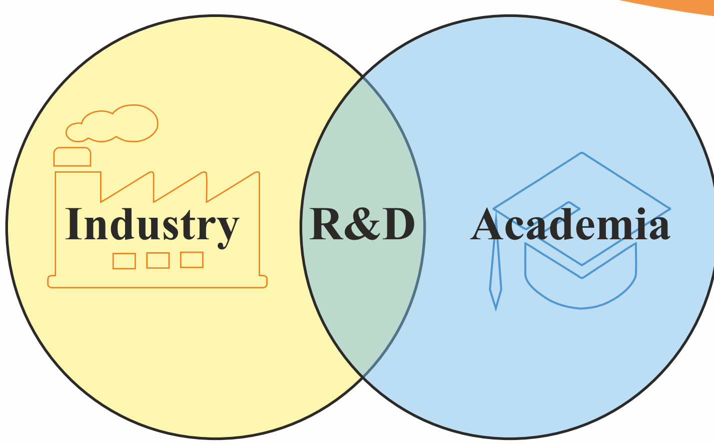
Industry-Academia R&D Ecosystem in India.....*an evidence based study*



Prof. Rupinder Tewari

Study
compiled by

DST Centre for Policy Research
at
Panjab University, Chandigarh

Under the aegis of

सत्यमेव जयते

Department of Science and Technology
Ministry of Science and Technology
Government of India

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Department of Science and Technology
Ministry of Science and Technology
Government of India

This Book is Dedicated

to

(15th October, 1931 – 27th July, 2015)

Dr A.P.J. Abdul Kalam

Former ***President of India,***

&

A Great Statesman, Acclaimed Scientist,

Teacher Par Excellence and Source of Inspiration to

Young Generation of India

मंत्री
विज्ञान और प्रौद्योगिकी एवं पृथ्वी विज्ञान
भारत सरकार
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सत्यमेव जयते

डॉ. हर्ष वर्धन
DR. HARSH VARDHAN

MINISTER
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MESSAGE

It is a well acknowledged fact that the development of a nation is closely associated with its Science & Technology programmes. India is aware of this situation and has continuously evolved its scientific policies for the same. In 1958, India published its first Scientific Policy Resolution (SPR) which laid stress on 'cultivation of science and scientific research' by establishing Higher Education Institutes and National Research Laboratories. Having achieved this goal, subsequent policies i.e. Technology Policy Statement (TPS,1983) followed by Science and Technology Policy (STP, 2003) and Science, Technology and Innovation Policy (STIP, 2013) emphasized the need to attain technological competence and integrating programmes of socio-economic sector with national R&D sectors to address national problems.

India's Gross Expenditure on Research and Development (GERD) is less than 1.0% of GDP, whereas, it should have been at least 2% of GDP. This is feasible, provided private sector, primarily the industrial sector, raises its R&D investment so that it matches the government's contribution as is prevalent in developed economies. Recently, the government has offered many incentives for private sector to stimulate its R&D activities. The government has also started many schemes for encouraging entrepreneurship, start-ups and skill development amongst the young and bright minds.

The Government earnestly desires that Industry and Academia should work hand in hand for nation building, as is the practice in developed nations. The setting up of a DST sponsored 'Centre for Policy Research' at Panjab University, Chandigarh is a welcome step in this direction. I am sure that the inputs provided by this Centre to the Ministry of Science and Technology, New Delhi, will be extremely helpful in designing national policy on Industry-Academia linkages.

I wish DST sponsored 'Centre for Policy Research' at Panjab University, Chandigarh all the best in its endeavours for strengthening Industry-Academia programme of India.

Harsh

(Dr. Harsh Vardhan)

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MESSAGE

Worldwide the academia of a nation plays a leading role in advancing the frontiers of Science and Technology. In recent years, one of the major concerns for policy-makers has been to ensure the seamless transfer of wealth of scientific knowledge generated within universities & research centres to industry so that the society in general, and local businesses in particular can be benefitted. The realization that important scientific research output would not reach the society as a result of bottlenecks in the commercialization of technologies has led to increasing interest in putting in place a mechanism to promote Industry-Academia partnerships for the transfer of technology.

National governments of advanced countries have implemented policies to promote Industry-Academia interactions and on account of this, the line between industry and academic research is gradually disappearing. As a result, industry is effectively translating the academic research into technologies, thus resulting in a win-win situation for both the parties. In India, there are few stories of successful Industry-Academia partnership in R&D, primarily limited to IITs. Specific models need to be created for the promotion of Industry-Academia partnership in R&D for our country by studying the evidence based on successful models of Industry-Academia interactions.

I am happy to know that Department of Science and Technology has established a 'Centre for Policy Research' at Panjab University, Chandigarh to understand the Industry-Academia ecosystem of India and make specific recommendations for bridging the gap between public and private sectors, for R&D in pursuit of over all economic growth of the nation.

New Delhi

22.08.2016

(Y S CHOWDARY)

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Secretary
Government of India
Ministry of Science and Technology
Department of Science and Technology

प्रो. आशुतोष शर्मा
Prof. Ashutosh Sharma

MESSAGE

The Science, Technology and Innovation Policy-2013 of India emphasizes on effective Industry-Academia partnership which is crucial to the advancement of Science, Technology and Innovations, ultimately contributing to the economy kitty of the nation. Industry-Academic collaborations are like partners skilled in different dance forms improvising a fusion between waltz and salsa leaving the audience spellbound. Both industry and academia need each other for their successful existence but their interests and priorities are by definition different in a number of ways. University researchers prioritize education, basic research and early research publications, whereas industries pursue products, profits and confidentiality. Despite this paradigm, there are quite a few successful stories wherein academic knowledge has been commercialized by the industrial sector and thus resulting in a win-win situation for both the partners. There is a need to study these successful stories and design country specific model for promotion of collaborative R&D.

Secondly, R&D is a capital intensive activity which neither any government nor industry can afford individually. In India, nearly two-third of the finances for R&D is provided by the public sector and rest (one third) is shared by the private sector. However, in developed countries, reverse trend is observed. A thorough study is required to understand how Indian private sector can be stimulated for enhancing the investments in R&D.

DST has taken the responsibility to address the above mentioned issues by establishing a DST-'Centre for Policy Research' at Panjab University, Chandigarh. I am sure that the study will prove to be an effective tool in understanding recent Industry-Academia developments in the world, especially Asia, and provide useful insights to policy-makers engaged in finding the most effective ways to promote the Industry-Academia partnership.

(Ashutosh Sharma)

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महानिदेशक

Girish Sahni
Secretary, Govt. of India
Department of Scientific & Industrial Research, and
Director General

MESSAGE

The hand-holding of industry with academia has gained momentum as the emerging era of science-based collaborations between academia and industry offers advantages to both entities and a means by which academic institutions and industry can address the global challenges to their mutual benefit and well-being of the society. The Industry-Academia collaborations have carved a successful niche in the R&D ecosystem of developed economies, but in most of the developing countries including India, Industry-Academia research collaborations are in the nascent stage. With new initiatives of the government for the stimulation of applied research, there is no doubt that India is poised to improve its global image in the domain of applied research and IPRs.

I am aware of the activities of DST sponsored 'Centre for Policy Research' (CPR) at Panjab University, Chandigarh for the promotion of Industry-Academia interface in India. I appreciate the efforts put in by the Centre to publish a book entitled, 'Industry-Academia R&D Ecosystem in India...*an evidence based study*'. For the first time, an attempt has been made to provide a comprehensive data on Industry-Academia R&D related schemes being floated by research funding agencies, industry associations and the banking sector. The book also describes industry-related research programmes of Higher Education Institutes such as IITs and a few other institutions. The chapter on the global rankings of Asian countries including India, based on Science and Technology parameters, clearly indicates that India has a lot of catching up, if it desires to be counted amongst top economies of the world. The steps needed to fill the gap for translating laboratory research into a technology/product is one such area which needs immediate attention of the government. The book has listed several recommendations for improving Industry-Academia ecosystem in India and boosting Public Private Partnership between the academia and industry. I strongly feel that many of the recommendations are worth pursuing further.

I wish good luck to the team CPR in their pursuits for improving Industry-Academia interface in India.

New Delhi

July 21, 2016

(Girish Sahni)

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Professor Arun K. Grover
Vice-Chancellor

MESSAGE

The DST sponsored 'Centre for Policy Research' (CPR) at Panjab University (PU), Chandigarh, is coming out with a book entitled, 'Industry-Academia R&D Ecosystem in India....... *an evidence based study'*. To the best of my knowledge, it is the first book of its kind which has compiled the Industry-Academia programmes of the public and private sectors of India.

Today, Industry-Academia collaboration has become the subject of great interest to the academicians, industry leaders and policy makers, as it is now acknowledged that scientific innovations will be the key driver of the economy of a nation. In developed countries, there is a healthy symbiotic relationship between R&D of the public and private sectors and is contributing greatly to the knowledge economy of the nation. India's global ranking on the parameter of 'University-Industry Research linkage' is not impressive even though, the country has nearly 700 universities, 300 national research laboratories and around 1700 DSIR accredited R&D laboratories in the private sector. Time has come to bring them on a single platform so that they collectively work together and contribute significantly towards the economic and societal progress of the nation.

This book highlights the Industry-Academia activities of the public sector especially IITs and presents their data in generating Patents, Technology Transfers, Entrepreneurs and Start-ups. It has a dedicated chapter listing recommendations for bridging the gap between the R&D of public and private sectors, which is an outcome of meetings with various stakeholders.

I am sure, this book will help in a better understanding of the Industry-Academia ecosystem prevailing in our country. All my good wishes for the staff of DST-CPR at PU, Chandigarh.

(Arun K. Grover)

Prof. Baldev Raj, Director

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MESSAGE

Knowledge economy with large demands on well being and security of the citizens and the nation coupled with aspirations of growing India mandates a productive, dynamic and creative interface between academia, research and industry. Universities and industries for long, have been operating in separate silos except for limited successes of working together to the purpose. Strategic sectors of atomic energy, space and defence are exceptions. These two entities are endeavouring to come closer to each other for realizing synergies. The nations with strong economies of the world have realized the importance of a robust and dynamic bridge between the academia and industry. Many novel innovations (technologies, products and processes) in these countries are the result of close and worthy collaborations between the academia and industry on a sustained basis in a framework of mutual respect and understanding.

Indian Industry, after the liberalization in 1990s, is becoming increasingly aware of the vital linkage between the education system, business and corporate productivity with value addition. These collaborations are essential for competitive industry.

Moreover, industry is working on products and processes where India has an ambition to research, innovate and lead, thus collaborations with universities and research institutes (in and outside the country) is emerging as robust strategies. The awareness has resulted in enhanced engagements. At best, these are beginnings only though, exceptions do exist where robust sustained collaborations have produced substantial results. IITs, ICT-Mumbai, IISc-Bengalore and a few other Higher Education Institutes are good examples of growing robust Industry-Academia synergy especially, in the domain of R&D which has resulted in increasing the IPRs, products and generation of resources for the academic institutes. For India to be counted amongst the stable growing large economies of the world, it is imperative that Industry-Academia synergy is enhanced amongst universities, national research laboratories and industries.

The broad mandate of DST sponsored 'Centre for Policy Research' (CPR) at Panjab University, Chandigarh is to make recommendations for the promotion of collaboration, based on success stories in the Indian ecosystem. I have been experiencing the activities of CPR at Panjab University since its inception. After a few initial experiments for finding approaches, this Centre is shaping up expeditiously and in a competent manner. Prof. Rupinder Tewari has consistently endeavoured to understand the Industry-Academia R&D ecosystem of public and private sectors in India. The data, discussions and analysis has been captured in this book, I understand that, the book is first of its kind on the R&D ecosystem of public and private sectors in India. The suggestions and recommendations brought out in book will be of great interest to the collaborators, policy makers, organizations and agencies involved in Science &Technology programmes of the country.

I wish successes to the 'Centre for Policy Research' at Panjab University in the pursuit for strengthening Industry-Academia research paradigm for changing and growing India. This success in this domain shall enhance competence of India and contribute to well being of our economy, citizens and the nation.

Baldev Raj

Dr Baldev Raj

Director, National Institute of Advanced Studies,

IISc, Bangalore & co-Chairperson, Policy Research Cell, DST, New Delhi

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MESSAGE

The Department of Science & Technology, Government of India, had taken a decision of setting up 'Centre for Policy Research' at Panjab University, Chandigarh with a clear mandate of investigating the current Industry-Academia regime of India and make recommendations, provide evidence based models/studies for (a) Preparation of country specific model for enhancement of public-private partnership in R&D (b) Stimulation of private sector investment in R&D, and (c) Identifying specific areas of generation of joint Intellectual Property Rights.

The 'Centre for Policy Research' has held many conferences/ seminars/meets involving scientists engaged in industry oriented research, industrial sector having research tie ups with universities/national research laboratories and industry associations. The Centre has also carried out case studies on (a) institutes engaged in industry oriented research and (b) scientists who have transferred products/technologies to the private sector. I appreciate the efforts of the Centre in comparing top Asian countries (India, China, Japan, S. Korea, Singapore and Taiwan) based on Science and Technology parameters. This study has provided systematic evidence regarding areas where India has to lay more stress to become global leader.

I believe, 'Centre for Policy Research' at Panjab University, Chandigarh is on the right track and will soon come out with recommendations for strengthening Industry-Academia ecosystem in India.

With best wishes

(Neeraj Sharma)

Dr M. K. Bhan
Former Secretary to Govt. of India
Department of Biotechnology
Ministry of Science and Technology, New Delhi

FOREWORD

Science and Technology is linked to economic and social development through several pathways. These include skilled human resource, generation of new knowledge and tools, generation of intellectual property and technology transfer to industry. Industry may on its own further R&D by funding academic institutions and/or use academic capabilities for problem solving or design.

Knowledge circles within which industry and academia operate at multiple levels – social interaction, interdisciplinary science and translationaly oriented meetings, opportunity landscaping, policy, business and trade or regulatory networks. The impact of academic industry interactions on social and economic development become particularly important as per capita income and labour costs increase in countries, i.e. to sustain high growth rates over decades.

Further, Industry-Academia collaboration is relevant to addressing major developmental challenges in health, food security, energy, climate change, employment generation and other areas. These collaborations must take into account context and wide access to processes, products and tools as end goals.

In this context, design of products, process and other type of solutions requires knowledge of the problems being addressed. This itself requires close working interactions among different academic and industry types, through multi faceted networks.

Innovation is therefore often described as a 'contact sport', and it happens within effective 'connectomes'. How does a nation or a state design the right ecosystem that allows for productive connectivity across sectors, institutions, disciplines to happen in hassle free manner which makes innovation and risk taking a desired path for many. This book reviews experiences and provides ideas for future for strengthening our innovation system, particularly academia industry interactions.

Prof. Rupinder Tewari and his team at DST sponsored Centre for Policy Research at Panjab University, Chandigarh have published a much needed book entitled, 'Industry Academia R&D Ecosystem in India.......*an evidence based study*'. The first chapter introduces the global rankings of India and five other Asian countries (China, S. Korea, Japan, Taiwan and Singapore) based on globally accepted Science & Technology indicators. India ranks amongst top five nations in the number of research publications, but its ranking nosedives in the indicators of translating research into technologies/products/patents. Publications of research papers may give the scientist a sense of pride and satisfaction, but its practical value to the nation depends on the extent to which academic knowledge and tools are commercialized. Translatable knowledge depends on the way questions of science are framed and inventiveness of our science. Knowledge of needs of society and of market demands informs translatable research. A robust ecosystem has to be created in public sector institutes of higher education and national research laboratories for technology driven and problem solving R&D.

The second chapter '*Industry-Academia Programmes/schemes of Public and Private Sectors'* puts across various initiatives of the public and private funding agencies/organizations for enhancing Industry-Academia activities. The funding agencies (DST, DBT, ICMR, CSIR, DSIR, etc.), industry associations (FICCI, CII, ASSOCHAM, etc.) and the banks (ICICI, SBI, SIDBI, NABARD, etc.) have launched many programmes/schemes to promote effective collaborations amongst industry and academia but the information regarding the schemes is rather scattered. There is no single place, where above mentioned information is available as a compilation. I applaud the efforts of the authors to collate much needed information at one place. This data will help the government and other stakeholders in identifying overlaps as well as gaps in industry-academia programmes/schemes.

Chapter three, '*Industry-Academia R&D Regimes in IITs*' and chapter four '*Industry-Academia Related Questionnaire Survey Report of IITs*', highlight the Industry-Academia regimes existing in IITs. The large number of patents and technologies coming out of IITs has been credited to the presence of vibrant Industry-Academia interface, IP Cell, Tech Transfer Cell, and Centres of Excellence where industry and academia join hands to work on futuristic innovations. In addition, industry leaders participates in their governing councils, others in teaching as well as designing of academic syllabi. These institutions can act as role models for other universities and research laboratories for setting up of robust Industry-Academia regime. These institutions are most productive in areas where they connect with real life situations is relatively close. Chapter five, '*Public Private Partnership Models for R&D in India*', enlists various institutes/organizations in the country that are conducting R&D programmes under PPP mode. ICT Mumbai and Bombay College of Pharmacy, Mumbai are examples of educational institutes established at the request of respective industry associations. Both institutes have been rated very highly, by the independent agencies, in the area of industry academia linkage. Another example of R&D activity under PPP mode is a Pune based industrial institute called Automotive Research Association of India (ARAI). It has been set up by Ministry of Heavy Industries and Public Enterprises (MoHI&PE), Government of India in collaboration with automotive industry. Similarly, The Energy Research Institute (TERI), a private research centre, is doing exemplary R&D in the area of energy and has transferred many technologies to industries. TERI has benefitted immensely by public funded agencies for their R&D programmes. A government funded agency, BIRAC, is yet another shining example of promoting R&D (Biotech sector) under PPP mode. In its five years of existence, it has brought 17 products in the market. Twenty two start-ups have graduated and nearly 70 industry-academia collaborations have been established. This successful model can act as a template for the establishment of BIRAC type organization in other funding agencies.

The sixth chapter of the book '*Patent Ecosystem in India Based on WIPO & IPO Indicators*' *Intellectual Property Rights Status in India*, highlights the strengths and weaknesses of Indian patent regime based on the reports from WIPO and IPO. China, Japan and S. Korea are well ahead of India in the number of patents filed/granted. In the year 2014-15, 42,763 patents were filed with the Indian Patent Office, New Delhi. Surprisingly, nearly two-third of the patents filed in India are by foreign companies! Amongst the R&D laboratories, CSIR research labs. and IITs (collectively) are the leading applicants of patents (filed/granted) in the scientific organization and institute categories respectively. As per the latest report available, the Chemical sector leads in the category of patents (granted), followed by Mechanical sector and Computer & Electronics sector. It is high time, India identifies and promotes areas for generation of IP.

The seventh chapter of the book '*Feedback from Select Scientists Engaged in Industry-Academia Research Projects*', comprises of a proforma-based case studies on the scientists engaged in Industry-Academia collaborative research projects. These scientists talk about the hindrances faced by them while doing collaborative research. They have also put forth many suggestions which should be taken seriously and addressed properly, if such collaborations are to be taken to greater heights in India.

The last chapter of the book '*Recommendations for Enhancing Industry-Academia Linkages*', is a compilation of key suggestions/recommendations, which are the outcome of various Industry-Academia 'Meets' organized by the Centre, and feedback from select scientists. All the recommendations are well thought out and deserve to be pursued further, especially the reforms needed in the promotion criteria of university professors. The long pending desire of the industry for the creation of a 'national web portal' to access the availability of scientific expertise, infrastructure, patents, technologies, and summary of Ph.D theses of the institutes, is highly desirable. The authors have also suggested the setting up of an apex body called National Industry-Academia Centre (NIAC) which should be responsible for designing as well as implementation of Industry-Academia policy for India. As Industry-Academia is an important component of S&T and the latter is linked with the economy of the nations, it is imperative that India should have a dedicated national Industry-Academia cell/council/centre.

In the end, I believe, the book gives an excellent overview of the industry-academia schemes and programmes of India. The data given in this book will be useful to the public sector (government agencies, universities, research laboratories and policy makers) as well as private sector (industries, industry associations, financial institutions and banking sector) for not only understanding the existing industry-academia ecosystem in India, but also making endeavours for strengthening and promoting public-private R&D interactions.

MKBhan

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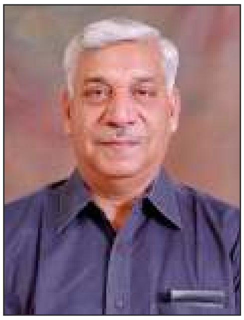

PREFACE

In the twenty first century, Science, Technology and Innovation (STI) are considered to be the key drivers of the economic development of a nation. To achieve success in these parameters, the Ministry of 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 development (R&D) outputs for commercial and societal gains. To achieve success in these parameters, the policy strongly advocates a) strengthening Industry-Academia (I-A) research collaborations, b) promoting private sector investments in R&D, c) stimulating public private partnership (PPP) for translating knowledge into wealth creation and seeking solutions for societal problems and d) identifying as well as promoting areas for generation of intellectual properties (IPs).

In order to address above mentioned objectives, the Department of Science and Technology (DST), GoI, New Delhi established a '*Centre for Policy Research*' (CPR) at Panjab University (PU), Chandigarh in 2014. For initiating work on these objectives, an Advisory Committee comprising of experts like, Professor G D Yadav (Vice-Chancellor, Institute of Chemical Technology, Mumbai); Professor Arun K Grover (Vice-Chancellor, Panjab University, Chandigarh); Dr V M Katoch (fmr. DG, Indian Council of Medical Research, GoI); Professor A K Puri (DG, Institute of Technology & Science, Gaziabad, UP); Dr Anil Wali (MD, Foundation for Innovation and Technology Transfer, IIT-Delhi); Mr Ajay Davessar (Vice-President, HCL Technologies, Noida, UP); Dr Arbind Prasad (fmr. DG, FICCI, New Delhi) and Dr Manu Chaudhary (MD, Venus Remedies Ltd., Panchkula, Haryana) was constituted. Under the guidance of the Advisory Committee, DST-CPR at PU, Chandigarh convened many meetings/brainstorming sessions with personnel from academia, industry, industry associations and funding agencies such as, DST, DBT, CSIR, TIFAC and NRDC. The outcome of the meetings has been compiled in the form of this book entitled, 'Industry-Academia R&D Ecosystem in India......*an evidence based study'*.

One of the initial activities undertaken by the 'Centre' was to ascertain India's global standing in the domains of Education and Science and Technology (S&T). For this, we reviewed the rankings of India based on S&T indicators like, Number of Publications, H-Index, IPR, University-Industry Collaborations in R&D, Capacity for Innovation, Availability of Scientists and Engineers, etc., as published by the World

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Economic Forum and SJR International Science Ranking. The data indicates the strength of India in the indicator of 'Number of Publications'. Unfortunately, in rest of the indicators India is far behind many countries including the Asian economies including Singapore, S. Korea, China, Taiwan and Japan. India's global ranking of 5th and 47th in the indicators of 'Number of Publications' and 'IPRs' respectively suggests a big gap in the conversion of research into patents. A robust ecosystem has to be created in public sector institutes of higher education and national research laboratories for fostering/promoting technology/product driven R&D.

The second task undertaken by the 'Centre' was to find out various schemes/programmes floated by the public and private agencies/organizations such as funding agencies (DST, DBT, ICMR, CSIR, DSIR, BIRAC, MeitY and many more), industry associations (FICCI, CII and ASSOCHAM) and banks (ICICI, SBI, SIDBI and NABARD). This data has been provided in the second chapter entitled, '*Industry-Academia Programmes/Schemes of Public and Private Sectors'*. Even though there is a plethora of information available on the promotion of I-A R&D, however, it is not available as a specific compilation. The authors have recommended for the setting up of a dedicated Centre/Council, which will act as a single window source for providing I-A related information to various stakeholders. The compilation of data at one place will also help the government and other stakeholders in identifying overlaps and gaps in the I-A programmes/schemes.

India has nearly 800 institutes of higher learning and majority of them are universities. Unfortunately, only a handful of universities are engaged in the generation of patents, technologies, entrepreneurships, start-ups, industry-engagements and consultancies on regular basis. By and large, IITs are at the forefront in these parameters. To understand the R&D ecosystem of IITs, scientists of the 'Centre' made visits to IITs, interacted with their faculty members and also sought information through a 'Proforma' on their I-A activities. The outcome of these studies has been presented in two chapters entitled, *'Industry-Academia R&D Regimes in the IITs'* and *'Industry-Academia Related Questionnaire Survey Report of IITs'*. The large number of patents and technologies originating from IITs have been credited to the presence of vibrant 'Translational Research Ecosystem' comprising of I-A Cell, IP Cell, Technology Transfer Cell and Centres of Excellence (CoEs), where industry and academia jointly pursue research. IITs can act as role models for the universities and R&D institutes for setting up robust and effective I-A regime.

Since the beginning of this century all nations, developed as well as developing, are facing the financial crunch. As development of scientific innovations is a capital intensive activity, each nation is developing its own model(s) for promoting PPP in R&D. The 'Centre' has studied the PPP mode of R&D existing in India and the observations are presented in chapter five, *'Public Private Partnership Models for R&D in India'*. The notable examples of PPP in R&D are Global Innovation and Technology Alliance (GITA), Biotechnology Industrial Research Assistance Council (BIRAC), Automotive Research Association of India (ARAI) and Institute of Chemical Technology (ICT), Mumbai. GITA promotes and supports innovation at national and international levels; BIRAC promotes R&D in the Biotech Sector. ARAI is a Pune based institute catering successfully to the R&D and other needs of the automobile sector. Amongst the educational institutes, ICT-Mumbai is a shining example of I-A collaboration in R&D. All the above mentioned organizations/institutes are regarded highly in their professional domains because of generation of large number of patents and technologies by them. These successful models can act as a template for other establishments for enhancing their R&D activities under PPP mode.

The 'Centre' also conducted a study on the patent regime of India, based on the reports from World Intellectual Property Organization (WIPO) and Indian Patent Office (IPO) and discussions with the officials of TIFAC and NRDC. The results are presented in the chapter, *'Patent Ecosystem in India Based on WIPO and IPO Indicators'* . China, Japan and S. Korea are well ahead of India in the number of patents filed/granted. In the year 2014-15, 42,763 patents were filed with the IPO, New Delhi. Surprisingly, nearly two-third of the patents filed in India are by the foreign applicants! CSIR research laboratories and IITs (collective) are the leading applicants of patents (filed/granted) in the 'Scientific and R&D Organizations', and 'Institute and Universities' categories respectively. As per the latest IPO Annual Report (2014-15) available, the Chemical Sector leads in the category of patents granted, followed by Mechanical, Computer and Electronics Sectors. It is high time, India identifies and promotes areas for generation of IP.

The 'Centre' also interacted with a few scientists of the universities and IITs who have carried out I-A collaborative research to seek their opinion on strengthening I-A R&D ecosystem in India. The outcome of the study is presented in the seventh chapter of the book '*Feedback from Select Scientists Engaged in Industry-Academia Research Projects*'. These scientists recount the hardships encountered by them while doing the collaborative research. They have also put forth many suggestions which should be taken seriously and addressed properly, if I-A collaborations are to be taken to greater heights in India.

The innumerable meetings with scientists from the academic sector, R&D institutes and industry representatives from IT, Pharma, Agriculture, Food, Chemical, Biotech and Automobile sectors have resulted in a plethora of valuable suggestions/recommendations which have been compiled in the last chapter *'Recommendations for Enhancing the Industry-Academia Linkages'*. All the recommendations are well thought-of and justified to be pursued further, especially the reforms needed in the promotion criteria of university professors. The much needed expectation of the industry for the creation of a 'national web portal' to access the availability of scientific expertise, infrastructure, patents, technologies, and summary of Ph.D theses is highly desirable. The establishment of an apex body, National Industry-Academia Centre (NIAC) will facilitate compilation of I-A R&D programmes, their assessment and implementation strategies in India.

In brief, this book provides a comprehensive view of the I-A ecosystem existing in the institutes of higher learning and funding agencies of India. The data compiled in this book will be useful to the public sector (government agencies, universities, research laboratories and policy makers) as well as the private sector (industries, industry associations and financial institutions sector) for bridging the gap between the industry and academia.

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In the end, we wish to apologise to those, whose names have been missed out inadvertently.

Authors

Industry-Academia R&D Ecosystem in India

......an evidence based study

Comparison of Select Asian Countries Based on Global S&T and Education Indicators

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1.1 Introduction

In the twenty first century, Asia has been perceived to be one of the dynamic part of the global economies. In this chapter, a comparative study has been undertaken on six Asian countries (India, China, Singapore, Japan, Taiwan and South Korea) based on 'The Global Competitiveness Report' 2016-17, published by the 'World Economic Forum' (WEF). Except Japan these nations were struggling economies till the middle of the twenty first century. However, countries like Singapore, Japan, Taiwan and S. Korea, despite being small in size and population, have made remarkable progress in various economic parameters and are rubbing shoulders with developed economies like the United States of America (USA), United Kingdom (U.K.), Germany, Canada and France. Singapore has been recognised as the world's leading international financial centre and Japan as the largest electronic goods industry. Taiwan has become the largest importer and exporter of merchandise and S. Korea has earned the reputation of being a leading manufacturer of information technology equipments. Unfortunately, India and China are yet to match the progress made by the other four Asian countries though, they are global players in a few sectors. China is being recognized as a major exporter of goods of various kinds, while, India has carved a global niche in the domain of space research and information technology. As per the prediction of pundits of the economic sector, China and India will be the leading economies of the world as they have all the ingredients needed for becoming economically stable nations. Both nations have plenty of natural resources, huge land mass and coastal areas, large number of universities, scientists and advanced R&D laboratories/institutions and abundance of young workforce.

Table 1.1 lists general information about select Asian countries i.e. India, China, Japan, Taiwan, Singapore and S. Korea. Four countries (India, China, S. Korea and Singapore) became independent around the middle of the twenty first century. Japan has always been an independent nation and there is no official independence day of Taiwan. Singapore tasted independence a bit later in 1965. All the six nations have different modes of governance and economy.

Table 1.1: General Information About Select Asian Countries

Attributes	Singapore	Japan	Taiwan	S. Korea	China	India
Independence	August 9, 1965	not applicable	No official day	August 15, 1948	October 1, 1949	August 15, 1947
Population[a] (billions)	0.055	0.126	0.023[b]	0.506	1.370	1.311
Land Area[a] (sq km)	707	364,560	36,193[c]	97,466	9,388,211	2,973,190
Mode of Governance	Parliamentary Republic	Constitutional Monarchy	Multi-party Democracy[c] (semi-presidential)	Presidential	Autocratic Socialist	Federal Republic
Mode of Economy	Free Market	Free Market	Capitalist Economy	Market Economy	Socialist Market	Mixed Economy

Source*: a - World Bank-2015 (www.worldbank.org), b - Trading Economy (http://www.tradingeconomics.com/taiwan/indicators), c- http://www.taiwan.gov.tw*

1.2 Structure of Global Competitiveness Index

The Global Competitiveness Index (GCI) (http://www3.weforum.org/docs/GCR2016-2017/05FullReport/TheGlobalCompetitivenessReport2016-2017_FINAL.pdf) compares and ranks the economic competitiveness of nations (138 nations, 2016-17 edition) based on the statistical data collected from internationally recognized agencies like International Monetary Fund (IMF), United Nations Educational, Scientific and Cultural Organization (UNESCO), World Bank, International Telecommunication Union (ITU) and World Health Organization (WHO). The index also includes indicators derived from the World Economic Forum's Executive Opinion Survey that provides qualitative aspects of competitiveness. The GCI data is divided into three broad categories ('Basic Requirements', 'Efficiency Enhancers' and 'Innovations and Sophistication Factors') comprising of 12 pillars (Fig. 1.1) encompassing 114 indicators. The classification of world economies is based on the stage of development (Table 1.2). The stage of development [Stage 1 (Factor Driven), Stage 2 (Efficiency Driven) and Stage 3 (Innovation Driven)] of a country is being proxied by its Gross Domestic Product (GDP) per capita (US$). In GCI, higher relative weights are given to those pillars which are more relevant for an economy according to its stage of development. Any country which falls between any two of the above mentioned stages is considered to be in a transition stage. Based on the GCI indicators, Singapore, Japan, Taiwan and S. Korea have been placed in 'Innovation Driven' stage, whereas China and India are grouped in 'Efficiency Driven' and 'Factor Driven' stages respectively (Table 1.2).

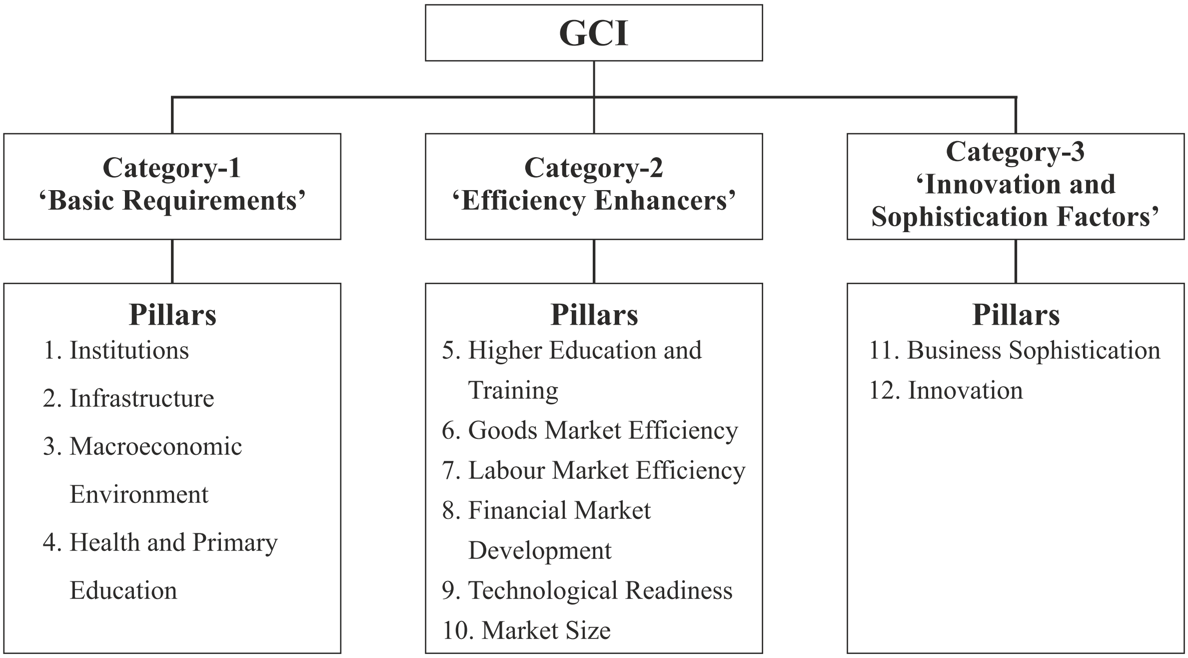

Figure 1.1: Classification of The Global Competitiveness Index (GCI)

Source: *The Global Competitiveness Report-2016-17*

Table 1.2: Income Thresholds and Subindex Weights for Stages of Development

Items	Stages of Development		
	Stage 1 (Factor Driven)	Stage 2 (Efficiency Driven)	Stage 3 (Innovation Driven)
GDP per capita (US$) thresholds	< 2000	3000-8999	>17000
Weight of Basic Requirements	60	40	20
Weight for Efficiency Enhancers	35	50	50
Weight for Innovation and Sophistication Factors	5	10	30
Number of nations in each stage	35 including India	31 including China,	37 including Singapore, Japan, Taiwan and S. Korea

Source: *The Global Competitiveness Report-2016-17*

The comparative global rankings of all the six Asian countries (Singapore, Japan, Taiwan, S. Korea, China and India) based on three categories 'Basis Requirements', 'Efficiency Enhancers' and 'Innovation & Sophistication Factor' is presented in figure 1.2.

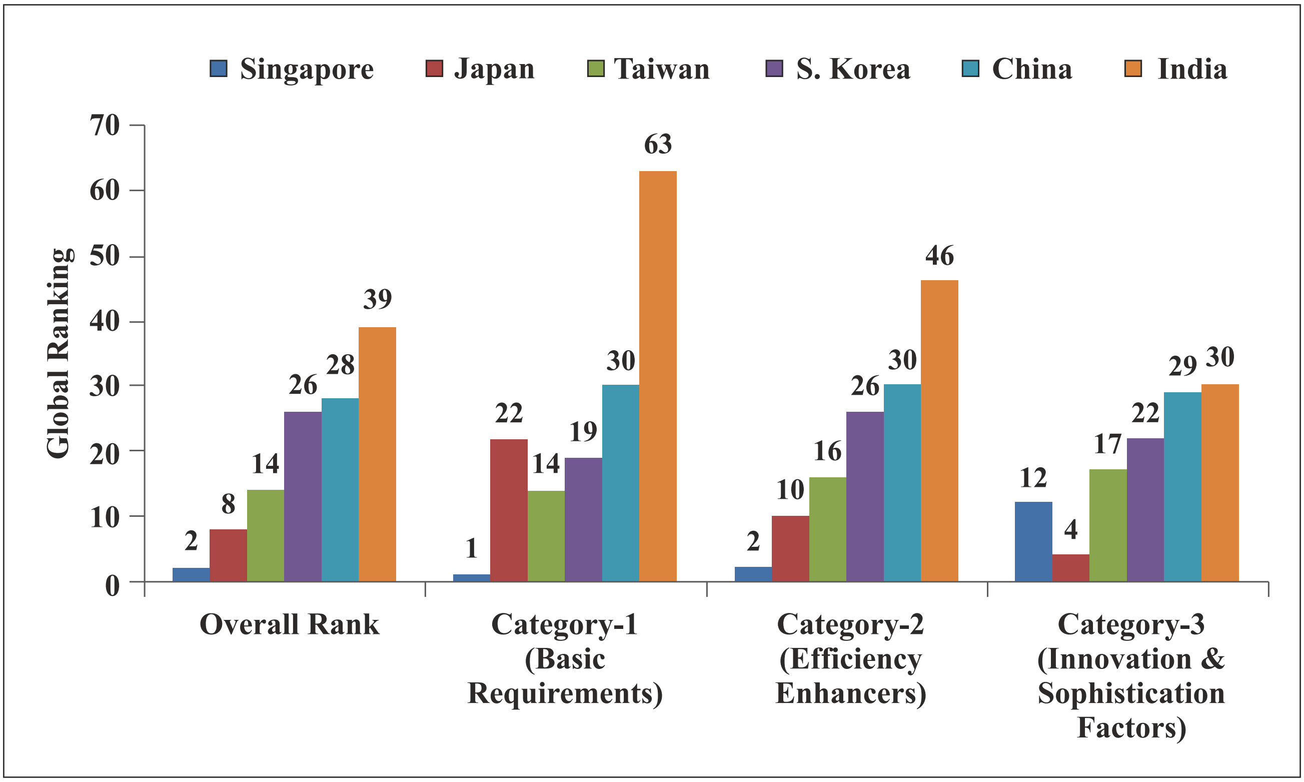

Figure 1.2: Global Rankings of Select Asian Countries Based on GCI

Source: *The Global Competitiveness Report-2016-17*

The data clearly indicates that Singapore (2) enjoys the best overall global ranking amongst the six Asian economies selected for the study, followed by Japan (8), Taiwan (14), S. Korea (26), China (28) and India (39). Only Switzerland (1) is ahead of Singapore (2) in overall ranking (out of 138 economies) and USA occupies third ranking.

Amongst these selected six Asian economies, Singapore leads in two categories ('Basic Requirements' and 'Efficiency Enhancers') and is the second best in the third category of 'Innovation & Sophistication Factors'. Japan is ahead of Singapore in this category. Unfortunately, India's global ranking is the lowest amongst the six Asian countries in all the three categories. Its best ranking (30^{th}) is in the category of 'Innovation & Sophistication Factors followed by 46^{th} in 'Efficiency Enhancers' and 63^{rd} in 'Basic Requirements'.

At the global level comparison of 138 economies (GCI Report, 2016-17) in all the three categories of GCI, Singapore is ranked number one in 'Basic Requirements' category, followed by Switzerland (2) and Hong Kong (3). In the second category of 'Efficiency Enhancers' top three rankings are occupied by USA (1), Singapore (2) and Switzerland (3).

