	Coca Cola Ltd	2012, 2014
24	Essilor International	2014

Source: *NAAC A Self Study Report 2015*

6. Generation of Entrepreneurs: The industry-institute-government relationship fostered by ICT-Mumbai has been exemplary and has been cited as a role model for other institutes. There are several first generation entrepreneurs (numbering over 500) who have done pioneering work in chemical and allied industries in and around Mumbai and other parts of India who are the alumni of the institute. Some distinguished Alumni of ICT-Mumbai who became successful entrepreneurs are mentioned below.

List of notable entrepreneurs generated:

1. Shri. Mukesh D. Ambani (CMD, Reliance industries Ltd)
2. Dr. Dinesh Patel (Chairman, Themis Pharmaceuticals)
3. Dr. K. Anji Reddy (Chairman, Dr Reddy's Laboratory Ltd)
4. Shri. Ashwin S. Dani (Vice Chairman and MD, Asian Paints Ltd)
5. Shri. C. J. Bhumkar (Chairman, Soujanya Chemicals)
6. Shri. Chandrakant V. Gogri (Chairman, Aarti Industries and Aarti Group of Companies)
7. Shri. D.M. Trivedi (Famous Textile Technologist l)
8. Shri. J.R. Vyas (CMD, Dishman Pharmaceuticals and Chemicals)
9. Shri. J.R.Shah (Former President, Plastindia Foundation; Chairman, Jayvee Organics and Polymers)
10. Shri. S.M. Mokashi (Managing Director, Xytel India)
11. Shri. U. Shekhar and Shri SudhirPatil (Galaxy Surfactants Ltd)
12. Shri. V.G. Rajadhyaksha (Chairman, Hindustan Lever Ltd)
13. Shri. Narendra Parekh (Chairman, Pidilite lndustries)
14. Shri. NarotamSekhsaria (Founder & Managing Director, Gujarat Ambuja Cement Ltd; Sekhsaria Chemicals)
15. Shri. Nikhil R. Meswani (Tech. Director, Reliance Industries Ltd)

Some important points for promotion of Intellectual Property Rights (IPR) of ICT-Mumbai

Research carried out at ICT-Mumbai caters to both academic need as well as industrial applications. Rules and regulation for carrying out consultancy research work with industry/corporate houses in terms of consultancy and sponsored projects and subsequently filing of intellectual property can be accessed from the document "NAAC Self Study Report, ICT-Mumbai, 2015"*(http://www.ictmumbai.edu.in/uploaded_files/NAAC-Self_Study_Report_2016.pdf)*

Some of the salient features adopted by ICT-Mumbai for promotion of IP are as follows:

1. In the case of patent filled by the faculty members, if there is no third party involved, the license fee should be shared between the institute and the faculty members in the proportion of 30% to the institute and 70% to the faculty members.
2. In the case of patent filled by the faculty members, if there is no third party involved, the Royalty shall be shared in the ratio of 1:4 i.e. 20% to the institute and 80% to the faculty member and the other inventors.
3. The institute shall not pay any annual renewal fee for the patent granted. It shall be the responsibility of the authors.

Annexure III

Biotechnology Industry Research Assistance Council (BIRAC)

www.birac.nic.in

India’s biotech sector is one of the fastest growing sectors, growing at ~16% with net size of US $ 7 billion in the financial year 2014-15 (India Brand Equity Foundation, 2016). This fast pace growth in field of biotech in India is likely to continue as it is expected that biotech industry size will grow to ~US $ 11 billion by 2017. Indian biotech industry market share is composed of various sectors such as Bio-pharma, bio-services, bio-agri, bio-industry, bio-informatics and others out of which bio-pharma is the leading one (Fig. 1).

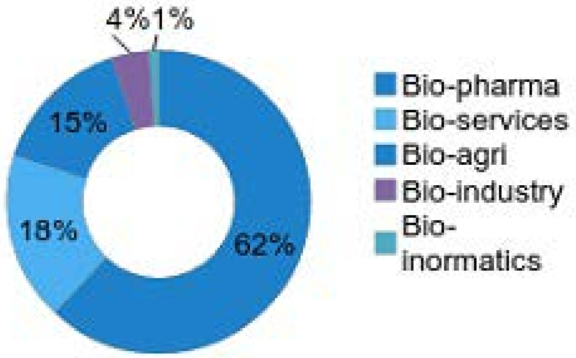


Figure 1: Biotech Market Break-Up Based on Revenues (2014-15)

Source: *Indian Brand Equity Foundation Report on Biotechnology, 2015 (http://www.ibef.org/download/Biotechnology-August_15.pdf)*

India ranks 12th in biotech destinations all over the world. Indian biotech industry holds 2% share of world’s biotech industry and comprises of close to 800 companies with an average growth rate of 20%. Since past two decades, high demand of various biotech products has led to increase in R&D activities and investment from various national and international organization/companies to set up base in India. Increase in innovation in biotech sector was kick started by Department of Biotechnology (DBT) under Ministry of Science and Technology in year 1986 through creation of number of biotech institutes such as National Centre for Cell Science (NCCS), National Agriculture Biotechnology Institute (NABI), National Institute for Plant Genome Research (NIPGR), Centre for DNA Fingerprinting and Diagnostics (CDFD), National Brain Research Centre (NBRC), mainly introducing various schemes for promoting biotech research in Indian education system. Transformation of biotech research to the market bench mark required strong I-A collaborations through which various biotech entities have been commercialized in past few years. Gradually DBT recognized the need of well built industrial partnerships for taking research through translational phase to market the product. For stimulating I-A interface in biotech sector and mounting capabilities of Indian biotech industry, DBT formulated National Biotechnology Development Strategy in 2007 and announced that 30% of its budget will be set aside for Public Private Partnership (PPP) via creation of separate organization in order to execute and implement PPP. Keeping this in mind, Government of India (GoI) through DBT has led to the creation of autonomous not-for-profit public organization **"Biotechnology Industry Research Assistance Council (BIRAC)"** in year 2012. BIRAC is registered as section 8 Company, scheduled B, public sector enterprise registered under Indian Companies Act 1935. It is an exclusive I-A interface agency that is working for strategic R&D activities catering to national societal needs of emerging biotech enterprise to make them globally competitive. BIRAC is working with the following mandate:

- To foster innovation and entrepreneurship
- To promote creation of affordable innovation in key social sectors of India
- To empower start-ups and small and medium enterprises
- To contribute to capability enhancement and diffusion of innovation in collaboration with different stakeholder/partners
- To enable commercialization of discovery/innovation and technology developed
- To ensure global competitiveness of Indian biotech enterprises

BIRAC is working to fulfil three main objectives which are:

1. Supporting early and late stage innovation research
2. Enabling services for promoting the innovation ecosystem
3. Product innovation and commercialization for addressing grand challenges of national relevance

BIRAC has taken responsibility for targeted funding for easy access to risk capital, technology transfer and management of IP. BIRAC within 4 years of its existence has strongly connected with different stakeholders, both from academia and industry, who are contributing to tremendous growth of biotech sector.

BIRAC is a unique organisation working under PPP mode. Creation of BIRAC has greatly enhanced the technology development and generation of useful products in biotech sector. It is a development agency in the field of biotechnology which addresses the national needs in terms of food security and health problems through competitive grants and product development programme in collaboration with the academic and industrial sector at national and international front.

Organization of BIRAC

BIRAC is governed by Board of Directors comprising of stakeholders from both DBT and Industry. Secretary of DBT, is the Chairman of BIRAC. The governing body along with chairman and managing director comprise of four non-executive independent directors, one government nominated non-executive director and one company secretary.

BIRAC's organizational structure is composed of diverse verticals with dedicated core functions that lead to its effective functioning (Fig. 2). These functioning groups are interlinked to each other to deliver the mandate of BIRAC. BIRAC has created horizontal and vertical groups to fulfil the core function of providing support for technology development and its diffusion across the country. Vertical group focuses on providing mentor and financial support at different stages of technological product development. It engages specialist/ scientists from different sectors to act as technical support for creation of technology. This group works in three areas, specialized with different domains which are as, a) Health Care (drugs and therapeutics, vaccine, diagnostics, biomedical devices, clinical trials and regulation); b) Agriculture (molecular biology, marker assisted breeding, RNAi) and; c) Green technology and industrial process (enzymes, fermentation, process optimization and chemical engineering).

On the other hand, horizontal group comprises of distinctive clusters as mentioned below, that assists the core functioning of vertical group:

- *Investment Cluster* that takes care of funding through various schemes.
- *Specialized Services Cluster* comprising of IP awareness, technology transfer facilitation and technology acquisition.
- *Strategic Partnerships Cluster* that has responsibility of knowledge networking, resource mobilization and establishing national and international collaborations.
- *Entrepreneurship Cluster* for providing infrastructural support in form of incubators and simultaneously mentorship via training and workshops to budding entrepreneurs.