In the third category of 'Innovation and Sophistication Factors' none of the Asian countries are ranked in the top three positions, which are occupied by Switzerland (1), USA (2) and Germany (3). Japan has been ranked at number 4 in this category.

1.3 Comparison Based on S&T and Education Indicators of GCI

In the current scenario, development in the areas of Science and Technology (S&T) and Education have special significance in the economic development of a nation. Nearly 22 of the total 114 indicators can be correlated with the domains of S&T and education are listed in table 1.3.

Table 1.3: Global Rankings of Select Asian Countries in S&T and Education Indicators Based on GCI Report (2016 -17)

S. No.	Indicators	Global Rankings					
		Singapore	Japan	Taiwan	S. Korea	China	India
1.	University-Industry Collaboration in R&D	7	18	17	29	30	24
2.	Availability of Latest Technologies	14	12	29	30	81	78
3.	Capacity for Innovation	20	21	24	30	45	39
4.	PCT Patents, Application/million populations	13	1	n/a	6	33	64
5.	Company Spending on R&D	15	4	12	23	25	28
6.	Availability of Scientists & Engineers	9	3	28	39	30	36
7.	Quality of Scientific Research Institutions	10	13	26	34	40	36
8.	Gov't Procurement of Advanced Tech. Products	4	16	25	37	10	7
9.	Firm-Level Technology Absorption	14	18	30	28	60	81
10.	FDI & Technology Transfer	2	32	35	55	59	54
11.	Imports as a %age of GDP	3	130	41	74	132	121
12.	Exports as a %age of GDP	3	118	20	43	105	112
13.	Country Capacity to Retain Talent	6	38	39	29	33	32
14.	Country Capacity to Attract Talent	4	77	62	49	23	22
15.	Local Availability of Specialized Training Services	5	23	30	58	61	55
16.	Quality of Education System	2	37	30	75	43	29
17.	Quality of Math & Science Education	1	18	15	36	50	44
18.	Quality of Management Schools	4	58	29	63	61	43
19.	Internet Access in Schools	1	38	41	20	50	74
20.	Primary Education Enrolment Rate, net %	1	3	7	54	1	92
21.	Secondary Education Enrolment Rate, gross %	26	36	40	58	65	102
22.	Tertiary Education Enrolment Rate, gross %	7	42	9	2	69	93

Total Economies - 138, n/a - Data on patents is not available for Taiwan in GCI because it is not signatory of Patent Cooperation Treaty (PCT)

***Source**: The Global Competitiveness Report-2016-17*

Singapore is way ahead of the other five Asian countries in nearly all the 22 indicators listed in table 1.3. It leads in 17 out of 22 indicators, and Japan leads in 4 indicators and S. Korea in 1 indicator. In fact, in 16 indicators Singapore's global ranking is amongst the top ten world economies, and in the 5 indicators, it is amongst the top 20 world economies, which is very impressive. Japan's ranking is highly commendable in four indicators (PCT Patents, Applications/million populations; Company Spending on R&D; Availability of Scientists & Engineers and Primary Education Enrolment Rate, net %) as it is globally ranked between 1-4. However, it has a few grey areas in the indicators of Country Capacity to Attract Talent; Quality of Management Schools and Imports & Exports as %age of GDP.

Singapore and Japan are succeeded by Taiwan and S. Korea in the global rankings of the indicators (table 1.3) pertaining to S&T and Education related indicators. Overall, both these nations have reasonable global rankings. The Tertiary Education Enrolment Rate, gross % indicator is in single digits for both the nations, which is exemplary. S. Korea is also ranked 6th in the indicator of PCT Patents, Applications/million populations. But, overall Taiwan's performance is better than S. Korea in most of the 22 indicators listed in table 1.3. The last two spots amongst the 6 Asian countries go to India and China. Both nations do not find a place in the top 10 global rankings except in indicator (Gov't Procurement of Advanced Tech. Products) and China is ranked one in indicator Primary Education Enrolment Rate, net %. In the two indicators of Imports and Exports as %age of GDP, their global rankings are in triple digits. In other indicators, 8 for India and 9 for China, the global ranking range between 50-100. Between India and China, India seems to be performing better than China as it is ahead (of China) in 13 indicators, whereas, China leads India in 9 indicators.

1.4 Comparison Based on R&D Indicators of Other Agencies

The studies carried out by other agencies/organizations on nations' S&T status, also indicate that India has to do a lot of improvement in its R&D domain. Table 1.4 depicts the data collected by various agencies [SJR-International Science Ranking, International Property Rights Index (IPRI) Report, World Bank, The Global Innovation Index (GII) and Global R&D Funding Forecast] on R&D related indicators.

Table 1.4: Global Rankings of Asian Countries Based on R&D Indicators of Selected Agencies

S. No.	Indicators	Global Rankings					
		Singapore	Japan	Taiwan	S. Korea	China	India
1.	**Publications**[a]	31	6	21	12	2	5
2.	**H-Index**[b]	27	6	n/a*	19	16	22
3.	**Intellectual Property Rights**[c]	17	2	26	29	56	47
4.	**High Technology Exports**[d] **(billion USD)**	5	8	n/a*	6	1	23

5.	**Gross Expenditure on R&D**[e] **(GERD Ranking PPP billion USD)**	20	3	14	5	2	6
6.	**R&D Manpower**[f] **(Researchers per million people)**	5	9	n/a*	6	45	87

Sources: *a - SJR-International Science Ranking (http://www.scimagojr.com/countryrank.php?year=2015)*

b - The Global Innovation Index (https://www.globalinnovationindex.org/gii-2016-report#)

c - IPRI Report 2016 (http://internationalpropertyrightsindex.org/ipri2016)

d **-** World *Bank (https://knoema.com/atlas/ranks/High-technology-exports)*

e - 2016 Global R&D Funding Forecast (https://www.iriweb.org/sites/default/files/2016GlobalR%26D FundingForecast_2.pdf)

f - World Bank (https://knoema.com/atlas/topics/Research-and-Development/RandD- personnel/Researchers-in-RandD

*n/a*Taiwan is not considered as an independent country. It is considered as a province of China*

In the indicator of Publications, China (2), India (5) and Japan (6) are doing very well at the global level. The performance of S. Korea (12), Taiwan (21) and Singapore (31) is also in the acceptable range. However, in terms of quality of research publications (H-Index) India, S. Korea and China drop down to rankings of 22, 19 and 16 respectively. Japan shows no change. Singapore's global ranking improves marginally by two units, but still ranks last amongst the six economies selected for this study. The third indicator i.e. Intellectual Property Rights (IPRs), is a reflection of the translation of laboratory research into commercial entity. Here again, the global rankings of China (56), India (47) and S. Korea (29) take a further dip. On the contrary, Japan and Singapore show a improvement in their global rankings. In fact, Japan is globally ranked number 2 (USA is number 1) and Singapore number 17. Plotting a graph (Fig. 1.3) of these indicators (Publications, H-Index and IPRs) for select Asian countries clearly reveals a continuous decrease in the global rankings of India, China and S. Korea. On the contrary, Japan and Singapore exhibit a marked improvement in the global rankings, thereby suggesting that these countries believe in quality publications and lay more emphasis on translating laboratory research into a product or a process or technology.

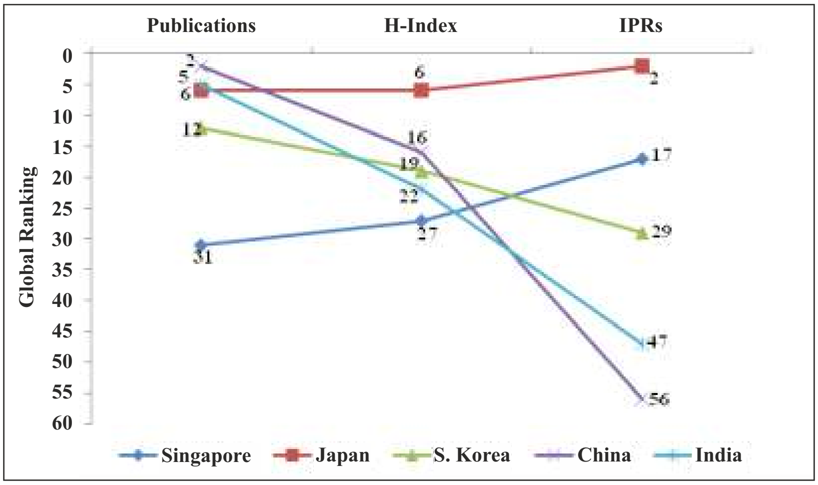

Figure 1.3: Global Rankings of Five Asian Countries Based on Publications, H-Index and IPRs

1.5 Summary

- A comparative study has been carried out on six Asian countries i.e. India, China, Japan, Singapore, Taiwan and S. Korea, based on S&T and Education indicators of international agencies/reports, such as GCI Report (2016-17), IPRI (2016), SJR-International Science Ranking (2015), Global R&D Forecast (2016), The Global Innovation Index (2016) and World Bank (2015).
- Based on the overall global rankings (GCI Report, 2016-17) India (39) has been placed in 'Factors Driven' stage, China (28) in 'Efficiency Driven' stage and Singapore (2), Japan (8), Taiwan (14) & S. Korea (26) in 'Innovation Driven' stage economies.
- Singapore leads the six Asian economies in two categories ('Basic Requirements' and 'Efficiency Enhancers') of GCI. Japan leads in the third category ('Innovation & Sophistication Factors'). Singapore has been globally ranked number one in 'Basic Requirements' category and number two in 'Efficiency Enhancers' category.
- India occupies last position in the eight S&T indicators out of maximum twenty two indicators. However, India is ahead of China in thirteen indicators.
- India does not figure in the top fifty global economies in eleven indicators of S&T and Education. Sadly, in three indicators (Imports as %age of GDP, Exports as %age of GDP, and Secondary Education Enrolment Rate, gross %) its global ranking is in triple digits.
- Singapore's global ranking ranges between 1-20 in 21 indicators out of 22 indicators. It is amongst the top 5 global economies in 11 indicators including Country Capacity to Attract Talent, Quality of Education System and Quality of Management Schools and so on.
- China (2), India (5) and S. Korea (12) enjoy very high rankings in the indicator of number of Publications. However, a downward trend is observed for these three nations in the indicators of H-Index and Intellectual Property Rights. Only Singapore which has a global ranking of 31 in the indicator of number of Publications shows an upward trend in H-Index (27) and IPR (17) indicators. Japan also shows an improvement in the ranking in IPR indicator (2) *vis-a-vis* number of publications (6) and H-Index (6) indicators.

1.6 Conclusion

India is perceived to be one of the important economies in the twenty first century as it has vast resources like huge land mass and coastal areas, natural resources, large numbers of universities, scientists & research laboratories and abundance of semi-skilled young workforce. Despite all these advantages, India's global ranking is not satisfactory in almost all the internationally accepted indicators pertaining to S&T and Education.

Out of 22 indicators (S&T and Education), India's ranking is in triple digits in 3 indicators (Imports as a %age of GDP, Exports as a %age of GDP and Secondary Education Enrolment Rate, gross %) and between 50-100 rankings in 8 indicators (PCT Patents, Application/million populations, Availability of Latest Technologies, Firm-Level Technology Absorption, FDI & Technology Transfer, Local Availability of Specialized Training Services, Internet Access in Schools, Primary Education Enrolment Rate, net % and Tertiary Education Enrolment Rate, gross %).

Although, India is amongst the top 5 nations in the indicator of Publications, but its global rankings in the indicators of University-Industry Collaboration in R&D (24), IPR Ranking (47) and Capacity for Innovation (39) is a clear indication of Indian scientists' inability to convert academic knowledge into commercial commodity in the form of technologies/patents. One of the reasons for poor IPR ranking is the lack of, or complete absence of an ecosystem needed for translational research in the universities and R&D institutes. Also, the awareness about patents and entrepreneurship is almost non-existent in universities, especially in state universities, which comprise of more than 46% of the total universities (759) in India, according to UGC database (http://www.ugc.ac.in/ oldpdf/alluni versity.pdf).

The Academic Performance Indicators (API) criterion set up by MHRD for promotions of college and university teachers is skewed towards research publications as compared to generation of patents/technologies. The promotions of the teachers can easily be secured by publishing research papers and not bothering at all about translational research. These factors along with a secured job after one year probation in a university are the major culprits for poor ranking of India in S&T related indicators. The success of a few institutes, such as IITs, IISc-Bangalore and ICT-Mumbai in the regime of I-A interactions is due to their autonomous status and the presence of translational ecosystem which helps the researchers regularly in churning out technologies and patents. These institutes have all the ingredients needed for applied/industry oriented R&D i.e. I-A Cell, Patent Information Cell, Centre of Excellence (R&D), Entrepreneurship Cell and Technology Business Incubators (TBIs). It is recommended that such systems should also be promoted in the universities and R&D institutes of India. Without improvement in these areas it would be a herculean task for India to move from 'Factor Driven' stage to 'Efficiency Driven' stage.

Since the beginning of twenty first century, Government of India has realized the importance of innovations in improving the economy of the nation. It has modified its policies and increased budget for S&T and Higher Education. A separate ministry for 'Entrepreneurship and Skill Development' has been established and provided with large amount of funds to create a skilled manpower for the industrial sector and also to encourage young minds of India to convert their novel ideas into 'Start-up' entities. The Department of Electronics and Information Technology (DeitY) has been upgraded to the Ministry of Electronics and Information Technology (MeitY) to promote R&D and other areas in Electronics and Information Technology. In addition, GoI has introduced many schemes/programmes for the promotion of entrepreneurship and bridging the gap between industry and academia e.g. *Atal Innovation Mission* for the establishment of TBIs in universities, *Prime Minister's Fellowship Scheme for Doctoral Research* for industry oriented research in academic sector. *Impacting Research Innovation and Technology (IMPRINT*) scheme for high end R&D in association with private sector, *Promoting Innovation in Individuals, Start-ups and MSMEs (PRISM*) scheme for promoting entrepreneurship and start up culture, *New Millennium Indian Technology Leadership Initiative (NMITLI*) programme for innovative research, *National Initiative for Developing and Harnessing Innovations* (NIDHI) scheme for enhancing innovation and entrepreneurship ecosystem in industry and academia; *CSIR-Industry Sponsored Research Fellowship Scheme* through which industry and academia aims to co-create scientific manpower in the country, and establishment of *University-Industry Inter Linkages Centres* in universities to promote collaboration with industries for skill development, employability and collaborative research. Recently, CSIR has created a dedicated *Innovation Fund* of an initial corpus of ₹ 400 crores, to fast track research activities and demonstrate the technologies developed by CSIR laboratories to the industries

To push the creation of high quality infrastructure, research and innovation activities in premier educational institutes, GoI has approved the establishment of *Higher Education Financing Agency* (HEFA) which would be jointly promoted by MHRD under which, corporates can contribute to R&D under their Corporate Social Responsibility (CSR) budget. To strengthen the IPR ecosystem in the country, DIPP has created a professional body *Cell for IPR Promotion and Management* (CIPAM) and entrusted it with the responsibilities of a) IPR awareness, outreach and promotion and b) facilitating commercialization of the IP assets in the country. On similar lines, DBT (GoI) has created and Autonomous *not for profit* enterprises called *Biotechnology Industry Research Assistance Council (BIRAC)* (public funding agency) for the promotion of entrepreneurship and industry oriented R&D for biotechnology products and many more.

The huge investment of the government in creating R&D ecosystem in India has started paying dividends. If we compare the performance of India for the last three years in S&T and Education indicators, a significant improvement is observed in 2016 as compared to previous two years (Table 1.5). In 5 indicators (University-Industry Collaboration in R&D, Availability of Latest Technologies, Firm Level Technology Absorption, FDI & Technology Transfer and Internet Access in Schools), India has shown remarkable improvement of >20 rankings. In 8 indicators (Capacity for Innovation, Availability of Scientists & Engineers, Govt. Procurement of Advanced Tech. Products, Country Capacity to Attract Talent, Local Availability of Specialized Training Services, Quality of Education System, Quality of Math & Science Education and Quality of Management Schools) there is a reasonable improvement in rankings ranging between 10-20.

Table 1.5: Global Rankings of India in Select S&T and Education Indicators Based on GCI Reports of last 3 Years

S. No.	Indicators	Global Rankings		
		2014-15	2015-16	2016-17
1.	University-Industry Collaboration in R&D	50	50	24
2.	PCT Patents, Application/million populations	61	61	64
3.	Availability of Latest Technologies	110	108	78
4.	Capacity for Innovation	48	50	39
5.	Company Spending on R&D	30	31	28
6.	Availability of Scientists & Engineers	45	49	36
7.	Quality of Scientific Research Institutions	52	45	36
8.	Govt. Procurement of Advanced Tech. Products	61	26	7
9.	Firm-Level Technology Absorption	102	102	81
10.	FDI & Technology Transfer	95	95	54
11.	Imports as a %age of GDP	112	116	121
12.	Exports as a %age of GDP	113	114	112
13.	Country Capacity to Retain Talent	42	40	32
14.	Country Capacity to Attract Talent	46	40	22
15.	Local Availability of Specialized Training Services	64	68	55
16.	Quality of Education System	45	43	29
17.	Quality of Math & Science Education	67	63	44
18.	Quality of Management Schools	56	55	43
19.	Internet Access in Schools	87	100	74
20.	Primary Education Enrolment Rate, net %	78	77	92
21.	Secondary Education Enrolment Rate, gross %	106	105	102
22.	Tertiary Education Enrolment Rate, gross %	87	86	93

Source*: The Global Competitiveness Reports-2014-16*

With enhanced importance to industry oriented R&D, IPR and innovation along with setting up of new Higher Education Institutes (HEIs), TBIs and Accelerators, India is bound to improve its global rankings in the domain of S&T.

Industry-Academia Programmes/Schemes of Public and Private Sectors

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2.1 Introduction

In the current century, the economic prosperity of a nation is associated with its scientific and technological competence. To achieve success in these parameters, it is imperative that academia and industry should forge a strong link to overcome the limitations of each other. In developed countries, the number of research partnerships between industries and universities has increased considerably in the last two decades. However, in India, the full potential of Industry-Academia (I-A) partnership is far from being exploited due to vital differences between industry and academia. Academicians give less priority to applied research and are not much inclined to leave the comfort zone of pure teaching. Academia is largely ignorant of national needs and industry desires and thus unable to commercialize/market its innovative research adequately. Industry, in general, has apathy for the tunnel vision of academia. Also, it is insensitive to the enormous academic resource potential and is dependent on foreign technologies which are easily available.

However, I-A synergy is a win-win situation for both the sectors and also for the progress (economical and societal) of the nation. Government, through its various organizations/agencies, has floated many programmes to promote I-A interactions leading to innovative research, technologies and patents. Private sector has also started acknowledging the importance of I-A collaborations and has initiated steps to promote collaborative Research and Development (R&D) for commercial gains and addressing the scientific needs of the nation.

In India, a plethora of information exists on the I-A R&D regime of public and private sectors, but there is no single platform where all such information is available. DST-Centre for Policy Research at Panjab University, Chandigarh has made an attempt to compile information on programmes/schemes of different agencies promoting I-A collaborations. Figure 2.1 represents various public and private organizations that have floated I-A programmes/schemes in India.

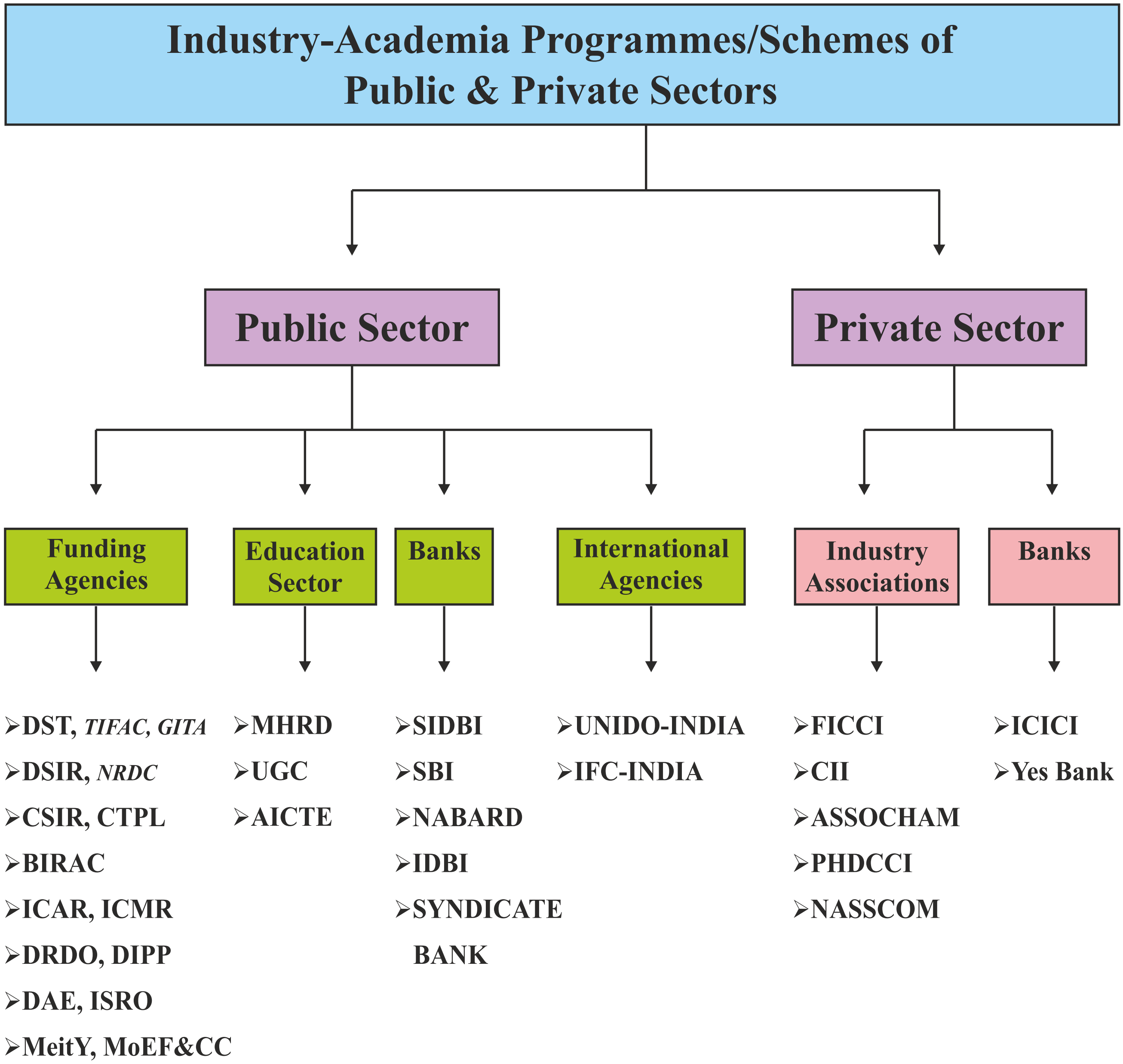

Fig. 2.1: Industry-Academia Programmes/Schemes of Public and Private Sectors
For meaning of abbreviations please see 'Symbols and Abbreviations'

2.2 I-A Programmes/Schemes of Public Sector

2.2.1 Funding Agencies

i) Department of Science and Technology (DST); www.dst.gov.in

DST is a nodal agency that connects science sector to the government verticals. It was established in 1971 following the success of 'Green Revolution' that signified innovative deployment of scientific methodologies. Table 2.1 enlists the industry related programmes/scheme of DST.

Table 2.1: Industry Related Programmes/Schemes of DST

S. No.	Programme/Schemes	Brief Details
1.	**Technology Development Board (TDB)** http://www.dst.gov.in/technology-development-board	Aims on accelerating the development and commercialisation of indigenous technologies. Through TDB, adoption of foreign technologies to address domestic problems is also promoted. TDB provides financial assistance (equity, soft loans, or grants). It also promotes industry to enter into hi-risk and hi-tech areas of R&D.
2.	**Technology Systems Development Programmes (TSDP)** http://www.dst.gov.in/technology-systems-development-programme-tsdp	New technologies in identified areas are promoted, developed and integrated. Promotion of advanced technologies for valuable addition to the products having high demand is carried out by TSDP.
3.	**National Science and Technology Entrepreneurship Development Board (NSTEDB)** http://www.nstedb.com/	Promotes entrepreneurs by providing hands-on training in the field of indigenous technologies for enhancing commercial exploitation of technologies. NSTEDB has started number of training programmes: · Entrepreneurship Awareness Camp (EAC) · Entrepreneurship Development Programmes (EDP) · Faculty Development Programme (FDP) · Technology based EDP (TEDP) It has also promoted development of different institutions for fostering entrepreneurship culture: · Innovation and Entrepreneurship Development Centre (IEDC) · S&T Entrepreneurship Development (STED) Project · Innovation S&T based Entrepreneurship Development (i-STED) · S&T Entrepreneurs Park (STEP) · Technology Business Incubator (TBI)
4.	**Scheme for Funding Industry Relevant R&D (Under SERB)** http://www.serb.gov.in/home.php	Promotes industrial research by utilizing expertise from the academic sector to address industrial and societal

		problems. SERB in association with CII, initiated '***Prime Minister's Fellowship Scheme for Doctoral Research'*** to encourage young, enthusiastic and result-oriented scholars to pursue industry-oriented research.
5.	**Drugs and Pharmaceutical Research Programme** http://www.dst.gov.in/drugs-pharmaceutical-research	Aims to synergize pharma industries and publicly funded R&D institutions and to establish close linkages.
6.	**Start-Up Research Grant (Young Scientists)** http://serb.gov.in/srg.php	Floats schemes for promoting industrial research: · Early Career Research Award (ECRA) · National Post Doctoral Fellowship (NPDF)
7.	**International S&T Co-operation** http://www.dst.gov.in/international-st-cooperation	Promotes innovation and commercial R&D via I-A applied R&D projects/Public Private Partnerships (PPP) under Global Innovation and Technology Alliance (GITA) platform for facilitating tech. development and transfer in association with partner country.
8.	**Nano Applications and Technology Advisory Group (NATAG)** http://nanomission.gov.in/org_stru.htm	Encourages implementation of industry oriented and application driven projects in the area of nano sciences.
9.	**National Initiative for Developing and Harnessing Innovations (NIDHI)** ww.nstedb.com/New_Programmes/NIDHI-Accelerator.pdf	NIDHI is one of the umbrella programmes of DST which is working for enhancing innovation and entrepreneurship for generating successful start-ups. Under NIDHI, following initiatives are planned to be undertaken: · NIDHI-Grand Challenges and Competitions for Scouting Innovations · NIDHI-Promoting and Accelerating Young and Aspiring Innovations and Start-ups (NIDHI-PRAYAS) · NIDHI-Entrepreneur in Residence (NIDHI-EIR) · Startup-NIDHI through Innovation and Entrepreneurship Development Centres (IEDCs) in Academic Institutions; Encouraging Students to Promote Start-ups

		· Start-up Centre in Collaboration with MHRD · NIDHI-Technology Business Incubator (TBI) · NIDHI-Accelerator-Fast Tracking a Start-up through Focused Intervention · NIDHI-Seed Support System (NIDHI-SSS)-Providing Early Stage Investment · NIDHI Centres of Excellence (NIDHI-CoE)-A World Class Facility to Help Startups go Global
10.	**Instrumentation Development Programme** http://www.dst.gov.in/instrumentation-development-programme	Through this programme the concept of '***Hub***' is introduced that acts as the translational platform for academics, industries and related organizations to convert laboratory level prototypes into packaged models and help in transfer of technology and knowhow to appropriate industries at a later stage for commercialization
11.	**Policy Research Centres (PRC)** http://dst.gov.in/policy-research-cell-0	DST established five Centres for Policy Research with an aim of making evidence based recommendations for strengthening STI policy of India. One such centre has been established in Panjab University with a mandate to strengthen I-A linkages in India.

Source: *www.dst.gov.in*

Under the aegis of DST dedicated agencies like, TIFAC and GITA have been established. These are briefed below.

ii) Technology Information, Forecasting and Assessment Council (TIFAC); www.tifac.org.in

TIFAC, an autonomous organization established in 1988 under the aegis of DST, is working with a mandate of assessing and supporting technology trajectories of various academic and private organizations. TIFAC is striving for sustainable innovations to lead technology development in the country through programmes run by TIFAC, keeping industry and academia in close association. The R&D promoting industrial programmes are enlisted in table 2.2.

Table 2.2: Industry Related Programmes of TIFAC

S. No.	Programme	Brief Details
1.	**Advanced Composites Programme** http://tifac.org.in/index.php?option=com	Through this programme close linkages are promoted between various centres of excellence from all over the country and industries for promoting technology absorption, development and dissemination.
2.	**Revolving Technology Innovation Fund [under TIFAC-Small Industries Development Bank of India (SIDBI) Programme]** http://www.sidbi.com/?q=tifac-sidbi-revolving-fund-technology-innovation-srijan-scheme	This programme aims to facilitate technology development, demonstration and commercialization leading to creation of new product or process and is mainly encouraging MSMEs to bring high-risk innovations to the market.
3.	**Technology Refinement and Marketing Programme (TREMAP)** http://tifac.org.in/index.php?option=com _	Through TREMAP, country's innovation pool is promoted by bringing out innovative technologies from the prototype stage to market level through a network of Technology Commercialization Facilitators (TCFs).
4.	**Home Grown Technology (HGT) Programme** http://www.tifac.org.in/index.php?option =com_content&view=article&id=48&Itemid=204	HGT programme, a past initiative (implemented from 1992-2005) was initiated by TIFAC to support R&D institutions, academia, start-ups and SMEs to carry out their innovative technologies at pilot scale.
5.	**Bioprocess and Bioproducts Programme** http://tifac.org.in/index.php?option=com _content&view=article&id=65&Itemid=96	Through this programme, TIFAC is supporting technology development in the field of biotransformation and enzyme technology in partnership with SMEs and in-house R&D units, academic and research institutes.
6.	**Collaborated Automobile R&D Core-Group** ifac.org.in/index.php?option=com_content&view=article&id=68&Itemid=99	This group comprise of academia, industries and state ministries to form a core-group with an aim to built user friendly database of technologies and scientists to promote technology development and commercialization in the field of automobile industry.

Source: *www.tifac.org.in*

TIFAC has established Patent Facilitation Center (PFC) under which Patent Information Centers (PICs) have been created in 20 states namely, Andhra Pradesh, Assam, Chhattisgarh, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Manipur, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttaranchal, Uttar Pradesh and West Bengal. These PICs aid government departments, universities and scientists for patent search, free of cost. The same services are open to attorneys, industry and public sector undertakings, with a levy of nominal charges. PFC has introduced a scheme named ***'Knowledge Involvement in Research Advancement through Nurturing' (KIRAN)*** for the empowerment of women in R&D in the field of IPR.

iii) Global Innovation and Technology Alliance (GITA); www. gita.org.in

To stimulate investments in R&D sector, GITA, an innovative pilot project was commenced in 2007 by DST in collaboration with CII. DST and CII hold 51% and 49% equities respectively. GITA is an industry managed body for promoting vigorous innovation clusters through PPP model. GITA is actively supporting emergence of open source innovations and venture capital industry for social inclusion. Various programmes of GITA promoting industrial research are listed in table 2.3.

Table 2.3: Industrial Research Oriented Programmes of GITA

S. No.	Programme	Brief Details
1.	**Bilateral Programmes**	Bilateral programmes of GITA are as: · **Technology Acquisition and Development Fund** a scheme launched by DIPP and is implemented by GITA. This scheme facilitates applicability of clean and green technologies available to Indian MSMEs sector. · **India UK Collaborative Industrial Research Development Programme**: ₹ 1.50 crores grant available to Indian companies and upto £ 300000 to U.K., Companies for joint co-development of industrial R&D and innovation project in the areas of cleantech, use of Electronic System Design and Manufacturing (ESDM) technologies, affordable healthcare to provide solutions to societal challenges.
2.	**Multilateral Programmes**	Multilateral programmes consist of network of foreign entities. Some of the multilateral programmes of GITA are: · The Enterprise Europe Network (EEN) · Innovation Driven Initiative for the Development and Integration of Indian and European Research (INNO INDIGO)

Source: *www.gita.org.in*

iv) **Department of Scientific and Industrial Research (DSIR); www.dsir.gov.in**

DSIR was established in 1985 as one of the agencies of Ministry of Science and Technology, with an objective to pursue activities relating to development of indigenous technologies and subsequently promoting and transferring these technologies for Commercialization level. I-A linked programmes of DSIR are presented in table 2.4.

Table 2.4: Industry-Academia Linked Programmes and Initiatives of DSIR

S. No.	Programme/Initiative	Brief Details
1.	**Building Industrial R&D and Common Research Facilities (BIRD-crf)** http://www.dsir.gov.in/12plan/bird-crf/bird-crf.htm	· **Industry R&D Promotion Programme (IRDP):** Various research laboratories are recognized to avail different types of fiscal incentives offered by the government. It recognizes In-House R&D Units (RDI); Scientific and Industrial Research Organization (SIRO) and Public Funded Research Institutions (PFRI) · **Common Research and Technology Development Hubs (CRTDH):** Working with a mandate to encourage technology development and research activities carried out by MSMEs in collaboration with public funded laboratories. · **Asian and Pacific Centre for Transfer of Technology (APCTT):** Assists associated members of United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP) in strengthening their innovation systems.
2.	**Patent Acquisition and Collaborative Research and Technology Development (PACE)** http://www.dsir.gov.in/12plan/pace/pace.htm	PACE is supporting industries to acquire patentable technology from within the country or overseas and also to add value to the acquired technology for commercial exploitation in Indian/foreign markets.
3.	**Promoting Innovations in Individuals, Start-ups and MSMEs (PRISM)** http://www.dsir.gov.in/12plan/prism/prism.htm	PRISM supports institutions/organizations to set up autonomous organization within host institutions for developing *state of art* technology solutions with an aim to help MSMEs, clusters and individual innovators.
4.	**Access to Knowledge for Technology Development and Dissemination (A2K+)** http://www.dsir.gov.in/12plan/a2k+/a2k+s.htm	This scheme is working for disseminating science, technology and innovation related information to the academic sector and industrial sector such as, in-house

		R&D units of industry, SIROs, consultants, industry associations, techno-entrepreneurs, government departments and others.
5.	**Technology Development and Demonstration Program (TDDP)** http://www.dsir.gov.in/tpdup/tddp/tddp.htm	To make industry competitive, development and demonstration of innovative need based technologies are undertaken by TDPP. It also contributes in strengthening the interface between industry and R&D establishments.
6.	**Technopreneur Promotion Programme (TePP)** http://www.dsir.gov.in/tpdup/tepp/tepp.htm	Under this programme micro technopreneurship support from DSIR is made available to budding entrepreneurs.
7.	**Technology Development and Utilization Programme for Women (TDUPW)** http://www.dsir.gov.in/tpdup/tdupw/tdupw.htm	Under this programme adoption of new technologies developed by women is promoted. It also promotes technological upgradation of MSMEs run by women entrepreneurs.
8.	**Technology Management Programme (TMP)** http://www.dsir.gov.in/tpdup/tmp/tmp.htm	Through this scheme, creation of dedicated resource centres for technology and innovation management is initiated. TMP programme can be availed by industry and related industrial associations, academic institutes, state level agencies, research organizations and government organizations, consultancy organizations and other government departments.
9.	**Encouraging Development and Commercialization of Inventions and Innovations: A New Impetus** http://www.dsir.gov.in/circulars/knowledge_equity_om_25may2009.pdf	Through this programme researchers are made to avail equity share in an enterprise. It is also encouraging creation of incubation centres in the scientific establishments and promotes mobilization of researcher/faculty from academics to industry and vice versa.
10.	**Consultancy Promotion Programme (CPP)** http://www.dsir.gov.in/tpdup/cpp/cpp.htm	This programme aims to promote uptake of consultancy services between academic and industrial sectors for technology acquisition and setting up of joint ventures.
11.	**International Technology Transfer Programme (ITTP)** http://www.dsir.gov.in/tpdup/ittp/ittp.htm	ITTP is supporting activities related to promotion of international technologies and trade including export of technologies, services, projects and innovative products to enhance the reach of Indian industry.

Source: *www.dsir.gov.in*

Industrial Expenditure on R&D as reported by DSIR

Under the initiative ***'Building Industrial R&D and Common Research Facilities' (BIRD-Crf)'***, DSIR has commenced granting recognition to **In-House R&D** units established by corporate companies and Scientific and Industrial Research Organizations. Recognition of In-House R&D Units 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.

DSIR has published a Report entitled ***'Directory of Recognized In-House R&D Units, 2014'.*** In the above mentioned report on In-House R&D units, 1793 industries have been listed which possess DSIR recognized R&D Units. During 2013 a whitepaper entitled **'Sectoral Innovation Council on Industrial R&D'** was released by DSIR. In this whitepaper a total of 1745 R&D Units are categorized sector wise as depicted in figure 2.2. State wise distribution of In house R&D units recognized by DSIR is presented in figure 2.3.

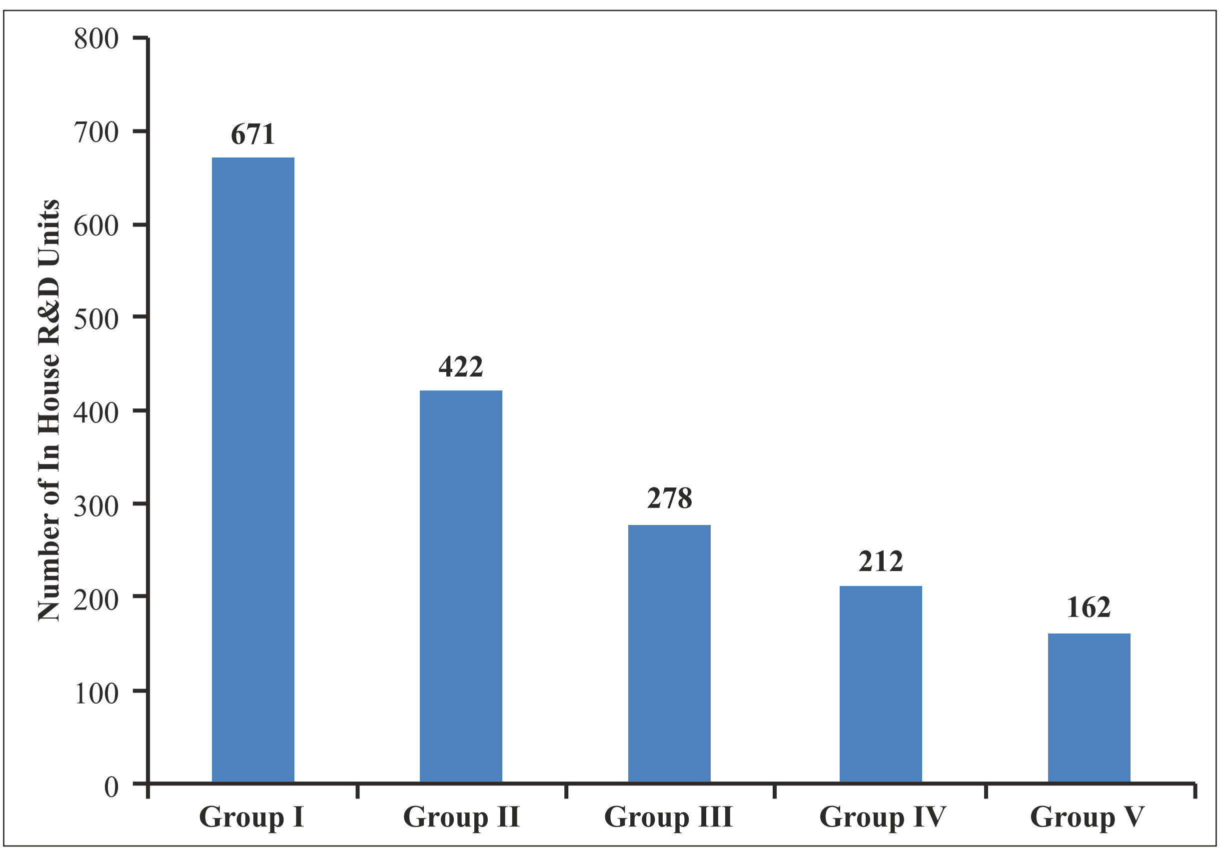

Figure 2.2: Sector Wise Categorization of DSIR Recognized In-House R&D Units

Source: *Whitepaper: Sectoral Innovation Council on Industrial R&D, DSIR,2013*

Group I-Chemical and Allied Industries including Drugs, Pharmaceuticals and Medical Biotechnology

Group II-Electrical and Electronics Industries

Group III-Mechanical Engineering Industries

Group IV-Processing Industries (Metallurgical, Refractories, Paper, Cement, Ceramics, Leather and others)

Group V-Agro including Agri-Biotechnology and food processing industries and others

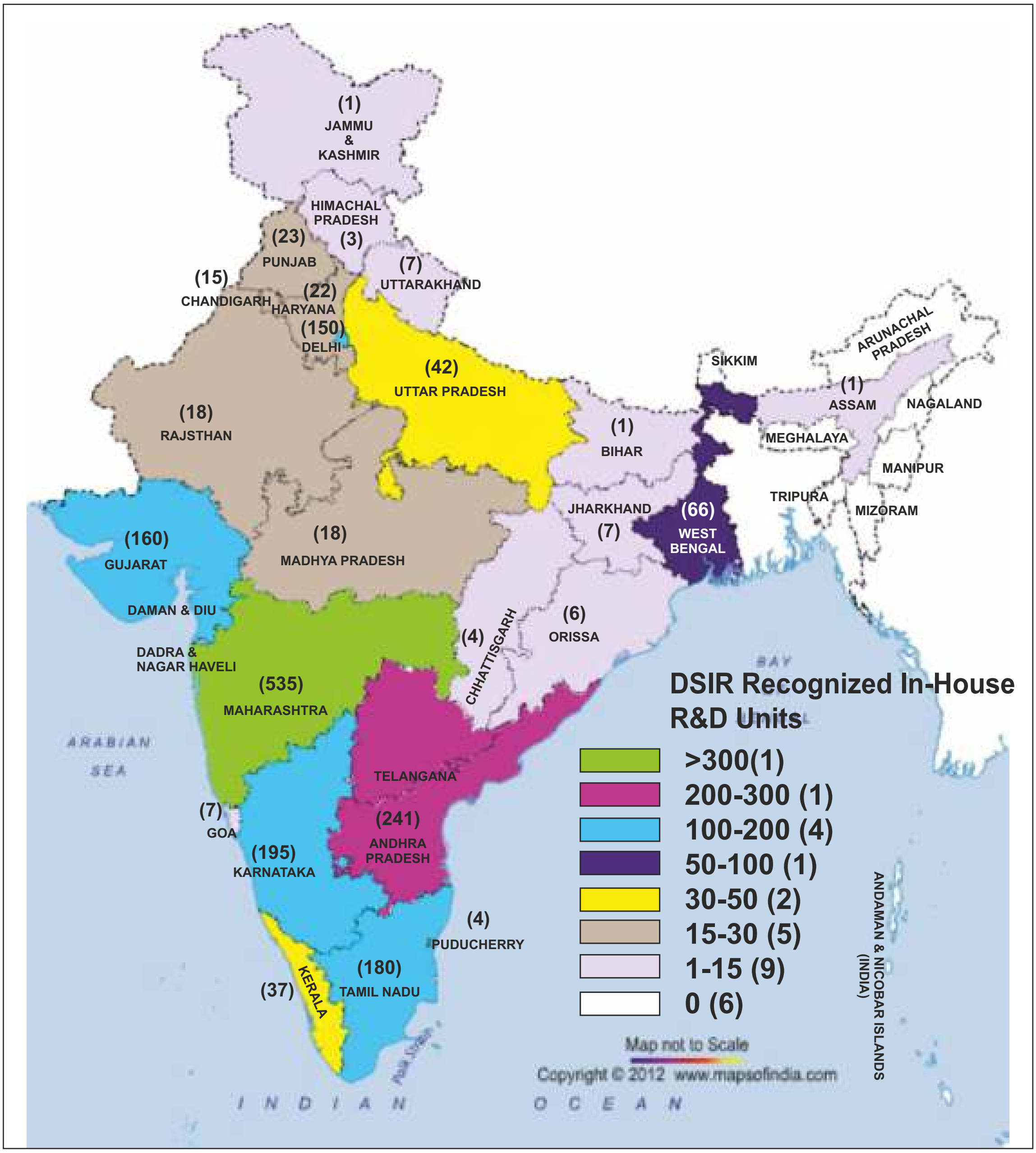

Figure 2.3: State Wise Categorization of DSIR Recognized In-House R&D Units

In-House Industrial R&D Expenditure

There has been a steady increase in the R&D expenditure of In-House Industrial R&D units in India. It was reported to be around ₹ 300 crores during 1980-81 which increased to ₹ 500 crores during 1985-86. During the year 2014-15 it was estimated that the total R&D expenditure of the DSIR recognised R&D units was in the tune of about ₹ 25,000 crores. Among these R&D units, a total of 80 units spent over ₹ 50.00 crores each on R&D activities, at the same time 399 units spent between ₹ 5.00 crores to ₹ 50.00 crores each and a total of 290 units spent between ₹ 2.00 crores to ₹ 5.00 crores. The list of top fifty (50) industries in terms of In-House R&D investment is presented in table 2.5 followed by a sectoral classification of the top 50 industries (Fig 2.4). The R&D expenditures of top five industries are represented in figure 2.5.

Table 2.5: Top Fifty (50) Industries in Terms of R&D Expenditure

S. No.	Name of the Firm	Sector	R&D Expenditure Reported (in Crores)
1.	Tata Motors Ltd.	Mechanical Engineering	1536.87
2.	Bharat Heavy Electrical Ltd.	Electrical	1114.00
3.	Reliance Industries Ltd.	Electronics, Processing (others)	989.16
4.	Mahindra & Mahindra Ltd.	Mechanical Engineering	988.75
5.	Maruti Suzuki India Ltd.	Mechanical Engineering	890.28
6.	Dr. Reddy's Laboratories Ltd.	Pharmaceutical	787.61
7.	Lupin Ltd.	Pharmaceutical	560.36
8.	Ranbaxy Laboratories Ltd.	Pharmaceutical	490.15
9.	Syngene International Ltd.	Pharmaceutical	425.04
10.	Cadila Healthcare Ltd.	Pharmaceutical	417.20
11.	Bharat Electronics Ltd.	Electronics	406.41
12.	Cipla Ltd.	Pharmaceutical	378.05
13.	Mylan Laboratories Ltd.	Pharmaceutical	366.38
14.	Oil and Natural Gas Corporation Ltd.	Processing Industry (Others)	340.15
15.	Apollo Tyres Ltd.	Mechanical Engineering	320.58
16.	Ashok Leyland Ltd.	Mechanical Engineering	292.86
17.	Infosys Ltd.	Electronics	260.55
18.	Aurobindo Pharma Ltd.	Pharmaceutical	256.67
19.	Larsen & Toubro Ltd.	Mechanical Engineering	253.19
20.	Bajaj Auto Ltd.	Mechanical Engineering	230.00
21.	Tata Power Co. Ltd.	Electrical	229.50
22.	Indian Oil Corporation Ltd.	Processing Industry (Others)	226.56
23.	VE Commercial Vehicles Ltd.	Mechanical Engineering	222.09
24.	Daimler India Commercial Vehicles Pvt. Ltd.	Mechanical Engineering	219.22
25.	Intas Pharmaceuticals Ltd.	Pharmaceutical	211.86

26.	E-I DuPont India Pvt. Ltd.	Agro	210.00
27.	Wipro Ltd.	Electronics	209.40
28.	Piramal Healthcare Ltd.	Pharmaceutical	189.93
29.	Rolta India Ltd.	Electronics	175.00
30.	Bharat Petroleum Corporation Ltd.	Processing (Others)	172.10
31.	Sun Pharmaceuticals Industries Ltd.	Pharmaceutical	159.19
32.	USV Ltd.	Pharmaceutical	158.47
33.	ITC Ltd.	Agro	153.37
34.	Agila Specialties Private Ltd.	Pharmaceutical	152.58
35.	Alembic Pharmaceuiticals Ltd.	Pharmaceutical	142.00
36.	Watson Pharma Private Ltd.	Pharmaceutical	139.87
37.	Tata Consultancy Services (TCS) Ltd.	Electronics	134.00
38.	Macleods Pharmaceuticals Ltd.	Pharmaceutical	130.62
39.	IPCA Laboratories Ltd.	Pharmaceutical	126.53
40.	Hindustan Aeronautics Ltd.	Mechanical Engineering	120.63
41.	Fresenius Kabi Oncology Ltd.	Pharmaceutical	119.23
42.	Steel Authority of India Ltd.	Processing (Metallurgical)	116.92
43.	Wockhardt Ltd.	Pharmaceutical	115.00
44.	Delphi Automotive Systems Pvt. Ltd.	Mechanical Engineering	111.36
45.	Glenmark Pharmaceutical Ltd.	Pharmaceutical	105.00
46.	Shantha Biotechnics Ltd.	Pharmaceutical	104.70
47.	Emcure Pharmaceuticals Ltd.	Pharmaceutical	101.02
48.	Medha Servo Drives Pvt. Ltd.	Mechanical Engineering	101.02
49.	Jubilant Biosys Ltd.	Pharmaceutical	100.54
50.	Ispat Industries Ltd.	Processing (Metallurgical)	100.00

Source: *DSIR Annual Report 2014-15*

Figure 2.4: R&D Expenditure of Top Fifty Industries

Group I (23)[a]

[Chemical and Allied Industries including Drugs, Pharmaceuticals and Medical Biotechnology]

- Dr Reddy's Laboratories Ltd.(*6*)[b]
- Lupin Ltd.(*7*)
- Ranbaxy Laboratories Ltd.(*8*)
- Syngene International Ltd.(*9*)
- Cadila Healthcare Ltd.(*10*)
- Cipla Ltd.(*12*)
- Mylan Laboratories Ltd.(*13*)
- Aurobindo Pharma Ltd.(*18*)
- Intas Pharmaceuticals Ltd.(*25*)
- Piramal Healthcare Ltd.(*28*)
- Sun Pharmaceuticals Industries Ltd. (*31*)
- USV Ltd.(*32*)
- Agila Specialties Private Ltd.(*34*)
- Alembic Pharmaceuitical Ltd.(*35*)
- Watson Pharma Private Ltd.(*36*)
- Macleods Pharmaceuticals Ltd.(*38*)
- IPCA Laboratories Ltd.(*39*)
- Fresenius Kabi Oncology Ltd.(*41*)
- Wockhardt Ltd.(*43*)
- Glenmark Pharmaceutical Ltd.(*45*)
- Shantha Biotechnics Ltd.(*46*)
- Emcure Pharmaceuticals Ltd.(*47*)
- Jubilant Biosys Ltd.(*49*)

Group II (8)

[Electrical and Electronics Industries]

- Bharat Heavy Electricals Ltd.(*2*)
- Reliance Industries Ltd.(*3*)
- Bharat Electronics Ltd.(*11*)
- Infosys Ltd.(*17*)
- Tata Power Co. Ltd.(*21*)
- Wipro Ltd.(*27*)
- Rolta India Ltd.(*29*)
- Tata Consultancy Services Ltd.(*37*)

Group III (12)

[Mechanical Engineering Industries]

- Tata Motors Ltd.(*1*)
- Mahindra & Mahindra Ltd.(*4*)
- Maruti Suzuki India Ltd.(*5*)
- Apollo Tyres Ltd.(*15*)
- Ashok Leyland Ltd.(*16*)
- Larsen & Toubro Ltd.(*19*)
- Bajaj Auto Ltd.(*20*)
- VE Commercial Vehicles Ltd.(*23*)
- Daimler India Pvt. Ltd.(*24*)
- Hindustan Aeronautics Ltd.(*40*)
- Delphi Automotive Systems Pvt. Ltd.(*44*)
- Medha Servo Drives Pvt. Ltd. (*48*)

Group IV (5)

[Processing Industries-Metallurgical, Refractories, Paper, Cement, Ceramics, Leather and others]

- Oil and Natural Gas Corporation Ltd.(*14*)
- Indian Oil Corporation Ltd.(*22*)
- Bharat Petroleum Corporation Ltd.(*30*)
- Steel Authority of India Ltd.(*42*)
- Ispat Industries Ltd.(*50*)

Group V (2)

[Agro including Agri-Biotechnology and food processing industries and others]

- E-I DuPont India Pvt. Ltd.(*26*)
- ITC Ltd.(*33*)

a- Number of industries; b- Ranking among 50 top industries by R&D investment.

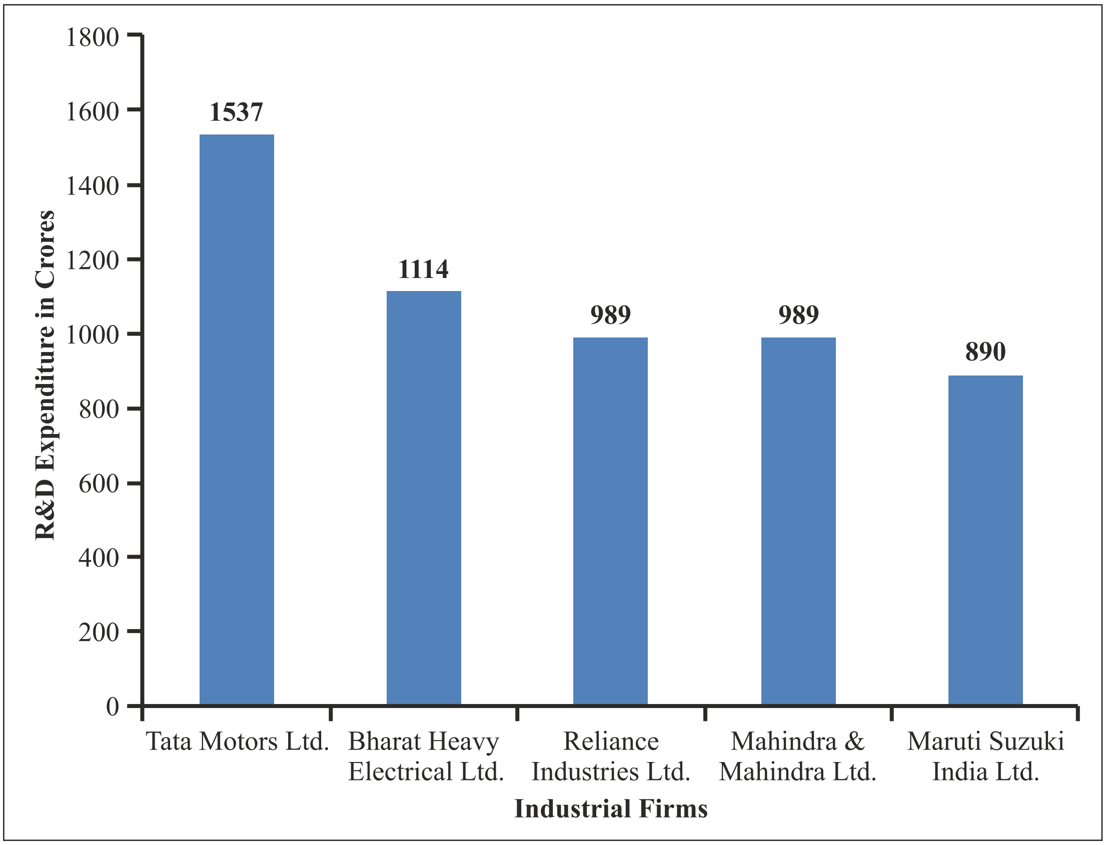

Figure 2.5: R&D Expenditure of Top 5 Industrial firms

Source: *DSIR Annual Report 2014-15*

v) National Research Development Corporation (NRDC); www.nrdcindia.com

NRDC, working under the administrative control of DSIR, was established by the GoI in 1953 with a mandate to develop and commercialize the technologies/inventions/patents generated/product and processes from various national R&D institutions/universities.

NRDC in its six decades of functioning has successfully forged strong linkages between scientific and industrial community in India as well as abroad and has also developed formal arrangements within academic and industrial segment for the commercialization of know-how developed in their laboratories. NRDC is also recognized as a large repository of technologies existing in all areas of industries.

NRDC undertakes number of activities under its structured promotional programme for encouragement and advancement of innovations, research and promotion of inventions, technical and financial assistance for IPRs protection. Industry linked programmes of NRDC are listed in table 2.6.

Table 2.6: Industry Linked Programmes of NRDC

S. No.	Programme	Brief Details
1.	**Innovation Portal/Technology Portal** http://www.nrdcindia.com/english/index.php/programmes/innovation-portal	This portal is an initiative to bridge the gap between inventor, manufacturer, industry and academia, that provides complete information related to the technologies in different areas.
2.	**Knowledge Management System for Technology Promotion** http://www.nrdcindia.com/english/index.php/programmes/knowledge-managment	This system is promoting development and commercialization of technologies under NRDC. Identification and evaluation of technologies is carried out by experts in self propelled mechanism for value addition leading to the complete technology package.
3.	**Entrepreneurship Development Programme** http://www.nrdcindia.com/english/index.php/technology-management/innovator-s-support/entrepreneurship-development-programme	It is working for fostering entrepreneurship culture and skill upgradation of unemployed youth and is also working for capacity building of Non Government Organizations (NGOs) by promoting industry oriented projects.
4.	**Patent Search Facility** http://ipindiaonline.gov.in/patentsearch/search/index.aspx	Through this facility inventors/scientists/technologists/industries can identify and search for patents in patent databases at global level. It also provides abstracts and bibliographic references from different sources for detailed analysis of desired sources for complete review of specific area.

Source: *www.nrdcindia.com*

NRDC is committed to provide IPR consultancy to interested academia, R&D organizations and industries. It also provides expert services in formulating and drafting the innovation, IP policy and technology transfer of these organizations. In order to assist stakeholders for technology landscaping and market analysis, NRDC and the Ministry of Micro, Small and Medium Enterprises (MSME) jointly started a project namely '***Intellectual Property Facilitation Centre***' ***(IPFC)***. This centre aims to promote IPRs awareness and adoption by MSMEs and budding entrepreneurs. IPFC regularly organizes various training programs on explicit themes associated with IP. IPFC also commenced 'Free IP Awareness Talk for MSMEs' to educate and train MSMEs on 'How to Protect Intellectual Property'. Number of IPR services provided by NRDC are listed in table 2.7.

Table 2.7: IPR Services Provided by NRDC

S. No.	Domain	Services
1.	**Patents**	Pre filing services, prior art search, preliminary patentability assessment, patent filing support for filing with provisional specification or/and with complete specification advice for filing in other countries, advice on examination reports and queries for the patent office, post grant support, support for infringement proceedings, opposition proceedings, technology transfer agreements, patent valuation, technology marketing and licensing.
2.	**Copyright**	Guidance and assistance in preparation of documents required for registration.
3.	**Trade Mark**	Guidance and assistance in preparation of documents required for registration.
4.	**Industrial Designs**	Guidance and assistance in preparation of documents required for registration.
5.	**Geographical Indicators**	Guidance and assistance in preparation of documents required for registration.
6.	**General Consultation**	Guidance and assistance in identifying the possible IP protection for the creativity.

Source: *www.nrdcindia.com*

vi) Council of Scientific and Industrial Research (CSIR); www.csir.res.in

CSIR, a well known organization for pursuing cutting edge R&D activities in diverse areas of S&T, was constituted in 1942. CSIR is composed of vibrant network of 39 outreach centres, 38 national laboratories, 5 units and 3 innovation complexes (www.csir.res.in). CSIR is leading in India's intellectual property regime with a strong portfolio of patents, technologies developed and licensed. Amongst Indian patents filed in US, 90% of patents granted belong to CSIR. On average, CSIR files 200 patent applications in India and 250 in foreign countries every year. Patents from CSIR are licensed at rate of 13.86% which is appreciable at global level.

CSIR has actively endorsed the industrial research through a unique initiative namely 'New Millennium Indian Technology Leadership Initiative' (NMITLI), one of the CSIR's most impactful and largest PPP efforts in R&D domain. NMITLI was conceptualized in 2001 and has generated 100 international patents and >150 publications in high impact journals. NMITLI has contributed significantly in R&D and national innovation system of India. It aims to catalyze innovative technological development for attaining global leadership position for Indian industries. It is working for synergizing the research competencies of academia, R&D organization and industries integrated to achieve industrial growth.

This programme is unique in following 'Inverse Risk Investment Profile' through which focus is given on low investment and high risk technology areas. Subsequently, investments increase as the project develops and risk decreases leading to higher innovation. NMITLI also provides IP mapping for continuous tracking of project potential for creating IP portfolio and aids in licensing of IP.

Almost all the projects under NMITLI are built in PPP mode. Through this programme, financial support is provided to institutional partners in public domain as grant-in-aid and to industrial partners in the form of soft loans with 3-5% interest rates. Till date, around 60 network projects have been completed, involving 280 R&D groups from various research institutes, 1750 researchers and 85 industrial partners. These projects came out to be at an outlay of ₹ 550 crores. Table 2.8 lists down some of the notable innovative technologies and products generated from NMITLI supported projects.

Table 2.8: Notable Technologies and Products Generated from NMITLI Supported Projects

S. No.	Technology/Product	Expertise Area
1.	Biosuite-Portable Software for Bioanalyses	Bioinformatics
2.	Genocluster-Package of Software Tools Comprising of Gene Prediction Software, Proteome Calculator and Prediction Software of Virulent Proteins	Bioinformatics
3.	Darshee-3D Visualization Software for Complex Bioprocess	Bioinformatics
4.	Sofcomp and Mobilis-Low Cost Computing Platforms	Information Technology
5.	Triple Play Braodband-First Internet Protocol Television Service	Information Technology
6.	Weather Forecasting System-Integrate Software and Hardware System for Weather and Monsoon Prediction	Information Technology
7.	Psoriasis-Herbal Formulation to be Taken Orally	Healthcare
8.	Sudoterb-Used for Treatment of Tuberculosis	Healthcare
9.	Lysostaphin-Biotherapuetic for Treatment of *Staphylococcus* Infections	Healthcare
10.	Docosa Hexanoic Acid (DHA)-Marine Based Nutrient Product	Healthcare
11.	Xcyto Screen Kit-Molecular Diagnostic Kit for Detection of Ocular Infection	Diagnostics
12.	Micro-Polymerase Chain Reaction (PCR)-PCR System for Identification of Hepatitis B Virus *in situ*	Diagnostics
13.	New Varieties of *Mentha Piperita*: CIM Indus and CIM Madhuras	Agricultural Biotechnology
14.	Low Lignin Containing *Ochlandra Travancoria* and *Leucaeina Leucocephala*	Agricultural Biotechnology

15.	Sugarcane Biorefinary-Production of Bioethanol from Sugarcane Bagasse	Agricultural Biotechnology
16.	Mitigation of Environment Pollution-Control of Pollution Associated with Leather Processing	Biotechnology
17.	Fuel Cell-1.00 KW Polymer Based Electrolyte Membrane Fuel Cell	Energy
18.	Wind Energy-500 KW Wind Turbine	Energy

Source: *http://www.csir.res.in/external/heads/collaborations/Nmitili/NMITLI%20Brochure%20and%20selected%20 achievements.pdf*

There are several research and sponsoring schemes of CSIR, promoting industry oriented research, such as 'CSIR Young Scientist Award' and 'Entrepreneurship Support Programme'. To assist industries, CSIR has created a knowledge base of 642 technologies which can be readily taken up for commercialization (http://www.csir.res.in/PDF/knowledge_base_080716.pdf). CSIR has also created a dedicated ‘Innovation Fund’ of initial corpus of ₹ 400 crores to fast track research from lab to industry. CSIR has decided to launch a new scheme viz. 'CSIR-Indusrty Sponsored Research Fellowship Scheme' which would provide platform for CSIR and industry to co-create scientific manpower (Ph.D level). CSIR has also supported creation of organizations for enhancing industrial research, such as Indian Plywood Industries Research and Training Institute (IPIRTI), Bengaluru for strengthening Indian Plywood industry, and Industry-Academia-Research/Government Interface (IARGI) to promote commercialization of technologies by facilitating strong I-A linkages.

vii) CSIR-Tech Private Limited (CTPL); www.csirtech.com

CSIR-Tech is a 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 has been established to promote entrepreneurship and commercialization of knowledge economy of academia and industry. It is located in the Innovation Park of National Chemical Laboratory (NCL), Pune. NCL is one of the premier institutes of CSIR organization.

CSIR-Tech works for the commercialization of IP, know-how and technology emerging from public and private R&D labs and academic institutions. CSIR-Tech works closely with R&D institutions in India, such as CSIR, IITs, DAE, DST, DBT and a few private R&D labs. It helps them to commercialize their IP and technologies, by facilitating technology transactions and by creating funds for their spin-out businesses. CSIR-Tech represents over 9,000 of the 25,000 plus scientists working in publicly-funded R&D labs across India.

CSIR-Tech is governed by a board of directors whose composition is as follows: Chairman (1), CEO (1) and members (8) from industries, banking sector and research organizations. Day to day functioning of CSIR-Tech is in the hands of CEO and its team comprising of 10 members which are Venture Consultant (1), Chief Business Officer (1), Technology Transfer Associates (3), Technology Transfer Analysts (3) and Consultants (2).

CSIR-Tech Services

- **Technology Venturing:** It invests in laboratory spinoffs and other S&T based start-ups to capture a maximum portion of the capital generated by technology commercialization.
- **India Science Venture Fund (ISVF):** This fund has been created to provide financial assistance for commercialization of lab R&D via sponsoring projects and technology transfer. This fund has been approved by Securities and Exchange Board of India (SEBI) for registration, spin off businesses and science based start-ups with the target of ₹ 50 crores. ISVF targets mainly sectors belonging to chemicals, biomaterials, engineering, life sciences and healthcare.
- **Technology Commercialization:** CSIR-Tech helps technology claimants to access technology assets across India's leading academic institutions and R&D labs. CSIR-Tech catalyzes the process of technology transfer by facilitating technology appellants to build a business case and reduce time of techno-commercial negotiation with academic institutions and R&D labs.
- **Market Insights and Consultancy:** CSIR-Tech provides consulting services and market insights to enterprises, labs and government agencies as CSIR-Tech has deep understating of ecosystem of Indian R&D. CSIR-Tech helps spotter for technology, search for R&D partners, IP valuation and technology transfer offices and create incubation centres.

Outputs and Offerings of CSIR-Tech

CSIR-Tech's output is of two folds i.e. (i) translation lab research to a commercial product, and (ii) setting up a company (e.g. spin off) as shown below:

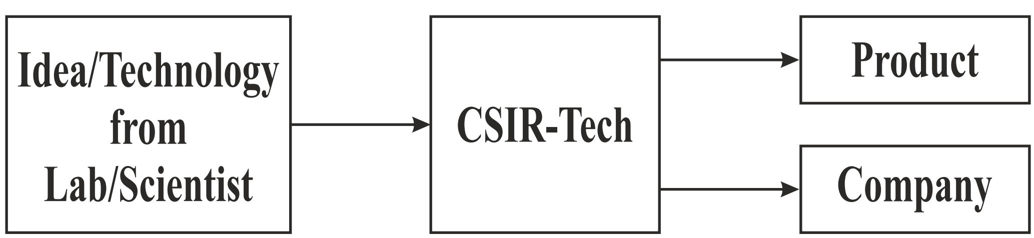

Figure 2.6: CSIR-Tech Output

The main offerings of CSIR-Tech are as follows:

- **Technology Transfer:** CSIR-Tech promotes the technology transfer process by identifying opportunities for technologies which are emanating from labs and are commercially relevant. It also identifies and engages with suitable industry partners to act as a commercialization channels.
- **IP Licensing:** CSIR-Tech helps R&D labs by identifying licensing opportunities for their patents and also support industry partner to diagnose valuable IP assets which provide a strong competitive advantage, cost and access to global market.

Other offerings of CSIR-Tech are:

- Technology scouting, R&D partner search
- Market research and consulting
- Open innovation
- Technology/IP evaluation

Industry advisory services

- Capacity building
- Research
- S&T development
- Opportunity identification

Government advisory services

- Market penetration
- Technology de-risking
- Synthesis, aggregation and agreements
- Business planning and raising finances
- Virtual business incubation support

Partners of CSIR-Tech

Partners of CSIR-Tech

CSIR: an autonomous society established in 1942. It consists of 38 national labs/Inst. 6 units, 3 innovation complexes and 39 outreach centres.

SBI: a Govt. multinational banking and financial services company founded in 1806. It is the largest banking and financial services company by assets in India.

VENTURE CENTER

VC: a non-profit, technology business incubator and initiative of CSIR. It provides facilities, resources and networks for start-ups and technology ideas.

Networking with R&D Labs

CSIR-Tech aims to aid the labs to encourage academic entrepreneurs who want to get involved in knowledge intensive ventures inculcated at their research institutes. It caters to around 60 R&D labs comprising of CSIR labs, IITs, DAE, ICAR, industry associations and universities (public and private).

As per CSIR-Tech website (http://www.csirtech.com), CSIR-Tech also helps out in forging partnership between industries and academia by :

· Creating greater commercial visibility for CSIR labs, their services, technologies and scientists.

- Working in synergy with business development divisions at labs to develop their efforts.
- Setting up a 'system integrator' approach for catalyzing 'lab to market' journey.
- Stimulating translation of ideas and inventions into products and services.
- Providing insights cum industry feedback and market trends to help direct R&D efforts.
- Executing, marketing and negotiating deals in technology transfers and IP licensing to enhance revenue generation for lab.

CSIR-Tech aims to encourage entrepreneurship in the academic institutes. CSIR-Tech has taken a few initiatives, such as:

- Identifying spin offs/joint venture creation opportunities around technologies of commercial value.
- Acting as a commercialization partner to labs to increase reach to private enterprise by several folds/year.
- Attracting entrepreneurs and industry professional to translate lab IP into technology spin offs.
- Creating capital gains for labs via enabling them to enter into equity arrangements in these spin offs/start-ups/joint ventures/enterprises.
- Supporting scientists and labs in realizing business benefits.

CSIR-Technologies

CSIR-Tech offers innovative technologies and know-how from recognized R&D labs and academic institutes. The technology offerings cover areas of biological, chemical, physical, environment, information sciences and earth, and their corresponding engineering discipline counterparts. Technologies transferred and technology providers are given in table 2.9.

Table 2.9: Technologies Providers and Technologies Transferred

Technologies	
Providers	**Transferred**
CSIR-NCL	68
CSIR-NIIST	42
CSIR-CLRI	39
CSIR-CSIO	36
CSIR-NML	32
CSIR-IIP	32
CSIR-IICT	29
CSIR-CSMCRI	28
CSIR-IHBT	27
C-Camp	25

Technologies	
Providers	**Transferred**
CSIR-CMERI	13
Manipal University	10
CSIR-CEERI	10
CSIR-NIO	9
CSIR-CIMAP	9
CSIR-NBRI	9
CSIR-IMTECH	8
CSIR-AMPRI	7
CSIR-NGRI	7
CSIR-IIIM	6

Providers	Transferred
CSIR-CFTRI	24
CSIR-NAL	24
CSIR-IMMT	20
CSIR-CECRI	20
CSIR-CBRI	18
CSIR-IICB	16
CSIR-SERC	16
CSIR-CGCRI	16
CSIR-IITR	15
CSIR-NPL	14

Providers	Transferred
CSIR-CDRI	6
CSIR-NEIST	6
IIT Kanpur	5
CSIR-CRRI	5
Science for society	3
BTRA	2
R.I.T.	2
CSIR-NEERI	1
Amrita Therapeutics	1
Others	4

Source: *www.csirtech.com*

For meaning of abbreviations please see 'Symbols and Abbreviations'

Spinoff Success Stories

1. **A biotech spinoff focused on microbial technology for treatment of ischemic strokes.** In this venture CSIR-Tech's role range from helping structure to the capitalization of the venture, exploring different models of accessing technology from the R&D labs, identifying/evaluating suitable entrepreneurial teams to applaud the scientific team and designing an appropriate path to enterprise value creation.

2. **A material science spinoff focused on polymer membranes for a range of industrial applications and clean tech.** CSIR-Tech helped this spinoff raise ₹ 50 lakhs in seed investment, including review of the business plan, investor pitch, financial model and investment term sheet.

3. **A Bench to Bassinet (B2B) genomics start-up which seeks to commercialize Indian and global technologies/products for diagnostics.** CSIR-Tech's main role is to strategize the fund raising plan and help raise pre Series A investment *(Series A round is the name typically given to a company's first significant round of venture capital financing)* to help the company achieve rapid revenue growth and profitability.

4. **A water treatment SME with ₹ 1 crores plus revenue, seeking to grow 10 times by leveraging R&D and risk capital**. One of CSIR-Tech's contributions is to scout for significant lab technologies in the water and waste water treatment industry that can be effectively commercialized via this enterprise. Given the capital expenditure (capex) intensive nature of this business, it is helping the company raise Series A investment to scale marketing and manufacturing in and outside India.

Success Stories

Some examples of success stories of CSIR-Tech are given below in table 2.10.

Table 2.10: Success Stories of CSIR-Tech

S. No.	Work Area	Examples
1.	**Technology Transfer Group**	· Largest tech-transfer deal in the lab's history by value from DST-South India based publicly funded laboratory to Gujarat based company. Technology provides a know-how for preparation of an ultra-efficient, advanced material with broad industrial applications. · CSIR-Tech successfully facilitated a technology transfer deal between a constituent laboratory of the CSIR and a Bangaluru based private company for the process of preparation of herbal formulation, having patent in India. The technology was licensed to the licensee for the period of three years on exclusive basis restricted to one southern state of India. · CSIR-Tech has contributed to the licensing of technology from DAE-BARC to a young SME operating in environmental technology business. The entrepreneur has initiated efforts to deploy this clean technology into the vast network of government and public undertakings. · A SME approached CSIR-Tech with its requirement for biogas plant technology and the technology has been licensed successfully from one of the CSIR labs.
2.	**Technology Scouting**	· CSIR-Tech, helped a global MNC to understand the technologies and capabilities available across various partner labs in specific technology domains. · An unnoticed need in the cashew import/export market was to check for cashew rancidity on the requirement of a MSME's, CSIR-Tech escorted for the necessary expertise from across its network of labs which resulted into a joint development program to address the objective mentioned above.
3.	**Generating Entrepreneurs**	· CSIR-Tech, helped an individual Gujarat based entrepreneur to understand and access the technologies available with various partner labs and shortlist the one that best fits with the entrepreneur's business goals. The innovation which relates to

		a food adulteration detection unit has provided the entrepreneur an opportunity to diversify his business, while the lab has been able to expand the reach and market visibility of the innovation. · CSIR-Tech, helped a Jamshedpur based company and a Delhi based entrepreneur to jointly launch a gold and silver cleaner liquid. That new product has considerable cost advantage over existing 'jewellery cleaning' solutions since it doesn't affect jewellery design and weight unlike traditional acidic cleaners which dissolve some precious metal during cleaning.
4.	**Advisory Services**	CSIR-Tech provided advisory services for a private, autonomous educational institution to market the inventions which were developed by the faculty and students. This can bring early stage research into the market.
5.	**Technology Validation**	CSIR-Tech enabled licensing of a corrosion inhibitor molecule technology for copper and silver based alloys to a Kolkata based company.
6.	**In-House Analysis**	CSIR-Tech has provided services for evaluation of technology and facilitates sample products for further in-house analysis of the technology, prior to licensing of patents to a foreign client. The client is a salt manufacturing start-up, based out of US, funded by Khosla Ventures.

Source: *www.csirtech.com*

viii) 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 The 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. Various schemes of BIRAC promoting I-A interface are presented in table 2.11.

Table 2.11: Industry-Academia Programmes Offered by BIRAC

S. No.	Programme	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, the 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 and Service 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 organizations and industries 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.	**University Innovation Cluster (UIC)** http://www.birac.nic.in/desc_new.php?id=95	Five universities possess Cluster Innovation Centres. 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-Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI)** 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 SMEs 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*

ix) Indian Council of Agricultural Research (ICAR); www.icar.org.in

ICAR is an autonomous organisation which was established in 1929, under the aegis of Department of Agricultural Research and Education (DARE), Ministry of Agriculture and Farmers Welfare, GoI. ICAR is composed of 101 institutes and 71 agricultural universities spread all over India, and is one of the world's largest national agricultural systems. Industry relative initiatives of ICAR are as:

➢ **ICAR-Industry Interface in Agriculture**

Under the National Agricultural Technology Project (NATP) of GoI, ICAR made specific provision for funding of public-private collaborative research programmes under '***Competitive Grant Scheme***'. It has also organized various I-A meets/events/brainstorming sessions and workshops for attracting industry and private sector in R&D activities in agriculture. Some of them addressing I-A interface in Indian agricultural sector are as:

1. Inducting Indigenous Technologies for Country's Growth (2016)
2. Training Programme on Financial Analysis of Business Plans and IP Valuation (2016)
3. International Design Structure Matrix Conference (2015)

➢ **MoU between ICAR and ABLE for Knowledge Partnership (2013)**

The objective of this MoU is to promote ICAR's mandates, along with its capabilities and achievements as an important stakeholder for addressing global issues in the agriculture areas. It has resulted in exploring collaborations and partnerships with the public and the private sectors in their endeavours and forging stronger linkages between academia and industry.

x) Indian Council of Medical Research (ICMR); www.icmr.nic.in

ICMR was set up in 1949 and holds the responsibility of formulating and coordinating promotion of biomedical research. ICMR has 26 national institutes with an aim to promote research in areas of medicine, public health and related areas in the country.

ICMR has introduced couple of schemes for promoting industrial research, such as:

➢ **Health Systems Research Cell (**http://icmr.nic.in/guide/nhrp.pdf**)**: Aimed at strengthening the Indian health systems to address the health needs of the citizen by encouraging research in health sector under PPP mode.

➢ **Intellectual Property Rights (IPR) Unit:** Unit provides technical and legal support on IPR related areas for ICMR sponsored intramural and extramural research.

xi) Defense Research and Development Organisation (DRDO); www.drdo.gov.in

DRDO, established in 1958 by Ministry of Defence, GoI and Department of Defence Research is dedicatedly working towards attaining self-reliance in Indian defence systems. From almost no industry base way back in the 1950s, it has now close collaboration with ~1000 industries. Industry and academia linked programmes of DRDO are presented in table 2.12.

Table 2.12: Industry and Academia Linked Programmes of DRDO

S. No.	Programme/Scheme	Brief Details
1.	**The DRDO-FICCI Accelerated Technology Assessment and Commercialization (ATAC) Programme** http://drdoficciatac.com/	This programme is working to create commercial pathway for delivering technologies developed by DRDO to industries. This is one of its kind programmes instituted by DRDO in association with FICCI to promote technologies developed at DRDO at national and international level.
2.	**Extramural Research (ER) Scheme** http://drdo.gov.in/drdo/English/index.jsp?pg=grantinaid.jsp	The ER scheme supports the instrumentality of Memoranda of Collaboration between DRDO laboratories, industry and academia.
3.	**Grant-in-Aid Scheme** http://drdo.gov.in/drdo/English/index.jsp?pg=grantinaid.jsp	Aeronautics R&D board has started grant-in-aid scheme to nurture the scientific talent and to develop facilities in higher education institutes and other research centers including industry.

Source: *www.drdo.gov.in*

xii) Department of Industrial Policy and Promotion (DIPP); www.dipp.gov.in

DIPP was established in 1995 and holds the responsibility of formulating and implementing industrial policy. It is also facilitating investment and technology flows from public to private sector, along with monitoring industrial development.

Key work areas of the department are as under:

➢ Formulation and implementation of comprehensive IPR policy on patents, geographical indicators (GIs), designs and trademarks of goods.

- IPR awareness by means of workshops/conferences in collaboration with organizations like World Intellectual Property Organization (WIPO).
- Implementation of developmental measures for the industrial sector growth especially focusing socio-economic issues and national priorities.
- Facilitation of foreign technology collaborations with Indian companies and assisting in proceedings of bilateral economic cooperation agreements.
- Supervision and stimulation of industrial growth and encouraging industrial activity in rural and underdeveloped regions of the country.

In order to facilitate industrial growth DIPP has initiated various programmes and schemes for promoting I-A linkages. Industry related programmes and initiatives of DIPP are listed in table 2.13.