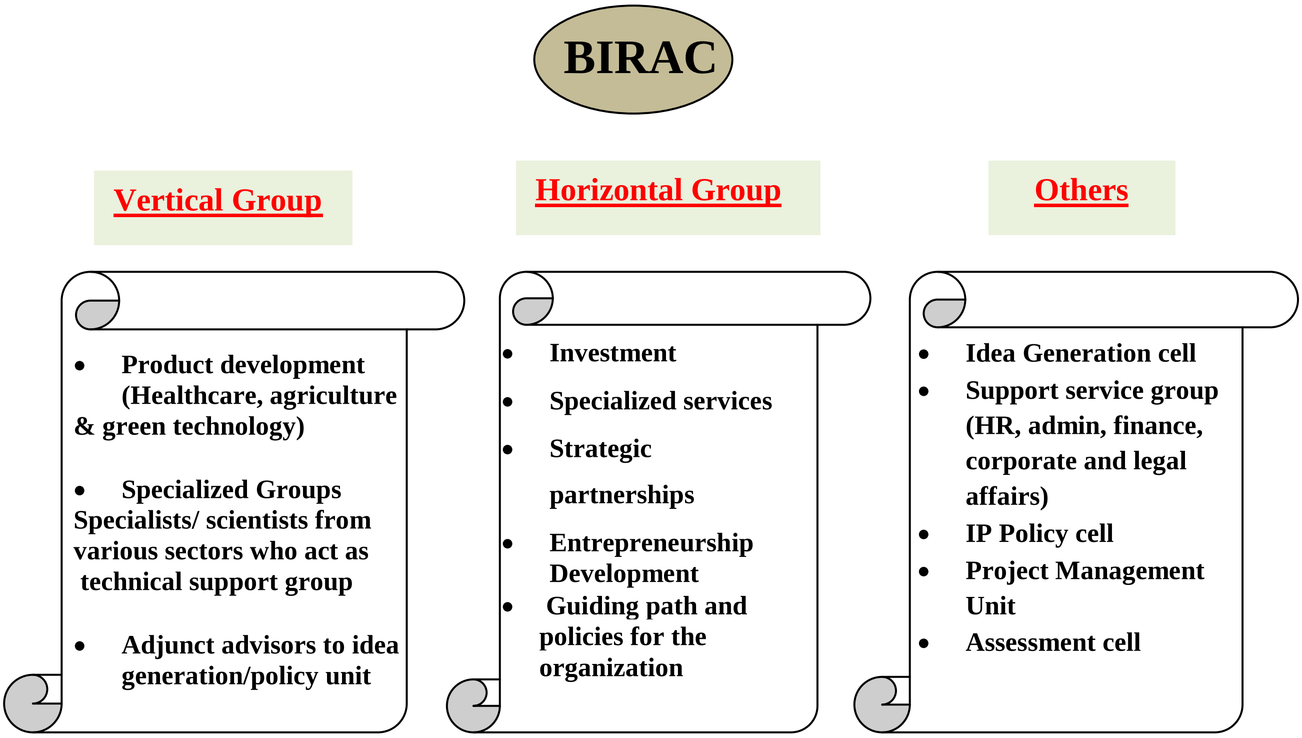


Figure 2: Organization Structure of BIRAC
Source: *http://www.birac.nic.in/*

BIRAC also has dedicated in house Policy and Analysis Cell (PAC). This dedicated cell analyses different proposals in field of agriculture, healthcare, industrial biotechnology mainly from techno-commercial view. This cell has responsibility of identifying priority areas in biotech sector that requires BIRAC support to address societal needs. Key areas where PAC works are as:

- Strategy and policy discussion with different stakeholders
- Identification of niche areas in biotechnology sector
- In-house technical and project management support for various proposals
- Creation of technology transfer unit of BIRAC
- Market analysis
- Creation of global databases in various sectors of biotechnology
- Commissioning of the reports in accordance to the needs of identified niche areas in biotech sector.

In addition, BIRAC has established Secondary Agriculture Innovation Cell (SAIC) to facilitate growth of agro based small and medium industries using modern technologies to create a mark in international market. Main responsibility of this cell is to build successful agriculture enterprise.

Programmes and schemes initiated by BIRAC

BIRAC is providing funding support through its different schemes to overcome intrinsic risk involved in innovation pathways right from the ideation to product development, scale up and market commercialization. Main focus of BIRAC is to a) support early and late stage innovation research; b) promotion of innovative ecosystem and; c) promoting product innovation and commercialization through partnerships. To achieve these goals BIRAC has introduced number of programmes/ schemes as presented in figure 3.

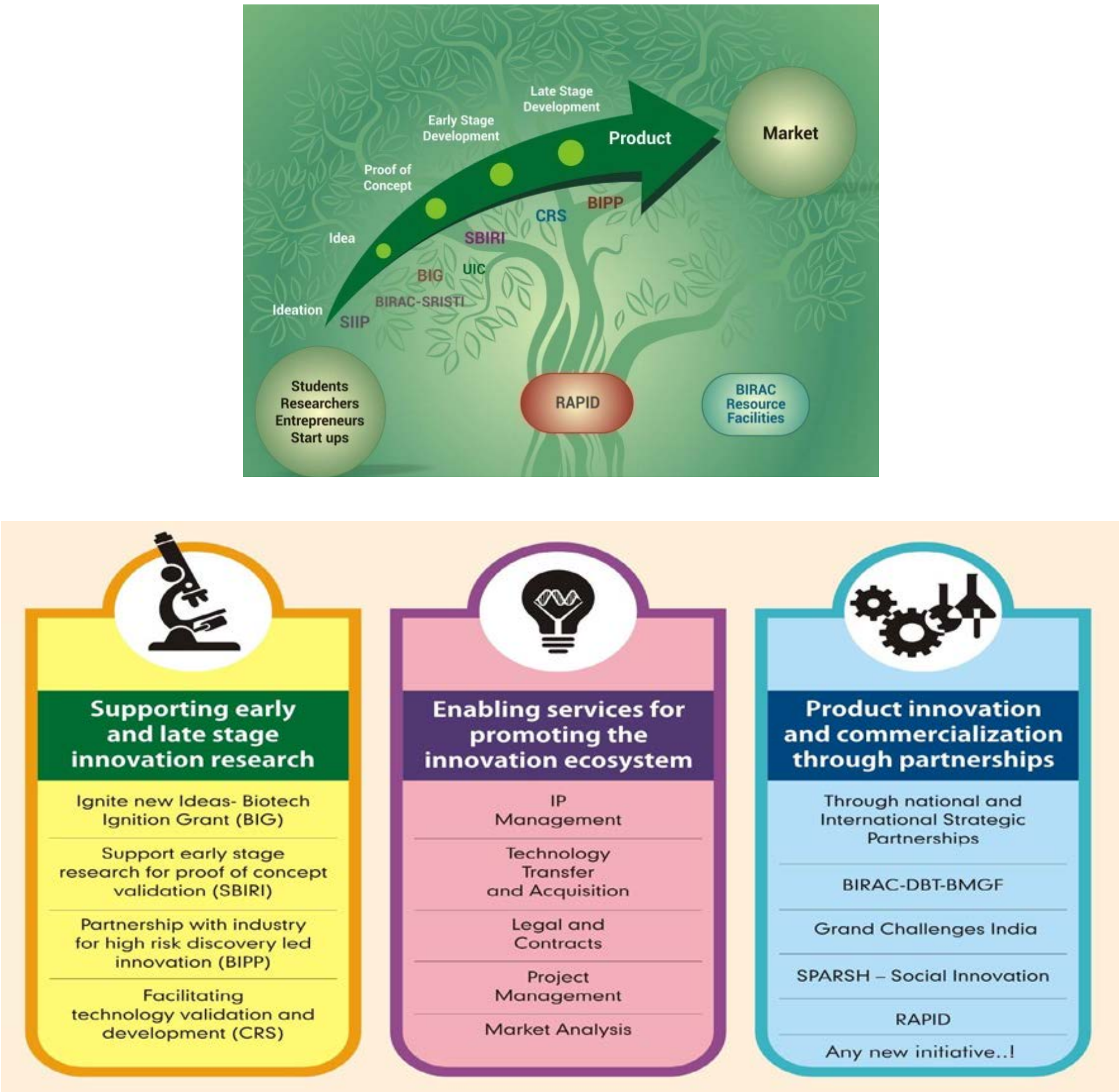


Figure 3: BIRAC's Support for Commercialization of Biotech Research

Source: *http://www.birac.nic.in/*

For meaning of abbreviations please see symbols and abbreviations

Through different programmes of BIRAC, three major domains are addressed which are:

- Promotion of PPP in biotech sector
- Bridging I-A collaboration of biotech companies and academic institutes pursuing biotechnology
- Supporting entrepreneurship culture in India.

Programmes/schemes started by BIRAC to address first two domains are described in table 1. Maximum amount of funding from industry has been obtained through SBIRI and BIPP (Fig. 4).

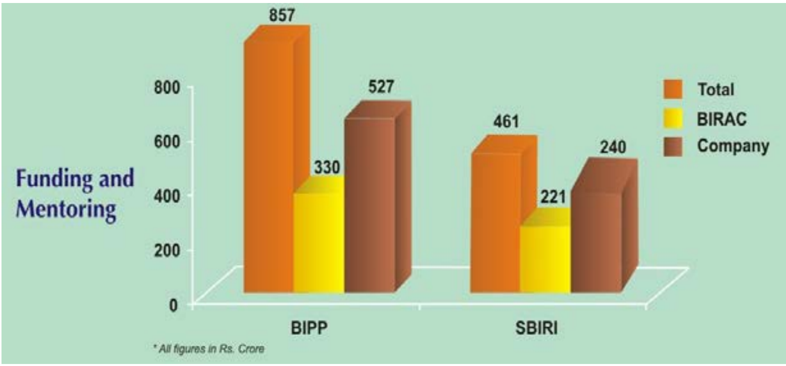


Figure 4: Impact of SBIRI and BIPP on Funding and Monitoring Support to Public and Private Sectors.

Source: *http://www.birac.nic.in/*

Table 1: BIRAC's Programmes/Schemes for Promoting Public Private Partnerships and Industry-Academia Collaborations

S. No	Programme/Scheme	Brief Details
1.	**Small Business Innovation Research Initiative (SBIRI)**	• Scheme started to boost PPP efforts in the country • It has facilitated innovation, risk taking by small and medium companies and bringing together the private industry, public institutions and the government under one roof to promote the research and innovation in the Indian biotech sector • It has consistently supported early stage funding for high risk innovative research in small and medium companies led by innovators with science backgrounds to generate products of societal relevance. • The proposals can be submitted solely by a Company incorporated under the Companies Act, 2013 or Limited Liability Partnership (LLP) incorporated under the Limited Liability Partnership Act, 2008 or Joint Ventures either in the form of Company/ LLP by any of the above entities jointly with other private or public partner(s) (Universities or Institutes) • The main industry applicant should have DSIR* recognized in-house R&D unit or patent granted or acquired, that will be used

		for the proposed project, alternatively the applicant should be incubated at an Incubation Centre/Biotech Park which has a valid DSIR Certificate.
	Outcome/ Impact	• SBIRI is supporting 204 projects • Investment contribution from private company: ₹ 16.77 crores. • Investment contribution from BIRAC: ₹ 16.30 crores. • SBIRI till now has supported 148 companies in diverse fields of biotechnology • Four technologies/products developed under this scheme in year 2014-15 are 1. A rapid test for qualitative detection of malaria antigen (infection) in humans. 2. Technology to extract lycopene, a phytonutrient, from high yielding varieties of tomato 3. Easier purification of *Escherichia coli K12* strain secreting variety of recombinant proteins of industrial and therapeutic importance 4. Production of dextranase (30000 du/gm) using solid state fermentation
2.	**Biotechnology Industry Partnership Programme (BIPP)**	• BIPP is working for setting up government partnership with industries for support on a cost sharing for innovative research that can lead to production of affordable products in accordance to societal need. • BIPP supports high risk led technology development for futuristic technologies. • Through BIPP, services such as product evaluation and validation through field trial for agriculture products and clinical trials (Phase I, II, III) for health care products are provided. • The proposals can be submitted solely by an Indian company* (small, medium or large having DSIR recognized in-house R&D unit) or jointly by an Indian company and national R&D organizations and institutions; or group of Indian companies along with national research organizations.
	Outcome/ Impact	• In totality under this scheme 157 projects have been sponsored • During 2014-15, BIPP supported 64 projects out of which 20 were collaborative • 110 companies have received support for their high risk innovative R&D projects • So far 134 agreements have been signed with 108 companies involving approximately 60 start-ups and Small and Medium Sized Enterprises (SMEs) • Investment contribution from private companies: ₹ 12.70 crores • Investment contribution from BIRAC: ₹ 12.36 crores • Three national patents have been filed by the companies

		supported under the BIPP scheme • Technology/product generated through this scheme: 1. Process for albumin and intravenous immunoglobulin (IVIG) production at a scale of 2500 L with a purity of 95%. Two products launched: Albucel and Globuce (developed by Celestial Biologicals Limited, Ahmedabad) 2. Novel portable Electroencephalography (EEG) system 3. Affordable mannequin for effective Cardiopulmonary Resuscitation (CPR) 4. Development and production of Balloon catheter 5. Software for next generation sequencing data analysis 6. Microfluidic based flow analyser technology for Cluster of Differentiation 4 (CD4) cell counting at point-of-care locations Technologies under pipeline: 1. Clinical trials of polysialylated erythropoietin 2. Clinical studies of Asia-specific 15-valent pneumococcal vaccine
3.	**Contract Research Scheme (CRS)** **Outcome/ Impact**	• It aims to facilitate I-A collaborations • Through this scheme validation of academic research having potential for commercialization by contract research and manufacturing (CRAMS) industry is promoted. • Funding is in the form of grant given to both the academic as well as industrial partners. While funding is provided to the academia for in-house research which forms a part of validation of the proof of concept, funds are provided to the industrial partner for validation. • Although the IP rights reside with the academia, the industry partner has first right of refusal for commercial exploitation of the new IP. • BIRAC facilitates FTO search, IP management, and preparation of Material Transfer Agreement (MTA) Memorandum of Understanding, (MoU), non-disclosure and IP protection contracts and licensing agreements as well as technology transfer for the academia. • Academia has to be the primary applicant with one or more partners of whom at least one is a company having DSIR recognized in-house R&D unit. The proposers if so required can opt for additional partners from another industry and/or academia • Till date 181 proposals (198 academia and 193 industries were involved) have been received and out of them 131 proposal are accepted under CRS scheme and 20 projects are presently executed. • Presently, 15 academia and 13 industrial partners have received grant of ₹13.48 Cr • Technologies/ products in pipeline:

		1. Recombinant vaccine for *Plasmodium vivax* 2. Production of laccase through a bioreactor system 3. Development of a linkage map in castor using genome wide SNP's

**The Companies in the process of obtaining DSIR recognition may also apply along with the proof of application for DSIR. However, the final decision on such applications would be subject to their getting DSIR recognition.*

Source: *http://www.birac.nic.in/; BIRAC Annual Report 2014-15*

BIRAC has also established dedicated facility/cells for promoting I-A linkages. These are as follows:

- **Early Translational Accelerator (ETA):** BIRAC is supporting different ETAs focussing on catalyzing young academic discoveries (publications/patents) with possible societal and commercial impact to transform into economically viable and technology oriented endeavor. Through ETAs linkages between academic investigators, industry and international public and private translation ecosystems have been successfully executed. One ETA has been set up in C-CAMP, Bangalore and nine are in the pipe line.
- **Integrated Facility for Protein Therapeutics and Peptides:** This facility has been established in INTAS Pharmaceuticals Ltd., Uttarakhand and comprises of almost all the latest instruments and facilities for pursuing high end structural and functional characterization of proteins and peptides.

BIRAC has also come forward to support entrepreneurship to young researchers and start-ups right from the idea generation to product development. It has initiated various schemes and programmes through which support in forms of grants, incubating space and mentoring to budding entrepreneurs working on idea of societal relevance is provided (Table 2).

Table 2: BIRAC's Programmes/Schemes for Promoting Entrepreneurship

S. No	Programme/Scheme	Brief Details
1.	**Biotechnology Ignition Grant (BIG)**	• BIG specifically provides early stage grants to bridge the gap between invention and technology development. • Entrepreneurs from different research institutes, academia and start-ups/registered company with functional R&D Lab or incubatee are eligible for this grant. • Currently, there are five BIG partner institutions in the country who are involved in providing mentoring, networking, business development and monitoring to BIG innovative awardees, which are:-

		1. IKP Knowledge Park, Hyderabad 2. Centre for Cellular and Molecular Platforms (C-CAMP), Bangalore 3. Foundation for Innovation and Technology Transfer, New Delhi 4. KIIT Technology Business Incubator, Bhubaneswar 5. Venture Center (Entrepreneurship Development Center), Pune
	Outcome/ Impact	• Through BIG scheme, BIRAC has provided funding support of ₹41 Cr to almost 100 entrepreneurial ideas • Presently, BIG is nurturing >150 entrepreneurial ideas (~28 women entrepreneurs) and has created 50 start-ups through its funding support • BIG is also supporting 104 start-ups to bring out innovations in the product/process range • BIG has led to generation of 553 employment opportunities and 65 IP • Important technologies/products developed under this schemes are as: 1. Development of an aptamer based platform to detect TB. 2. Modular resilin mimetic elstomeric platform for wound healing and other uses. 3. Enzymatic maceration of mango pulp to produce wine. 4. Industrial application of a novel cancer drug screening method. 5. Development of a fucose knockout technology platform in CHO S cell line for improved biotherapeutics. 6. Novel inhibitors of DNA gyrase for treatment of multidrug resistant infections. 7. Pharmacological evaluation of N-oxide metabolite of antipsychotic drug for type 2 diabetes. 8. Novel oncotherapeutic measles virus using eSame system. 9. Fetal ECG and Uterine Activity signa extraction from maternal ECG eliminating the need for use of conventional transducers. • Number of Innovators/entrepreneurs supported under BIG at different BIG Partner institutes are: ➢ C-CAMP: 47 ➢ IKP Knowledge Park: 40 ➢ FITT: 34 ➢ Venture Centre: 20 ➢ KIIT-TBI: 13 ***Total number of support under BIG: 154***
2.	**BIRAC-Society for Research and Initiatives for Sustainable**	• BIRAC in collaboration with SRISTI located at IIM Ahmedabad encourages entrepreneurship by awarding grass root level innovations (*under Gandhi Young India Innovation*

	Technologies and Institutions (SRISTI)	*Awards*) of students at the university/college level from across India with nurturing and grant of ₹ 15 lakhs support *in situ*. Also, ₹ **1 lakh** to **100 young innovators was provided** to take their innovations to next level. • Awardees of BIRAC-GYTI Awards 1. Flexicast: breathable, washable and customized cast for immobilization of fractured limb innovator 2. Rightbiotic: fastest antibiotic finder innovator 3. Redefined spoon for parkinson's patient innovator 4. Development of a powerful new antibiotic that kills all drug-resistant bacteria innovator 5. Real time wound management system wound segmentation and analysis using image processing on mobile platform (android) innovator **Some of the impactful initiatives of SRISTI are as:** • **Honey Bee Network (http://www.sristi.org/hbnew/index.php):** It is a crucible of like-minded individuals, innovators, farmers, scholars, academicians, policy makers, entrepreneurs and non-governmental organizations (NGOs). This network is spanning whole country for innovative ideas and plays a crucial role in protection and value addition of local traditional knowledge, grassroots innovations and assists in protection of their IP. Till date, this network has registered 1,000,000 innovative ideas which can be taken up by public/private sector for commercialization to generate products/processes as per societal needs. • **Techpedia (http://techpedia.sristi.org/): SRISTI initiated a platform "Techpedia" with an aim of** putting the problems of micro, small and medium enterprises, informal sector, grassroot innovators and other social sectors on the agenda of the young technology students across the country. Techpedia comprise of project archive consisting of academia projects, industry defined projects, grassroot innovations for augmentation, assistive technologies and children innovations for augmentation. • **Social Innovation Fund (http://sif.sristi.org/):** Social Innovation Fund (SIF) would be to provide mentoring, financial support, fabrication, validation, and value addition facilities in labs, fields, and R&D Institutions, part of honey bee network, for nurturing creativity in culture, education, technology and governance.
6.	**BIRAC AcE Fund**	• This programme acts as co-founding model in which

		incubators, angel firms, business accelerators and early stage venture capitalists joined hands to provide funding (equity based) upto ₹ 1 crore to entrepreneurs. • This fund also provides an equity based support to entrepreneurs who have faced failure. Mentorship and guidance is also provided them to relocate their start-up business.
7.	**Social Innovation programme for Products: Affordable & Relevant to Societal Health (SPARSH)** **Outcome/ Impact**	• Through this programme BIRAC supports the development of innovative solutions for persisting social problems. • SPARSH provides support to innovators in form of impact funding of biotech product innovations that can solve society problems and produce affordable biotech products [e.g. calls for solving challenges in Human Papillomavirus (HPV)] • It also caters to creation of common platform where pool of social innovators in biotech can share their best practices and understand intricacies of business models in social innovations. • SPARSH has initiated fellowship component [Social Innovation Immersion Programe (SIIP)] to promote entrepreneurial ideas and generating a pool of social innovators with a job to identify the specific needs and gaps in healthcare arena. • SIIP is managed by four incubator centres [Venture Centre, Pune; Kalinga Institute of Industrial Technology (KIIT), Bhubaneswar; T*ranslational Health Science and Technology Institute* (*THSTI*), Faridabad and Villgro Possible, Chennai] • SPARSH has led to initiation of 20 projects in the focus areas of maternal and child health, and 16 SIIP fellowships have been granted. • SPARSH has supported 7 individuals and 10 companies in last two years. • Seed fund (₹ 113 lakhs to ₹ 695 lakhs for early translations) of SPARSH is has been created. • Technologies/ products under pipeline: 1. Microfluidics based on-chip real time PCR device for neonatal and maternal health. 2. A novel technique for monitoring foetal growth through volume imaging of the fundus and estimating the gestational age, amniotic fluid index and intra-uterine growth abnormalities of the foetus. 3. Non-invasive electrical device for transcutaneous iron replenishment. 4. Electricity-free baby incubator.