Table 2.13: Industry and Academia Linked Programmes of DIPP

S. No.	Programme/Scheme/Initiative	Brief Details
1.	**Industrial Corridor Projects** http://dipp.gov.in/English/Schemes/DMIC/About_DMIC.aspx	· Central sector schemes involving industrial corridor projects such as Delhi-Mumbai corridor projects spanning six states have been initiated. · Aims to generate strong economic base to enhance investments and accomplish sustainable development in both public and private sector.
2.	**Rajiv Gandhi National Institute of Intellectual Property Management (RGNIIPM)** http://dipp.gov.in/English/Publications/Annual_Reports/AnnualReport_Eng_2015-16.pdf	Established in 2010, is a central government institute under the Ministry of Commerce and Industry, to create an institute at par with international levels to provide training for the IP professionals and officials.
3.	**Project Based Support to Autonomous Institutions** http://dipp.gov.in/English/Publications/Annual_Reports/AnnualReport_Eng_2015-16.pdf	This scheme provides grant-in-aid support to autonomous institutions in order to strengthen them and provide technical support for enhancing industry competitiveness.
4.	**Invest India** http://www.investindia.gov.in/	It is a joint venture company (*not for profit* company) of DIPP, FICCI and various state governments with shareholding of 45%, 51% and 4% respectively. It holds the responsibility of facilitating investments in R&D in India.
5.	**Atal Innovation Mission (AIM) with Self-Employment and Talent Utilization (SETU) Programme**	It aims to organize start-up fests to showcase innovations. It provides collaborative platforms and facilitates harnessing private sector expertise for

	http://dipp.gov.in/English/Publications/Annual_Reports/AnnualReport_Eng_2015-16.pdf	incubator setup in association with NITI Aayog. In the year 2016, DIPP announced setting up of incubation centres and research parks by partnering with private sector for harnessing private sector expertise.
6.	**Modified Industrial Infrastructure Upgradation Scheme (MIIUS)** http://dipp.gov.in/English/Publications/Annual_Reports/AnnualReport_Eng_2015-16.pdf	MIIUS was launched in 2003 with an aim to promote growth of domestic industries by giving access to infrastructure developed under PPP mode. Under MIIUS, some of the successful projects are as follows: Bamboo Technology Park, Guwahati; Kolhapur Foundry Cluster, Maharashtra; Marathwada Automobile Cluster, Aurangabad; Narol Textiles Infrastructure and Environment Management, Narol, Gujarat and Readymade Garments Cluster, Jabalpur.
7.	**Cell for IPR Promotion and Management (CIPAM)** http://dipp.gov.in/English/publications/RFP/CIPAM_RFP_04November2016.pdf	CIPAM is established for creating IPR awareness in the country. It is working with mandate of implementing national IPR policy in association with government ministries and department and various other stakeholders.

Source: *www.dipp.gov.in*

DIPP has also undertaken various technical cooperation programmes with WIPO for the up-gradation and modernization of IPR administration and development of human resource. In addition, DIPP has issued '***National IPRs Policy***' on 12th May, 2016. The main mission of this policy is to foster creativity, innovation and entrepreneurship to enhance socio-economic upliftment and cultural development.

xiii) Department of Atomic Energy (DAE); www.dae.nic.in

DAE, established in 1954 under the direct charge of the Prime Minister of India, consists of five public sector undertakings, five research centres, three industrial units and service organizations. DAE is actively engaged in promoting R&D in radiation technologies in the fields of basic and industrial research related to agriculture, medicine and nuclear power technology. Table 2.14 lists the initiatives of DAE to bring R&D programmes in industry.

Table 2.14: DAE's Initiatives to Promote Industrial Research

S. No.	Programme/Scheme/Initiative	Brief Details
1.	**Nuclear Fuel Complex (NFC)** http://www.nfc.gov.in/	· It is the major industrial unit of DAE. This complex provides the material, nuclear fuel reactors and bundles required for carrying out research in nuclear technology by the industries involved.
2.	**Heavy Water Board (HWB)** http://www.hwb.gov.in/	· It is a constituent unit of mineral sector and industries which holds the responsibility of producing and supplying heavy water for research

		purposes to the private industries. · HWB also has been working with various educational and research institutions in further development of heavy water based applications. · HWB has also been offering value added services and spin-off technologies to other chemical process industries.
3.	**Board of Radiation and Isotope Technology (BRIT)** http://www.britatom.gov.in/	· Aims to bring benefits of the radioisotope applications and associated technology to industry sector, health sector and agricultural sector. BRIT is working in close collaboration with industries to provide various desired products and services. Several well known industries such as Apollo Agro Gujarat, Aligned Industries, Avantee Mega Food Park and Electromagnetic industries are closely associated with DAE.
4.	**BARC Entrepreneur's Corner-Technology Transfer and Consultancy & Scientific Services** http://www.barc.gov.in/	· Dedicated Entrepreneur's Corner Cell has been established in BARC and is responsible for interaction with industries, academic and research institutes for technology transfers and consultancy services. · It has also instituted ***'DAE Technologies Display and Dissemination Facility' (DTDDF)*** to display technologies developed by DAE which can be readily taken up by industries.
5.	**Patents and Technology Transfer Cell at Indira Gandhi Centre for Atomic Research (IGCAR)** http://www.igcar.gov.in/pttc/	· This cell was established in IGCAR, Kalpakkam with an aim of displaying DAE's technologies to the industries which can be readily take up the technologies and commercialize them. · The cell takes care of technology transfer mechanism, licensing and liaising with the industry and inventor for technology transfer process.

Source: *www.dae.nic.in*

xiv) **Ministry of Electronics and Information Technology (MeitY); www.meity.gov.in**

MeitY, earlier known as DeitY, has been set up for developing human resource, promoting innovation and ensuring a secure cyber space through digital services. MeitY's programmes for enhancing I-A collaborations are listed in table 2.15.

Table 2.15: Programmes of MeitY for Promoting Industry-Academia Collaborations

S. No.	Programme/Scheme	Brief Details
1.	**Visvesvaraya Ph.D Scheme for Electronics and IT** http://phd.medialabasia.in	· An industrial organization and MeitY jointly funds Ph.D candidates at academic institute, working in the research area identified by the industrial organization. The funding is provided by industry and MeitY is in the ratio of 3:7
2.	**Funding and Support to Industry and Academic Institutions through GITA** http://meity.gov.in/content/gita	· It is a combined initiative of DST, MeitY and GITA in association with foreign agencies, such as Global Affairs Canada, Canada, and Centre for the Development of Industrial Technology (CDTI), Spain, for generation of innovative products, processes or services.
3.	**Scheme of Financial Assistance for Setting Up of Electronics and ICT Academies** http://meity.gov.in/content/scheme-financial-assistance-setting-electronics-and-ict-academies	· Under this scheme financial assistance (₹ 148.47 crore) will be provided by MeitY for establishing 7 Electronics and ICT academies in IITs (IIT Guwahati, IIT Kanpur and IIT Roorkee), NITs (NIT Patna, NIT Warangal and MNIT Jaipur), IIIT (IIITDM Jabalpur) for enhancing technology development, up-gradation of faculty and increase in employability. · Two ICT academies have also been set up at Tamil Nadu (ICT Academy of Tamil Nadu located in Chennai) and Kerala (ICT Academy of Kerala located in Trivandrum) respectively, as *not for profit* autonomous organizations focusing to make faculty and students industry ready.
4.	**Scheme for Financial Assistance to Select States/UTs for Skill Development in Electronics System Design and Manufacturing (ESDM) Sector**	· Main objective of this scheme is to enhance skill capacity in domain of ESDM through public and private partnerships. It will also facilitate resource sharing between the academia and industry

	http://meity.gov.in/content/schemes-projects	partners. · There are many other schemes to promote skill development in association with industries. These schemes are: ➢ Scheme for 'Digital Saksharta Abhiyan' under 'Digital India' ➢ Capacity building in the areas of electronic product design and production technology ➢ Sector skill councils-Electronics, Telecom, Information Technology and its enabled services.
5.	**Incubators for Electronics** http://meity.gov.in/esdm/incubators	MeitY has approved setting up of an Electropreneur Park for development of ESDM industry. Some of the instituted incubators for technology generation and commercialization are: · Software Technology Parks of India (STPI), New Delhi in association with India Electronics & Semiconductor Association (IESA) and University of Delhi. · Incubation Centre Set up at IIT, Patna for development of product and IP creation with focus on medical electronics
6.	**National Portal of India** www.india.gov.in	· It is the government official portal designed by National Informatics Centre (NIC). · This portal acts as a single window access point for seeking information related to services offered by the government for all the stakeholders under various domains, such as agriculture, rural and urban development.

Source: *www.deity.gov.in*

xv) Ministry of Environment, Forests and Climate Change (MoEF&CC); www.envfor.nic.in

MoEF&CC, established in 1985, is supporting environmental research in academia, research institutes and private organizations including industries via funding grant-in-aid research projects for environment protection and management. Table 2.16 lists the MoEF&CC initiatives and programmes for strengthening I-A collaborations.

Table 2.16: Programmes and Initiatives taken under MoEF&CC for the Promotion of Industry-Academia Collaborations

S. No.	Programme/Initiative	Brief Details
1.	**Creation of Indian Plywood Industries Research and Training Institute (IPIRTI), Bengaluru** http://ipirti.gov.in/	· IPIRTI was set up in 1962 as a co-operative research laboratory of Indian plywood industry, CSIR and MoEF&CC. · It is working with a mandate of strengthening plywood and wood panel industry in India.
2.	**National Natural Resources Management System (NNRMS) Programme** http://envfor.nic.in/division/call-proposals-under-nnrms-programme	This programme aims to support research projects utilizing optimal utilization of techniques of remote sensing for addressing environmental and ecological issues. All academic institutes, national research laboratories and DSIR certified industries can send their proposals. Under this programme, proposals with public and private partnerships are promoted.

Source: *www.envfor.nic.in*

xvi) Indian Space Research Organisation (ISRO); www.isro.gov.in

ISRO, a unit of Department of Space, was established in 1969 and pursues a systematic policy for generation and transfer of technologies developed by the Indian Space Centres, to draw maximum benefit of spin-offs that are generated from such technologies. ISRO has strong IPR portfolio of 270 patents, 45 copyrights and 10 trademarks. ISRO is working with an approach to facilitate commercial exploitation of its resources through proper channel of technology transfers and licensing. More than 300 technologies have been productively licensed/transferred to industries in the fields of satellite communications, broadcasting, meteorology, speciality polymer chemicals and materials, electronics and computer based systems, mechanical equipments and electro optical instruments. It has also generated ~28 space spin-offs. ISRO has taken several initiatives to aid technology transfer from ISRO to corporate houses and Indian space industry (Table 2.17).

Table 2.17: ISRO's Initiatives to Aid Technology Transfer

S. No.	Programme/Initiative	Brief Details
1.	**Antrix Corporation Limited** http://www.antrix.gov.in/	It is a commercial and marketing arm of ISRO established in 1992. It is a complete government undertaking company and aims to promote ISRO's technologies for commercial utilization of space products. It also provides consultancy services to industries for enhancing their industrial capabilities in space technology.

2.	**Sponsored Research (RESPOND)** http://www.isro.gov.in/sponsored-research-respond	This programme aims to provide financial support for conducting R&D activities (space science, space technology and space application) to academia and industries.
3.	**ISRO Technology Transfer Group** http://www.isro.gov.in/isro-technology-transfer/contact-us	ISRO has established dedicated technology transfer groups all over India for nurturing the industrial sector leading to advancements in space program and encouraging wider participation of industries through technology transfer and industry cooperation for commercialization.
4.	**Space Application Centre (SAC) Industry Portal and Industry Interface** www.sac.gov.in	· SAC is one of the major centres of the ISRO dealing with a wide variety R&D activities and capacity building in space technology. · SAC has created SAC Industry Portal for displaying its technologies developed which can be readily taken up by industries.

Source: *www.isro.gov.in*

2.2.2 Educational Sector

i) Ministry of Human Resource Development (MHRD); www.mhrd.gov.in

MHRD was established in 1985 with an aim to promote education so it reaches to masses. The Department of Higher Education under MHRD is working in direction to create world class institutes of higher learning with well equipped research laboratories and experienced professors for generating ample opportunities for research and skill development resulting in world's biggest skilled workforce. MHRD's programmes for promoting I-A linkages are listed in table 2.18.

Table 2.18: Programmes of MHRD Promoting Industry-Academia Linkages

S. No.	Programme/Scheme	Brief Details
1.	**Council for Industry Higher Education Cooperation (CIHEC)** http://mhrd.gov.in/collaboration	The CIHEC comprises of an advisory group that consists of MHRD with members from industry, academia and other stakeholder ministries. CIHEC aims to facilitate development of '***Innovative Instruments of Collaboration Between Industry and Academia***' as an endeavour to utilize resources to strengthen I-A linkages and to promote more of research to be taken up by students. Initiatives undertaken by CIHEC are as following:

		· Setting up of new institutions for science education and research. · Creation of centres of excellence and facilities in emerging and frontline areas in academic institutes. · Establishment of new and attractive fellowships. · Strengthening of the infrastructure of R&D in universities. · Encouraging PPP. · Recognition of R&D units and national awards for outstanding R&D for industries.
2.	**Research Parks** http://www.itbhuglobal.org/chronicle/Report%20of%20the%20Expert%20Committee%20on%20Research%20Parks.pdf	This scheme aims to boost innovation ecosystem in higher education institutes in collaboration with industry and academia leading to development of cutting edge technology.
3.	**Technical Education Quality Improvement Programme (TEQIP)** http://mhrd.gov.in/technical-education-12	This scheme aims to generate well trained post-graduate students in order to reduce the shortage of qualified faculty that can pursue industry oriented R&D projects. This programme is working in association with AICTE. A total of 190 institutions i.e. 26 centrally funded, 127 state government funded and 37 private unaided institutions have been selected for participation in the Project
4.	**Impacting Research Innovation and Technology (IMPRINT) India** http://imprint-india.org/	It is a Pan-IIT and IISc-Bangalore joint initiative to develop a roadmap for R&D addressing major engineering and technology challenges in specific technology domains relevant to India's societal needs.
5.	**Global Initiative for Academic Network (GIAN)** http://www.sici.org/programmes/details/global-initiative-for-academic-network-gian-programme/	It is the network for attracting the talent pool of budding entrepreneurs and scientific fraternity to encourage utilization of academic resources to enhance India's technological capabilities to match global excellence.
6.	**KAUSHAL Kendras** http://mhrd.gov.in/sites/upload_files/mhrd/files/lu3667.pdf	Under this scheme, 100 Deen Dayal Upadhyay Centres for Knowledge Acquisition and Up-gradation of Skilled Human Abilities and Livelihood (KAUSHAL) will be created. These Kendras aim to design and formulate courses at undergraduate and postgraduate level in

		accordance to industrial needs.
7.	**Rashtriya Ucchtar Aavishkar Abhiyaan (RUSA)** http://mhrd.gov.in/	The scheme was initially started in IITs for promoting innovation as per industrial needs and thereby improving and stimulating competitive edge to Indian manufacturing sector. RUSA is now implemented in various universities and colleges.

Source: *www.mhrd.gov.in*

ii) University Grants Commission (UGC); www.ugc.ac.in

UGC was created by Indian Union Government in 1956 under UGC Act 1956 with an aim to determine, coordinate and maintain standards of higher education in India. UGC is functioning under MHRD, New Delhi. UGC is the nodal agency to endorse teaching and research in emerging areas of science, social sciences, pure sciences, engineering, pharmacy, medical, agricultural sciences, languages, humanities and literature. Although, the government has a network of S&T institutes for R&D, the major base of research and researchers lies with the universities. Programmes under UGC for strengthening I-A interface are presented in table 2.19.

Table 2.19: Programmes of UGC for Promoting Industry-Academy Linkages

S. No.	Programme	Brief Details
1.	**University-Industry Inter Linkage (UIL) Centres** www.ugc.ac.in	Scheme of setting up of UIL centres in the universities which will become an effective goal oriented and enriched entities to promote collaboration with industries for skill development, employability and pursuing collaborative research.
2.	**The Council of Industry-Higher Education Collaboration (CIHEC)** http://mhrd.gov.in/collaboration	MHRD has instituted CIHEC in collaboration with UGC in order to promote innovation ecosystem and university-industry linkages in various universities all over India.
3.	**Global Initiative for Academic Network (GIAN)** http://www.sici.org/programmes/details/global-initiative-for-academic-network-gian-programme/	It is an initiative of MHRD, through which network for attracting the talent pool of budding entrepreneurs is created and updated for universities. GIAN aims to utilize university resources to set linkages with scientists, entrepreneurs and industries in order to promote technology development and commercialization.
4.	**KAUSHAL Centres** http://mhrd.gov.in/sites/upload_files/mhrd/files/lu3667.pdf	These centres are established to encourage skill development in higher educational institutions in accordance to the industrial needs.

Source: *www.ugc.ac.in*

iii) All India Council for Technical Education (AICTE); www.aicte-india.org

AICTE, set up in 1945, is a national level advisory body for conducting survey on status of technical education in integrated manner. AICTE is the statutory authority for planning, formulation, maintenance and implementation of norms of higher education institutes in India. Programmes under AICTE to promote I-A collaborations are listed in table 2.20.

Table 2.20: Industry Related Programmes of AICTE

S. No.	Programme	Brief Details
1.	**Industry Institute Partnership Cell (IIPC)** http://www.aicte-india.org/schiipc.php	IIPC acts as focal point for setting up close collaboration between industry and academia, and to reduce gap between both the sectors.
2.	**Research Park** http://www.aicte-india.org/schrp.php	This scheme aims to provide financial support to institutions for setting up research park in collaboration with the industry.
3.	**Innovation Promotion Scheme (IPS)** http://www.aicte-india.org/schips.php	This scheme aims to provide financial support to institutions for accomplishing technical projects exhibition at union territory and state level. Through this scheme research activities for the industry are promoted for commercialization.
4.	**AICTE- Indian National Academy of Engineering (INAE) Distinguished Visiting Professorship (DVP)** http://inae.in/aicte-inae-distinguished-visiting-professorship-scheme/	· AICTE in association with INAE has launched DVP programme for promotion of industry-institute interaction by stimulating knowledge transfer from industry to academia and vice versa to synergize industrial experience with technical education. · Under this programme, distinguished visiting professors who are eminent scholars/experts in their field working with an industry or R&D organization will visit the higher educational institutes to deliver mentoring sessions and lectures on the state-of-art of industry and its R&D needs.
5.	**AICTE-CII Survey of Industry-Linked Technical Institutes 2016** http://www.aicte-india.org/CII-15.php	The AICTE-CII survey is an online survey which is hosted on the server of AICTE at *www.aicte-india.org*. In the past, AICTE-CII survey on I-A linkages has analyzed institutes and colleges all over India for industry linkages.

6.	**Global Initiative for Academic Network (GIAN)** http://www.sici.org/programmes/details/global-initiative-for-academic-network-gian-programme/	GIAN an initiative of MHRD was applied to the technical institutes under AICTE for enhancement of innovation and development of technologies. It aims to build a network of talent pool of scientists, researchers and entrepreneurs to get associated with academic resources to boost their R&D efforts.
7.	**Pradhan Mantri Kaushal Vikas Yojana (PMKVY)** pmkvyofficial.org/	AICTE under mentorship of MHRD has launched this scheme with an objective of promoting skill development via skill training sessions as per industrial needs in technical institutes during off hours.

Source: *www.aicte-india.org*

2.2.3 International Agencies

i) United Nations Industrial Development Organization in India (UNIDO-India)

www.unido.org

UNIDO is an independent autonomous body, constituted in 1985 within United Nations (UN), which is playing the role of a catalyst in gearing up industrial development in the weaker economies of the world. Till date, UNIDO has 170 member states and is composed of three units as mentioned in figure 2.7.

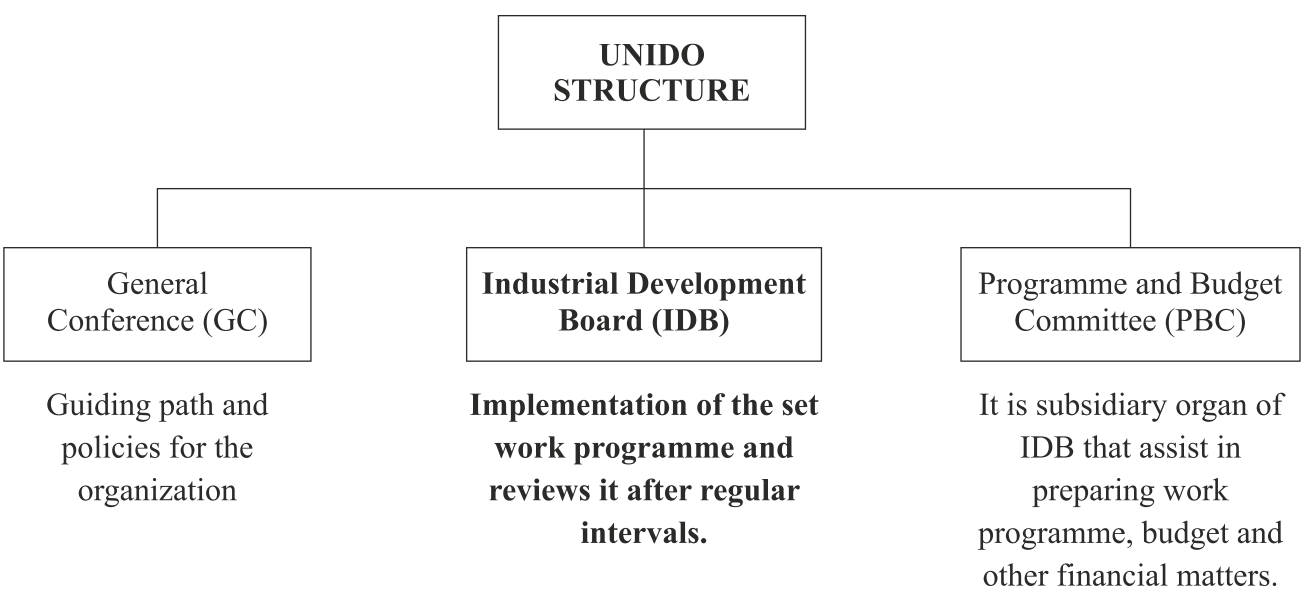

Figure 2.7: Structure of UNIDO

Presently, UNIDO is working for 2030 agenda 'Sustainable Development Goals' (SDGs) which calls for building infrastructure, fostering innovation and promoting inclusive and sustainable industrialization in weaker economic nations. Four thematic priority areas of UNIDO are listed in table 2.21.

Table 2.21: Priority Areas of UNIDO

S. No.	Creation of Shared Prosperity	Activities *(Industry related activities are in bold)*
1.	**Creation of Shared Prosperity**	· **Agribusiness and rural entrepreneurship development** · Women and youth in productive activities · Human security and post-crisis rehabilitation
2.	**Advancing Economic Competitiveness**	· **Investment, technology and SME development** · Competitive trade capacities and corporate responsibility · **Entrepreneurship development *[Entrepreneurship Curriculum Programme (ECP)]***
3.	**Cross Cutting Services**	· Partnerships for prosperity · **Industrial policy advice, research and statistics** · Gender equality and the empowerment of women

Source: *www.unido.org*

The impact of UNIDO is brought forward through four major functions (www.unido.org):

(a) Technical co-operation, (b) Analytical and research functions, (c) Policy advisory services, normative functions and standards and quality related activities, (d) Arranging and setting up partnerships within member countries for knowledge transfer, promoting networking and industrial cooperation.

UNIDO-Delhi Centre: India became member of UNIDO in 1985 and has its Head Office in New Delhi. It has been a successful initiative of UNIDO in collaboration with GoI and has brought industrial growth in different sectors. Now, UNIDO-Delhi also covers Afghanistan, Bangladesh, Bhutan, Nepal, Maldives and Sri Lanka. UNIDO-Delhi has played significant role in enhancing industrial development of India via number of programmes and initiatives of UNIDO (Table 2.22).

Table 2.22: Activities of UNIDO-Delhi Centre

S. No.	Initiative	Brief Details
1.	**India-Combining Businesses**	UNIDO in association with United Kingdom's Department for International Development (DFID) has initiated a dedicated programme for strengthening SMEs of India in the field of handlooms, handicrafts and non-timber wood products.

2.	**India-Gears of growth [UNIDO-ACMA Automotive Component Supplier Development Programme]**	UNIDO in association with Indian Automotive Components Manufacturers Association (ACMA) has assisted Indian SMEs in the field of automobiles and automotive related sector to meet challenges related to insufficient productivity, low quality, and scalability issues.
3.	**CSR South East Asia**	UNIDO initiated Triple Bottom Line demonstration project for facilitating market access for potential suppliers of developing countries and provides global market access to the SMEs to increase their value chain.
4.	**India-Climate-Friendly Refrigerators**	UNIDO in collaboration with the Swiss State Secretariat for Economic Affairs has supported Indian refrigeration manufacturers (Godrej & Boyce Mfg. Co. and Videocon Appliances Ltd.) for developing improved CDM methodologies in order to increase competitiveness and reduce environmental pollution.
5.	**UNIDO Centre for South-South Industrial Cooperation (UCSSIC)**	Launched in New Delhi in collaboration with Indian government with the following aims: · To provide platform to encourage closer industrial cooperation among developing countries · Design practical and innovative projects to facilitate the transfer and diffusion of appropriate technologies · Skill development and capacity enhancement in entrepreneurship, trade and investment

Source: *www.unido.org (http://www.unido.org/office/india.html)*

ii) International Finance Corporation in India (IFC-India); www.ifc.org

IFC is one of the largest global development institutions established in the year 1956. It consists of 184 member countries. IFC focuses on enhancement of private sector of developing countries to attain sustainable development. IFC gives financial assistance along with technical expertise, global experience and innovations to address financial, political and operational challenges of the country. IFC also creates long term partnerships with various stakeholders of country to overcome constraints of finance, employee skills, infrastructure and regulatory environment.

India got associated with IFC in 1956 and since then IFC has supported ~346 companies by providing financial assistance worth 10.3 billion US$ and arranging 2.9 billion US$ from other stakeholders. For India, IFC has provided support to bring development of underserved, low income, rural and fragile regions in field of energy, roads, water, healthcare, education, waste management and sanitation.

IFC mainly invests in different ventures of early growth companies which are involved in innovative technologies to match demands of emerging markets. Early growth companies in the field of healthcare, education and information technology mainly are supported by financial assistance from IFC. it also plays important role in promoting cross border technology transfer to spread the success of innovative technologies.

2.3 I-A Programmes/Schemes of Private Sector

2.3.1 Industry Associations

i) Federation of Indian Chambers of Commerce and Industry (FICCI); www.ficci.com

FICCI is the largest and oldest existing apex business organization of India. It was established in 1927. It is a *not for profit*, non-government organisation and holds the responsibility for drafting policy and its execution that mainly concerns industry. Schemes by FICCI to strengthen I-A interface in country are presented in table 2.23.

Table 2.23: Programmes of FICCI for Promoting Industry-Academia Linkages

S. No.	Initiative	Brief Details
1.	**National Knowledge Functional Hub** http://ficci-nkfh.com/	Creation of hubs to increase I-A interactions by creating mentoring services between industry and academia.
2.	**FICCI Ladies Organization (FLO)** http://www.ficciflo.com/	Women wing of FICCI that has developed all India forum for women. FLO represents over 4000 women entrepreneurs and professionals for promoting entrepreneurships.
3.	**I-A-Research/Government Interface (IARGI)** http://www.ficcifwi.com/ppts/rnd2.pdf	Industrial partner and FICCI along with Ministry of Food Processing Industry (MFPI) and CSIR together has financed IARGI to promote I-A linkages and commercialization of technologies.
4.	**DRDO-FICCI ATAC programme** http://drdoficciatac.com/	FICCI in association with DRDO initiated this programme for creating active commercial pathway for DRDO's technologies to the commercial markets.
5.	**Invest India** http://www.investindia.gov.in/	It is a joint venture of FICCI, DIPP and state governments with shareholding of 51%, 45% and 4%, respectively. It holds the responsibility of enhancing R&D investments in India.

***Source**: www.ficci.com*

ii) **Confederation of Indian Industry (CII); www.cii.in**

CII is an industry managed *not for profit* organization. It was founded in 1895 with a mandate of creating sustained environment conducive for industrial growth in India, by encouraging partnering and close linkages between government and industry through consultative processes. CII's initiatives to enhance I-A interface in India are listed in table 2.24.

Table 2.24: Programmes and Initiatives of CII for Promoting Industry-Academia Linkages

S. No.	Programme/Initiative	Brief Details
1.	**Recommendation of CII National Committee on Higher Education on New Education Policy** http://cii.in/WebCMS/Upload/CII%20Recommendations%20on%20New%20Education%20Policy%202015269.pdf	It was drafted in 2015 and specifically stressed on meaningful partnership of education sector with the private sector and engagement with industry to link education and employability.
2.	**Quality Enhancement in Engineering Education (QEEE)-CII Industry Bridge Programme** http://www.pilot.edureform.iitm.ac.in/phases.php	Programme was carried out in 2014 to bring industry and academia together. It focussed on industry bridge sessions on technology trends in the industry and the engineering applications in the industry.
3.	**AICTE-CII Survey of Industry-Linked Technical Institutes 2016** http://www.aicte-india.org/CII-15.php	· The AICTE-CII survey is an online survey which is hosted on the server of AICTE at *www.aicte-india.org*. In past, AICTE-CII survey on I-A linkages has analyzed institutes and colleges all over India for industry linkages. · At the end of the survey, awards and citations are given to the best industry linked institute/college in specific domain areas.
4.	**Global Innovation and Technology Alliance (GITA)** http://gita.org.in/aboutus.aspx	CII in collaboration with DST instituted GITA for promoting innovations in Indian Industry. GITA holds the responsibility of making goal oriented national and international R&D collaborations involving industry and academia.
5.	**Prime Minister's Fellowship Scheme for Doctoral Research** http://primeministerfellowshipscheme.in/Home.aspx	CII in association with SERB, DST initiated Prime Minister's Fellowship scheme for Ph.D students pursuing industry oriented research, who can avail double fellowship, 50% from the government and 50% from the sponsored industry.

Source*: www.cii.in; www.aicte-india.org*

iii) National Association of Software and Services Companies (NASSCOM); www.nasscom.in

NASSCOM, established in 1988, is the industry association for the information technology sector in India. It is an industry funded, not-for-profit organization working with an objective to establish growth led business and service sector in the country.

NASSCOM in association with ICICI Knowledge Park (IKP), Hyderabad is promoting *'The India Innovation Fund' (IIF; http://www.indiainnovationfund.in/)* created for strategic investors ranging from information technology to telecommunications and life sciences. IIF is the collaboration of diverse institutions (public and private) as anchor investors who along with investments also provide the investee with guidance for technology development and market access. It is one of the first kinds of PPP at this scale for providing funds to entrepreneurs. Major anchor investors under IIF are Tata Consultancy Service (TCS), IKP Trust, DST and Bharti Airtel. Currently IIF has a corpus of around ₹ 40 crores.

iv) Other Industrial Associations

ASSOCHAM (Associated Chambers of Commerce & Industry of India; www.assocham.org) took an initiative through its various events for promoting 'Mega Food Parks' set up by Ministry of Food Processing in various parts of country to provide *state of art* infrastructure, technology and mentoring support to the enterprise engaged in food processing sector in association with higher educational institutes.

PHDCCI (PHD Chambers of Commerce and Industry*;* www.phdcci.in) is a multi-state and proactive apex organisation functioning for creating strong linkages nationally and internationally. It acts as a catalyst for promoting industry, entrepreneurship and trade. PHDCCI is working for 'Skilling India for Global Competitiveness'.

2.4 I-A Programmes/Schemes of Banking Sector

i) Small Industries Development Bank of India (SIDBI); www.sidbi.com

SIDBI, established in 1990, is one of the principal financial entities for financing and promoting MSMEs development in India. Major initiatives taken by SIDBI to promote industrial R&D are listed in table 2.25.

Table 2.25: SIDBI's Initiatives to Promote Industrial R&D

S. No.	Initiative	Brief Details
1.	**Creation of SIDBI Innovation and Incubation Centre (SIIC) at IIT Kanpur** http/www.iitk.ac.in/siic/d/about-siic	SIIC was established in collaboration with SIDBI to foster innovation and entrepreneurial activities in IIT Kanpur.

2.	**Financing Schemes for Sustainable Development Including Energy Efficiency and Cleaner Production of MSMEs**	SIDBI started four different schemes to support R&D in MSMEs. These schemes are as follows: · JICA-SIDBI financing scheme for MSME projects · Financing End to End Energy Efficiency Investments in MSMEs · Green Loan Scheme for health sector · Sustainable Finance Scheme · Global Environment Facility in association with the World Bank.
3.	**TIFAC-SIDBI Revolving Fund for Technology (SRIJAN Scheme)** http://www.sidbi.com/?q=tifac-sidbi-revolving-fund-technology-innovation-srijan-scheme	This scheme provides financial aid to MSMEs to develop, demonstrate, upscale and commercialize their innovative technology based projects.
4.	**Technology and Quality Upgradation Support to Micro, Small and Medium Enterprises (TEQUP)**	It aims to encourage the Indian MSMEs to improve their manufacturing processes in direction of energy efficient technologies in order to reduce emission of Green House Gases. Financial support under TEQUP is provided by SIDBI along with other banks.
5.	**Scheme for Food Processing Industries**	This scheme was launched in collaboration with Ministry of Food Processing Industries, GoI, to promote technology up-gradation, modernization of food processing industries by giving financial assistance.
6.	**Technology Upgradation Fund Scheme for The Textile Industries (TUFS)**	This scheme was launched to promote technology up-gradation and modernization in textile industries
7.	**Integrated Development of Leather Sector Scheme (IDLSS)**	This scheme was launched in association with leather sector of DIPP to promote technology up-gradation for strengthening leather industry to compete with global markets.
8.	**SIDBI Start-Up Mitra**	It provides funding support for incubation, acceleration and training programmes for start-ups.

Source: *www.sidbi.com*

ii) State Bank of India (SBI); www.sbi.co.in

SBI, India's largest public bank was constituted in 1955. It actively participates in large number of welfare activities of community and is playing important role in nation building. Various initiatives of SBI for promoting industrial R&D in India are listed in table 2.26.

Table 2.26: Initiatives of SBI to Promote Industrial R&D

S. No.	Initiative	Brief Details
1.	**CSIR-Tech** http://www.csirtech.com/	Founded in 2011, as the initiative of CSIR. The ownership of CSIR-Tech lies with Entrepreneurial Development Centre of CSIR-National Chemical Laboratory (CSIR-NCL), Pune; CSIR-Scientists Welfare Trust (CSIR-SWT) and the State Bank of India. Bank provides the funding support for carrying out different activities of CSIR-Tech.
2.	**Entrepreneurship Development Institute of India (EDI)** www.ediindia.org	It is an autonomous *not for profit* institute established in 1983, in association with number of financial institutions support. SBI provided financial support of ₹ 20 Lakhs.

iii) Industrial Credit and Investment Corporation of India (ICICI) Bank; www.icicibank.com

ICICI Bank, established in 1994 is India's largest private sector bank. It is engaged in human and economic developmental activities at national level. Bank has created ***'ICICI Foundation'*** that works for supporting innovation across diverse programmes and sectors. Programmes and initiatives of ICICI bank to promote industrial R&D activities are listed in table 2.27.

Table 2.27: Industrial Research Oriented Programmes and Initiatives of ICICI Bank

S. No.	Programme/Initiative	Brief Details
1.	**Creation of Sponsored Research and Development Board (SPREAD)**	SPREAD was created in collaboration with the World Bank, ICICI Bank and the Indian government for supporting industry oriented research in academic institutions.
2.	**Social Initiatives Group (SIG)** http://www.icicicommunities.org/sig.html	SIG was established in 2000, a *non profit* group for encouraging research in the field of primary health and elementary education by providing access to finance. Under this group further, 'ICICI Foundation for Inclusive Growth' (ICICI Foundation; http://www.icicifoundation.org/)' was founded in 2008 for promoting inclusive scientific and technological growth.
3.	**Creation of ICICI Knowledge Park (IKP)** http://www.ikpknowledgepark.com/	ICICI has also played substantial role in the creation of IKP-Hyderabad (http://www.ikpknowledgepark.com/) and providing incubation support to budding entrepreneurs.

4.	**Entrepreneurship Development Institute of India (EDI)** www.ediindia.org	It is an autonomous not-for-profit institute established in 1983, in association with number of financial institutions support. ICICI provided financial support of ₹ 28 Lakhs
5.	**Technology Finance Group (TFG)** http://www.icicibank.com/corporate/technologyfinance/technology-finance.page	ICICI bank has dedicated TFG that implements many programmes in association with World Bank and USAID to help industry and institutions to undertake collaborative research and technology oriented projects. Programmes presently implemented by TFG are: · **Agricultural Commercialization & Enterprise (ACE) Title III Programme**: This programme actively focuses primarily on promoting agribusiness innovations and diversity by linking technology and labour requirements, reduction of post-harvest losses and encouraging projects that are highly visible and replicable. · **Technology Institution (TI) Programme:** This programme aims to strengthen institutional potential for technology development, marketing and business development ability and commercialization. Under this programme sensitization of training scientists, up-gradation and expansion of facilities is promoted by collaborating with national and international TIs. Till date programme has supported 50 such projects.

Source: *www.icicibank.com*

iv) National Bank for Agriculture and Rural Development (NABARD); www.nabard.org

NABARD has a corpus fund of ₹ 50 crores for R&D. This dedicated fund aims at promoting research in field of agriculture and rural development. Bank provides grant-in-support for carrying out research projects, workshops, conferences, publication cost, chair units and internship programmes. In the year 2014-15, NABARD R&D fund has supported 14 research projects all over in India.

v) Others: Many other banks have introduced various schemes for promoting industrial R&D which are listed in table 2.28.

Table 2.28: Industrial Research Oriented Programmes of Banks

S. No.	Bank	Schemes
1.	**Industrial Development Bank of India** hwww.idbi.com	Technology financing scheme for commercialization of indigenous technology and start-ups related to indigenous technologies. Gives financial assistance to STEPs scheme introduced by NSTEDB.
2.	**YES Bank** www.yesbank.in	In collaboration with IFC India, YES Bank has introduced schemes for elevating women owned technology business in India's priority area.
3.	**Industrial Finance Corporation of India (IFCI)** www.ifciltd.com	· IFCI in collaboration with Ministry of Social Justice and Empowerment launched a scheme for credit enhancement facility for budding entrepreneurs especially for lower strata of society. · IFCI also contributed to the creation of Entrepreneurship Development Institute of India (EDI) by providing financial support of ₹ 28 Lakhs.
4.	**Punjab National Bank (PNB)** www.pnbindia.in	PNB Mahila Udyam Nidhi Scheme, PNB MAHILA Samridhi Yojna, PNB Mahila Sashakitaran Abhiyan and PNB Kalyani card scheme are the schemes available for budding women entrepreneurs.
5.	**Oriental Bank of Commerce** www.obcindia.co.in	Under 'Oriented Mahila Vikas Yojana' women entrepreneurs can avail financial support from the bank.
6.	**Bhartiya Mahila Bank** www.bmb.co.in	Bank has commenced various women entrepreneurship funding schemes.
7.	**Syndicate Bank** www.syndicatebank.in	It has created Syndicate Bank Entrepreneurship Research and Training Centre at IIT-Kanpur (SBERTC–IITK). This centre is promoting cutting edge research, training and teaching in entrepreneurship by utilizing the facilities and intellectual pool of IIT-Kanpur.