Source: *http://www.birac.nic.in/, BIRAC Annual Report 2014-15*

Along with the programmes for promoting entrepreneurship, BIRAC has taken initiative to set up several incubator facilities and innovation centres of world class level in different institutes of higher education, located in different parts of India.

1. **BIRAC University Innovation Cluster (UIC):** In order to encourage techno-entrepreneurship in Indian education system, BIRAC has created University Innovation Clusters (UICs). UIC focuses on creating industry focused R&D by supporting postdoctoral and postmasters 'Innovation Fellowships' in the area of biotechnology. So far, five UICs have been established at **Anna University, Chennai; Panjab University, Chandigarh; Tamil Nadu Agricultural University, Coimbatore; University of Rajasthan, Jaipur and University of Agricultural Sciences, Dharwad.** These clusters provide pre-incubation support for translation product development to the innovators. Each UIC is composed of 5-6 students/young entrepreneurs to develop their ideas/discoveries. Through these centres, industries participation for training, mentoring and sponsored research and networking opportunities is also encouraged.

2. **BIRAC Regional Innovation Centre (BRIC) at IKP Knowledge Park**: BIRAC in collaboration with IKP Knowledge Park, Hyderabad has set up BIRAC Regional Innovation Centre (BRIC) at IKP to promote entrepreneurship in southern part of India. It has also facilitated network opportunities for budding start-ups with other academicians and industries.

   BRIC is working for mapping regional innovations of Andhra Pradesh, Karnataka, Tamil Nadu and Kerala. It has assigned a task of developing database of technologies for in and out licensing, IP and technology evaluation and is also fostering the entrepreneurship in different research institutes. It has also created IP and technology transfer cells to promote conversion of innovations to market affordable products.

3. **Bio-Incubators:** BIRAC's Bio-Incubator support, harnesses entrepreneurial potential of start-ups by giving access to them for proper infrastructure, mentoring and required networking for developing their ventures. BIRAC has provided support to the existing biotech parks, IITs, research institutes/universities and biotech clusters (Fig. 5). Till date, BIRAC has strengthened the existing fifteen incubation facilities in the country to develop world class bio-incubation facilities which are as ICICI *Knowledge Park* (IKP), Hyderabad; Society for Biotechnology Incubation Centre (SBTIC),

Hyderabad; The Gujarat Biotechnology Council (GSBTM), Savli; *Kerala State Industrial Development Corporation* (KSIDC), Trivandrum; Women Bio Park, Chennai; Healthcare Technology Innovation Centre (HTIC), Chennai; Foundation for Innovative and Technology Transfer (FITT), IIT Delhi, New Delhi; Bio-Incubator, IIT Madras, Chennai; SIDBI Innovation and Incubation Centre (SIIC), IIT Kanpur, Kanpur; Zonal Technology Management and Business Planning and Development (ZTM-BPD), *Indian Agricultural Research Institute* (IARI), Delhi; Kalinga Institute of Industrial Technology-Technology Business Incubator (KIIT-TBI), Bhubaneswar; National Chemical Laboratory (NCL), Pune; B. V. Patel Pharmaceutical Education and Research Development (PERD), Ahmedabad; Centre for Cellular and Molecular Platforms (C-CAMP), Bangalore; Regional Centre for Biotechnology (RCB) Bio Cluster, Faridabad. Additionally, BIRAC has also indentified CCAM, Bangalore and NABI, Mohali for developing bio-incubator facility via bio-incubator support scheme.

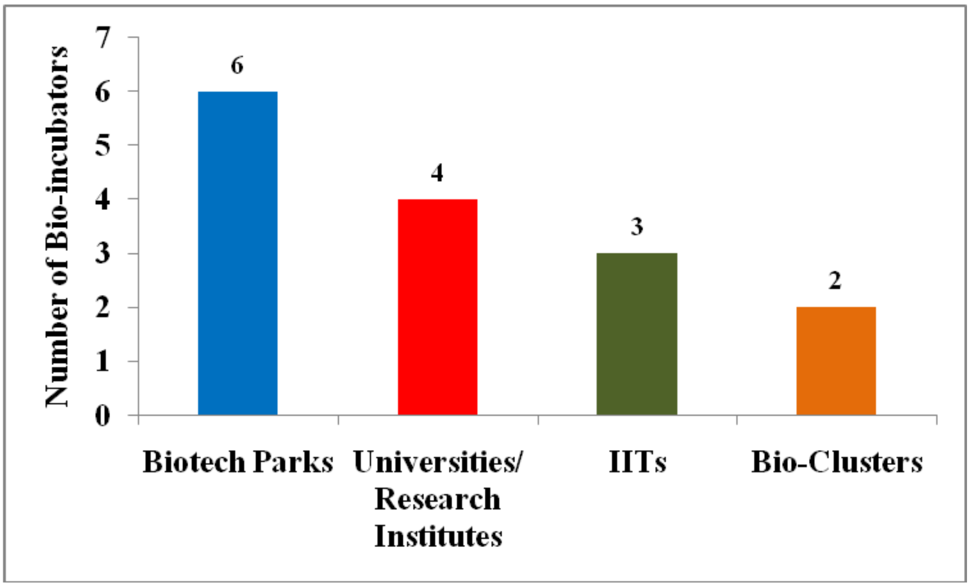


Figure 5: Distribution of Bio-Incubators Created by BIRAC
Source: *http://www.birac.nic.in/*

Outcome/ Impact of Bio-incubator support:

- Through bio-incubator support ~1,24,000 sq. ft. of functional bio-incubation space has been created and number of resident incubatees under them are listed in table 3.

Table 3: Number of Resident Incubatees under Bio-incubators

Bio-Incubator	Resident Incubatees
C-CAMP, Bangalore	6
Venture Centre, NCL, Pune	20
ZTM&BPD Unit, IARI, New Delhi	5

IKP Knowledge park, Hyderabad	22
KIIT, Bhubaneswar	5
Alexandrial Knowledge Park, SBTIC, Hyderabad	10
BBIF, IIT Delhi	7
SIIC, IIT Kanpur	6
IIT Madras Research park	10

Source: *http://www.birac.nic.in/*

- These bio-incubation facilities have supported ~199 start-ups/entrepreneurs.
- They have provided access to cutting edge instrumentation, space for start-ups, mentorship for start-ups and aid in connecting them to different stakeholders-business and scientific advisors, angel firms and venture capitalists to bring out successful innovations.

Strategic Alliances and Partnerships of BIRAC

BIRAC has undergone alliance and partnerships with various national and international authorities to boost innovations in biotech sector. These partnerships have led to the promotion of Indian innovation ecosystem at global level. BIRAC has partnered with various global organizations to bring advancements in Indian biotech (Table 4).

Table 4: Strategic Alliances and Partnership of BIRAC

S. No	Alliance/Partner	Description
International Alliance		
1.	**DBT-BIRAC-GATES foundation**	• Provides support to health research and innovations following under 'Grand Challenges of India'. • ~200 farmers have applied improved technologies and management practice as result of programme assistance • ~200 individuals have received food security training
2.	**Welcome Trust**	Grants provided by global charity organization of UK to support innovations in traditional medicines.
3.	**CEFIPRA-BPI France**	Support high quality bilateral research and encourage Indo-French for SMEs/start-ups in the area of red biotechnology.
4.	**BIRAC-USAID+IKP**	Grant from USA to IKP-Hyderabad to carry out innovations in tuberculosis control in India.
5.	**BIRAC-DBT-ICAR-USAID**	• To support production of improved wheat for heat tolerance and climate resilience. • RAPID programme for rapid development of nationally important technologies and products.
6.	**BIRAC-Queensland University of Technology (QUT) Australia**	Bio-fortification and disease resistance in Banana under 'Grand Challenges of India'.

7.	**BIRAC and Centre of Entrepreneurial Learning (CfEL) of Judge Business School, University of Cambridge, U.K.**	Enables five BIRAC supported applicants to take part in CfEL's flagship intensive entrepreneurial boot-camp programme called "IGNITE", which is aimed at providing academicians (PhDs, post-docs and scientists) the entrepreneurial opportunities to explore their innovative ideas and transform them into a business project. CfEL provides one week intense mentorship and training to the BIRAC supported candidates and for second week encourage them to interact and learn from the Cambridge's Entrepreneurial Cluster.
	National Alliance	
8.	**Department of Electronics and Informational Technology (DeitY;)- BIRAC Industry Innovation Programme**	**In year 2015, BIRAC** in association with Department of Electronics and Information Technology (**DeitY;** presently known as MeitY) initiated Industry Innovation Programme on Medical Electronics (IIPME) in order to generate significant investments in the medical devices sector to develop indigenous medical devices in healthcare sector. Through this scheme, BIRAC has supported more than 100 industries to develop medical devices in collaboration with DeitY and is also nurturing many ideas of young individual researchers, SME and large companies.
9.	**Secondary Agriculture Bio-Cluster (SAB)**	Alliance with CIAB, Mohali; PSCT, Punjab and NIFTEM, Sonepat to develop agricultural strategies for farmers.

Source: *http://www.birac.nic.in/*

BIRAC has proposed a mission programme on anti-microbial resistance (AMR) with an aim to tackle the menance of anti-microbial resistance by focussing on discovery, development and diffusion of new drugs, diagnostics, and infection treatment options under PPP consortia for promoting innovation research.

BIRAC: A Successful Model

In a short span of 5 years, BIRAC has successfully addressed the challenges of biotech industry in particular, requirement of intense capital, high end infrastructure, regulatory scrutiny and long gestation phase for products to be market ready. In totality, through BIRAC ~315 companies and ~89 institutes have been benefitted (http://www.birac.nic.in/List_of_Beneficiaries.php) so far. Table 5 presents the list of products generated with help of BIRAC funding having societal relevance:

Table 5: List of Products Generated Under BIRAC Funding

S. No.	Product	Details	Collaborators/Companies/ Start-ups
1.	**Fluorescence Reader to Detect**	• Detects multiple infections (HIV, HCV, HBV, Syphilis and TB) simultaneously	[1]ICGEB, [2]DBT and University of Turku (http://www.utu.fi/), Turku,

	Multiple Infection	• Ensures less medical waste in blood banks	Finland.
2.	**AINA Device**	• Measures blood glucose, HbA1C, lipids, creatinine and haemoglobin • Commercialized by Janacare Solutions • Company has already got pre orders for 25000 units from India	Janacare Solutions (www.janacare.com), [3]AIIMS and Narayana Hrudayalaya (http://www.narayanahealth.org/)
3.	**Optra-SCAN**	• It is a digital oncopathology slide scanner • Offers complete digital pathology solutions with ease of operations, scalability, security and integration with software image viewed and management at affordable costs	Optra Systems (http://optrahealth.com/)
4.	**PDT Laser Systems**	Indigenous and low cost Photo Dynamic Laser system for cancer treatment	Vinvish Technologies (http://vinvish.com/)
5.	**Maxico**	Device used for execution procedure for tumour ablation	Perfint Healthcare (http://www.perfinthealthcare.com)
6.	**POC Diagnostic Kit**	Diagnosis of multiple diseases such as malaria, dengue and typhoid	Bigtec Labs (http://www.bigteclabs.com/)
7.	**Immunodiagnostic Kit**	Kit for detection of autoimmune diseases	Amar Immunodiagnostics (http://www.amarimmunodiagnostics.com/)
8.	**Malaria Detection Kit**	Qualitative detection of malarial parasite antigens in human whole blood	Genomix Molecular Diagnostics (http://www.genomixbiotech.com/)
9.	**Fibroheal**	• Use of silk protein based cosmaceutical product for burn wound management • Already in use in AIIMS	Healthline (http://www.healthline.com/)
10.	**Autochem Ingenious**	Low cost clinical chemistry analyser and helps early diagnosis	Span Diagnostics (http://www.span.co.in/)
11.	**PCR Kit for Aquaculture Industry**	Robust and economical indigenous single tube nested PCR Kit	Aristogene Biosciences (http://www.aristogene.com/)
12.	**Pandyflu**	H1N1 pandemic influenza vaccine using egg based technology	Panacea Biotec (http://www.panaceabiotec.com/)
13.	**Rotavac**	Oral Rotavirus vaccine It is India's first indigenously developed vaccine and is included in publically funded universal immunization programme	Bharat Biotech (http://www.bharatbiotech.com/)
14.	**Foligraf**	First recombinant FSH product important for development of follicles produced by ovaries	Bharat Serum and Vaccines (https://www.bharatserums.com/)
15.	**OncoPrint**	Safe and affordable therapy to cancer patients in India.	Mitra Biotech and Anthem Biosciences (http://www.mitrabiotech.com/, http://www.anthembio.com/)

16.	**Maleriscan**	A rapid test for the qualitative detection of malarial parasite antigens	Bhat Biotech India (http://bhatbiotech.com/)
17.	**Rasburicase (Tuly)**	It is recombinate uricase, used to control hyperuricemia in cancer patients undergoing chemotherapy	Virchow Biotech (http://www.virchowbiotech.com/)

Source: *http://www.birac.nic.in/*

Annexure IV

Pfizer-Foundation for Innovation and Technology Transfer (FITT)

http://fitt-iitd.in/

GoI established FITT in 1995 in the campus of Indian Institute of Technology, Delhi (IIT-D), a premier engineering institute of India by GoI as the first I-A interface (FITT Annual Report, 1994-95). The GoI at that time provided an amount of ₹ 16.2 million as an aggregated fund to IIT-D for initiation and build up of FITT. The centre was set up as an autonomous and self governing body, to act as a single window utility to the industrial sector with complete professionalism and function as a marketing arm for the IIT-D developed technologies (Sengupta, 2009).

The broad organizational structure is composed of a) Governing Council and b) Research Council. The governing council consists of representatives from industries; industrial associations and nominee from MHRD, selected nominated members from IIT-D senate and its board of governors. On the other hand, research council is composed of selected faculty members of IIT-D having experience in I-A collaborations. The management is vested with the managing director of the organization, guided by governing council and research council.

Programs and Services at FITT

Since the inception of FITT, a large number of programs and initiatives have been introduced in an effort to catapult the I-A linkages to the next level. The programs initiated by FITT can broadly be categorized as the following:

a) Incubation Centers
b) Research/Technology Development Projects
c) Knowledge Augmentation Courses
d) IPR Management Programmes
e) Corporate Partnership for the Industrial Sector
f) Government Schemes
g) Memorandum of Understandings (MoUs) with Private Sector
h) FITT Awards and Recognitions

a) Incubation Centers

In an endeavor to promote entrepreneurship and start-up companies, FITT initiated the task of setting up incubators on the campus of IIT-D. These incubation centers were set up with the aim of providing the entrepreneurs with space for a prototype laboratory and other basic infrastructural and instrumentation facilities, without getting into the hassle of paper work. In addition, FITT also promotes start-ups having credible business plan(s) with focused knowledge. The incubator centre provides facilities such as product innovation, product development, software testing, pilot experimentation, prototype development, industrial training etc. and works in close coordination with the institute. Major activities of incubation centers are Technology Business Incubation Unit (TBIU), Bio-Incubator Facility, Science Parks and the units set up under Bio-Accelerator Programme.

Various incubation facilities provided by FITT are as under:

- **Technology Business Incubation Unit (TBIU)**

TBIU was started in 2000 under the aegis of Technology Institution Program (TIP), as a part of the Industrial Credit and Investment Corporation of India (ICICI)/World Bank Funded TIP at IIT-D (Bhattacharya, 2005).

Under this scheme, the start-ups/technology entrepreneurs are provided with an initial seed money and space for converting new ideas/concepts/service into a business opportunity that is commercially viable. TBIU, permits activities such as innovative product development, software development and testing, simulation and prototyping, pilot scale experimentation and training. FITT not only provides modern infrastructure but also provides for hand-holding, managerial and material support for establishing themselves. In return, minimal space utilisation charges and equity share of the company rests with FITT.

A list of resident companies in TBIU in the year 2014-15 is mentioned in Table 1.

Table 1: Start-Ups Resident at TBIU during the Financial Year 2014-15

S. No	Start-Up	Work Area
1.	**Novo Informatics Pvt. Ltd.** (http://novoinformatics.com)	Bridging the gap between bio-informatics and experimentation
2.	**Wring Nano Systems Pvt. Ltd.** (http://www.truehb.com/team.php)	Advanced bioelectronics technologies (e.g. hemometer)

3.	**PLANiN Innovation and Consultancy Services Pvt. Ltd.**	Basket of innovative products with proprietary technologies (e.g. vehicool, smart wipes and flexible notice board)
4.	**Silver Knight Technologies Pvt. Ltd.** (http://www.silverknight.info/)	Development of Anti-theft bag with unique features like pilfer proof casing, unique zip and lock mechanism & track and trace system
5.	**Carbon Neutral Technologies Pvt. Ltd.**	Develop an alternative manufacturing process for isoprene
6.	**Kentellus Welding and Manufacturing Pvt. Ltd.**	Production of welding electrodes of better quality using green technology
7.	**Ekam Eco Solutions Pvt. Ltd.** (www.ekamecosolutions.com)	Ecological solutions in the field of sanitation, water conservation, nutrient recovery and sustainable habitat
8.	**Inkilab Technologies Pvt. Ltd.** (http://www.inkilabtechnologies.com)	Diagnostics based technologies to facilitate process design
9.	**Credext Technologies Pvt. Ltd.** (http://www.credextechnologies.com)	Development of falcon virtual PC device that enables a user to access his/ her desktop at remote locations
10.	**Creditas Solutions Pvt. Ltd.**	Developing online platform for debt negotiation and settlements
11.	**Innovator Lab Consultants India Pvt. Ltd.** (http://www.innovatorlabindia.com)	Development of mechanical heart valve fixation system
12.	**VM Trans Innovations Pvt. Ltd.**	Development of intelligent online platform for road transport management and exchange system

Source: *FITT Annual Report, 2014-15*

The above-mentioned list of start-up companies is just a glimpse of what TBIU has done in order to promote entrepreneurship via the I-A interface. In the last two decades, there have been innumerable start-ups and incubatees at TBIU and quite a few of them have graduated and are working independently as successful, self-sufficient, profit generating companies (Table 2).