2.5. Summary

In the present chapter, an overview of various schemes/programmes/organizations of public and private sectors has been presented for enhancing I-A interactions, under the following sub-heads:

a) ***Funding Agencies*** (DST, DSIR, CSIR, BIRAC, ICAR, ICMR, DRDO, DIPP, DAE, MeitY, MoEF&CC, ISRO)

b) ***Education Sector*** (MHRD, UGC, AICTE)

c) ***Financial Institutions*** (ICICI, Yes Bank, SIDBI, SBI, NABARD, IDBI, Syndicate Bank)

d) ***Industrial Associations*** (FICCI, CII, NASSCOM, ASSOCHAM, PHDCCI)

e) ***International Agencies*** (UNIDO-INDIA, IFC-INDIA)

➢ ***Funding Agencies:***

DST has floated maximum number of schemes/programmes. There are dedicated I-A research schemes for individuals e.g. 'Prime Minister's Fellowship Scheme for Doctoral Research', as well as theme based programmes like 'Drug and Pharmaceutical Research Programme' and 'Nano Application and Technology Advisory Group' (NATAG). For the promotion of innovative products and technologies and enhancing I-A collaborative R&D, DST has introduced programmes like 'Technology Systems Development Programmes' (TSDP), 'Instrumentation Development Programme' (IDP) and many more. The schemes for the promotion of entrepreneurship 'National Scheme for Technology Development Programme' (NSTED) and 'Start-Up Research Grant' are very popular amongst young and enthusiastic researchers for shaping their ideas into commercial success. DST provides funds for the setting up of 'Technology Business Incubators' (TBIs) all over India to promote industry oriented, technology oriented and patent oriented research in the universities and research labs. belonging to public and private sectors. Recently, DST has introduced 'National Initiative for Developing and Harnessing Innovation' (NIDHI) scheme, through which it proposes to set up incubators and accelerators in various parts of India to boost up start-up culture in the country. DST has also established 'Policy Research Centres' in five institutes to collect evidence based data for strengthening I-A partnership, entrepreneurship and innovation ecosystem in India. DST has led to the creation of autonomous organizations, such as **'TIFAC'** and **'GITA'**. TIFAC is striving for technological advancement of the country. It has initiated programmes such as 'Advanced Composites Programme', 'Revolving Fund' and 'Technology Refinement and Marketing Programme' (TREMAP) to strengthen technological development of academia and industries. TIFAC has also created 'Patent Facilitation Centre' in 20 states for providing patent related services to public and private sectors. GITA, a joint initiative of DST and CII, is working with a specific mandate for (a) the promotion of applied and innovative research, and (b) creating international research collaborations amongst the scientists/institutes/industries of different countries.

Ministry of Science and Technology created a dedicated department **‘DSIR’** for promoting scientific and industrial research in the country. It has effectively promoted industrial R&D via different schemes, such as ‘Building Industrial R&D and Common Research Facilities’ (BIRD-crf) through which recognition to ‘Industrial R&D Units’ and ‘Scientific and Industrial Research Organization’ (SIRO) is carried out. DSIR recognized R&D units avail fiscal benefits such as tax relaxation from the government. DSIR promotes I-A collaborative research and entrepreneurship through its different programmes namely ‘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+) and ‘Consultancy Promotion Programme’ (CPP). It has been playing important role in technology development in industries and academia through ‘Technology Development and Demonstration Program' (TDDP), 'Technopreneur Promotion Programme’ (TePP), ‘Technology Development and Utilization Programme for Women’ (TDUPW), ‘Technology Management Programme’ (TMP) and ‘International Technology Transfer Programme’ (ITTP). Under DSIR, a dedicated agency **‘NRDC’** has been established which provides assistance to R&D institutes and universities, in developing and commercializing patents/technologies. It is acting as a large repository of patents and technologies available for commercialization. It also provides IPR consultancy services and supports programmes for entrepreneurship development.

CSIR started one of its kind programmes ‘New Millennium Indian Technology Leadership Initiative’ (NMITLI) and 'CSIR-Industry Sponsored Research Fellowship Scheme' to synergize academia, R&D laboratories and industry. CSIR has created a dedicated ‘Innovation Fund’ of initial corpus of ₹ 400 crores to fast track research from lab to industry. CSIR has also led to the creation of an organization **‘CSIR-Tech’** which provides assistance in commercialization of lab research by helping the scientists/institutions in IPR issues and scouting market for their products/technologies. Many public funded research labs. including CSIR, DRDO, DAE, IISc and industries avail the services of CSIR-Tech.

Another public funded organization, DBT, has created a nodal agency **‘BIRAC’** for promoting R&D activities in the biotechnology sector. BIRAC is effectively implementing Public Private Partnership (PPP) mode for collaborative research leading to technology development and commercialization for market and societal benefits. It has implemented schemes, such as ‘Small Business Innovation Research Initiative’ (SBIRI),‘Biotechnology Industry Partnership Programme’ (BIPP) and ‘Contract Research Scheme’ (CRS) to promote I-A linkages in biotech research. BIRAC is also stimulating entrepreneurship development in the country via programmes such as ‘Biotechnology Ignition Grant’ (BIG), creation of ‘University Innovation Clusters’(UICs) and ‘Bio-Incubators’. BIRAC has collaborated with voluntary organization ‘**Society for Research and Initiatives for**

Sustainable Technologies and Institutions' (SRISTI) with an aim to strengthen creativity and innovation at grass root level.

DRDO, the premier institute for defense research has initiated 'DRDO-FICCI ATAC programme', 'Grant-in Aid' and 'Extramural Schemes' to promote I-A interface in defense related research.

DIPP, one of the foremost institutes dealing with industry policy design and formulation has introduced programmes, such as 'Industry Corridor Projects','Invest India', 'Atal Innovation Mission' (joint initiative of DIPP and NITI Aayog) and 'Modified Industrial Infrastructure Upgradation Scheme' (MIUS) to support industrial growth by synergizing academia and industry for collaborative research. DIPP also provided support for creation of institutes, such as 'Rajiv Gandhi National Institute of Intellectual Property Management' (RGNIIPM), 'Quality Council of India' (QCI), 'National Institute of Design' (NID), 'National Productivity Council'(NPC) and many more for IPR management and technology development (e.g. Cell for IPR promotion and Management) in order to enhance industrial competitiveness.

DAE has created industrial units, such as 'Nuclear Fuel Complex', 'Heavy Water Board' and 'Board of Radiation and Isotope Technology', where government, academia and industries are working collaboratively to address industrial problems. DAE has also introduced schemes for 'Enhancing Entrepreneurship and IPR Awareness' in field of atomic energy.

The 'Ministry of Electronics and Information Technology' **(MeitY),** acts as I-A interface in fields of electronics and information technology. It has led to the setting up of Electronics, and Information and Communication Technologies (ICT) academies all over India and incubators for electronics-related R&D entrepreneurship. MeitY has also commenced 'National Portal' for displaying technologies that can be readily taken up by industries for commercialization.

ISRO via its initiative of sponsored research programmes named 'RESPOND', 'Technology Transfer Group' and 'SAC Industry Portal' and creation of unique corporation arm 'Antrix Corporation Limited' has aided in technology development and technology transfer to space industry.

- ***Educational Sector***: **MHRD** has instituted 'Council for Higher Education Cooperation' (CIHEC) comprising of advisory members from industry, academia and stakeholder ministries. CIHEC is working towards a special task of bringing industry and academia closer to each other to pursue collaborative R&D activities. MHRD has also initiated programmes for setting up of 'Research Parks' to promote innovation ecosystem in higher educational institutes. 'TEQIP' programme was commenced by MHRD with an aim of making post graduate students industry ready by involving industries with TEQIP centers located in universities and other HEIs. MHRD also initiated a programme 'IMPRINT India' to promote innovations and technology commercialization in specific target research areas at pan IITs level. To generate skilled manpower and entrepreneurship culture, MHRD in association with its regulatory bodies, UGC and AICTE, has initiated programmes like GIAN and Kaushal Kendras.

- ***Financial Institutions***: Banking sector of India, both public and private, has significantly contributed for the promotion of research in the industrial sector especially MSMEs, entrepreneurship and creation of institutes for promoting culture of innovation. Amongst the public banks, **SIDBI**, through its various programmes has contributed towards technology development and incubation support for start-ups. SIDBI has also played crucial role in the creation of 'SIDBI Innovation and Incubation Centre' (SIIC) at IIT Kanpur. **ICICI**, a private sector bank, as a part of their corporate social responsibility is playing an important role in promoting innovation through creation of dedicated 'Innovation Fund'. ICICI has a dedicated 'Technology Finance Group' to support technology development and creation of technology based institutions. In addition, ICICI played a crucial role in establishing 'Knowledge Park' in Hyderabad for promoting entrepreneurship. **SBI** has played a crucial role in the creation of an organization CSIR-Tech which is meant for promoting technology development and commercialization. Other public banks, such as NABARD and Syndicate Bank are also doing their bit in supporting innovations at higher educational institutes.
- ***Industrial Associations***: Industrial associations, such as **FICCI, CII** and **NASSCOM** are contributing to the growth of I-A interactions and innovations by conducting national and international level workshops/conferences/I-A meets. These associations are also playing an important role by assisting the government and its agencies in formulating national policies in the areas of reforms in higher education system and carrying out surveys in the domains of academia and research.
- ***International Agencies:*** India being a member of United Nations has received funding support from international agencies, such as **UNIDO** and **IFC** for promoting industry oriented research and technological advancements to compete with rest of the world.

2.6. Conclusion

The economic prosperity of a nation is linked to its scientific and technological competence. To achieve success in these parameters, it is essential that industry and academia forge linkages to overcome the limitations of each other for commercializing R&D into innovative products/technologies. To bring government, industry and academia together, various public and private organizations have floated I-A programmes/schemes. In India, majority of R&D is being carried out by the funds provided by public sector funding agencies, such as DST, CSIR, DBT, BIRAC, DAE, DRDO, ISRO, MeitY, ICAR, MHRD and so on. In addition, government has set up dedicated agencies which aid in the promotion of applied research. IPO, NRDC and TIFAC assist public and private sectors in patent related matters; DSIR provides accreditation to R&D labs (public and private), which then become eligible for seeking incentives and R&D programmes from the government. CSIR-Tech assists many research labs, universities and entrepreneurs at all stages leading to commercialization of their research. BIRAC has been established for promoting entrepreneurship and R&D of MSMEs in the domain of biotechnology. GITA is engaged in enhancing R&D by forging national and international alliances. Financial institutions are contributing by way of providing financial assistance for creation of *Centres of Excellence* and *Technology Parks* and soft loans to entrepreneurs. Industry associations have set up dedicated research institutes with financial assistance from the public sector. All these industry-academia associated activities suggest that there is plethora of I-A related activities/schemes/programmes existing in India. However, there is no single platform where such information is either available or compiled. It is suggested that a national level centre be created where all the information pertaining to industry-academia regime of India is available. Such information will be helpful in identifying gaps and overlaps in the domain of I-A ecosystem in India. This piece of information will also be of great importance to policy makers for designing futuristic plans for Science, Technology and Innovations for India. This centre may be termed as National Industry-Academia Centre (NIAC) and governed by a council comprising of eminent scientists, industry personals, heads of funding agencies and representatives of NITI Aayog. The council should be responsible for designing as well as implementation of I-A Policy. Asian countries like China and S. Korea have a single body responsible for designing and implementation of policy programmes.

Appendix

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).

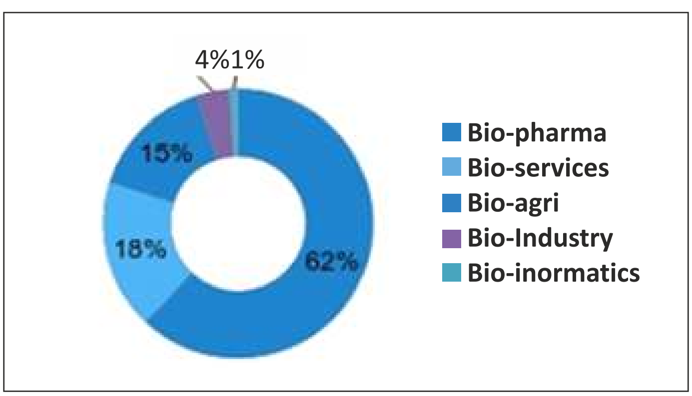

Figure 1: Biotech Market Break-Up Based on Revenues (2014-15)

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 PPP via creation of separate organization in order to execute and implement PPP. Keeping this in mind, 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 5 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.

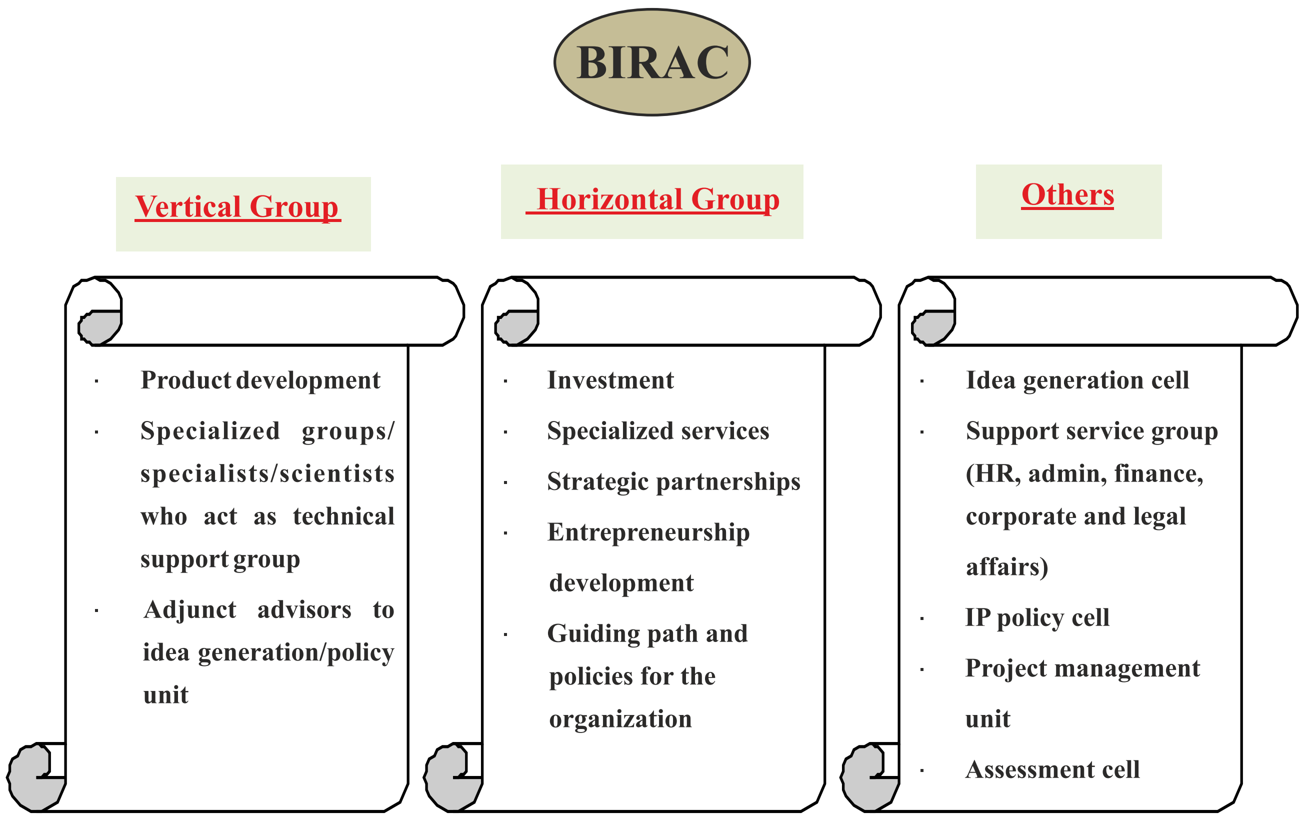

Figure 2: Organization Structure of BIRAC

Source: *http://www.birac.nic.in/*

BIRAC also has dedicated in house Policy and Analysis Cell (PAC). This dedicated cell analyses different proposals in the 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.

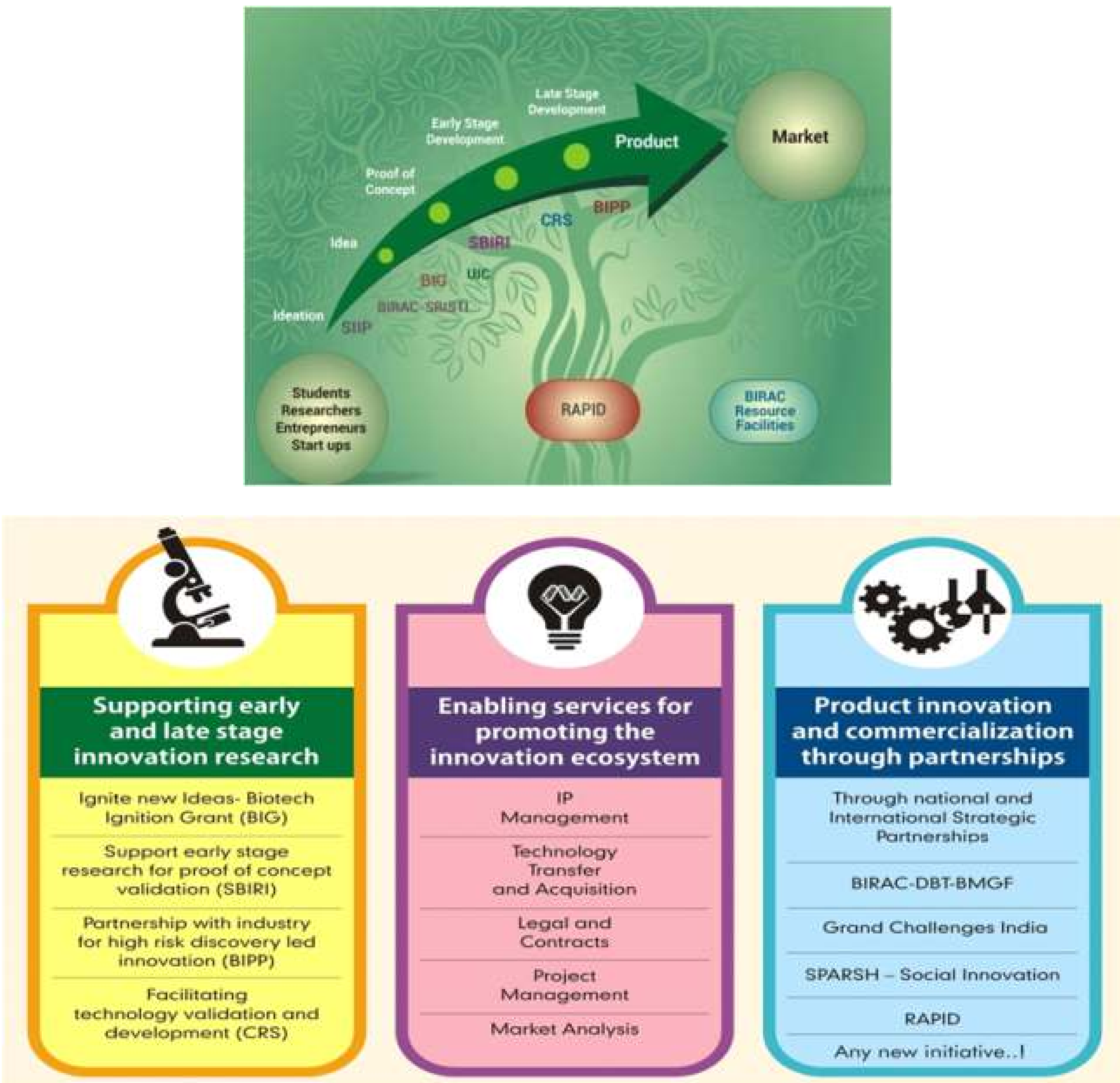

Figure 3: BIRAC's Support for Commercialization of Biotech Research

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).

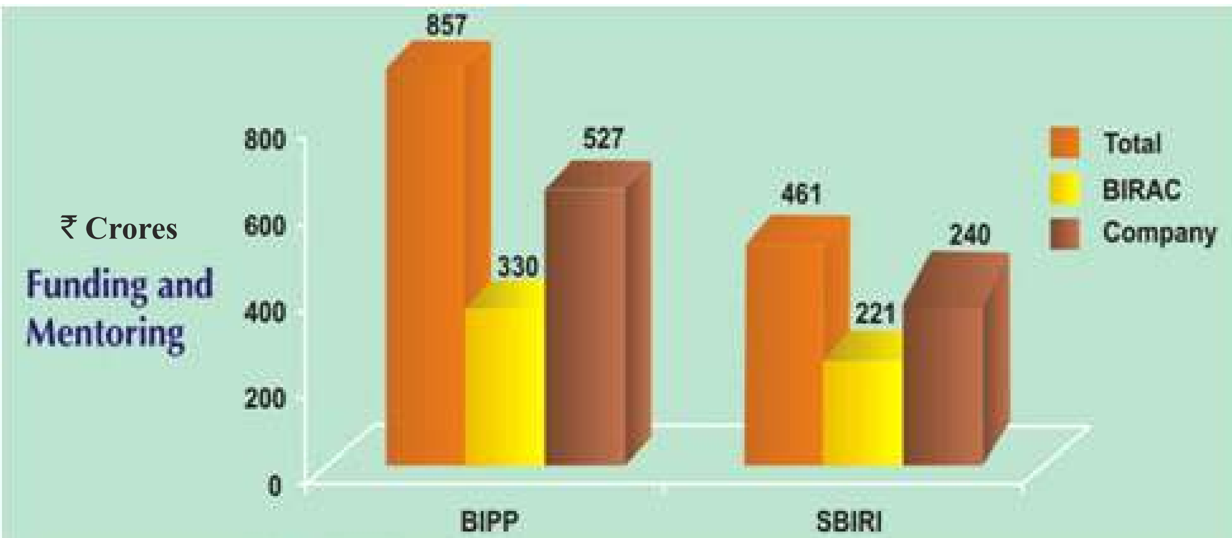

Figure 4: Impact of SBIRI and BIPP on Funding and Monitoring Support to Public and Private Sectors.

Source: *http://www.birac.nic.in/*

Table 1: BIRAC's Programmes/Schemes for Promoting Public Private Partnerships and Industry-Academia Collaborations

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 200 companies in diverse fields of biotechnology
- Products generated: 13, early stage technologies: 8
- Four technologies/products developed under this scheme in year 2014-15 are as:
    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
- 146 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 SMEs
- Investment contribution from private companies: ₹ 12.70 crores

- Investment contribution from BIRAC: ₹ 12.36 crores
- Products generated: 16, early stage technologies: 17
- Three national patents have been filed by the companies supported under the BIPP scheme
- Technology/product generated through this scheme in 2014-15 are as:

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 and Service Scheme (CRS)

- 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

Outcome/Impact

- 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, 21 academia and 17 industrial partners have received grant of ₹ 28 crores · 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

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. ICICI Knowledge Park, Hyderabad
2. Centre for Cellular and Molecular Platforms (C-CAMP), Bangalore
3. Foundation for Innovation and Technology Transfer (FITT), New Delhi
4. Kalinga Institute of Industrial Technology (KIIT) Technology Business Incubator, Bhubaneswar
5. Venture Center (Entrepreneurship Development Center), Pune

Outcome/Impact

- Through BIG scheme, BIRAC has provided funding support of ₹ 41 crores to almost 100 entrepreneurial ideas
- Presently, BIG is nurturing >170 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 more than 65 IP
- Important technologies/products developed under this schemes are as:
  1. Development of an aptamer based platform to detect tuberculosis.
  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 Electrocardiogram and Uterine Activity signa extraction from maternal Electrocardiogram 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

2. BIRAC-Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI)

- BIRAC in collaboration with SRISTI located at IIM Ahmedabad encourages entrepreneurship by awarding grass root level innovations (*under Gandhi Young India Innovation 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 MSMEs, 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 (SIF) (http://sif. sristi.org/):** It is utilized to provide mentoring, financial support, fabrication, validation, and value addition facilities in labs, fields and R&D institutions for nurturing creativity in culture, education, technology and governance.

3. 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.

4.	Social Innovation programme for Products: Affordable & Relevant to Societal Health (SPARSH)

- 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; KIIT University, Bhubaneswar; Translational 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.

Outcome/Impact

- 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 UICs. These clusters 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** : BIRAC in collaboration with IKP, 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.

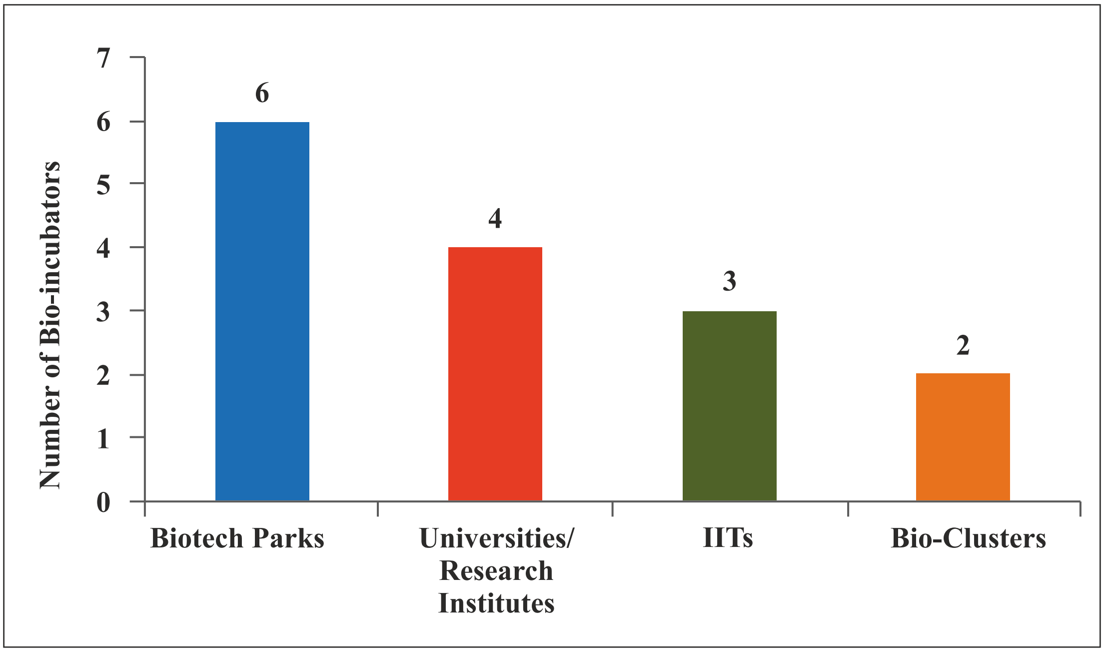

Figure 5: Distribution of Bio-Incubators Created by BIRAC

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, 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 Partnerships 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.	**Centre for the Promotion of Advance Research (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 for 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 (Ph.Ds, 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; Punjab State Council for S&T, Punjab and National Institute of Food Technology Entrepreneurship and Management, 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 ~346 companies, ~88 institutes, 150 SMEs, 104 start-ups and 170 entrepreneurs 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 Multiple Infection**	· Detects multiple infections simultaneously · Ensures less medical waste in blood banks	ICGEB, DBT and University of Turku (http://www.utu.fi/), Turku, 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), 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 follicle-stimulating hormone 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.co m/)

Source: *http://www.birac.nic.in/*

Industry-Academia R&D Regimes in IITs

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3.1 Introduction

India ranks third, next to USA and China, in terms of size and diversity of higher education system. However, it has not been able to accomplish the desired technological advancement. One of the major reasons for this is attributed to the lack of, or absence of, ecosystem needed for transforming academic research into patents/technologies/processes. Out of >700 Higher Education Institutes (HEIs) in India, only a handful of academic institutes e.g. IITs, ICT-Mumbai and IISc-Bangalore are known for generating patents and technologies. These institutes are also in the forefront of engaging industrial sector in its R&D programmes. In fact, IITs at Chennai, Kanpur, Mumbai, Khargapur and Delhi are considered to be the flag-bearers of I-A collaborative R&D in India. Each IIT has a dedicated academic programme (Table 3.1 A & B) comprising of undergraduate, post graduate and Ph.D programmes which primarily caters to engineering domain, though biology related courses, such as biotechnology, are making inroads in these institutes. The IITs have contributed to the nation's growth and are accepted world over as the notable institutes in the domain of teaching and R&D. Table 3.2 lists the achievements of first generation of IITs in different parameters of Science & Technology (S&T). The IITs possess almost all determinants of good I-A interface, such as I-A Cells, Intellectual Property Rights (IPRs) Cell, Technology Transfer Cell, Entrepreneurship Cell, Technology Business Incubators (TBIs) and so on. Till date, 23 IITs have been established by MHRD. This chapter portrays the I-A regime of 16 IITs which were established before 2014. Seven new IITs, established after 2014, have not been included in the study as they do not have enough data pertaining to I-A activities. These IITs have been established at Jammu, Palakkad, Tirupati, Goa, Raipur, Dharwad and Dhanbad.

Table 3.1 (A) : Academic Programmes of First Generation IITs i.e. Established Before 2000

Attributes	IIT-Kharagpur	IIT-Bombay	IIT-Madras	IIT-Kanpur	IIT-Delhi	IIT-Guwahati
Year of Establishment	1950	1958	1959	1959	1961	1994
Campus Area (acres)	2100	530	617.8	1055	325	700
Academics						
Departments	19	15	16	20	13	12
Centres	-	14*	16	27	-	08
UG Students	2818	7400	10,000	2255	3590	2570
PG Students	7612			1476	4239	1069
Ph.Ds (enrolled)	616	2600	2120	-	-	1544
Faculty Members	600	700	614	309	459	372

**(9 centres+4 interdisciplinary programmes +1 school of management)*

Source: *IIT-Kharagpur, IIT-Bombay, IIT-Kanpur, IIT-Madras, IIT-Delhi, IIT-Guwahati Annual Reports (2010-2015); http://www.iitkgp.ac.in/; http://www.iitb.ac.in/, https://www.IIT-M.ac.in/, http://www.iitd.ac.in/, http://www.iitk.ac.in/, http://www.iitr.ac.in/*

Table 3.1 (B) : Academic Programmes of Second Generation IITs i.e. Established After 2000

Attributes	IIT Roorkee	IIT Bhubaneswar	IIT Hyderabad	IIT Gandhinagar	IIT Patna	IIT Jodhpur	IIT Ropar	IIT Indore	IIT Mandi	IIT BHU
Year of Establishment	2001	2008	2008	2008	2008	2008	2009	2009	2009	2012
Campus Area (acres)	356	936	567	450	501	900	525	510	520	400
Academics										
Departments	21	7 (schools)	14	13	8	8	7	11	4 (schools)	13
Centres	12[a]	3	-	-	3	2	-	-	-	3
UG Students	4472	164	900	123	599	NA	NA	294	400	NA
PG Students	2093	71(76*)	450	36	131	NA	NA	242		414
Ph.Ds (enrolled)	1471	48	500	2 (degrees awarded)	185	NA	NA	264	100	210
Faculty Members	369	125	145	150	66	53	70	70	100	265

***Joint M.Sc-Ph.D integrated**; [a] 1 academic centre, 3 centres of excellence, 5 academic service centres and 3 supporting units.

Source: *www.iitr.ac.in, www.iitbbs.ac.in/, www.iith.ac.in/, www.iitgn.ac.in/, www.iitj.ac.in, www.iitp.ac.in/, www.iitrpr.ac.in/, www.iiti.ac.in/, http://www.iitmandi.ac.in/, www.iitbhu.ac.in/*

Table 3.2: Science and Technology Indicators of First Generation IITs

Intellectual Property (IP) Attributes	IIT Kharagpur	IIT Bombay	IIT Madras	IIT Kanpur	IIT Delhi	IIT Guwahati
Publications (2014-15)	2162	~1500	1194	1298 (2014)	1300	1250
Patents (2010-15)						
-Filed	231	569	239	204	146	37
-Granted	13	>61	25	9	25	6
Technology Available	214	409	358	6	50	05
Technology Licensed (till date)	24	>140	60	60	15	06
Revenue Generated from Tech. Transfers (Crores ₹; upto 2015)	186.80	209	461	2.38	135.83	1
Incubating Companies	172	71	95	52	44	13
Start-ups (till date)	104	>26	89	26	16	10
Industrial Collaborations (MoUs; 2010-15)	72	225	~176	124	8	09
Corporate Clients	~400	~400	227	~124	48	50
Sponsored Projects (Crores ₹; 2010-15)	577.45 (2011-2016)	1149.95	491.11	401.23	328 (2010-2014)	220.53
Revenue Generated Consultancies (Crores ₹; 2010-15)	69.75 (2011-2016)	143.5	251.11	52.25	138 (2010-2014)	16.37

Source: *IIT-Bombay, R&D Highlights 2016, Annual Reports (IIT-Kanpur) 2010-15, Annual Reports (IIT-Madras) 2010-15, Annual Reports (IIT-Bombay) 2010-15, Questionnaire filled by IITs for DST-CPR at PU, Chd., http://www.iitk.ac.in/, http://www.iitr.ac.in/, http://www.iitb.ac.in/, https://www.IIT-M.ac.in/, http://www.iitd.ac.in/, http://www.iitkgp.ac.in/, http://www.iitg.ac.in/, External Peer Review Committee Report (IIT-Delhi-2015), External Peer Review Committee Report (IIT-Kharagpur-2015).*

3.2 Industry-Academia R&D Activities of IITs

3.2.1. Indian Institute of Technology, Kharagpur (IIT-KGP)

(http://www.iitkgp.ac.in/)

Introduction: IIT-KGP was the first IIT to be established in 1950 in Kharagpur, West Bengal. The institute published close to 2100 research articles in the academic year 2014-15. In the last five years, the institute has filed over 230 patents, out of which 15 patents have been granted. 214 technologies are available to be commercialised and ~25 have been licensed, generating a revenue close to ₹186 crores. The institute has 72 industrial collaborations (2010-15), ~ 400 corporate clients, 172 incubatees and 104 start-ups till date. In the last five years (2011-16), IIT-KGP has earned close to ₹ 76 crores from consultancy projects and ₹ 577 crores from sponsored projects.

Industry Related Programmes

i) Sponsored Research & Industrial Consultancy (SRIC) (http://www.ttg-sric.iitkgp.ernet.in/sric/): To monitor the high volumes of sponsored research and consultancy projects, SRIC was initiated in 1982. The centre has well built infrastructure and the capacity to handle approximately 700 R&D projects at a time. Under the aegis of SRIC, the institute has set up an IPR and Industrial Relations Cell to look after the interests of faculty, funding agencies and industry partners. Currently, SRIC cell has 773 on-going research projects. In the last five years, the total funds received by IIT-KGP were over ₹ 630 crores through more than 1500 research and consultancy projects.

ii) Technology Transfer Group (http://www.ttg-sric.iitkgp.ernet.in/ttg/research.php): This is an initiative of the students under the aegis of SRIC. The main objective of this group is to act as a link between the academia and the industry to facilitate the transfer of technologies (industry-ready) developed at IIT-KGP and to utilise the intelligentsia of the institute as a research consultant.The services offered by this group includes:

- *Consultancy*: Industry or any external agency can approach the institute for problem solving.
- *Technology Assessment*: Helps in assessment of existing processes/ technologies to reach upon possible areas for improvement.
- *Research Lab Services*: The *state of art* laboratories with avant-grade instruments and skillful research staff cater for technology evaluation, laboratory based testing and analysis, and research collaborations.
- *Expert Access*: The large pool of highly accomplished scientists and researchers can be contacted for consultancy on key technical areas.
- *Know-how Transfer*: This group is responsible for research reports/publications, procedures, protocols, formula, designs/drawings and any other information with regard to a particular technology, product and process.
- *Product Design*: This service brings together various partners for idea generation, concept

development, testing, and implementation thereby converting the ideas into final commercial entity.

The Technology Transfer Group has also initiated **IndAc**, a confluence of industry and academia. It provides platform to the industry to present their needs and to the academia for showcasing itself as a research consultant.

iii) The **Science & Technology Entrepreneur's Park-Technology Business Incubator (STEP-TBI) (**http://www.step-iit.org/): STEP at IIT-KGP was established in 1986 with financial support from DST, IDBI, IFCI and ICICI. STEP has created conducive ambience to nurture and guide entrepreneurial efforts. It has led to a number of technology transfers and successfully converted research outcomes to commercially viable entities. STEP works in unanimity with the other programmes like Technology Business Incubation (TBI) and Technology Incubation and Entrepreneurship Training Society (TIETS). It acts as a pipeline amid the institute and the world outside to enable facilitation of transfer of technology along with conversion of research outcomes of entrepreneurs into commercially viable entities.

STEP-TBI gets funding support through various schemes of GoI such as Promoting Innovations in Individuals Start-ups and MSMEs (PRISM), Technology Incubation and Development of Entrepreneurs (TIDE) scheme and Technology Development Board (TDB).

- **Technology Incubation and Entrepreneurship Training Society (TIETS)** (http://www.step-iit.org/about_tiets.html): This society was created in the year 2006 and seeded the efforts to create infrastructure to trigger the generation of entrepreneurs, idea generation, incubation and integration amongst students and alumni. TIETS has created an avenue for incubates where they get fund support, mentoring and prototype branding. It works in close association with STEP.

- **Entrepreneurship Cell (E-Cell)** (http://www.ecell-iitkgp.org/index.php): This *not for profit* organization, run by the students, is dedicated to the cause of boosting entrepreneurship among students. The cell acts as a forum to provide opportunity for student entrepreneurs to trial their idea with the help of TIETs and STEP. It has also led to the design of courses and training programmes for IIT stakeholders and public in general. E-Cell organizes various patent workshops, case study workshops and knowledge camps to promote entrepreneurship among students. It has successfully linked investors with the entrepreneurs.

iv) **Technopreneur Promotion Programme (TePP) Outreach cum Cluster Innovation Centre (TOCIC) (**http://www.step-iit.org/TePP.html): With the initiatives of DST and DSIR, TOCIC was started in 2014 for promoting independent innovators and transforming them into entrepreneurs by facilitating them with government grants, mentoring and technical guidance through academic and industry experts.

v) **Telecom Centre of Excellence (TCOE)-Vodafone IIT Centre of Excellence in Telecommunications (VICET) at IIT-KGP:** Established under PPP mode in 2007, VICET is one of the successful examples of government [Dept. of Telecommunication (DoT)], academia (IIT-KGP) and industry (Vodafone Ltd.). The main research of VICET is "Next Generation Networks and Technology".

Examples of technologies developed, patents and MoUs signed by IIT-KGP in 2015-16		
S. No.	**Technologies Developed**	
1.	Venucane: An electronic travel aid for visually impaired and blind people	
2.	Ultrafiltration membrane for cold sterilization of bottle gourd juice (*Lagenaria siceraria*) for extended shelf life and method thereof	
3.	Ultra-sensitive simultaneous electrochemical determination of arsenic, mercury and copper	
4.	Surveillance using partial gait sequences of a human being	
5.	Purification of lactic acid and its polymerisation to polylactic acid with improved property	
6.	Non-invasive blood glucose measuring system	
S. No.	**Patents**	**Application Number**
1.	A low complexity generalized frequency divion multiplexing transceiver	1018/KOL/2015
2.	A micro-reactor based energy efficient process for cellulosic ethanol production	961/KOL/2015
3.	Stable hybrid polymer adapted for superhydrophobicity and process for manufacture thereof	758/KOL/2015
4.	Reconstituted rice grains and its process of manufacture	699/KOL/2015
5.	A precoded generalized frequency division multiplexing system to combat inter symbol interference and reduce peak to average power ratio	453/KOL/2015
6.	An adverse environmental effect resistant seamless wireless sensor network system.	425/KOL/2015
S. No.	**MoU With Industry**	**Signed With**
1.	MoU with Hindustan Aeronautics Limited (HAL), Bangalore.	Hindustan Aeronautics Ltd. (HAL)
2.	MoU with SAP Lab India Doctoral Fellowships	SAP Lab India

Source: *https://www.iitsystem.ac.in/*

3.2.2. Indian Institute of Technology, Bombay (IIT-B)

(http://www.iitb.ac.in/)

Introduction: IIT-B was the second of its kind and established in the year 1958 in the western part of the country. This was the first institute to be established with the aid of foreign funds provided by UNESCO.

Since its inception, institute has received huge amount of R&D funds from both national and international organizations and industrial sectors. Government funding accounts for ~70%, where as, industry funding accounts for ~21% (IIT-B, Industry Interaction Flyer 2016). The financial insight to the R&D funding of IIT-B in last five years is depicted in figure 3.1.