Table 2: List of a Few TBIU Start-Ups Graduated into Successful Companies

S. No.	Name of the Incubating Unit	Technology /Product /Process in incubation	Residency	
			Entry	Exit
1	**M/s eCapital Solutions Pvt. Ltd. / Trigyn Technologies (I) Pvt. Ltd.**	Telecommunication and internet application	1999	2001

2	**Sintex ESCO**	R&D on insulated lightweight prefabricated building structures for thermal comfort and energy conservation	2001	2003
3	**M/s INRM Consultants Pvt. Ltd.** (http://inrm.co.in)	GIS based integrated watershed management	2002	2004
4	**M/s KritiKal Solutions Pvt. Ltd.** (http://www.kritikalsolutions.com)	Computer vision and image processing, wireless adhoc networks	2002	2005
5	**M/s Mechartes Researchers Pvt. Ltd.** (http://www.mechartes.com)	Software products for simulation of product development in auto component industry	2005	2008
6	**M/s SM OnYoMo Infotech Pvt. Ltd.**	Consumer searches over the internet	2005	2009
7	**M/s LeadInvent Technologies** (http://www.leadinvent.com)	Novel drug discovery & computational biology	2007	2010
8	**M/s Appin Software Security Pvt. Ltd.** (http://www.appinonline.com)	Software security	2007	2009
9	**M/s Care-pro Biotechnologies Pvt. Ltd.** (http://www.careprobio.com)	Fermentation based biomolecules	2007	2010
10	**M/s. Sunurja Renewable Energy Pvt.** Ltd. (http://www.sunurja.com)	Design and development of renewable energy solutions	2008	2011
11	**M/s. Faros Technologies Pvt. Ltd.** (http://www.farosindia.com)	Development of simulator sub components, simulators and providing simulation services	2008	2013
12	**M/s. Innovative Transport Solutions Pvt. Ltd.** (http://www.itrans.co.in)	Scientific and technical solutions for traffic and transport systems and development of models for sustainable transport for cities	2008	2012
13	**Gram Vaani Community Media Pvt. Ltd.** (http://www.gramvaani.org)	Building innovative models of media delivery for rural areas of india	2009	2013
14	**Yonyx Infomedia Pvt. Ltd.**	Building teacher replication platform to enable teachers to pack instruction with predicted student interaction	2010	2012
15	**Innovative Mechatronix Solutions Pvt. Ltd.**	Design, development and manufacture of micromachining system, mass production finishing processes and mechatronic embedded systems	2010	2013
16	**Simplyfeye Softwares Pvt. Ltd.** (http://www.simplyfeye.com)	User-friendly operating platform for biopharmaceutical manufacturers to capture, share and analyze information from biopharmaceutical processes	2010	2013
17	**Genesis Location Services Pvt. Ltd.** (http://genesis-locationservices.com)	Location based products and services	2011	2014
18	**Novo Informatics Pvt. Ltd.** (http://novoinformatics.com/)	Scientific software application products/tools	2011	2014
19	**Wring Nano Systems Pvt. Ltd.** (http://www.truehb.com/team.php)	Advanced blood haemoglobin testing	2012	2014

20	**Ekam Eco Solutions Pvt. Ltd.** (http://www.ekamecosolutions.com)	Ecological solutions in the field of sanitation, water conservation, nutrient recovery and sustainable habitat	2013	2015
21	**Inkilab Technologies Pvt. Ltd.** (www.inkilabtechnologies.com)	Analytics to the manufacturer on defective parts and processes	2013	2014

Source: *http://www.fitt-iitd.org*

Some of the successful examples of the start-ups graduated from FITT:

- ***Ekam Eco Solutions Pvt. Ltd.***

  Ekam Eco Solutions Pvt. Ltd. (www.ekamecosolutions.com) was initiated in financial year 2013-14 with the aim of developing and providing solutions in the field of nutrient recovery, water conservation, sanitation and sustainable habitat (FITT Annual Report 2013-14). Ekam has successfully commenced its objectives by addressing the gap in innovation and product development and is in the process of delivering out a number of innovative solutions which could be implemented at rural and urban levels.

- ***Kritikal Solutions India Pvt. Ltd.***

  The first faculty-student led business incubation unit, KritiKal Solutions India (Pvt.) Ltd. (http://www.kritikalsolutions.com), was founded in 2002. The company started functioning as a full-scale commercial venture by the year 2005 (Annual Report, 2005-06). The main focus of the company is embedded system design and real time computer vision and imaging solutions. As of date, KritiKal can boast of significant presence in India and United States and is also extending to Europe, Africa and other parts of Asia.

- ***Gram Vaani Community Media Pvt. Ltd.***

  Another successful spin-off from TBIU is GramVaani (http://www.gramvaani.org), based at IIT-D since 2008. The basis of this company is social technology and it provides information and community technology based solutions. This company works in collaboration with the institute and encourages interns/trainees to work on real-life problems and situations. The company is now a 35 employee strong group.

- **FITT as a Biotech Ignition Grant (BIG) Partner**

BIG is one of the highly successful I-A interface programmes of Biotechnology Industry Research Assistance Council (BIRAC), an autonomous body of Department of Biotechnology (DBT), GoI, New Delhi. The BIG scheme, which aims to invite proposals for the ignition grant twice a year, supports entrepreneurs from the academia and research institutes for the commercialization of technologies resulting from research in the area of biotechnology, which has been recognized as an emerging and conspicuous area for growth. BIG has identified a few institutes, including FITT, as official partners. FITT holds the responsibility of screening the applications received; review the projects that have been shortlisted, provide mentoring in issues related to IPR, legal affairs and other business development related issues, facilitate interaction with experts of the field and other academic partners of the institute.

This is a one of a kind scheme, which aims at establishing and validating proof of concept ideas and thereby enabling spin-offs, which is now gaining pace. Some of the key projects under BIG partnerships are:

- Cutting Edge Medical Devices Pvt. Ltd. (http://www.cemd.in) developed portable analyzer SCINTILLA for detection of protein levels in urine samples.
- Sakosh Biotech Pvt. Ltd. is working on development of lateral flow immunoassay based rapid diagnostic tests for various infectious diseases.

➢ **Bio-Accelerator Programme**

In 2013, FITT in association with National Institute of Immunology (NII) at New Delhi and BIORx Venture Advisors (http://www.biorxventureadvisors.com) started a Bio-accelerator programme, which laid emphasis on "accelerating innovation to marketplace" (FITT Annual Report, 2013-14). It is a joint initiative to strengthen the bio-economy of the nation by composing a 'Master Class on Bio-entrepreneurship'. This programme is devised for working executives, research scholars and post-doctoral scientists who aspire to work towards a path of commercialization for their discovery.

➢ **Biotech Incubator Facility**

DBT, GoI, has recommended supporting the setting up of a Biotech Incubator Facility at FITT, IIT-D (FITT Newsletter, October 2014). A sanction of ₹ 87 million has been granted for the incubator, for a period of initial three years. This facility, like other incubators, will support start-ups and provide incubation facilities for R&D work at minimal charges so as to promote innovation in the field of biotechnology.

FITT, with funding from BIRAC, has also established a **Biotechnology Business Incubator Facility (BBIF)** in 2014.BBIF provides incubator facilities such as specialized equipments, experimental facility, IP guidance and market linkages to the budding bio-tech start-ups (FITT Annual Report 2014-15).

- **Science and Technology Parks**

The most recent endeavour of FITT is to set up S&T Parks. These parks have been conceptualised in a way such that they will have all facilities for start-ups as well as well established firms. These facilities include legal, banking, R&D, consultancy, networking spaces and so on (IIT-D eNewsletter, April 2013).

b) Research/Technology Development Projects

FITT is mainly involved in the transfer of technologies to the industry, initiation of joint research programs, consultancy assignments from the industry. The centre has aided the licensing of technologies developed at the institute (Table 3).

Table 3: List of Technologies Developed at IIT-D and Licensed Through FITT Since 2002

S. No.	Year	Technology Licensed
1.	**2002-03**	Know how transfer of fiber optics educational kit
		Low molecular weight organic compound using liquid carbon dioxide
		Pilling tester based on digital image processing
2.	**2003-04**	Three phase watt hour meter
		RUSTGARD (Industrial grade & superior grade)
		Microwave Integrated Circuit (MIC) Kit
3.	**2004-05**	Local FE stress analysis and know how transfer of ASME Div-two reactors for Panipat refinery expansion
		Transfer of technology for *Trichoderma*
		Drape meter based on digital image processing
4.	**2005-06**	Technology transfer- VCO and detector
		Technology for manufacture of alluritic acid
5.	**2006-07**	High pressure bio gas (Gobar Gas) enrichment and bottling system
		Statistical scenario analysis software package
		Vehicle under side scanner
		Design & development of reusable pilfer proof currency carrying FRP cases
6.	**2007-08**	Computer aided design of components at microwave frequencies
		Design and development of active microwave integrated circuit trainer kit
7.	**2008-09**	Limiting torque bolt mechanism
		A smart cane for obstacle detection for the physically impaired

		A novel back panel design for efficient heat transfer in solar cells
		Polymer composite sheets with enhanced properties
8.	**2009-10**	RF magnetron target holder
		Selective and sensitive detection of mercuric ion by novel dansyl-appended Calix[4]arene molecules via fluorescence quenching
		An apparatus and method for packet error correction in networks
		System and method for decorticating hard shell seeds and fruits
9.	**2010-11**	Development of the iontophoratic kit for a transdermal delivery of methotrexate and insulin and validation of iontophoratic parameters for diclofenac
		Odourless, waterless urinal traps and associated structures
10.	**2011-12**	An apparatus for measuring fabric hand value
11.	**2012-13**	Real time based supervisory control of AC drive
		A method for preparation of cross- linked protein coated micro-crystal
12.	**2013-14**	Knowhow for the technologies on drug discovery and proteomics
		In-plane wicking measurement system
13.	**2014-15**	A small chaperone
		Thermal NDE: Modelling framework for crack detection
		A process of generating magnetically controlled ball and smart abrasive laden shape for finishing 3D intricate shaped surface
		Odour prevention device
		Concrete vibration sensor technology

Source: *FITT Annual Reports, 2002-15*

One of the most successful projects has been the development of the 'Smart Cane for the Visually Impaired', which was developed as an improvement to the white cane and defeats the limitation of white cane by detecting knee above and hanging obstacles (Singh *et al.*, 2010). This unique device was developed in collaboration with Phoenix Medical Systems, Chennai (industrial partner) and Saksham Trust, Delhi (NGO working for the visually impaired). Some other successful technologies that have been developed and commercialised are "FruWash" and "EnNatura".

FITT devotes itself to problem solving (short term) projects that help in developing better working relations with the industrial sector and confidence amongst the two and is continuously working on transferring technologies outside. During the financial year 2014-15, 96 technology development/ transfer projects of worth ₹ 168 million have been contracted. Out of these projects, 5 intellectual property (IP) licenses were executed in financial year 2014-15 (Table 4).

Table 4: IP Licenses Executed During 2014-15

S.No.	Title	Client
1.	A small chaperone	Theramyst Novobiologics Pvt Ltd, Bangalore
2.	Thermal NDE: Modelling framework for crack detection	GE India Technology Centre Pvt Ltd, Bangalore
3.	A process of generating magnetically controlled ball and smart abrasive laden shape for finishing 3D intricate shaped structure	Innovative Mechatronix Systems Pvt. Ltd.
4.	Odour prevention device	Ekam Eco Solutions Pvt. Ltd., New Delhi
5.	Concrete vibration sensor technology	Central Electronics Ltd., Delhi

Source: *FITT Annual Report, 2014-15*

FITT also undertakes selected investigative projects involving foreign contribution that aid in technology development and asset share between national and foreign research partners. Some of the successful foreign collaborated projects of year 2014-15 are listed in table 5.

Table 5: Select Foreign Collaborative Projects (2014-15)

S. No.	Title	Client
1	Optimization and growth of pyroelectric thin film stack	Ultrasolar Technologies, Inc, U.S.A
2	Optimization of chromatography process steps for purification of monoclonal antibody based therapeutics	Purolite Limited, U.K
3.	On line Devanagri handwritten character recognition on a smartphone through touch interface	Qualcomm Inc, U.S.A
4	Polypropylene foaming and recyclability	Borealis AG, Australia
5	Advice for development of long term monitoring	Asada Lab, University of Tokyo, Japan
6	EEG signal based recognition module with low computational load	Safran, France
7	Algorithmic framework for MEMS sensor fusion applications	ST Microelectronics, U.S.A

Source: *FITT Annual Report, 2014-15*

c) Knowledge Augmentation Courses and Professional Development Programmes

FITT understands that higher education is a continuing process and there is no limit to the enhancement of one's qualifications and in order to facilitate this increasing demand and providing a platform for working professionals, FITT in association with IIT-D, introduced several knowledge augmentation & skill enhancement courses as well as a number of short-term courses devised on emerging technologies.

- One such programme initiated was **Professional Candidate Registration (PCR).** This course involves registration of the candidate for one semester (as per the course chosen) and is certified at the end of the program. This program is confined to the Delhi region as of now due to accessibility issues although a few selected courses are covered under the on-site delivery program by a two-way audio-video link.

- Another programme that was initiated was **Knowledge Augmentation and Skill Enhancement programme**. Various add-on courses for professionals and students have been commenced with the aim of honing the students to be job ready.

Other programmes conducted by FITT for academicians and industry employees are as follows:

- Frost & Sullivan's Technology Partnership Program: Initiated by IIT-D has access to the Frost & Sullivan's portal thereby getting useful market, technology and econometric information along with the latest updates on technology trends across a broad range of industry sectors (FITT Annual Report; 2014-15).
- Technology Incubation and Development of Entrepreneurs (TIDE) and Entrepreneurial and Managerial Development of SMEs through Incubators (MSME scheme): Adopted by FITT to endow the entrepreneurial environs and efforts to commercialize technology being made at the institute.
- FITT in association with BIRAC and Association of Biotechnology Led Enterprises (ABLE) conducted short courses on Economic and Financing of Renewable Energy Technologies and Nascent Entrepreneurship Development Programme (FITT Annual Report, 2014-15).

d) Intellectual Property Rights (IPR) Management Programmes

Another responsibility taken up by FITT is the IPR management of the institute's academic community. A number of campaigns were initiated at FITT for promoting IPR filing for novel inventions/technologies/research outputs amongst the academic community. Complete assistance for filing of applications was provided by FITT by way of evaluation of proposals for patents and other IPR applications for the final submission to Indian Patent Office (IPO) and other establishments. The decisions pertaining to the application of technologies are taken by the IPR standing committee. The licensing policy followed by FITT is pliable and the payment terms are mutually secured. A comprehensive list of the technologies developed and being developed can be accessed from FITT website (http://www.fitt-iitd.org). This makes it extremely easy for the industry to search for any technologies of their interest and contact the person in question hence boosting the institute's technology commercialization.

Since the inception of IPR body in 1995, FITT has seen enormous growth with respect to IP generation and technology transfer and in the process it has become more than self-sufficient financially. In the past two decades, more than 200 IPR applications have been filed in the form of patents, copyrights and designs as opposed to a mere count of 15 patent applications filed from IIT-D between the years 1963 and 1995 i.e. before the inception of FITT (Fig. 1).

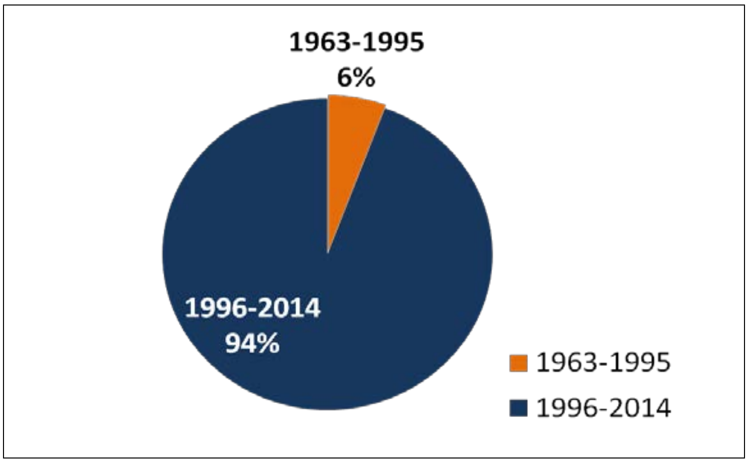


Figure 1: Patents Filed Before and After the Inception of FITT

Source: *FITT Annual Report, 1994-95, 2012-15*

e) Corporate Partnership

FITT has also started a corporate partnership program on the payment of nominal annual fee, for public and private sector industries, ministries and organizations and industry associations and financial institutes, and offers the advantage of concessional services to its members. The corporate members are regularly updated with the information of various programs at the institute and other opportunities of collaboration. The corporate members receive, among other benefits, advance notifications of all patent applications/technologies available and marketed by FITT, customized research presentations and seminars, industrial trainings and workshops, newsletters and select information. Most significant, however, is the advantageous working relation that the member develops with FITT thereby allowing them to gain access to research performed at IIT-D, as well as a variety of local businesses and services.

As of date, more than 250 companies worldwide have benefited from the programs of FITT (http://www.fitt-iitd.org). This number speaks volumes not only about the success of the organization but also about the way in which the industry is ready to collaborate with the academia. Some corporate members that are a part of this are: Pfizer India Pvt. Ltd., L'Oreal India Pvt. Ltd., LG Electronics India, Fresenius Kabi Oncology Ltd., Samsung Research Institute, Delhi, Dabur Research Foundation, Cube Software Pvt. Ltd., Reliance Industries Ltd., National Thermal Power Corporation, Bharat Heavy Electricals Ltd, Munjal Showa Ltd., JCB India, Canon India, Danfoss Industries, Carborundum Universal, Tata Chemicals, Jubilant Organosys Ltd., National Research and Development Corporation and Indian Grameen Services.

Recently, FITT has collaborated with one of the leading pharmaceutical company Pfizer for promoting healthcare innovations in country by commencing IP programme for young entrepreneurs (Laha, 2015) to provide training and short courses in IP related issues and also to support development of technologies in healthcare sector. Under this corporate collaboration individual support system for healthcare innovations are provided. This programme needs direct involvement of BBIF of FITT which was set up only a year ago to meet growing demands among biotechnology/ healthcare sector. The collaboration has resulted into "the Pfizer IIT Delhi Innovation and IP Programme (PIDIIP)" which will provide funding support of upto ₹ 4.8 million, mainly into two sectors one is from idea to IP and other is IP support. Gamut of advantages can be availed by health science innovators in this facility where technical manpower from different fields such as engineering, life sciences and healthcare are engaged towards finding solutions for demanding assignments and to develop innovative healthcare products which will cater to some of the critical issuesthat our country faces in the healthcare sector (Laha, 2015).

f) Government Schemes

FITT is also actively involved in the facilitation of all technology based government schemes. It provides for background checks on government technology development projects. Some of the prominent government schemes that are facilitated by FITT are listed below

- *N-WISE:* The National Information System for Science and Technology [NISSAT– Department of Scientific and Industrial Research (DSIR)] Window to Information Services to Entrepreneurs was initiated in 2001-02.
- *Technopreneur Promotion Program (TePP)* by DSIR and Technology Information, Forecasting and Assessment Council (TIFAC) of the DST: FITT has taken up various modules to enhance the environment of entrepreneurship and technology transfer at the institute, one of them being TePP. FITT is a partner in the program initiated by DSIR & TIFAC and also one of the TePP Outreach Centres (TUCs), wherein a financial support of up to ₹ 1.5-4.5 million is provided by DSIR and all the technical support & mentoring for development of an idea/prototype of the project is provided by FITT.
- *Entrepreneurial and Managerial Development of Small and Medium scale Enterprises (SMEs) through Incubators:* This scheme was started for the promotion of knowledge/technology based innovative ventures, in all fields of science and technology, to improve the competitiveness of SMEs, through a financial support of up to ₹ 40.1 million.
- *PRISM (Promoting Innovation in Individuals, Start-ups and MSMEs):* This program initiated under the aegis of DSIR, aims to support one of the most crucial agenda of the XIIth Five Year Plan (2012-17) i.e. inclusive growth and development. This program, which is offered in two phases, promotes the development of technologies needed in the market and the transfer of IP of such developed technologies, which is where a major gap lies, mainly due to the lack of funds by start-up firms. FITT as a confederate, through this scheme helps in promotion of the development of such technologies, which could otherwise be shelved only due to lack of resources.
- *Department of Information Technology-Technology Incubation and Development Entrepreneurs (DIT-TIDE):* Department of Information Technology (DIT) has introduced Technology Incubation and Development of Entrepreneurs (TIDE) for providing seed support in the area of IT. FITT has partnered for promoting this scheme, which provides incubators during early stages of the development of various IT and ITES enabled firms.

g) Memorandum of Understanding (MoU)

Formal agreement between FITT and other institutes/industrial partners has been set up to promote innovation and technology transfer. Some of the advantageous MoUs (2014-15) are mentioned below

- MoU with the **American Society for Quality (ASQ) India Pvt. Ltd**: An MoU was signed with ASQ India Pvt. Ltd., with a central agenda of achieving forwardness in knowledge/adeptness and its implementation for the benefit of IIT-D community in fields of engineering and management sciences
- MoU with **Security Printing and Minting Corporation of India Ltd. (SPMCIL),** New Delhi for focusing on research collaborations in the domain of common interest. Vide this memorandum, the training and exchange of expertise shall also be undertaken amongst the two stakeholders.
- MoU with **Wallonia Foreign Trade and Investment Agency (AWEX)**, Belgium. The main aim of this MoU was to evolve strong and globally competitive companies from path breaking start-ups with Wallonia as a hub for their expansion in Europe for obtaining market access in the European Union.

h) FITT Awards and Recognitions

FITT, in order to promote the spirit of innovation and entrepreneurship has launched various appreciation ceremonies in the form of awards and rewards. These activities are generally carried out in collaboration with various corporate players and are as follows.