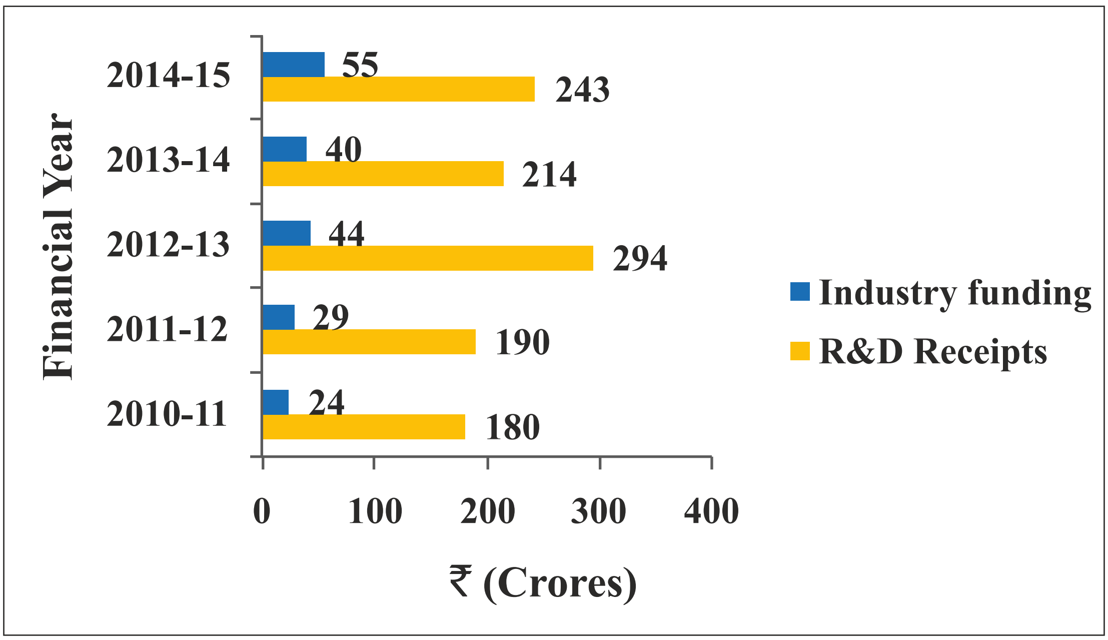


Figure 3.1: R&D Funding of IIT-B (2010-15)

Source: *IIT-B Annual Report 2014-15*

To set a benchmark in research directed towards industrial growth, IIT-B has established various centres. IIT-B has over 1500 publications in the academic year 2014-15. In the last five years, the institute has filed ~ 570 patents of which nearly 60 patents have been granted. An astounding increase in the number of patent filings was witnessed e.g. in 2010, 46 Indian patents were filed from IIT-B. The number rose to 102 in year 2015. IIT-B is credited with National Intellectual Property Award (2015) and Thomas Reuters India Innovation Award (2014) for its enhanced role in country's R&D development.

IIT-B is actively involved in translating its research into commerce through licensing and start-ups. The institute has about 400 technologies that are ready for transfer/licensing and approx. 140 technologies have been licensed till date, which have generated total worth close to ₹ 210 crores. To bolster I-A interactions, it has signed 225 MoUs with various industrial organizations. It has approx. 400 corporate clients, 71 incubatees and > 25 start-ups till date. IIT-B, in the last five years, has drawn ~ ₹ 140 crores and ~ ₹ 1150 crores from consultancy and sponsored projects respectively.

Industry Related Programmes

i) **Industrial Research and Consultancy Centre (IRCC)** (http://www.ircc.iitb.ac.in/IRCC-Webpage/rnd/index.jsp): The centre set up in 1975, facilitates and co-ordinates all R&D activities of the institute. The centre aids in generating and protecting the IP of the institute, and their deployment for economic development through commercialisation. It is involved in facilitating short term projects to solve industrial problems as consultancy projects (~2690 consultancy projects in past 5 years worth ₹ 144.5 crores) or industrially/government sponsored fully fledged long term technology development projects (~1198 sponsored projects in past 5 years worth ₹ 1149.95 crores) (Fig. 3.2). All the research funding and interaction of the institute with the industries/private sector are managed under the umbrella of IRCC.

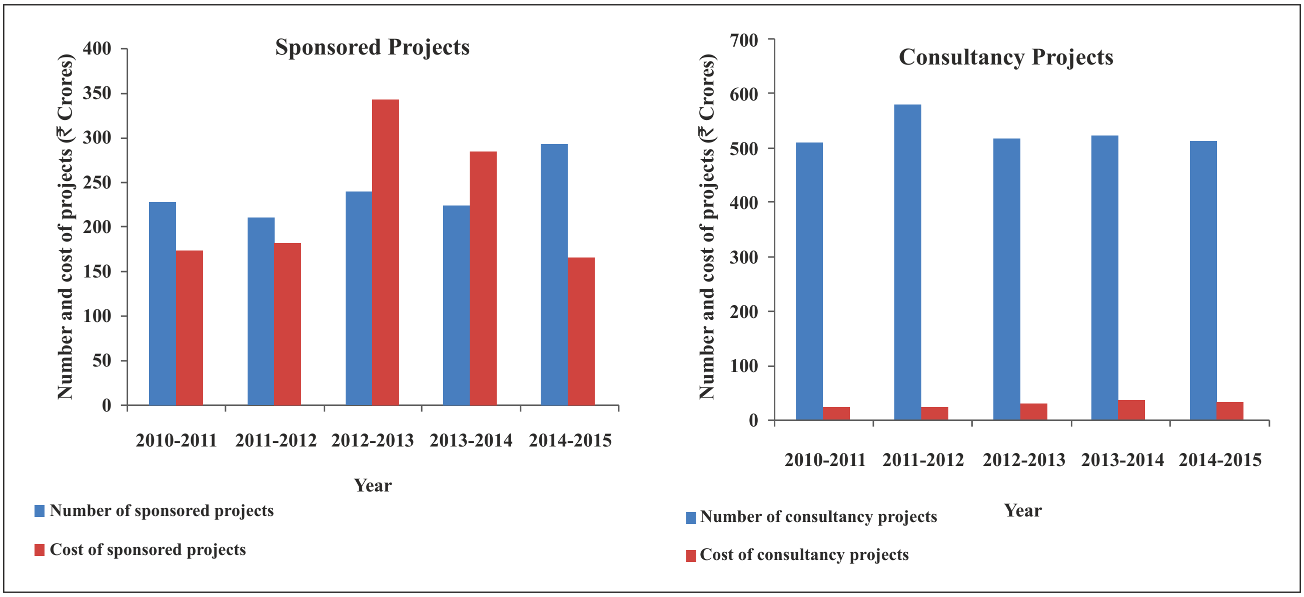


Figure 3.2: Number of Sponsored and Consultancy Projects and the Revenue Generated

Source: *IIT-B Annual Report 2014-15*

Under the aegis of 'Industry Partnership Scheme' industry sponsored labs have been set up where industry and IIT-B faculty can jointly undertake project work. Select major industry sponsored laboratories set up in recent years include:

- 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

In addition, various consortia groups of IIT-B-Government-Industry, under PPP mode have been established. These consortia are as following:

- Centre of Excellence in Telecom
- Healthcare Research Consortium
- Industry Affiliates Program at the National Centre for Photovoltaic Research and Education (NCPRE)
- National Centre for Aerospace Innovation and Research
- National Solar Thermal Power Research Testing and Simulation Facility

The relations of IIT-B with the industry are such that the industry may also sponsor a student in the field of their interest and some of the industries that have sponsored students of IIT-B are Konecranes, Areva, TCS, Infosys and Intel. Along with this, around 20 Chair Professorships have been established at IIT-B by both the alumni and the industries e.g. TATA Chair, Praj Industries Chair, Forbes Marshall Chair and Bajaj Group Chair in order to promote I-A collaborations and industry participation in academics.

IIT-B has upheld the social responsibility very well by contributing to both urban and rural community by means of technology based solutions under the Centre for Technology Alternatives in rural areas. IIT-B has led to the development of various technological advancements especially for rural areas like development of dry sanitation system, dhoop stick making machine, bore recharge system, water storage system of natural fibres, low cost check dams and herbal oil extraction unit. IIT-B also designed the symbol of Indian Rupee (₹) which is now the official Indian currency symbol used globally (IIT-B, R&D Highlights 2016).

In the year 2014, under IRCC, a Research Park was established in IIT-B with financial support from the MHRD. Research Park provides an ecosystem where academia and industry/research fraternity can work in close collaboration on research problems, product innovation and technology challenges. IRCC has also released revised IP policy of IIT-B for licensing of IP developed by IIT-B.

ii) Society for Innovation and Entrepreneurship (SINE) (http://sineiitb.org/sine/home): SINE was established in 2004 with the support from IIT-B alumni. SINE is a platform for promotion of entrepreneurship and administers business incubator that supports technology based entrepreneurship. It maintains a support system for knowledge based start-ups founded by IIT community thereby leading to the creation of wealth and social upliftment. Till date it has incubated 64 companies, 38 companies have graduated and 19 resident incubatees under SINE. It has generated more than 1500 jobs (IIT-B, R&D Highlights 2016). SINE also manages a TBI at IIT-B.

iii) The **Desai Sethi Centre for Entrepreneurship (DSCE)** (http://www.iitb.ac.in/dsce/en/about): It was established in 2013 in collaboration with Desai Sethi Foundation. It aims in spurring entrepreneurship in the campus by introducing various entrepreneurship academic programmes. It has initiated 'Proof of Concept Centre' (PoCC) to support students to convert their ideas into tangible products through performance management, validation facilities and rapid prototyping. It also supports budding entrepreneurs through micro-grants and mentoring.

iv) The **Entrepreneurship Cell (E-Cell)** (http://www.ecell.in/2015/): It is *not for profit* organization of students initiative in which regular workshops, innovative games, speaker sessions, competition for aspiring entrepreneurs, provides financial resources such as seed funding, networking and consultancy for budding student entrepreneurs. It has led to various initiatives that support the upcoming student start-ups. These initiative are as:

- Freelancers and Co-Founder Platform (FCoF)
- E-Summit
- Eureka Road to Enterprise
- National Entrepreneurship Challenge (NEC) in Association with Lenovo
- Entrepreneurship and Business (ENB) Club
- Start-up Services Platform (SSP)

The vision behind these initiatives was to build a strong and flexible ecosystem in the organization for allowing the expansion of knowledge according to the changes in the socio-economic needs of the society.

v) **Tata Teleservices IITB Centre of Excellence in Telecommunications (TICET):** This centre was established under the PPP mode in 2007 vide signing of an MoU between DoT, GoI, IIT-B and Tata Teleservices Ltd. The main focus area of the TCOE at IIT-B is "Rural Telecom Technology". The TCOE have been set up with an aim to create novel services/applications, develop global level manufacturing capability, generation of intellectual property, entrepreneurship etc. and will meet the challenges that have been faced by the telecom industry in India.

IIT-B in its quest for dispersing knowledge and to deliver this knowledge to the society, engages in several activities to interact with local and global organizations. Its major activities include:

- **Continuing Education Programme (CEP):** Short, intensive courses for working professionals in industry or government, for enhancing expertise in their respective fields. In-house courses are also conducted for special training of a particular group according to the needs of a particular industry.

- **Quality Improvement Programme (QIP):** This programme was launched by the GoI in 1970, to upgrade the faculty of other institutions. QIP enables them to obtain Master's and Doctoral degrees.
- **Centre for Distance Engineering Education Programme (CDEEP):** CDEEP intends to provide distance education through different media such as video recordings of classroom lectures, web-based courses, live interaction and so on. The prowess of IIT-B's faculty is freely available for learners everywhere. The courses that the institute offers through their distance education programme are the same as the ones taken by the students of IIT-B.

IIT-B, since its initiation, has reaped huge benefits from its locale, which is one of the largest industry-intensive areas in India. The R&D activities of the institution have been largely governed and promoted by its geographical location.

Examples of technologies developed and patents by IIT-B in 2014-15

S. No.	Technologies Developed
1.	Supercritical fluid extraction system design for extraction of food flavours, additives and medical components
2.	Palletized tea storage methodology employing controlled atmosphere
3.	Vermiculture technology for solid and liquid waste management
4.	Graphs theoretic algorithms for automatic index determination of differential algebraic equations
5.	Design analysis and simulation of batch distillation and pressure swing adsorption units.

S. No.	Patents	Application Number
1.	A method and a system for producing thermolabile nanoparticles with controlled properties and nanoparticles matrices made thereby	2213/MUM/2011
2.	A solar cell having three dimensional junctions and a method of forming the same	3467/MUM/2010
3.	Electrodiagnostic equipment	Patent application no. 14/MUM/2001 Patent grant no. 206022
4.	A diagnostic method for determining deformations in a transformer or reactor winding	Indian patent application no. 1893/MUM/2007 US patent Grant no. 8,278,939

Source: *IIT-B Annual Report 2014-15*

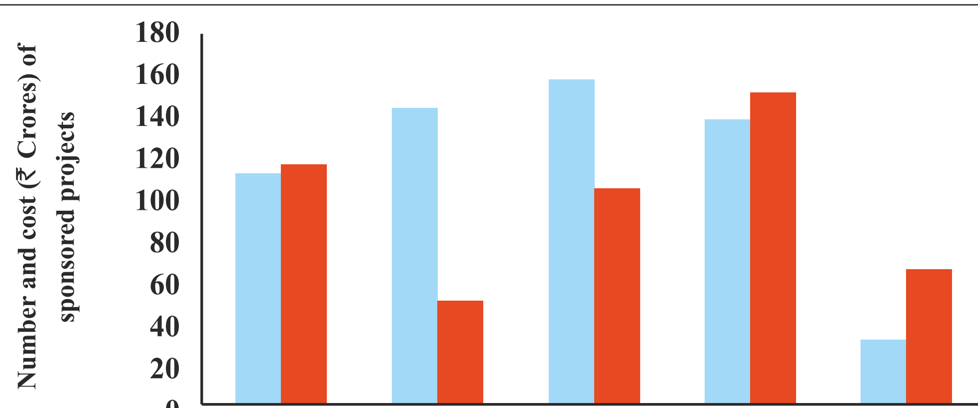
3.2.3. Indian Institute of Technology, Madras (IIT-M)

(https://www.iitm.ac.in/)

Introduction: IIT-M was established in 1959 with partial assistance from West Germany, which provided for services of experts, foremen, training facility and the supply of equipment for setting up 20 laboratories and a central workshop at IIT-M. Amongst all IITs, IIT-M leads in the industrial collaborations and functioning in industry-funded projects. IIT-M published over 1100 research articles during 2014-15. Out of 239 patents filed in the academic years 2010-15, 25 have been granted. The institute has approx. 350 technologies ready to be licensed and 60 have been licensed till date, which have generated a worth of ₹ 461 crores. Further, the institute is emerging as one of the most vibrant start-up hub of the country. Till date, a total of 89 start-up companies have been incubated in IIT-M and 95 are present incubatees. The institute has signed MoUs with close to 175 industries and has 227 corporate clients. In the last five years (2010-15), IIT-M has undertaken sponsored projects worth ₹ 491 crores and has generated ₹ 251 crores from consultancy projects.

Industry Related Programmes

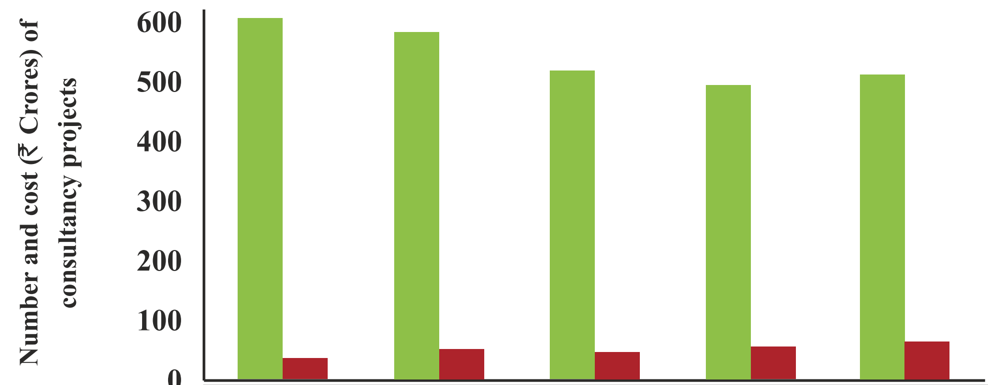
i) The **Centre for Industrial Consultancy and Sponsored Research (IC&SR)** (https://www.IIT-M.ac.in/icsr): Established in 1973, this centre aims to promote interaction between the industry and the institute facilitating sponsored and consultancy projects. It holds the responsibility for industrial collaboration in terms of research and consultancy, technology licensing and intellectual property related issues. Today, the centre for IC&SR stands as an independent section of the institute. It has initiated the industrial association scheme to attract industrial sectors and at present hosts 227 industries under this scheme. IC&SR facilitated the emergence of number of centres for excellence in the institute and also taken up sponsored and consultancy projects worth crores of rupees as depicted in figure 3.3 (A & B).



	2010-11	2011-12	2012-13	2013-14	2014-15
No. of sponsored projects	113	144	158	139	33
Cost of sponsored projects (₹ Crores)	117.1	50.77	105.2	151.47	66.57

Figure 3.3 (A): Number and Cost of Sponsored Projects Carried Out in IIT-M

Source: *IIT-M Annual Report 2014-15*



	2010-11	2011-12	2012-13	2013-14	2014-15
No. of consultancy projects	570	549	487	464	482
Cost of consultancy projects (₹ Crores)	36.3	50.77	45.88	54.01	64.15

Figure 3.3 (B) : Number and Cost of Consultancies Projects Carried Out in IIT-M

Source: *IIT-M Annual Report 2014-15*

ii) IIT-M Research Park (http://respark.IIT-M.ac.in/about_us.php): The Research Park at IIT-M is one of the most accomplished set up in the country. It is an independent company promoted by IIT-M and its alumni registered under Section 25 (now Section 8 of The Companies Act 2013) of The Companies Act 1956 and is India's first university driven Research Park. It facilitates promotion of R&D in partnership with industry, generation of new ventures and promoting rural economic development. IIT-M Research Park assists newly formed companies with a research focus to set up base in IIT-M Research Park and provides expertise of IIT-M to develop knowledge and innovation ecosystem. It contains more than 30 corporate clients from various different segments as depicted in figure 3.4. The golden triad of industry, faculty and students working together has generated many successful innovations.

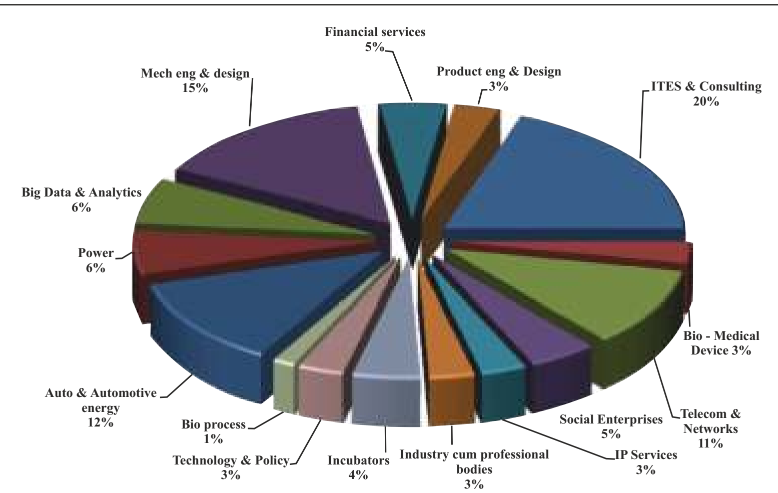


Figure 3.4: Industrial Sectors in Collaboration with IIT-M in IIT-M Research Park
Source: *http://respark.IIT-M.ac.in/about_us.php*

iii) IIT-M Incubation Cell (http://www.incubation.IIT-M.ac.in/): It aims to synergize and coordinate innovation, entrepreneurship and facilitate industrial interactions. It is working in the field of industrial solutions, rural technologies and social impact. It supports creation of ecosystem for R&D development including staff, students, alumni, faculty, industry and R&D partners in creation of successful ventures. It has also been registered under Section 8 of the Companies Act 2013 and recognized as a TBI by NSTEDB. In totality, 94 incubatees have been incubated in the IIT-M incubation cell and more than 50 companies converted to successful ventures. IIT-M incubation cell taps vast faculty and alumni network to provide mentoring support associated with IIT-M entrepreneurship forum specifically designed to help entrepreneurs to move in direction from business idea to actual start-up.

The IIT-M incubation cell has also launched the **Entrepreneur-in-Residence Programme** where current incubatees can avail unique opportunity to interact one-on-one with accomplished entrepreneurs. It has further nurtured several incubators which were established for specific sectors like:

- The **Rural Technology Business Incubator (RTBI)** (http://www.rtbi.in/) was set up in 2006 in association with World Bank's Infodev project and DST. Major focus area of RTBI is rural and social development. It has incubated over 41 companies and has graduated 14 successful start-ups which are working for solving rural India challenges such as, water, food, power and education.
- **Bio-incubator** (http://www.bioincubator-IIT-M.in/) was established by BIRAC under Bio Incubator Support Scheme (BISS) and aims to foster Indian biotech entrepreneurship and innovation enhancing R&D capabilities of SMEs, MSMEs and start-ups. It offers space, high-end equipments, research facilities, scale-up facilities, technical support and financial assistance to researchers with nascent ideas to transform into commercialized process/product. It contains 24 corporate clients and has incubated 11 companies.
- The **Cell for Technology Innovation, Development and Entrepreneurship Support (C-TIDES)** (http://www.c-tides.IIT-M.ac.in/), also named as Entrepreneurship Cell, is a core for student entrepreneurship activities in IIT-M to promote student led entrepreneurship and pre-incubation support. It was established in 1998.

IIT-M has recently adopted business incubation policy to set guidelines for coordination of growing entrepreneurial culture in IIT-M. IIT-M incubation cell specifically holds responsibility of implementing the policy effectively.

iv) Reliance IITM Centre of Excellence (RITCOE): RITCOE was founded in 2007, when an MoU was signed between DoT, GoI, IIT-M and Reliance Communications Ltd. This centre, which focuses on "Telecom Infrastructure and Energy" was established with an aim to position India as a global telecom manufacturing hub and along with other CoEs aims to cope up with the problems that the telecom industry faces.

v) The **Centre for Innovation (CFI)** (http://cfi.IIT-M.ac.in/main/): CFI was founded with funds donated by the alumni of the 1981 batch and is a student lead body. The CFI provides for infrastructural support, and guidance nurture innovation in engineering.

vi) The **Centre for Social Innovation and Entrepreneurship (CSIE)** (http://csie.IIT-M.ac.in/): Founded in 2010 this centre works towards developing the social enterprise in India by focusing on teaching and research in the said domain.

vii) **IIT-M Entrepreneurship Forum**: The IIT-M Alumni Association initiated this forum to bring awareness and promotion of entrepreneurial activities amongst the other IIT members. This forum intends to contribute by providing the students with a culture/apprenticeship in start-ups and tutorship.

IIT-M, in its future activities, is planning a large project on contemporary manufacturing, focusing on virtual technologies and sustainability. Over the next decade, the success of these projects could become important for laying the foundation for a competitive technology industry.

Examples of technologies developed and patent by IIT-M in 2015-16		
S. No.	**Technologies Developed**	
1.	A steering/seat assembly for monitoring and alerting a driver based on his/her fatigue and/or behavior	
2.	Boss mool lab	
S. No.	**Patent**	**Application Number**
1.	A method of measuring the air-fuel ratio of a spark ignition engine	3194/CHE/2008

Source: *https://www.iitsystem.ac.in/*

3.2.4. Indian Institute of Technology, Kanpur (IIT-K)

(http://www.iitk.ac.in/)

Introduction: IIT-K was established by GoI in the year 1959 under "The Kanpur Indo-American Programme". The institute received technical assistance from a group of top nine institutes of USA. IIT-K has emerged as an institute that has excelled in education and research activities in tune with the needs of the society. IIT-K has close to 1300 research publications in the year 2014-15. In the last five years, 204 patents were filed from the institute out of which 9 patents have been granted. IIT-K presently has 6 technologies ready to be transferred and the institute has already licensed 60 technologies, resulting in earnings of ₹ 2.38 crores. With 52 incubatees and 26 start-ups till date the institute has been promoting innovation and entrepreneurship actively. IIT-K has generated ₹ 52.25 crores and ₹ 401 crores from consultancies and sponsored projects respectively. It has close to 124 corporate clients and has signed MoUs with approx. 120 industrial organizations.

Industry Related Programmes

i) SIDBI Innovation and Incubation Centre (SIIC) (http://www.iitk.ac.in/siic/d/about-siic): Set up at IIT-K in collaboration with Small Industries Development Bank of India (SIDBI), it fosters innovative research and activeness in entrepreneurship, in technology related fields/areas. It was established in 2000 with the perception of being able to transform the knowledge of the institute into wealth. The centre has a twofold vision:

- To create a generation of zealous entrepreneurs.
- To convert novel research into valuable intellectual property.

For IIT-K, SIIC acts as a single platform for agendas in regard to innovative research, development and commercialization of technology, incubation, entrepreneurship, etc. The profile of incubating and graduated companies is presented in figure 3.5 and 3.6.

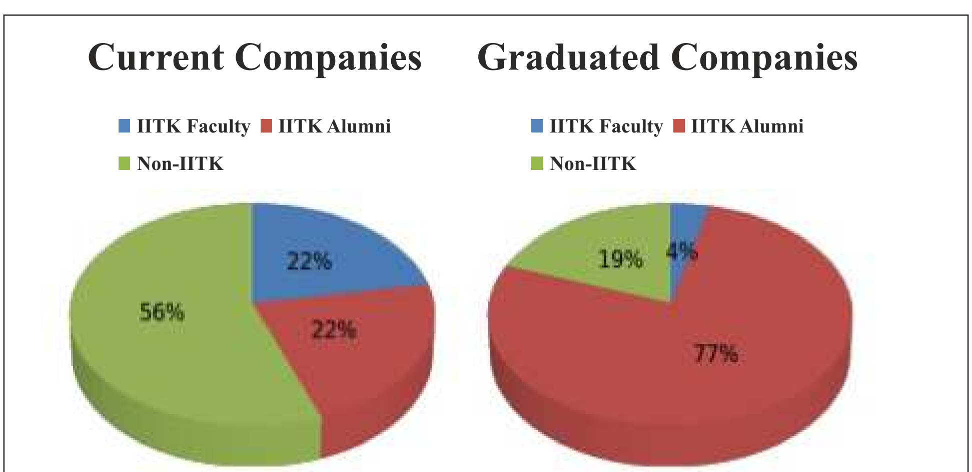


Figure 3.5: Pie Chart of IIT-K for Current Incubatees and Graduated Companies
Source: *http://www.iitk.ac.in/*

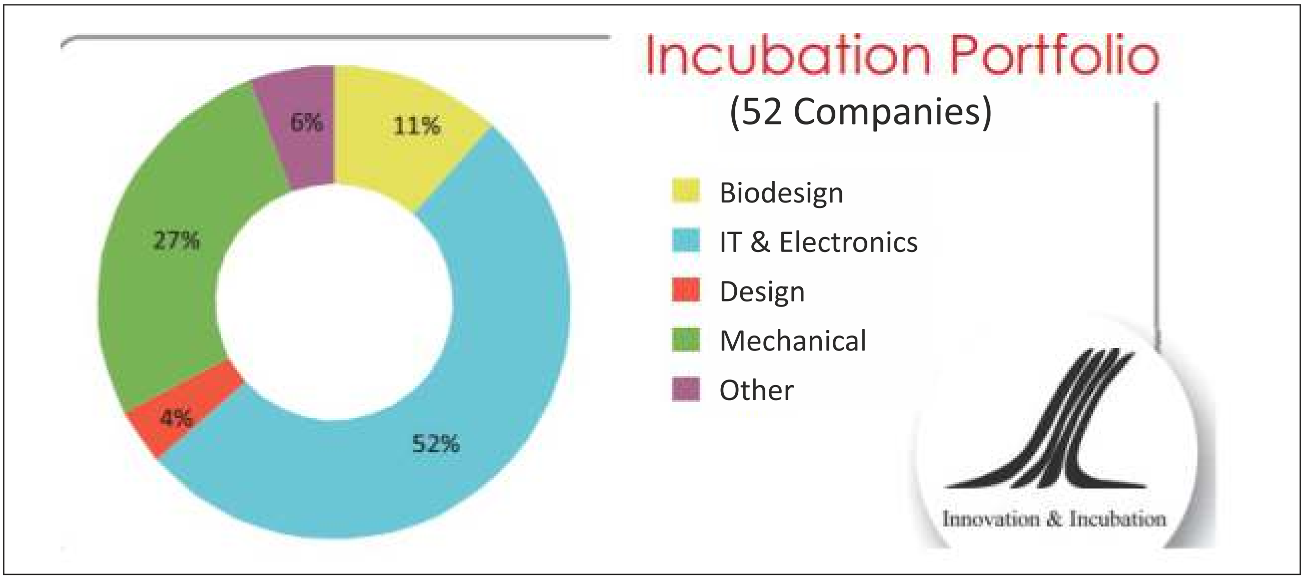


Figure 3.6: Sector Wise Incubation Portfolio of IIT-K

Source: *http://www.iitk.ac.in/*

So far, SIIC has successfully:

- Incubated and mentored ~52 companies
- Disbursed seed funds of ₹ 50 crores
- Collaborated with organizations like NEN, SUM, IIMA
- Commercialized 56 patents (worth ₹ 2.38 crores)
- Sponsored projects (2010-2015) = 619
- Consultancy projects (2010-2015) = 451

Major Activities of SIIC Include -

a) Incubation: A whole spectrum of incubation related facilities and other services are provided by SIIC to the eventual entrepreneurs and also help the entrepreneurs realize the conversion of their novel ideas into commercially viable results. The incubatees at SIIC explore different domains such as, scientific know-how, engineering and other integrative areas. The centre has gained a decent visibility and developed a fine interface through events like the entrepreneurial talk series, conferences, workshops and seminars that it has been hosting/organizing. Today, SIIC is one of the most prestigious incubators in India and it has grown tremendously since its initiation in 2003. From one incubation centre, representing IIT-M, SIIC has evolved to being seven centres representing various arms of government. It acts as a:

- SIDBI Innovation and Incubation Centre (for SIDBI)
- Technology Business Incubator (for DST)

- MSME Incubator (for MSME)
- Technology Incubation & Development of Entrepreneurs (for MIT)
- Technology Entrepreneurship Promotion (for DSIR)
- Bio-Incubator (for DBT)
- MoLE Incubator

b) Patenting: The IIT-K faculty members and disciples take professional aid from SIIC, for filing of IP (patents, copyrights, etc.). Thus, the centre also acts as Technology Transfer Office (TTO) of the institute. So far, the centre has been responsible for filing more than 264 patents for the IIT-M faculty and students. In collaboration with a commercial partner; to meet the needs of the industry, this centre facilitates up-gradation/modification of the technology developed at the institute, so that the technology is ready for the market. The faculty member related to development of the technology acts as a mentor for the same. Marketing of the product and customer support are the responsibilities taken up by the commercial partner. SIIC also has strategic alliances with organizations like National Entrepreneur Network (NEN), Singapore Management University (SMU), IIM Ahmedabad and others. SIIC, in collaboration with these organizations, regularly holds workshops and trainings to promote entrepreneurship.

ii) Knowledge Incubation for Technical Education Quality Improvement Programme (TEQIP) (http://www.iitk.ac.in/tkic/teqip.html): The centre acts as a nodal archive for all the emerging academic knowledge, along with being a platform for teacher training activities and knowledge up-gradation of the students.

The objectives of TEQIP are:

- Strengthening institutions to produce high quality engineers for better employability.
- Scaling-up postgraduate education and demand-driven R&D and innovation.
- Establishing 'Centres of Excellence' for focused applicable research.
- Training of faculty for effective teaching.
- Enhancing institutional and system management effectiveness.

iii) TePP Outreach cum Cluster Innovation Centre (TOCIC) (http://www.iitk.ac.in/siic /d/article/siic-becomes-tepp-outreach-centre): As a new initiative during 1998-99, the Ministry of Science and Technology, GoI, launched a novel programme known as "Technopreneur Promotion Programme" (TePP) jointly operated by DSIR and TIFAC (DST) to highlight and bring out the boundless amounts of novel and innovative ideas of the nationals of the country. TePP is an initiative to bolster innovators and transform them into technology-based entrepreneurs (Technopreneurs).

The objectives of the TePP are:

- Promote and support untapped creativity of individual innovators.
- Assist the individual innovators to become technology based entrepreneurs.
- Assist the technopreneur in networking and forging linkages with other constituents of the innovation chain for commercialization of their developments.

iv) National Centre for Flexible Electronics (FlexE): This centre was set up in the year 2014, with the grant from DeitY (now known as MeitY), under the ESDM scheme of Electronics Policy 2012 of GoI. The FlexE Centre provides a platform for meaningful interactions amongst the industry and the academia. The main objectives of the centre include:

- *Research & Development*: Scientific investigations and studies in the field of flexible electronics.
- *Manufacturing*: Developing partnership with the industry to conduct research with a view of taking it to the manufacturing level.
- *Ecosystem*: Facilitating formation of a conducive ecosystem for both the industry and the academia by addressing aspects such as materials, machinery, links with reputed national and international centres.
- *Entrepreneurship*: Scope for incubating small scale industries in the field of flexible electronics.
- *International Partnerships*: Develop strategic partnerships to aid accelerated product development cycle.
- *Human Resources*: Development of human resources for the relevant expertise.

v) BSNL IITK Telecom Centre of Excellence (BITCOE): Another CoE, under the PPP mode was established at IIT-K. An MoU signed between the DoT, GoI, IIT-K and Bharat Sanchar Nigam Ltd. founded this centre. The setting up of TCOE is a big initiative wherein the govt., academia and industry are working collaboratively and the biggest telco's of India have joined hands as principal sponsors. The main focus area of this centre is 'Multimedia & Telecom, Cognitive Radio & Computational Mathematics'.

Examples of technologies developed, patents filed and MoUs signed by IIT-K in 2014-15		
S. No.	**Technologies Developed**	
1.	Design and fabrication of autonomous flapping wing unmanned air vehicle for surveillance and aerial photography	
2.	Development of autonomous rotary unmanned aerial vehicle (RUAV) in 10 kg weight	
3.	Opto fluidic optical lens and lens filter system	
4.	Comprehensive air sampling device	
5.	Water purification filter	
6.	Laser-facilitated synthesis of metal	
S. No.	**Patents**	**Application Number**
1.	An instrument for tonic note selection & voice range determination for Indian music singer	1272/DEL/2014
2.	Remote monitoring and control for power system network using mobile SCADA application	1322/DEL/2014
3.	Coiled carbon nanomaterial coated carbon fiber reinforced high perfomance polymer nanocomposites for structural applications and method of manufacturing the same	1331/DEL/2014
4.	Compact air cooler using nano-structured surfaces	3246/DEL/2014
S. No.	**MoUs With Industry**	**Signed With**
1.	To design and develop computer programming course.	IREO Private Limited, New Delhi
2.	Experimental evaluation of textile reinforcement for seismic strengthening of masonry infills.	Saint Gobain Research India, Chennai
3.	Development of high strength highly ductile low carbon alloy multiphase steels for structural applications.	Tata Steels Ltd., Mumbai
4.	Conducting the CODE competition.	Hindustan Unilever Limited, Mumbai

Source: *https://www.iitsystem.ac.in/*

3.2.5. Indian Institute of Technology, Delhi (IIT-D)

(http://www.iitd.ac.in/)

Introduction: IIT-D was established in 1959 by GoI in collaboration with the British Government. Strong industrial links have been maintained by the faculty of the institute by means of consultancy assignments. These assignments include various aspects like process and product development, troubleshooting, parameter checks and many more. In addition to these activities, the faculty members of the institute also hold short-term training programmes that are company specific. To achieve enhanced industrial participation in the engineering education, the institute has taken an initiative to start with a masters degree programme which will be sponsored by the industry. It has dedicated centres to provide specific administrative and directorial aid for industry sponsored and consultancy projects and related R&D activities and has earned huge revenues of approx ₹ 0.36 crores from I-A interface. In the year 2014-15, there were 1300 research publications from the institute. From the year 2010 to 2015, the institute filed 146 patents, of which 25 were granted. Till date, 15 technologies have been licensed by the institute generating worth amounting nearly to ₹ 135 crores and 50 are ready to be transferred/ licensed. The institute earned ₹ 328 crores and ₹ 138 crores from sponsored projects and consultancy projects respectively (2010-14), generated 16 start-ups and has 44 incubatees presently. In the last five years, IIT-D has signed eight MoUs with industries.

Industry Related Programmes

i) The **Industrial Research and Development (IRD)** (http://ird.iitd.ac.in/content/about-ird): The IRD unit is responsible to provide administrative backing and management for the varied types of projects that are undertaken by the faculty of IIT-D. Through IRD, IIT-D has laid strong emphasis on sponsored research and industrial interactions (Fig. 3.7). It has contributed to solving industrial problems relevant to the needs of the country. IRD has initiated various industry sponsored master degree programmes to enhance industrial participation in R&D and engineering education. Main area for which IRD is working:

- Sponsored research projects (high impact projects)
- Consultancy jobs
- Professional development fund
- Intellectual property rights
- Sponsored fellowships
- Industry sponsored M. Tech programmes

Financial Year	Sponsored Research Projects	
	Numbers	Sanctioned Value (₹ Lakhs)
2010-11	130	12107
2011-12	123	5712
2012-13	142	8863
2013-14	150	6865
2014-15	164	15377

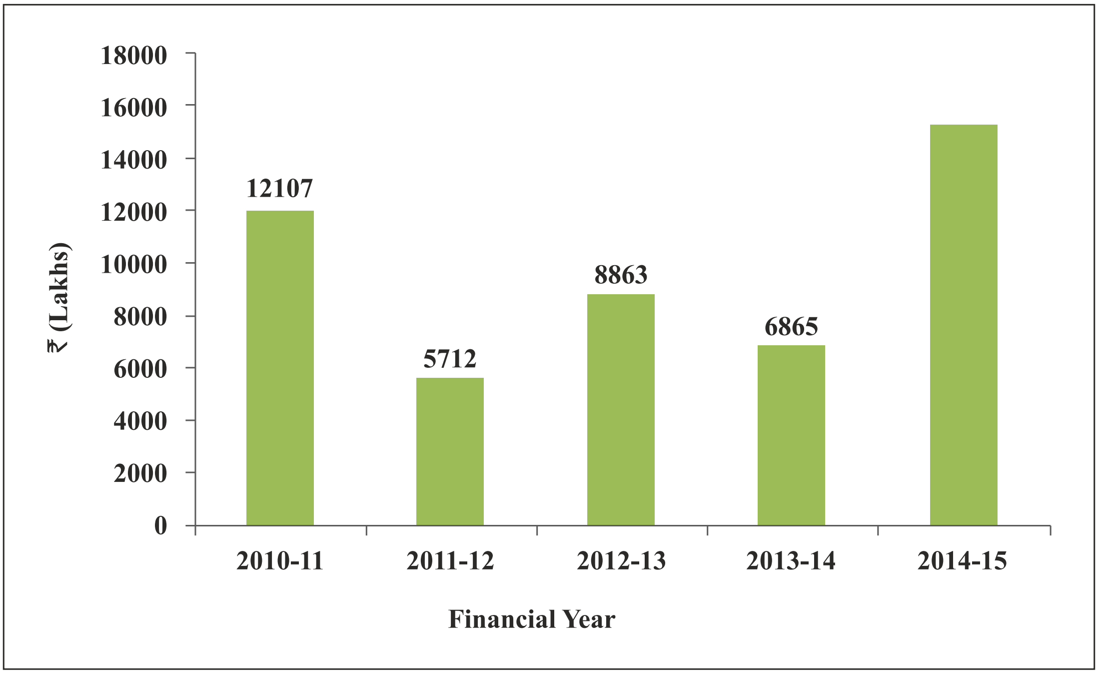


Figure 3.7: Sponsored Research Projects Undertaken Under IRD (2010-15)

Source: *http://ird.iitd.ac.in/IRD/Highlights.pdf*

ii) Foundation for Innovation and Technology Transfer (FITT) (http://www.fitt-iitd.org/): FITT was established in 1992 as a registered society. It is one of the most successful industrial interface organizations in the country. It aims to foster, encourage and build-up commercialization of R&D in IIT-D for mutual memberships. It has grown as self sustaining centre having numerous financial reserves in form of ₹ 0.36 crores in year 2015. FITT itself consists of number of services that are involved in innovation, technology and product development in collaboration with number of industries and generation of entrepreneurs and start-ups. Services offered by FITT are as following:

- Information support service to industry and R&D organisations
- Transfer of technology relating to proven R&D outputs
- Research partnership with industry for technology development and its commercial

applications

- Innovative problem solving consultancy with industry clients
- Industrial access to the array of specialised equipment and central facilities HRD programmes
- Corporate membership of FITT
- Facilitate funding for development of innovative ideas of commercial implications

With strong support from the government, FITT has established **Incubation Centres** such as **TBI, Biotech Incubation Facility, Science and Technology Parks.** FITT has been a huge success in terms of I-A collaborative project which has generated ₹ 52 crores of assets since last 5 years. There are more than 64 corporate clients who avail corporate membership of FITT and draw mutual benefits from the services that FITT offers and in return contributed to ~ ₹ 17 lakhs of FITT earnings. Further, >46 companies are presently incubated in FITT that has potential to become successful ventures.