- **Launch of Industrial Credit and Investment Corporation of India (ICICI)-Trinity program**: The program launched by ICICI for budding entrepreneurs is an initiative of the bank to reward innovation and entrepreneurship amongst the youth community in India. The ICICI Trinity programme comprises of three stages – idea generation, prototype and be an entrepreneur. This program has been launched in several top institutes across the country, with IIT-D being one of them.
- **POSOCO power system award (PPSA)-2015:** The Power System Operation Corporation (POSOCO), a wholly owned subsidiary of Power Grid Corporation of India Ltd., launched these awards, in the form of cash prizes, to recognise the outstanding contribution made in the field of power systems and its related fields. The collaboration with FITT encompasses the IITs and National Institute of Technologies

(NITs). This award aims to bring about cutting edge research in the field of power systems by cultivating and nurturing the individuals for the same.

FITT has instituted awards for Ph.D and M.Tech/ M.S projects. The best industry relevant projects(in both the programmes) are provided financial and marketing assistance to incubate their project.

Financial Synopsis

FITT has not only promoted the intellectual and infrastructural facilities of IIT-D but also added industrial relevance and commercial value to the academic knowledge/ research being performed at IIT-D. Among the many functions and objectives of FITT, marketing and business development is one of the most important aspects of FITT. It is the only way of advertising the expertise available at IIT-D that led to enormous asset generation for FITT and IIT-D.

FITT has bank deposits and bonds worth ₹ 356 million in financial year 2014-15. Major earnings of FITT came from interests (₹ 33 million), project activities (₹ 6.6 million) and corporate membership fees (₹ 0.1 million) for the year 2014-15. On the other hand, total expenditure of FITT cost around ₹ 13 million. Thereby, leading to an operational growth worth ₹ 177 million from projects and other activities performed in financial year 2014-15.

Financial assets generated by FITT were achieved by conducting I-A summits, active participation in industry exhibitions at national and international level, publication of a quarterly bulletin, regular propagation of knowledge about IIT-D and FITT through means of articles and write ups in newspapers/magazines and occasional promotional advertisements, initiating corporate membership scheme for the industry, establishment of relationships with associations like Federation of Indian Chambers of Commerce and Industry (FICCI), Associated Chambers of Commerce & Industry of India (ASSOCHAM), Confederation of Indian Industry (CII) and so on. Figures 5.5 and 5.6 depicts the asset and resource generation for IIT-D by FITT since 2002.

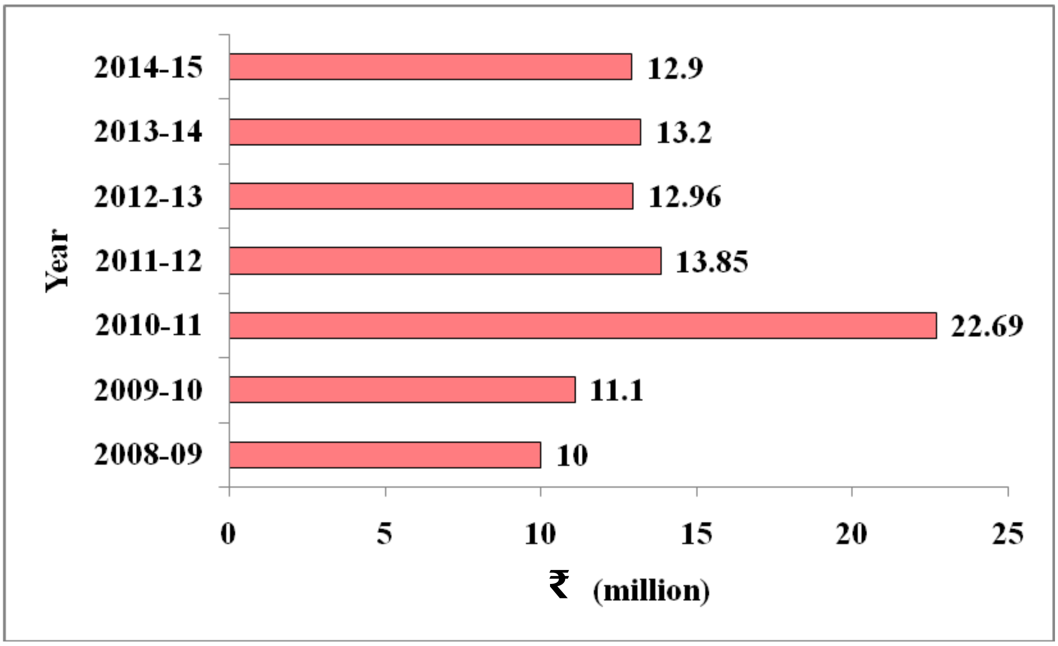


Figure 2: Asset Generation (Infrastructure, Equipments and Transfer of Funds) from FITT for IIT-D

Source: *FITT Annual Report, 2008-15*

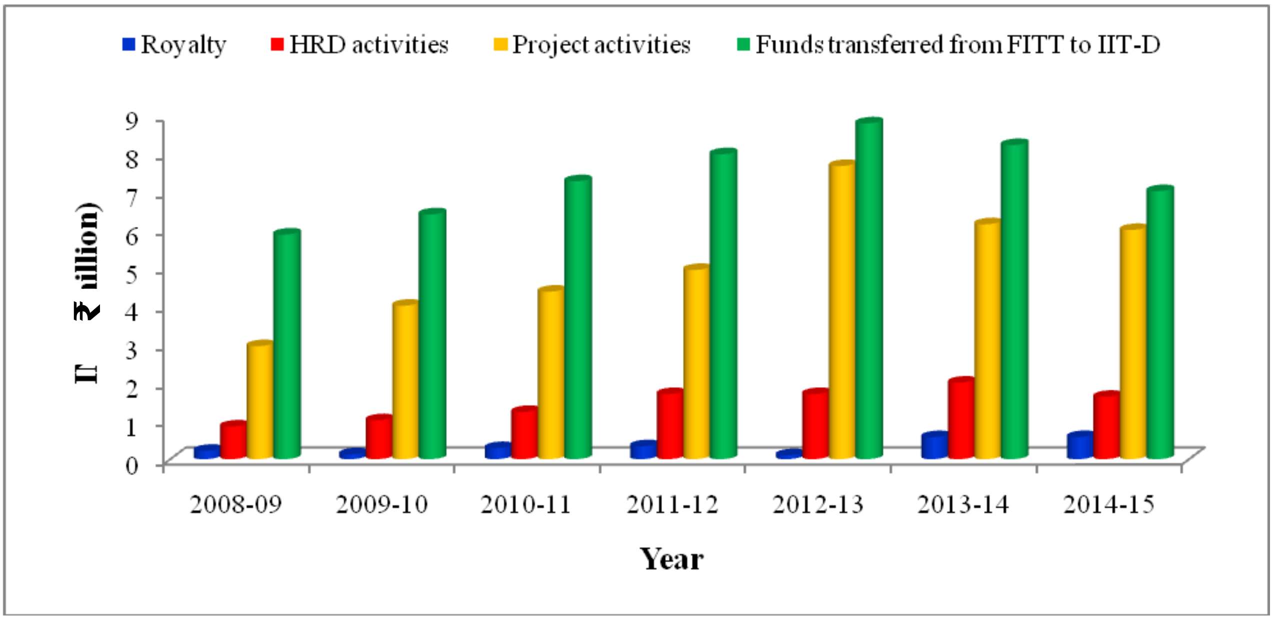


Figure 3: Resource Generation for FITT and IIT-D

Source: *FITT Annual Report, 2008-15*

D. I-A Enablers

HEIs possess various R&D enablers for enhancing industry collaborated research in academic institution. These enablers are listed below

1. Industrial Research Cell (Sponsored and Consultancy)
2. Intellectual Property Cells
3. Technology Development Cell
4. Entrepreneurship and Innovation Cells

Notable examples of each in academic institutions are given in table below.

Table 6: R&D Enablers in Higher Education Institutes (HEIs)

S. No.	HEIs	I-A Cell / Centre
1.	IIT Kharagpur	Sponsored Research & Industrial Consultancy (SRIC) Cell
2.	IIT Bombay	Industrial Research & Consultancy Centre (IRCC)
3.	IIT Madras	Industrial Consultancy and Sponsored Research (IC&SR) Centre
4.	IIT Kanpur	SIDBI Innovation and Incubation Centre (SIIC)
5.	IIT Patna	Sponsored Research and Industrial Relations Unit (SRIRU)
6.	IISc Bangalore	• Centre for Scientific and Industrial Consultancy (CSIC) • Society for Innovation and Development (SID) • Intellectual Property (IP) Cell
7.	Panjab University, Chandigarh	Centre for Industry Institute Partnership Programme (CIPP)
8.	Amity University, Noida	Industry Interaction Cell
9.	Anna University, Chennai	**Centre for Intellectual Property Rights** (IPR)
10.	Punjab Agriculture University, Ludhiana	Technology Marketing and IPR Cell
11.	Jadavpur University, Kolkata	Industry Institute Partnership Cell
12.	University of Agricultural Science, Bangalore	University Consultancy Cell