FITT works towards bringing the research outputs of the scientific community to the market by way of patenting their innovative research and preparing a business model for their applied research *(For details please see pages 122-137).*

iii) Airtel IIT Delhi Centre of Excellence in Telecommunications (AICET): Collaboration between DoT, GoI, IIT-D and Bharti Airtel Ltd. (tri-partite MoU), lead to the establishment of AICET at IIT-D. This centre mainly focuses on 'Telecom Technology and Management' and is a part of the Bharti School of Telecommunication Technology and Management, which was set up at IIT-D in 2000. It aims to generate technology that is at par with the world standards thereby evolving India into a global leader in the area of telecom.

Examples of technologies developed by IIT-D in 2015-16

S. No.	Technologies Developed
1.	Dual functionalized redox sensitive biodegradable polymeric nanosystems for targeted drug delivery in cancer therapy
2.	Piezo-based foot pressure sensor
3.	Nanopatterned cadmium selenide langmuir-blodgett platform for leukemia detection
4.	Smart and innovative textile materials (SMITA)
5.	Limb immobilization device (LID)

Source: *https://www.iitsystem.ac.in/*

3.2.6. Indian Institute of Technology, Guwahati (IIT-G)

(http://www.iitg.ac.in/)

Introduction: IIT-G was established on September 1st 1994 and its academic programme commenced in 1995. IIT-G is the sixth member in the IIT fraternity and within a brief span of time it has evolved and built up a world class infrastructure for advanced scientific R&D activities. Research is an integral part of the academic activities at IIT-G. The sponsored research has helped to bridge the gap between the academia and industry, added to the infrastructure of the institute and acted as training ground for young researchers. The R&D Office is the wing of the institute which facilitates, channelizes, records, and regulates all the funded research projects and consultancy works. During the academic year 2014-15, the institute published 1250 research publications and total R&D funding received during the same time period was ₹ 73.95 crores. IIT-G has filed 37 patents (2010-15), of which six were granted. A revenue of ₹ 1 crore has been generated from the six technologies that have been transferred till date and five technologies are available with the institute for transfer. With over 50 corporate clients and close to 10 industrial collaborations, IIT-G has earned ₹ 220 crores from various sponsored projects and ~ ₹ 16 crores from consultancy projects. Ten start-ups have evolved from the institute and there are 13 incubating companies presently.

Industry Related Programmes

i) **IITG-Technology Incubation Centre (IITG-TIC):** In order to strengthen technology commercialization and entrepreneurship, IIT-G has established IITG-TIC (http://www.iitg.ac.in/tic/home.html) as a society under the Registration of Societies Act XXI of 1860. Its main objective is to back the entrepreneurial efforts amongst the faculty and alumni of the IIT-G. IITG-TIC provides a platform to explore and implement the innovative ideas into a commercially viable product through technology start-up companies. This centre facilitates interdisciplinary research with special emphasis on development and innovation of high-growth knowledge-based-business and nurtures the indigenous products with innovative hardware/embedded designs. The centre offers technical support, business mentoring and soft loan facility.

IITG-TIC also possesses one of the **Business Incubators** approved and recognized by the MSME. The TDB, GoI, has also approved grant assistance to IITG-TIC to support start-ups units.

ii) The **Rural Technology Action Group, North-East (RuTAG-NE):** The RuTAG-NE (http://www.iitg.ernet.in/mech/Rutag-pal/about1.htm) was established in 2006. The main objective of this centre is to modify and enhance the systems/technologies that have been developed and are functioning, to a better level, by means of S&T. For example, the process of production of Eri Silk, traditionally is very laborious and lengthy, for which, RuTAG-NE has developed a machine that has the ability to complete a day's work in an hour. This centre has also successfully established a pilot plant for the production of Muga Silk. RuTAG-NE is responsible for developing quite a few accessory machines such as Hank to Bobbin Winding Machine and Sectional Warping Machine, etc. The cost of these machines is lower as compared to their cost in the market. RuTAG-NE has also been training group of women from an NGO for the production of cost effective necessities.

In the academic year 2014-15, a technology '*Grating array based zonal wavefront sensor board setup*' was developed at the institute.

3.2.7. Indian Institute of Technology, Roorkee (IIT-R)

(http://www.iitr.ac.in/)

Introduction: The College at Roorkee was established in 1847 AD and was the first engineering college in the British Empire. It attained the status of a University under the Act No. IX of 1948 of the United Province (Uttar Pradesh). In 1949, Pt. Nehru elevated the status to the First Engineering University of Independent India, through a Charter. The Roorkee University was declared as an institute of national importance, with the passing of a bill in the parliament, on September 21st 2001 and was then renamed to Indian Institute of Technology Roorkee (IIT-R). In the year 2014-15, IIT-R has 1209 publications to its credit and generated a revenue of ₹ 38.05 crores through industrial consultancy in the same year.

Industry Related Programmes

i) **Sponsored Research and Industrial Consultancy (SRIC)** (http://www.iitr.ac.in/research/pages/SRIC.html)**:** IIT-R recognizes the importance of the teamwork of education with research and industrial consultancies. Under the Dean, an office of SRIC operates, that caters towards providing organizational and accounting support to the members of the faculty that are performing sponsored research and industrial consultancy work. The centre also offers backing/support by working closely with the private sector and government organizations and facilitating IP protocols.

Some examples of industrial consultancy are:

- Development of industrial projects/systems/processes
- Development of laboratories
- Testing of industrial products/samples
- Development and application of information technology
- Pre-feasibility and feasibility studies

ii) The **Entrepreneurship Development Cell (EDC)** (http://edciitr.com/): The EDC of IIT-R, was set up to encourage entrepreneurial activities among the scholars of IIT-R and to foster the spirit of creativeness and innovation. Initiatives taken by EDC cell are:

- Endeavour entrepreneurship
- E-Club to overcome problems of students
- Start-up internship programme to lessen the gap amongst the students and the start-up ecosystem
- An online database of start-ups (startups.edciitr.com) of students and alumni of IIT-R
- PrernaYatra which is an entrepreneurial journey organized by EDC IIT-R
- Incubate which is a B-Plan competition organized by TIDES Centre

iii) Intellectual Property Right Cell (http://www.iitr.ac.in/ipr/index.html**):** IIT-R has also created a cell to generate alertness and administer guidance to staff, students and outside agencies. This IPR cell contributes by equipping every one of the practices and the rules of institute regarding IPR and the obligations to be followed in course with the IPR policy of the institute. DST started a programme known as "Technopreneur Promotion Programme" (TePP) in 1998-1999 to promote and support the creative intellect of innovators of the country and to assist technopreneur in developing linkages with organizations. Outreach centres of TePP, known as TePP Outreach Centre (TUC), have been opened in different parts of the country and also at IIT-R.

iv) RailTel IITR Centre of Excellence in Telecom (RICET): This CoE was established by DoT in association with RailTel and IIT-R to work in the area of 'ICT and Broadband Applications'. The main objectives of this centre include developing applications that are specific to the needs of India and therefore will add value to the economic and social activities of the citizens. These CoEs also aim to generate market ready workforce and continuously upgrade the technical know-how in their domains.

v) Continuing Education Centre: The Centre conducts 60 to 70 short term training programmes for personals of the industrial sector and govt./semi govt. organizations and public undertakings, research institutions and industries.

Patent and a technology developed by IIT-R in 2015-16		
S. No.	**Technology Developed**	
1.	ED cell/ CD cell with membrane for zero discharge of waste water	
S. No.	**Patent**	**Application Number**
1.	A novel fractionating hydrolysis process for production of fermentable sugars from lignocellulosic biomass of kans grass (*Saccharum spontaneum*)	201611005358 Dt 16.2.2016

Source: *https://www.iitsystem.ac.in/*

3.2.8. Indian Institute of Technology, Bhubaneswar (IIT-BBS)

(http://www.iitbbs.ac.in/)

Introduction: IIT-BBS was established in 2008 from the campus of its mentor institute IIT-KGP and in 2009 it commenced its operation from the city of Bhubaneswar. The institute has been undertaking a number of research projects from funding organizations like DST, CSIR, DRDO, NIC and ISRO and consultancies to industries. Till now the institute has published ~ 1000 research publications and has filed 12 patents. Industries like M/s MGM Minerals Group have helped the institute develop, by establishing "MGM Chair Professor" in the School of Minerals, Metallurgical and Materials Engineering with an endowment of ₹ 300 lakhs.

Industry Related Programmes

i) **Sponsored Research and Industrial Consultancy (SRIC) Cell** (http://www.iitbbs.ac.in/sric-application/)**:** SRIC coordinates all sponsored research and consultancy projects. MoUs have been signed with various industrial collaborators such as the MGM Minerals Group to work in areas of common interest. A large number of research projects along with industrial consultancy projects are carried out independently in each school though IIT-BBS does not have any dedicated cell for I-A activities. From 2010-15, IIT-BBS has carried out 170 sponsored projects, mainly government funded and 41 industrial consultancy projects.

Since 2010, industry has actively collaborated with the institute by means of consultancy and has contributed to more than ₹ 48 crores of revenue (Fig. 3.8).

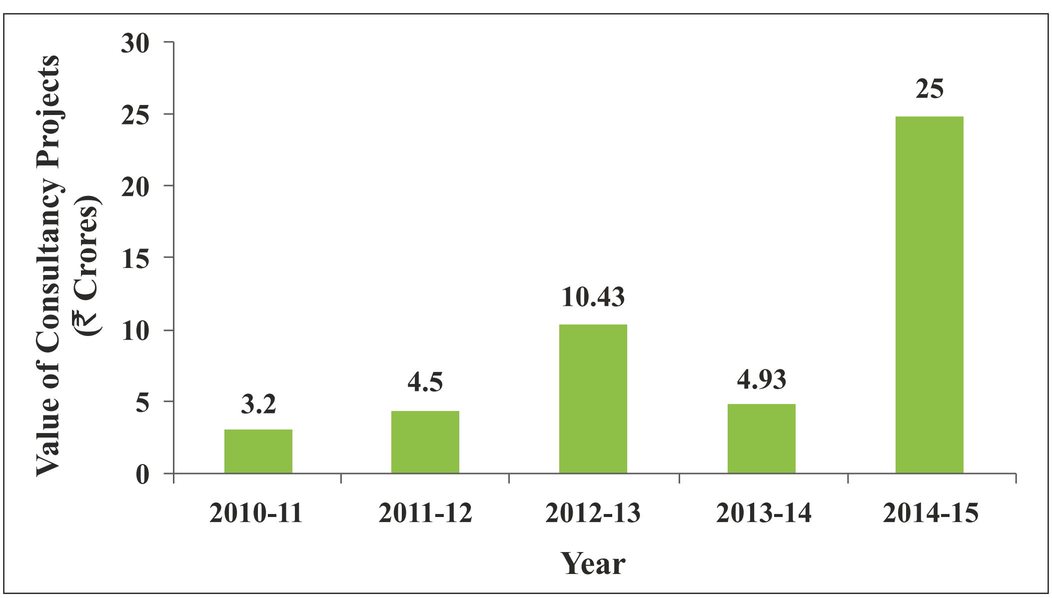


Figure 3.8: Value of Consultancy Projects Undertaken by IIT-BBS
Source: *IIT-BBS Annual Report 2014-15*

Examples of technologies developed and MoU signed by IIT-BBS in 2015-16		
S. No.	**Technologies Developed**	
1.	Verification of virtual live migration between data centres in cloud	
2.	Fuel for all: Optimization of indian LPG cylinder distribution system	
3.	A thousand eyes: Ensuring a safer world through a vehicle mounted surveillance system	
4.	Development of structural lightweight concrete using sintered flash aggregate	
5.	Development of an integrated zero energy modular system for the treatment of rural domestic wastewater: emphasis on nutrient removal	
S. No.	**MoU With Industry**	**Signed With**
1.	Advanced research laboratory on big data analytics	Affine Analytics Private Ltd.

Source: *https://www.iitsystem.ac.in/*

3.2.9. Indian Institute of Technology, Hyderabad (IIT-H)

(http://www.iith.ac.in/)

Introduction: IIT-H was found in 2008 at a makeshift campus in ordinance factory in Medak district and in 2009 shifted to its main campus in Kandi. IIT-M acted as mentor institute for IIT-H by supporting it at various levels. IIT-H today boasts of around 1850 students, 145 faculty members and 14 academic departments covering areas of engineering, sciences, liberal arts and design. The scientific staff and the disciples of the institute are at the forefront of academic innovations and innovative research. IIT-H has had approx. 930 publications, 15 patents filed and close to 230 sponsored research and consultancy projects (Annual Report 2014-15). IIT-H has tie-ups with industrial giants who provide the students scholarships and research internships.

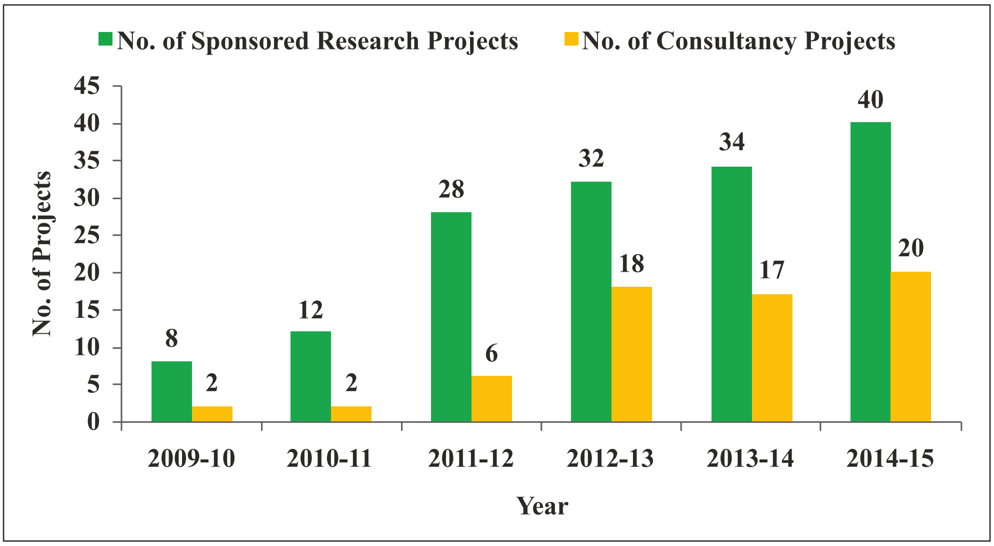


Figure 3.9 (A): Number of Sponsored Research and Consultancy Projects Undertaken by IIT-H

Source: *IIT-H Annual Report 2014-15*

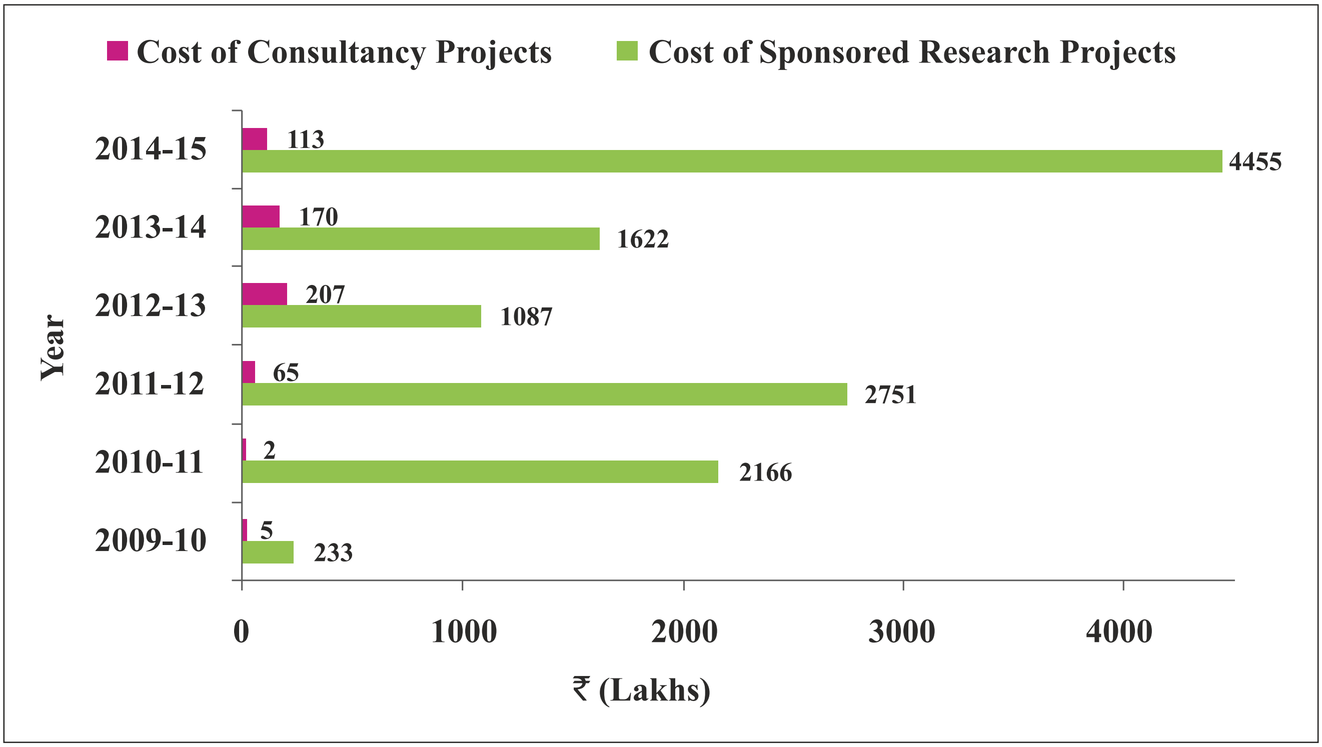


Figure 3.9 (B): Cost of Sponsored Research and Consultancy Projects Undertaken by IIT-H

Source: *IIT-H Annual Report 2014-15*

IIT-H has established collaboration with various industries located in and around Hyderabad. Mainly the institute offer consultancy to the industries. IIT-H has undertaken more than 45 industry consultancy projects. Figure 3.9 (A & B) shows the trend in sponsored and consultancy projects undertaken by IIT-H, 2010 onwards. Over 100 sponsored projects from national funding agencies and private companies have been undertaken by the institute. IIT-H is in association with ~100 companies and is on the way to establish strong I-A interface in coming years.

Recently, the institute launched its **Technology Business Incubator** to promote entrepreneurial culture. The incubator has incubated 4 companies. In IIT-H, **TEQIP** has also been set up to aid transformation in technical education system with support from World Bank. IIT-H is associated with **Unnat Bharat Abhiyan** and working for rural development by producing technologies for accelerating growth in rural areas.

Industry Related Programmes

i) Center for Healthcare Entrepreneurship: This center was inaugurated in the year 2015 and is sponsored by two entrepreneurs (IIT Bombay alumini) from the Silicon Valley. This center aims towards innovative, affordable healthcare solutions for addressing the needs of India's population, particularly the underserved. The centre identifies and groom innovators, mentor them to the level of production, scale up and eventually societal adoption of the technology/ product and its impact.

ii) Entrepreneurship Cell (E-Cell): The E-Cell at IIT-H is a student run body that aims to foster entrepreneurial temper amongst the students of the institute. The cell supports the innovative streak in the students by providing them with resources, networking, guidance and motivation. Various events hosted by the cell include idea to business workshops, lecture series (by entrepreneurs from all over the country) and prototyping events.

Examples of technologies developed and patents by IIT-H in 2015-16		
S. No.	**Technologies Developed**	
1.	Earthquake disaster management system	
2.	Snake robot for search and rescue missions	
S. No.	**Patents**	**Application Number**
1.	Silver nanoparticle array sandwiched multilayer thin film amorphous silicon photovoltaic device	–
2.	An apparatus for measuring transverse pullout resistance of a reinforcing element and method thereof	CHE/2015
3.	Lateral reinforcement system and method for concrete structures	3001/CHE/2015

Source: *https://www.iitsystem.ac.in/*

3.2.10. Indian Institute of Technology, Gandhinagar (IIT-GN)

(http://www.iitgn.ac.in/)

Introduction: IIT-GN was founded in 2008 and is located in Ahmedabad (Gujarat). The institute is strongly working to attract industries for carrying out research and consultancy projects. For industrial outreach it has started a couple of programmes i.e. Industry Open House and Industry Partnership Retreat. The institute has partnered with >25 industrialists for carrying out research in various domains. These events showcase expertise, infrastructure capabilities of institute that can be availed by industrial sector. Till now, the institute has undertaken 54 sponsored research projects and 23 consultancy projects from government and industrial collaborators. Till date it has filed 8 patents and ~1266 publications.

Industry Related Programmes

i) IIT-G Incubation Centre (IIC): It has been established to promote innovation and entrepreneurship. In 2012, the institute received TIDE grant from MeitY to enable creation of incubator. IIC is well connected with ecosystem partners and incubators in Ahmedabad. It contains one non-resident and 2 resident incubatees. The institute has launched a deferred placement policy in 2014 for enabling students to opt out of placement and pursue their entrepreneurship dreams.

ii) **Innovation and Entrepreneurship Centre (IIEC)** and **Technology Business Incubator** (under aegis of DST) were established to support incubation and technology commercialization is under progress. IIT-GN has also launched **Women in Start-ups (WINS)** an initiative for fostering techno-entrepreneurship skills among women.

iii) The institute has community outreach programme namely **Nurture and Empower Entrepreneurial Ventures (NEEV)** to promote growth of entrepreneurship through training, mentoring and networking opportunities.

Examples of technologies developed and MoUs signed by IIT-GN in 2015-16		
S. No.	**Technologies Developed**	
1.	Smart eye	
2.	One touch doctor	
S. No.	**MoUs With the Industries**	**Signed With**
1.	To encourage collaborative research with leading industries around the globe for providing technological innovation	KHS Machinery Pvt. Ltd., Ahmedabad
2.	Analog lab setup	M/s EdGate Technologies Pvt. Ltd., University Program partner of Texas Instruments, India
3.	To organize a program for academic cooperation in areas of mutual interest	Xylem Water Solutions India Pvt. Ltd., Vadodara, Gujarat
4.	To promote collaboration between industry and academia for joint research and development of bio-medical information processing/instruments, healthcare/lifestyle products and security systems.	Pracsol Health India Pvt. Ltd. (PHIPL)
5.	Analog teaching lab setup	Cranes Software International Ltd.
	For intensifying academic cooperation	Tata Consultancy Services Ltd.

Source: *https://www.iitsystem.ac.in/*

3.2.11. Indian Institute of Technology, Patna (IIT-P)

(http://www.iitp.ac.in/)

Introduction: IIT-P was established on August 06, 2008. Initially the institute was under the mentorship of IIT-G. The institute has now carved a niche in the domains of education, inquests and research. It has ten academic departments with student strength of 670 in the undergraduate courses, 160 in postgraduate courses and 250 in the doctoral program. The institute has been growing steadily with the increase in number of faculty members to 101 and a non teaching staff of 70 members. In the year 2014-15, the institute published nearly 75 research publications.

Industry Related Programmes

i) Sponsored Research and Industrial Relations Unit (SRIRU) (http://www.iitp.ac.in /index.php/research/r-and-home.html): IIT-P considers the need to facilitate R&D efforts in a disciplined manner to ensure a strong base and growth in research by generating resources, effective collaborations and links with the private sector. SRIRU, established in 2009, is a special unit set up to act as a unit to coalesce the funding agencies and IIT-P for handling the industrially sponsored research and consultancy works. SRIRU handles the directorial and logistics aspects related to recruitments, accounts, audits, liaisons with sponsors, and prepare the status reports.

ii) IIT-P has also set up an **Incubation Centre (IC)** in the area of Electronic System Design & Manufacturing with focus on Medical Electronics. This is funded by DeitY (now known as MeitY) & Bihar State Government. IC focuses on developing products for commercial exploitation via the route of physical infrastructure, technical expertise and networking support to new enterprises with innovative technologies.

iii) Entrepreneurship Club (http://www.iitp.ac.in/ecelliitp/): This club is established by the students of IIT-P with the goal of forming a common point for the aspiring entrepreneurs at the institute. The students aim to foster an environment that would empower aspiring students by coordinating with successful entrepreneurs who have undertaken this path. Various lectures and workshops on business topics are held, successful entrepreneurs and industry leaders are invited for business talks and speeches. This plan has been devised by the students to promote entrepreneurship within the IIT-P community

IIT-P has also taken initiative in curriculum development for the industry. The institute offers post graduate courses for industry personnel.

Examples of patents and MoUs signed by IIT-P in 2015-16		
S. No.	**Patents**	**Application Number**
1.	Automatic booklet scanning machine (ABSM)	Indian Patent Application No. 1082/KOL/2015
2.	New design application - Handle operated garbage & soil Collector	Indian Design Application No : 272013/D/NF/SKM
S. No.	**MoUs With the Industries**	**Signed With**
1.	Centre of excellence of natural language processing	Reed Elsevier India Private Limited
2.	Research on NLP and machine learning	Process Nine Technologies Pvt. Ltd, Gurgaon
3.	EzDI research lab of health informatics	Mediascribes Solutions (India) Pvt. Ltd.

Source: *https://www.iitsystem.ac.in/*

3.2.12. Indian Institute of Technology, Jodhpur (IIT-J)

(http://www.iitj.ac.in/)

Introduction: The MHRD announced the establishment of eight new IITs in the country on March 28th 2008. IIT-J (formerly known as IIT Rajasthan), was one of them. The institute has collaborations with Microsoft R&D, IBM, and TCS. Representatives from top industries pay regular visits to the department for delivering seminars, conducting workshops.

Industry Related Programmes

i) IIT-J has a well placed **Office of R&D**, which is responsible for organizational and directorial support for sponsored research projects, industrial consultancies and other R&D activities of IIT-J. It facilitates and promotes collaborations between the industry and academia, and the liaisons between the institute and various funding agencies. This office also carries the responsibility of facilitating documentation of the intellectual property of the institute and filing of patents. The office runs the interface for:

- Management of projects (sponsored, consultancy & other research projects).
- Management of office-Publishing of R&D newsletters, research magazine of the institute, developing a database of R&D contacts in industry, academia and other organizations (national and international).
- It also manages the MoUs, IPRs and other corporate communications of the institute.
- Industry liaisons are also held with the Office of R&D. All the interactions with the industry, industrial R&D, consultancy, extension services, technology transfers, industry internship for faculty mainly are looked after by the Office of R&D.

ii) **Entrepreneurship Cell** (http://iitjecell.in/index.html): IIT-J has started an entrepreneurship cell to develop the entrepreneurial mindset in aspiring entrepreneurs. Organizing the start-up visits and conducting case studies on successful start-ups are main events organized by this cell.

iii) **Blended Technical Education Program:** IIT-J is initiating to collaborate with industries towards enhancing the learning experience of students and faculty members. The thought behind the Blended Technical Education Program was to inspire the students to help solve the obstacles of the Indian industry. The aegis of the program desired to have industry captains lay a framework by giving a real life picture of sectoral technologies, needs of the industry, challenges and research opportunities. The program encompasses other programs, such as:

- **Vanguard Lectures**-The Vanguard Lecture Series form an integral part of Blended B. Tech. Program. These lecture series enable the students to get a know-how of the industrial ecosystem and deeper insights in the technological areas, by listening to talks given by distinguished experts from the industry and academia. The first phase of the program began in July 2014, and since then it has witnessed two successful series of vanguard lectures delivered by the domain experts from industry and academia.

- **Industry Immersion Program (IIP)**-The Institute has signed MoUs with leading Indian industries to strengthen its undergraduate technical education. Currently, five industry partners have joined the IIP, namely: (1) Mahindra & Mahindra Ltd., Mumbai; (2) Larsen & Toubro Ltd., Mumbai; (3) Tata Motors Ltd., Mumbai; (4) TVS Motor Company Ltd., Chennai; and (5) Tata Power Ltd., Mumbai. The IIP is an impressive module that focuses on learning by doing and working on live assignments under the mentorship of industry professionals. This program will also help the faculty members by broadening their horizon and giving them the ability to look beyond the institute for developing relations with the industry. A precedent of the same is an MoU signed between the institute and TVS Motor Company, Chennai. It is aimed at expanding I-A collaboration by giving the faculty and students of the institute an experience of the industry and in turn, the professionals of TVS can get academic experience.

A patent and a technology developed by IIT-J in 2015-16		
S. No.	**Technology Developed**	
1.	Open volumetric air receiver (OVAR)	
S. No.	**Patent**	**Application Number**
1.	A black chromium coating bath	1433/DEL/2013

Source: *https://www.iitsystem.ac.in/*

3.2.13. Indian Institute of Technology, Ropar (IIT-RPR)

(http://www.iitrpr.ac.in/)

Introduction: IIT-RPR was established in 2008 by the MHRD under the mentorship of IIT Delhi. The institute of national importance is located at Rupnagar in the state of Punjab. The institute in its endeavour to live up to the status and brand name created by its predecessors is keen to establish a robust academic environment along with facilitating cutting edge R&D. The faculty at IIT-RPR is encouraged to initiate research work and are also provided with facilities/initial grants to sustain research work. The institute pushed the faculty to perform collaborative research with other research labs and also with the industry. The institute has a number of consultancy projects to its credit. IIT-RPR is soon going to establish a 'Central Research Facility' to amplify its research activities. The institute has set up dedicated cells to strengthen and reinforce the spirit of innovation and entrepreneurship amongst its faculty and students.

Industry Related Programmes

i) **Prototype Development and Innovation Fund (Entrepreneurship Cell):** This initiative was set up in collaboration with the Punjab Technical University, to foster innovation within various domains of knowledge and technology development. It aims to work towards finding innovative solutions for industrial and societal concerns that are critical to the world. This fund was established to address the gap between research laboratories and the market. It funds projects that are commercially viable and have the potential to serve the technological needs of the nation.

ii) **Intellectual Property Rights (IPRs) Cell:** The Patent Information Centre (PIC), located in Punjab State Council for Science & Technology, Chd., has set up an IPR Cell at IIT-RPR to provide IPRs protection information and patenting facilities to the institutes faculty and students. The cell is responsible for all activities related to patenting and technology transfers to the industry.

iii) **Technology Business Incubator (TBI):** The institute has received a grant of ₹ 500 lakhs to set up a TBI in Punjab. This grant shall be devoted towards the central government's "Start-Up India Programme". The incubator will foster innovation and entrepreneurship ecosystem. TBI will provide various facilities like mentoring, physical office space, library and equipments among other things. Key focus will also be on providing networking and marketing support to all incubatees in order to enable and prepare them to raise capital through angel funding. The TBI, with specialized *state of art* facility will focus on providing the incubatees unlimited access to the skilled resources in the field of S&T, in order to help them grow. The main objectives of this incubator are:

- To promote new technology/knowledge/innovation based startups.
- To build a vibrant startup ecosystem, by establishing a network between academia, financial institutions, industries and other institutions.
- To provide cost effective, value added services to startups like mentoring, legal, financial, technical, intellectual property related services.
- To provide a platform for speedy commercialization of technologies developed by the host institution or by any academic/technical/R&D institution or by an individual.
- To create jobs, wealth and business in alignment with national priorities.

iv) IIT-RPR has a **Centre for Innovation & Business Incubation (CIBI),** which provides incubation services for start-ups with a technology and knowledge base. Established in 2013, this center focuses on accelerating innovation, business incubation and growth of entrepreneurship at IIT-RPR. The objective of CIBI is to facilitate the 'conversion of research activity into entrepreneurial ventures'. It has received financial assistance from various sources along with from DST, GoI. The institute is supporting four start-ups, at the moment.

3.2.14. Indian Institute of Technology, Indore (IIT-I)

(http://www.iiti.ac.in/)

Introduction: The institution was set up in 2009. IIT-I through its endeavours has attained international importance and recognition. The institute has been a participant in several projects of international repute and also is in partnership with different research organizations. IIT-I has gained recognition due to its collaborative research efforts with agencies from many foreign countries like USA, France, S. Korea, Japan, Germany, Portugal etc. The institute has generated a net worth close to ₹ 22 crores through approximately 82 sponsored projects.

Industry Related Programmes

i) **Innovation and Entrepreneurship Development Centre (IEDC):** This centre was funded by DST, with a purpose to foster an environment of innovation and entrepreneurship. This centre has supported the on campus student activities by setting up **Student Entrepreneurship Support Cell (SESC).** SESC has been proactively generating awareness amongst the pupils through the means of events and workshops and bolstering them for entrepreneurial efforts. In a time span of six months, since the initiation of this cell it conducted nearly 50 events and also bagged the 2nd position at National Entrepreneurship Challenge organized by IIT Bombay in February, 2014 and Best Debutant Award in E-Week in March, 2014, organized by National Entrepreneurship Network. IIT-I students are charged and are in the process of initiating their entrepreneurial ventures thereby applying their innovative ideas into practical applications.

ii) To develop linkages with the private sector and to cater to their needs of enhancing their academic qualifications, IIT-I has initiated **Continuing Education Programme (CEP)** and 'Short Courses' for working professionals in industry, institutions and other organizations across India. These courses enable them to update their knowledge and skills, and also to train them in *state of art* facilities.

Examples of patents and MoU signed by IIT-I in 2015-16		
S. No.	**Patent**	**Application Number**
1.	Method device and apparatus for managing phone/device Profile based on an event	3415/MUM/2015
S. No.	**MoUs With the Industries**	**Signed With**
1.	Technical mentoring of the students at IIT Indore	IBM India Private Limited
2.	Training programs for the life sciences student community	Wipro GE Healthcare Pvt. Ltd., Bengaluru

Source: *https://www.iitsystem.ac.in/*

3.2.15. Indian Institute of Technology, Mandi (IIT-MN)

(http://www.iitmandi.ac.in/)

Introduction: IIT-MN is an autonomous premier engineering institute located in Himachal Pradesh, which was established in 2012, in association with IIT Roorkee.

The institute encourages linkages with the industry and the students are required to undergo industrial training. The **Career and Placement Cell** at the institute facilitates the internship of the students at various reputed industries.

Example of a technology developed and MoU signed by IIT-Mandi in 2015-16		
S. No.	**Technology Developed**	
1.	Interactive landslide simulator for risk communication against landslides (http://pratik.acslab.org/)	
S. No.	**MoUs With the Industries**	**Signed With**
1.	TCS research scholar program	Tata Consultancy Services Limited

Source: *https://www.iitsystem.ac.in/*

3.2.16. Indian Institute of Technology, BHU (IIT-BHU)

(http://www.iitbhu.ac.in/)

Introduction: The Institute of Technology, Banaras Hindu University (IT-BHU), was converted into Indian Institute of Technology (Banaras Hindu University), Varanasi by the GoI, New Delhi on 29th June, 2012. The institute gives due importance to links with the industry and it is mandatory for students to undergo industrial internship which is facilitated by the **Training and Placement Cell.** The campus placements of the students in various industries are also looked after by the cell. Soft skill development programmes to make the students industry ready are undertaken by the cell. To inculcate the spirit of innovation and creation of entrepreneurs the institute has set up a dedicated cell.

Industry Related Programmes

i) Malaviya Centre for Innovation, Incubation and Entrepreneurship (MCIIE): All the industrial and societal activities of IIT-BHU are being coordinated by MCIIE. This centre is also registered as a separate society. This centre was set up with a dedication to promote innovation and entrepreneurship. The centre aids the guidance of knowledge driven enterprises and facilitates the commercialization of a product. This centre fosters the establishment of newer firms that create jobs, commercialize novel technologies thereby strengthening the national economy.

Examples of technologies developed and patents by IIT-BHU in 2015-16		
S. No.	**Technology Developed**	
1.	Synthesis of water based adhesives (http://www.shrimalibond.com)	
2.	Extraction of silica from rice husk ash (http://www.bridgedots.com/)	
3.	Reverse osmosis based potable water system with improved yield (http://www.aquvio.com/)	
S. No.	**Patents**	**Application Number**
1.	Application of grafted amylopectin for waste water treatment	60/Cal/2001
2.	An innovative polyherbal bioabsorbable dermal patch for wound healing	2087/DEL/2015
3.	A novel polyherbal formulation for growing adolescent girl and process for its preparation	736/DEL/2015
4.	A novel polyherbal formulation for reduction in obesity and process for its preparation	735/DEL/2015
5.	An improved caving longwall method for winning of coal from thick seam in single life under massive and hard roof conditions in underground mines	212/DEL/2002
6.	Device for sealing inside an upward drilled borehole for high pressure water injection in underground mines	855/DEL/2001

Source: *https://www.iitsystem.ac.in/*

3.3 Summary

- IITs not only impart top class teaching but also carry out globally competitive R&D in the domains of engineering and biotechnology. Industry-Academia (I-A) engagements are the highlight of all IITs.
- Each new IIT is being mentored by one of the first generation IITs, e.g. IIT-H and IIT-RPR are being mentored by IIT-M and IIT-D respectively.
- IIT-KGP leads all IITs in the parameter of *Publications* (2162) in the time period 2014-15. IIT-B (~1500), IIT-D (1300) and IIT-K (1298) occupy second, third and fourth position respectively. IIT-KGP also leads in the number of Incubating Companies (172), followed by IIT-M (95) and IIT-B (71).
- IIT-B leads in the following parameters: *Patents filed* (569) and *granted* (>61) in the period 2010-15), *Technologies available* (409) and *licensed* till date (>140), and *industrial collaborations* (225) in the time period 2010-15.

- First generation IITs have been generating large amount of revenues through their linkages with the industrial sector by means of sponsored projects and consultancy projects. IIT-M ranks number one amongst all IITs in *Revenue generated through Technology Transfers* (₹ 461 crores) till 2015 and *Consultancies* (₹ 251 crores).
- A vibrant *I-A interface* is present in IITs e.g. *SRIC* at IIT-KGP, IIT-R, IIT BBS, *IRCC* at IIT-B, *IC&SR* at IIT-M, *SIIC* at IIT-K, *IRD* at IIT-D and *SRIRU* at IIT-P. This interface manages the industrial relations of the institute and monitors the R&D activities being performed at respective IITs.
- To protect and promote the IP of the institute, nearly all IITs have set up dedicated *IPR Management Cells.*
- To encourage the spirit of entrepreneurship and start-ups, most IITs, such as IIT-KGP, IIT-B, IIT-M, IIT-R, IIT-H, IIT-GN, IIT-P, IIT-J, IIT-I, IIT-BHU have established *Entrepreneurship Cells.*
- A few IITs, namely IIT-KGP, IIT-D, IIT-M, IIT-G, IIT-H, IIT-GN and IIT-RPR have established *Technology Business Incubators* (TBIs) to nurture technology and knowledge based enterprises and assist them during their start-up period, which is close to three years. TBIs offer space, services, technical assistance, legal assistance, networking support, access to infrastructure and equipment, financial support, as well as, assistance in the development of business plans.
- A few IITs like IIT-KGP, IIT-M, IIT-B have come up with *Research Parks* which aim to create an environment for innovation and entrepreneurship.
- The IITs have also been working towards dispersing knowledge to the society outside. Barring a few, most of the IITs have *Continuing Education Programme (CEP)* for the industry personals. IIT-D also offers a special *Professional Candidate Registration (PCR) programme,* and IIT-RPR offers *Part-time Ph.D for industry personals*.

3.4 Conclusion

The ever thriving economy of India demands committed technical resources (manpower) and technology creators. This requires an environment conducive for fostering innovative intellect that is driven by the knowledge base. The IITs not only impart top class teaching but are also equally effective in converting their academic wealth into commercial success by means of patents, technology transfers etc. The presence of all components needed for translational research namely, I-A Cell, IP Cell, Entrepreneurship Cell, Centres of Excellence (R&D) is responsible for the success stories of technologies, products, patents and start-ups in the first generation IITs. Second generation IITs are in the process of developing infrastructure needed for translational research. Once it is in place, these IITs will also be a force to be reckoned with in the domains of publications, patents and technologies.

In India, majority of 700 universities and > 300 national research laboratories are devoid of value chain needed for converting scientific knowledge into innovative product. However, there are handful of universities which are regularly publishing large number of research papers in reputed journals and also have a few patents/technologies to their credit. Such institutes should be identified and provided funds for the creation of translational research ecosystem (TRE). The establishment of such value chain in these institutes will certainly help in boosting the number of patents and technologies. Also, on the lines of having one older IIT mentoring a new IIT, universities having potential for generating IP can also be allocated one mentoring IIT.

Addendum

Impacting Research Innovation and Technology (IMPRINT) India Initiative for IITs; (www.imprint-india.org)

To achieve economic prosperity and growth, the R&D efforts need to be directed towards finding solutions for the societal and economical challenges faced by our country. To address such challenges, MHRD, adopted engineering and technology as the key solution drivers and therefore initiated a new innovative programme i.e. IMPacting Research INnovation and Technology or IMPRINT. This programme, which is a joint initiative of the Pan-IIT and IISc-Bangalore, will cater to the challenges in science and engineering sector to enable, empower and embolden the nation for inclusive growth and societal development. The programme will be carried out by the scientific fraternity of sixteen IITs and IISc-Bangalore. The domains and coordinators of IMPRINT will be steered by the Director of IIT Kanpur, Prof. Indranil Manna who is heading IMPRINT India Initiative. IMPRINT has signed MoUs with 25 ministries to support them to carry forward research work carried out in IITs.

The 10 identified domains of societal importance, and the institute responsible for accomplishing the objectives of these domains, are as mentioned below:

Institute	Domains# (10)
IIT Kharagpur	· Information and Communication Technology · Health Care
IIT Bombay	· Nano-technology Hardware · Energy
IIT Kanpur	· Water Resources and River systems · Advanced Materials
IIT Madras	· Manufacturing · Security and Defense
IIT Roorkee	· Sustainable Habitat
IISc Bangalore	· Environmental Science and Climate Change

#Each domain is categorized into themes, sub-themes, target and topics for promoting research and innovation.

These 10 domains are the ones which categorically represent the most relevant areas, with respect to achieving sustainable growth and self reliance for our country. Each domain is further sub divided into themes, sub-themes and so on to enable comprehensive and thorough education and research in the areas of relevance.

- IMPRINT is working with a task force to map the strength and weakness in Indian education system to champion the engineering targets.
- Under IMPRINT initiative, focus is on strengthening academia and industry linkages in order to create and sustain an inclusive scientific eco-system in society to develop novel goods and services to add both competitive edge and add value in serving the nation.
- Presently, IMPRINT is in its first phase which is focusing on creation of a policy document that will define the scope, mandate and strategy for pursuing engineering challenges in the country.
- Second phase of IMPRINT will focus on developing technological products/ processes through well developed innovation system for the societal need.
- 229 projects worth ₹ 59,589 lakhs have been proposed under the India specific research, IMPRINT scheme. These projects will be co funded by 31 ministries and government departments.
- The health ministry has proposed to co-fund 62 projects, the DRDO will support 43 projects, DST will aid 24 projects, MeitY will co-fund 21 projects and ISRO has proposed to support 7 research projects.

Appendix

Foundation for Innovation and Technology Transfer (FITT)

1. Introduction

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.

2. 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.

Table1: 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 BIORxVenture 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., Bengaluru
2.	Thermal NDE: Modelling framework for crack detection	GE India Technology Centre Pvt. Ltd., Bengaluru
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, USA
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, USA
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, USA

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. 5.3.2).

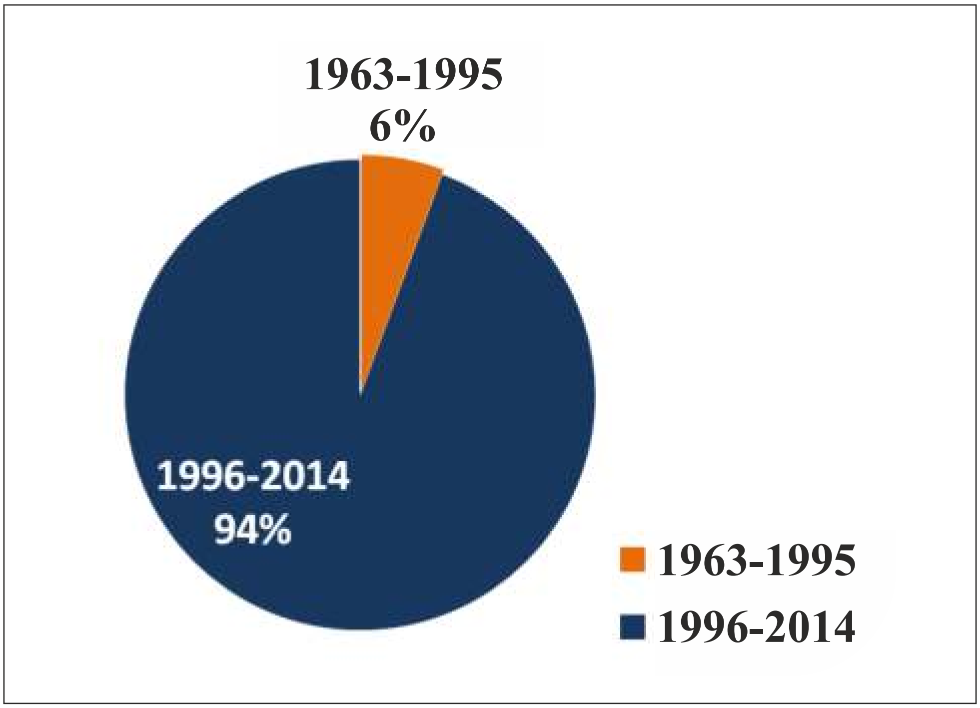


Figure 1: Patents Filed Before and After the Inception of FITT

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 India Pvt. Ltd., 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 issues that 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.

3. 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

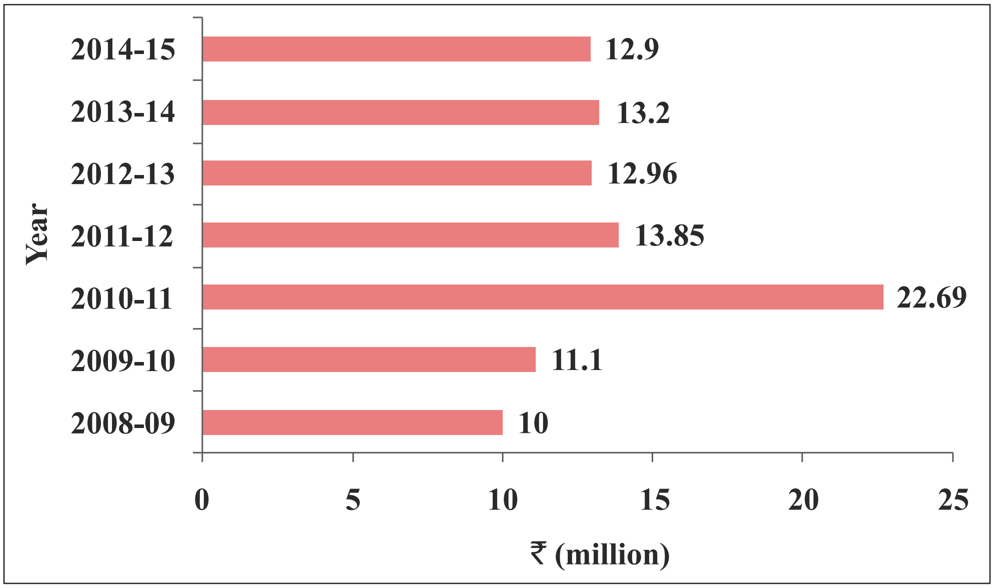


Figure 2: Asset Generation (Infrastructure, Equipments and Transfer of Funds) from FITT for IIT-D

Source: *FITT Annual Reports, 2008-15*

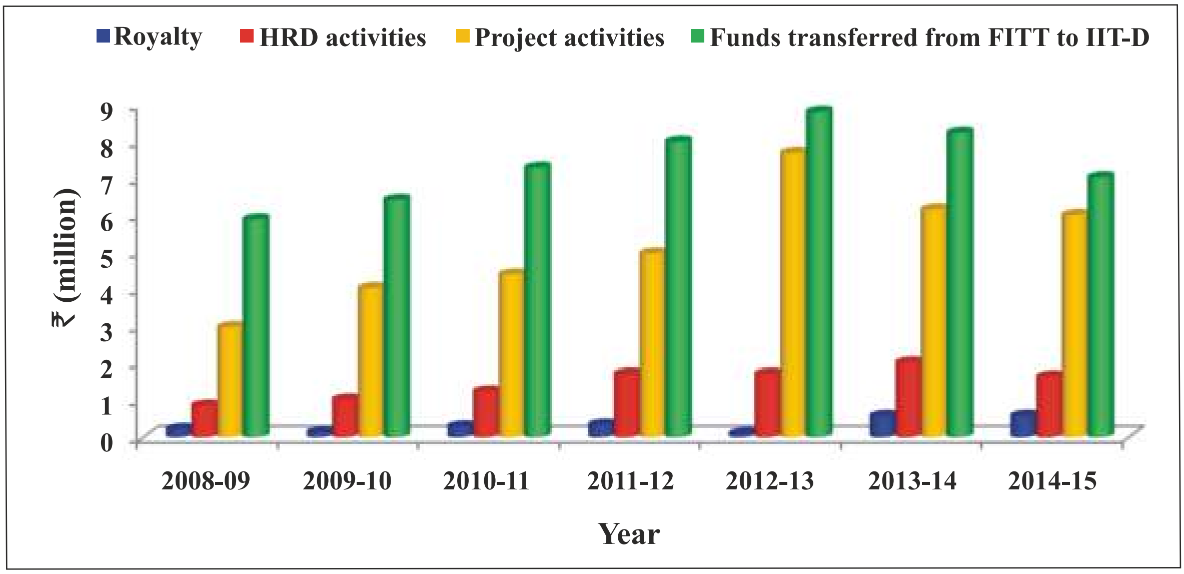


Figure 3: Resource Generation for FITT and IIT-D

Source: *FITT Annual Reports, 2008-15*

4. Summary and Conclusion

FITT is one of the successful cases of I-A interface located in a premier institute, IIT-Delhi. It has added commercial value to the academic knowledge of the institute and has become a financially stable centre by way of licensing out home grown technologies, consultancy, running various teaching programmes and investments in bank reserves and company shares. Over 200 patents have been filed since its inception nearly two decades ago. The Technology Business Incubator Unit (TBIU) of FITT has resulted in many spin-off ventures/start-up companies that have effectively motivated job seekers to become job creators. FITT enjoys the corporate partnership of many multinational companies. Undoubtedly, FITT can serve as an effective model for the promotion of I-A interactions for the developing nations. The tangible benefits include creation of entrepreneurs, who later on become owners of start-up companies. In other words, a job seeker becomes an employer. I-A centres like FITT helps scientific community in bringing its research outputs to the market by way of patenting their innovative research and preparing a business model for their applied research.

By adopting FITT model, we cannot even comprehend the advantages it might provide, not only in financial terms, but by way of promoting the development of indigenous technology, creating entrepreneurial spirit and thereby boosting the Indian economy.

5. References

- Bhattacharya, P., 2005. Technology Transfer from a Technical University: A Case Study of IIT Delhi. *Journal of Intellectual Property Rights,* 10(5), pp.413-416.
- Laha H. 2015. Start-ups with IP can help India's innovation capacity: Dr Wali. Hindustan Times.
- Sengupta, A.K., 2009. Case Study of an Industry–Academia Interface The FITT Story. *Global Business Review,* 10(2), pp.299-344.
- Singh, V., Paul, R., Mehra, D., Gupta, A., Sharma, V.D., Jain, S., Agarwal, C., Garg, A., Gujral, S.S., Balakrishnan, M. and Paul, K., 2010. 'Smart'Cane for the Visually Impaired: Design and Controlled Field Testing of an Affordable Obstacle Detection System. In *TRANSED 2010: 12th International Conference on Mobility and Transport for Elderly and Disabled Persons.*

Industry-Academia Related Questionnaire Survey Report of IITs

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4.1 Introduction

The hand holding of industry with academia has gained momentum as the evolving system of collaborations amongst the two, provides benefits to both the entities and gives them the prowess to address the challenges at the global and national level. The Industry-Academia (I-A) collaborations have carved a successful niche in the R&D ecosystem of the developed economies and are contributing greatly to the knowledge economy of the nations. However, in developing countries including India, I-A research collaborations are in the nascent stage. India's global ranking in the parameter of 'university-industry research linkage' is not impressive even though more than 700 universities (public and private) and nearly 1700 Department of Scientific and Industrial Research (DSIR) accredited labs exist in our nation. The time has come to bring them on a single platform so that they collectively work together and contribute significantly towards economic and societal progress.

In India, Indian Institutes of Technology (IITs) have been successfully carrying out I-A activities and can act as role models for other higher educational institutes, primarily universities. Keeping this in mind, the Centre for Policy Research at Panjab University, Chandigarh established by Department of Science and Technology (DST), New Delhi, Govt. of India (GoI) has carried out a study on the existing I-A interface in IITs. The present study focuses on existence of I-A cells in IITs, industrial research carried out in the form of sponsored research and consultancy and promotion of entrepreneurship culture. Table 4.1 enlists the officials who provided the information sought in the Questionnaire, of their respective institutes. The study has been divided into Methodology; Results & Discussion; and Conclusion.

Table 4.1: List of Professors who Provided the Information Sought in the Questionnaire

S. No.	Institute	Name & Designation
1.	**IIT-Kharagpur**	Prof. Partha P. Chakrabarti Director, IIT-Kharagpur
2.	**IIT-Bombay**	Prof. K.P Kaliappan Acting Dean (R&D)
3.	**IIT-Madras**	Prof. Krishnan Balasubramaniam Dean (Industrial Consultancy & Sponsored Research)
4.	**IIT-Kanpur**	Prof. Siddhartha Panda Associate Dean (Industrial Collaboration)
5.	**IIT-Delhi**	Prof. Naresh Bhatnagar, Associate Dean (R&D)
6.	**IIT-Guwahati**	Prof. D. Chakraborty Dean (R&D)
7.	**IIT-Roorkee**	Prof. Deepak Khare Head, Dept. of Water Resources Development & Management
8.	**IIT-Bhubaneswar**	Prof. Rabindra Kumar Panda Dean (R&D)
9.	**IIT-Gandhinagar**	Prof. Surya P. Mehrotra In-Charge (R&D)
10.	**IIT-Patna**	Prof. Pushpak Bhattacharyya Director, IIT-Patna
11.	**IIT-Jodhpur**	Prof. V. Narayanan Coordinator (R&D)
12.	**IIT-Ropar**	Dr. Harpreet Singh Assoc. Dean (Industrial Relations, International & Alumini Affairs)
13.	**IIT-Indore**	Dr. Santosh Kumar Vishvakarma, Faculty In-charge (Placement)
14.	**IIT-Mandi**	Prof. B.D. Chaudhary Dean (Sponsored Research & Industrial Consultancy)
15.	**IIT-BHU, Varanasi**	Prof. P.K. Jain Dean (R&D)

QUESTIONNAIRE

सत्यमेव जयते

Department of Science and Technology
Government of India

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)

SURVEY ON INDUSTRY-ACADEMIA LINKAGES ***(For Academia)***

The information sought pertains to your Institute only. This survey consists of 17 objective type questions. For questions 2-9, pl. fill up the columns 'Yes/No/Other'. For questions 12-17, please underline / tick / bold the option(s) mentioned in the question.

The filled up Questionnaire can either be emailed at dstprc2014@pu.ac.in or a hard copy may be sent to ***Prof. Rupinder Tewari,*** *Co-ordinator, DST – Centre for Policy Research, Deptt. of SAIF/CIL, CIL Building, Panjab University, Sector-14, Chandigarh-160014.*

(I) Name of the Institute:

(ii) Complete address:

1.	**Interaction of the Institute with the Industries**				
	Life Sciences (Please specify the field)	**Engineering Sciences (Please specify the field)**	**Business Management**	**Legal Studies**	**Other(s)**
Industrial training					
Campus recruitments					
Research collaborations					
Members of the governing body					

		Yes	**No**	**Other**
2.	Does the Institute have a dedicated "Industry - Academia Cell" or its equivalent?			
3.	Is the Institute aware of the Industry oriented Govt. funded programs like DSIR, TDB, BIRAC, PM's Fellowship Programme for Doctoral Research?			
4.	Does any Industry have a set up (research facility / laboratory) in the Institute?			
5.	Is there any Industry sponsored research fellowship in the Institute?			

		Yes	No	Other
6.	Do the students of the Institute visit industrial facilities on a regular basis?			
7.	Are there any incentives for faculty members / researchers who have obtained patents/ transferred technology?			
8.	Does the Institute provide leave to the faculty to take an assignment in the Industry?			
9.	Does the Institute offer special courses/ modules for regular employees of the Industry?			
10.	Does the Industry use infrastructure resources like instruments, library, legal services, any other (pl. mention) of the Institute?			
11.	Does the Institute have an IPR Cell/ Entrepreneurship Cell/ Placement Cell/ Technology transfer Cell/ any other (pl. mention)?			
12.	Does the Institute engage Industry personnel for teaching programmes? If yes, are they engaged as: (a) Invited speakers for a few lecture, (b) Guest faculty, (c) Adjunct faculty			
13.	Please fill in the appropriate details relevant to the Institute (last five years): (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...............			
14.	Does the Institute hold workshops/ conferences/ seminars in association with the Industry (pl. mention)?			
15.	Factors hampering the growth of Industry-Academia linkages in the Institute are : (a) Lack of common area of interest (b) Lack of co-operation from the Industry (c) Intellectual property rights (IPR) issues (d) Not much weightage given by Institute to develop industrial linkages (e) Lack of incentives for Industry- driven research			
16.	Lack of sensitization of Intellectual Property Rights (IPR) in the Institute is because of: (a) Compulsion of publication (as a part of doctoral programs) hampers going in for patents. (b) Tedious protocols of IPR (c) Lack of IPR related guidance and awareness (d) Lack of a dedicated IPR cell in the Institute			
17.	The barriers preventing the successful technology transfers from the Institute to Industry are: (a) Inadequate legal support services (b) Inadequate technical facilities (c) Any other			
18.	Please pen down any other suggestions you wish to share:			

Signature/ Seal: Dated:

Name, Designation and Complete address:

4.2 Methodology

a) **Setting:** This study was conducted at DST-Centre for Policy Research at Panjab University, Chd., India. The approval for conducting this study was obtained from DST, GoI, New Delhi, India.

b) **Study Design:** This study was based on a Questionnaire *(please see Pg 140),* which was designed particularly for this study. The participating institutes included all the IITs established until the year 2012 (excluding IIT-Tirupati and IIT-Palakkad).

   The Questionnaire contained 17 objective type questions with subparts, related to I-A interactions, start-ups, intellectual property, entrepreneurship, technology transfer, and patents. The reference year and instructions regarding filling of the Questionnaire were mentioned on top of the Questionnaire. The institutes were asked to answer these questions by either writing yes/no/other or by ticking (✓) the appropriate options.

   This survey was carried out to check the status and strength of I-A interface in all IITs. By exploring the scenario of I-A interaction in IITs, we can analyse and understand the benefits of collaboration of industry and institutes and can formulate policy to promote I-A interactions in India.

c) **Data Collection:** The data was collected through a survey conducted using a Questionnaire. A stipulated time period was given for filling up of the Questionnaire. During analysis, the answers were represented by using numbers zero (0) and one (1). '1' was for marked option and '0' for unmarked options.

d) **Statistical Analysis:** An excel sheet of all the questions was prepared and coded accordingly. For every question and its sub question, the total number of options ticked were counted and totalled, following which the percentage was calculated.

e) **Graphical Representation:** Graphs were plotted/made in accordance with the percentage calculations.

4.3 Results & Discussion

The Questionnaire was sent to 16 IITs of which 15 responded positively, corresponding to an overall response of 93.75%. Two IITs (IIT-Tirupati and IIT-Palakkad) were not sent the Questionnaire because they were established in the very same year that the survey was initiated. Despite repeated reminders IIT-Hyderabad failed to respond to the Questionnaire.

Question: 1

a) Industrial Training Programme:

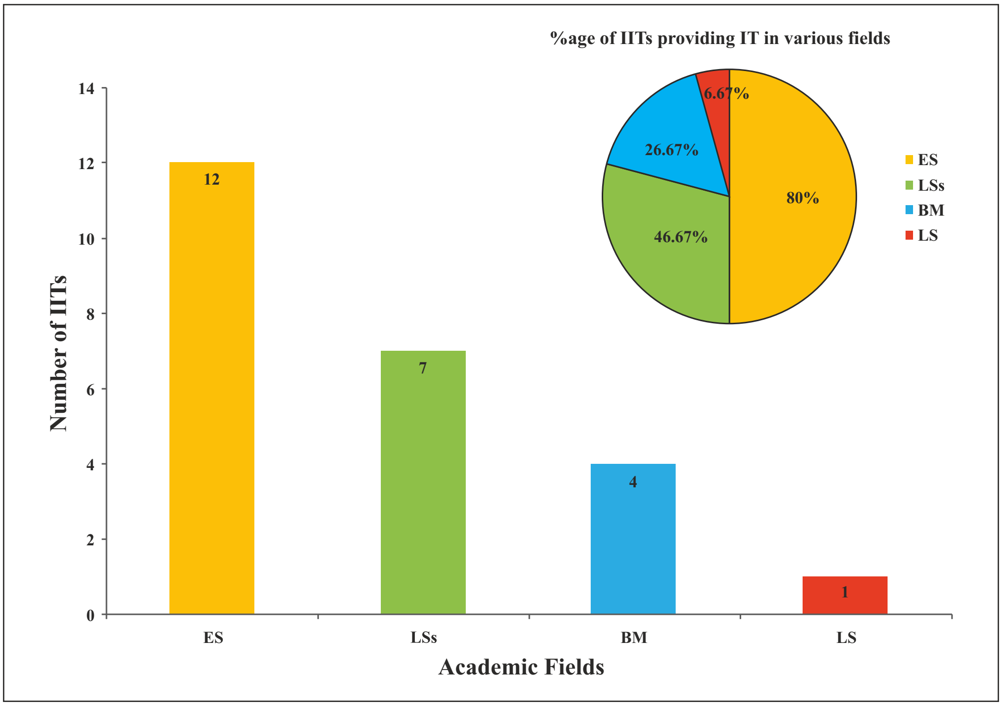

Figure 4.1: Number and Percentage of IITs Providing Industrial Training in Different Fields

* Abbreviations - Life Sciences (LSs), Engineering Sciences (ES), Business Management (BM), Legal Studies (LS)

Table 4.2: Fields in Which Industrial Training is Provided by IITs

S. No.	Institute	Life Sciences	Engineering Sciences	Business Management	Legal Studies
1.	**IIT-Kharagpur**	✓	✓	✓	✓
2.	**IIT-Bombay**	✓	✓	✓	N/A
3.	**IIT-Madras**	–	–	–	N/A
4.	**IIT-Kanpur**	✓	✓	✓	N/A
5.	**IIT-Delhi**	✓	✓	✓	N/A
6.	**IIT-Guwahati**	✓	✓	N/A	N/A
7.	**IIT-Roorkee**	✓	✓	–	N/A
8.	**IIT-Bhubaneswar**	N/A	✓	–	N/A
9.	**IIT-Gandhinagar**	–	–	–	N/A
10	**IIT-Patna**	–	✓	N/A	N/A
11.	**IIT-Jodhpur**	–	✓	N/A	N/A
12.	**IIT-Ropar**	–	✓	N/A	N/A
13.	**IIT-Indore**	–	–	N/A	N/A
14.	**IIT-Mandi**	–	✓	N/A	N/A
15.	**IIT-BHU, Varanasi**	✓	✓	N/A	N/A

* N/A – Not Applicable

* — – Industrial Training not provided

As depicted in the figure 4.1 and table 4.2, all the IITs have 'industrial training' in their curricula which is undertaken in association with industries. Out of 15 IITs, the students of 12 IITs go for industrial training in the field of engineering sciences, which is justified by the fact that IITs are majorly institutes of higher technical education, specialising in engineering. According to the information provided on the websites of respective institutes, it was gathered that out of 15, 14 institutes have life science programs but industrial training is a part of the curriculum in only 7 of them. It was also noted that business management is present as a course in 8 IITs, 4 of which participate in industrial training. A course on legal studies is present only in IIT-Kharagpur, where industrial training in the said field is also undertaken (Appendix, page 166).

b) Campus Recruitments:

Campus Recruitment is an important aspect of collaboration of the academic sector with the industries and hence can be referred as a parameter for gauging the readiness of the students for the industrial sector. Table 4.3 and figure 4.2 depict the status of the campus recruitment in different fields in the IITs. As all the IITs have expertise in engineering sciences, highest campus recruitment was observed in the same. Eight of the 14 IITs, which provide courses in life sciences, also engage in campus recruitment. In the field of business management (course provided by 8 institutes), 5 IITs are actively involved in campus recruitment. A course on legal studies is provided by IIT-Kharagpur only, and it engages in campus recruitment for the same.

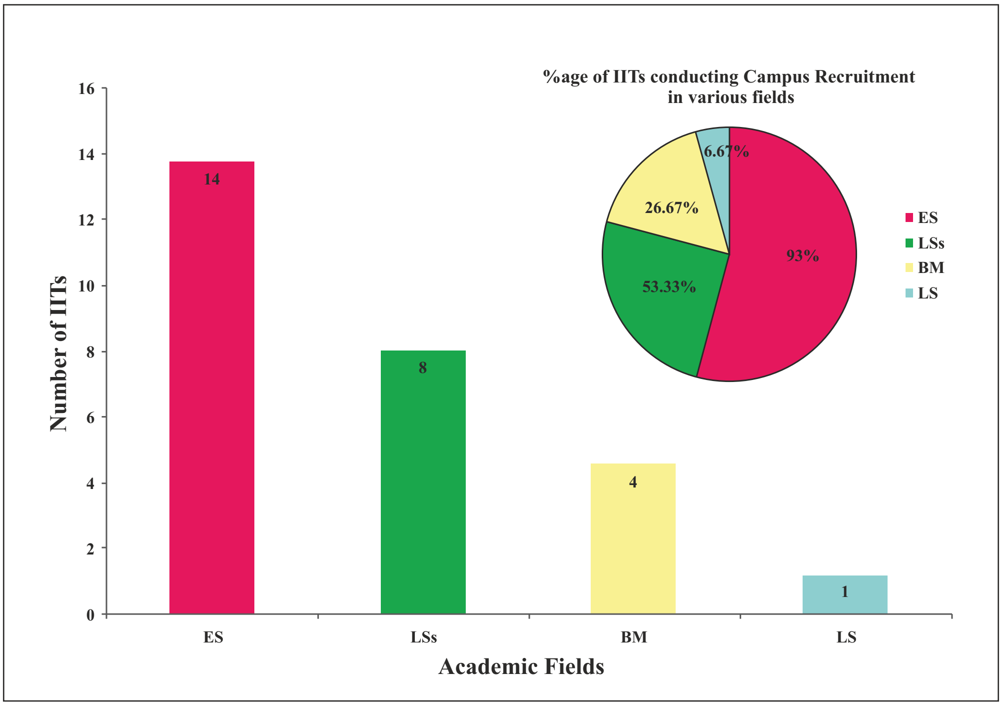

Figure 4.2: Number and Percentage of IITs Providing Campus Recruitment in Different Fields

* Abbreviations - Life Sciences (LSs), Engineering Sciences (ES), Business Management (BM), Legal Studies (LS)

Table 4.3: IITs Providing Campus Recruitment in Various Fields

S. No.	Institute	Life Sciences	Engineering Sciences	Business Management	Legal Studies
1.	**IIT-Kharagpur**	✓	✓	✓	✓
2.	**IIT-Bombay**	✓	✓	✓	N/A
3.	**IIT-Madras**	–	–	–	N/A
4.	**IIT-Kanpur**	✓	✓	✓	N/A
5.	**IIT-Delhi**	✓	✓	✓	N/A
6.	**IIT-Guwahati**	✓	✓	N/A	N/A
7.	**IIT-Roorkee**	✓	✓	–	N/A
8.	**IIT-Bhubaneswar**	N/A	✓	–	N/A
9.	**IIT-Gandhinagar**	–	✓	–	N/A
10	**IIT-Patna**	–	✓	N/A	N/A
11.	**IIT-Jodhpur**	✓	✓	N/A	N/A
12.	**IIT-Ropar**	–	✓	N/A	N/A
13.	**IIT-Indore**	–	✓	N/A	N/A
14.	**IIT-Mandi**	–	✓	N/A	N/A
15.	**IIT-BHU, Varanasi**	✓	✓	N/A	N/A

* N/A – Not Applicable

* — – Campus Recruitment not provided

c) ***Research Collaborations:***

To bring out the best in innovative research to the market, 'research collaborations' between industrial sector and academic sector are essential. As most of the IITs are majorly specialised in engineering sciences therefore maximum research collaborations have been witnessed in the said field followed by life sciences. Of the 8 institutes that provide business management courses, 5 of them are actively involved in research collaborations as well. Table 4.4 and figure 4.3 reflect the successful research collaborations of IITs in different domains.

Table 4.4: IITs Having Research Collaborations in Various Fields

S. No.	Institute	Life Sciences	Engineering Sciences	Business Management	Legal Studies
1.	**IIT-Kharagpur**	✓	✓	✓	✓
2.	**IIT-Bombay**	✓	✓	✓	N/A
3.	**IIT-Madras**	✓	✓	✓	N/A
4.	**IIT-Kanpur**	✓	✓	✓	N/A
5.	**IIT-Delhi**	✓	✓	✓	N/A
6.	**IIT-Guwahati**	✓	✓	N/A	N/A
7.	**IIT-Roorkee**	✓	✓	–	N/A
8.	**IIT-Bhubaneswar**	N/A	✓	–	N/A
9.	**IIT-Gandhinagar**	–	–	–	N/A

10	**IIT-Patna**	–	✓	N/A	N/A
11.	**IIT-Jodhpur**	✓	✓	N/A	N/A
12.	**IIT-Ropar**	–	✓	N/A	N/A
13.	**IIT-Indore**	✓	✓	N/A	N/A
14.	**IIT-Mandi**	–	✓	N/A	N/A
15.	**IIT-BHU, Varanasi**	✓	✓	N/A	N/A

* N/A – Not Applicable

* — – No Research Collaborations

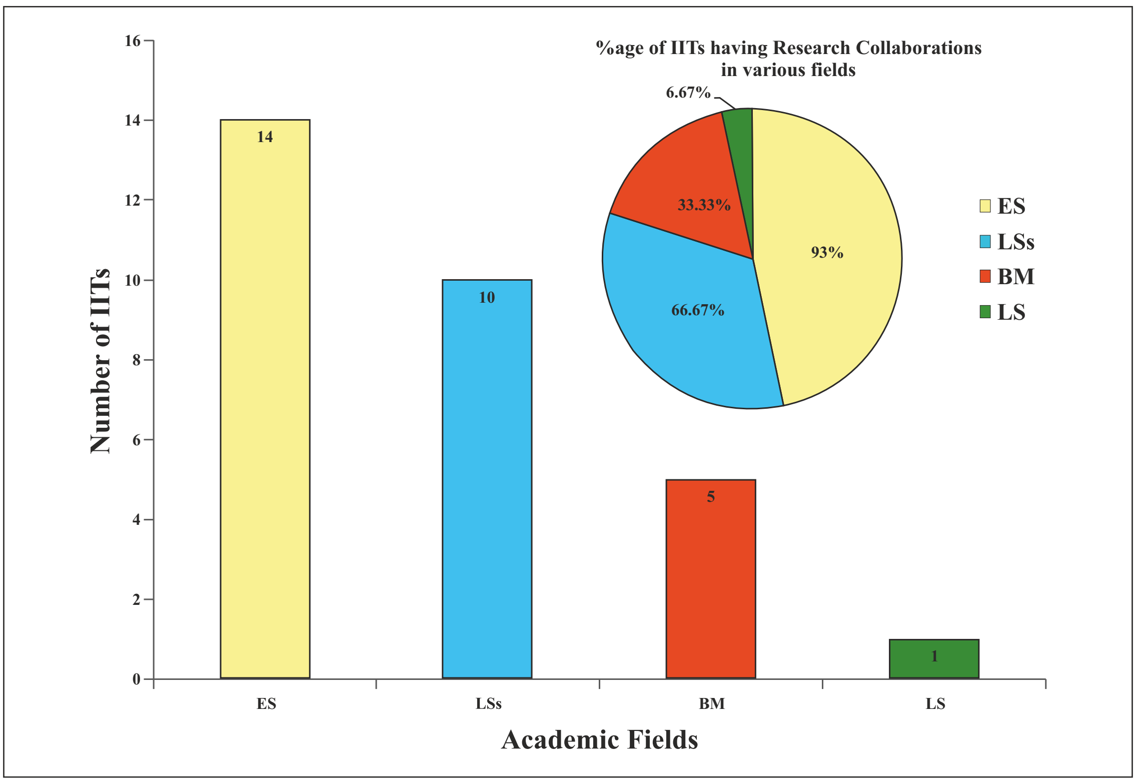

Figure 4.3: Number and Percentage of IITs Having Research Collaborations in Different Fields

* Abbreviations - Life Sciences (LSs), Engineering Sciences (ES), Business Management (BM), Legal Studies (LS)

d) Industry Representation in the Governing Body:

It is an accepted fact that the involvement of industry personnel in designing the study and research modules of an academic institute will enhance the performance of the institute. This has been well implemented by a few IITs, which have included industry representatives in the governing body of the institute (Table 4.5).

Table 4.5: IITs Having Industry Representation in the Governing Body

S. No.	Institute	Life Sciences	Engineering Sciences	Business Management	Legal Studies
1.	**IIT-Kharagpur**	–	–	–	–
2.	**IIT-Bombay**	–	✓	✓	N/A
3.	**IIT-Madras**	–	–	–	N/A
4.	**IIT-Kanpur**	–	–	–	N/A
5.	**IIT-Delhi**	–	✓	✓	N/A

6.	**IIT-Guwahati**	–	✓	N/A	N/A
7.	**IIT-Roorkee**	✓	✓	–	N/A
8.	**IIT-Bhubaneswar**	N/A	–	–	N/A
9.	**IIT-Gandhinagar**	–	–	–	N/A
10	**IIT-Patna**	–	✓	N/A	N/A
11.	**IIT-Jodhpur**	–	✓	N/A	N/A
12.	**IIT-Ropar**	–	✓	N/A	N/A
13.	**IIT-Indore**	–	–	N/A	N/A
14.	**IIT-Mandi**	–	–	N/A	N/A
15.	**IIT-BHU, Varanasi**	✓	✓	N/A	N/A

* N/A – Not Applicable

* — – No Industry Representation

Question: 2 Presence of a dedicated "Industry-Academia Cell" or its equivalent?

Apart from having industry oriented syllabi, presence of dedicated I-A Cells in IITs fosters conversion of academic knowledge into technologies. As mentioned in table 4.6, out of 15 IITs, 14 (93.3%) have dedicated cells for I-A interface e.g. Sponsored Research & Industrial Consultancy (SRIC) in IIT-Kharagpur, Industrial Research & Consultancy Centre (IRCC) in IIT-Bombay, Centre for Industrial Consultancy & Sponsored Research (IC&SR) in IIT-Madras, Industrial Research & Development (IRD) & Foundation for Innovation and Technology Transfer (FITT) in IIT-Delhi.

Table 4.6: Presence of I-A Cell or its Equivalent in IITs

S. No.	Institute	Name of I-A Cell
1.	**IIT-Kharagpur**	· Sponsored Research & Industrial Consultancy (SRIC) Cell · Science & Technology Entrepreneur's Park-Technology Business Incubator (STEP-TBI) · Technology Incubation & Entrepreneurship Training Society (TIETS) · Technopreneur Promotion Programme (TePP) Outreach cum Cluster Innovation Centre (TOCIC) · Research Park at Rajarhat
2.	**IIT-Bombay**	· Industrial Research & Consultancy Centre (IRCC) · Society for Innovation and Entrepreneurship (SINE) · The Desai Sethi Centre for Entrepreneurship (DSCE) · The Entrepreneurship Cell (E-Cell)
3.	**IIT-Madras**	· Industrial Consultancy and Sponsored Research (IC&SR) Centre · IIT Madras (IITM) Research Park · IITM Incubation Cell · The Cell for Technology Innovation, Development and Entrepreneurship Support (C-TIDES) · The Rural Technology Business Incubator (RTBI) · Bio-Incubator

4.	**IIT-Kanpur**	· SIDBI Innovation and Incubation Centre (SIIC) · TePP Outreach cum Cluster Innovation Centre (TOCIC)
5.	**IIT-Delhi**	· The Industrial Research and Development (IRD) · Foundation for Innovation and Technology Transfer (FITT)
6.	**IIT-Guwahati**	· IITG-Technology Incubation Centre (IITG-TIC) · The Rural Technology Action Group (RuTAG), North-East
7.	**IIT-Roorkee**	· Sponsored Research and Industrial Consultancy (SRIC) Cell · Technology Incubation and Entrepreneurship Development Society (TIEDS) · Entrepreneurship Development Cell (EDC) · Technopreneur Promotion Programme (TePP) Outreach Centre (ToCIC).
8.	**IIT-Gandhinagar**	· IIT-Gandhinagar Incubation Centre (IIC) · IIT-Gandhinagar Innovation and Entrepreneurship Centre (IIEC) · Technology Business Incubator (DST-TBI)
9.	**IIT-Patna**	· Sponsored Research and Industrial Relations Unit (SRIRU) · Entrepreneurship Club
10.	**IIT-Jodhpur**	· Entrepreneurship Cell
11.	**IIT-Ropar**	· Prototype Development and Innovation Fund (Entrepreneurship Cell) · Intellectual Property Rights (IPR) Cell · Centre for Innovation and Business Incubation (CIBI) · Technology Business Incubator (TBI)
12.	**IIT-Indore**	· Innovation and Entrepreneurship Development Centre (IEDC)
13.	**IIT-BHU, Varanasi**	· Malaviya Centre for Innovation, Incubation and Entrepreneurship (MCIIE)

Question: 3 Is the institute aware of the industry oriented Govt. funded programs like DSIR, TDB, BIRAC, PM's fellowship programme for doctoral research?

Govt. funding plays a very crucial role in science based innovations and technologies that determine the global competitiveness of the nation. All the IITs are aware of govt. funded programmes which provide financial support for research and infrastructure development.

Question: 4 Industrial set up in the institute

Nine IITs that have an industrial set up on the campus are at Kharagpur, Bombay, Madras, Kanpur, Delhi, Guwahati, Roorkee, Gandhinagar and Patna (Table 4.7). It can be assumed, that one of the main reasons for the industries being attracted to these IITs is that they are well established and have acquired experience and a broad base of knowledge which is of immense value to the industry. Another reason for the same can be that these IITs are situated at locations which are industry dominant. Therefore, both the entities are easily accessible to each other, to address the needs of their respective domains.

Table 4.7: Presence of Industrial Set Up in IITs

S. No.	Institute	Name of the Set-up/Laboratory
1.	**IIT-Kharagpur**	· Vodafone Essar-IIT Centre of Excellence in Telecommunications (VEICET) · Steel Technology Centre · General Motors-IIT-Kharagpur Collaborative Research Laboratory on Electronics, Controls and Software
2.	**IIT-Bombay**	· Xilinx FPGA Laboratory · The Tata Infotech Laboratory · Intel Microelectronics Laboratory · Laboratory for Intelligent Internet Research · Tata Consultancy Services Laboratory for VLSI Design and Device Characterization · Texas Instruments Digital Signal Processing (TI-DSP) Laboratory · Wadhwani Electronics Laboratory · Cummins Engine Research Laboratory · Applied Materials Nano manufacturing Laboratory · Tata Teleservices-IITB Centre of Excellence in Telecommunications (TICET) · VLSI Design Consortium
3.	**IIT-Madras**	· Autodesk, Microsoft and Intel have established Centres of Excellence and sponsored research laboratories in the campus. · Reliance IITM Telecom Centre of Excellence (RITCOE)
4.	**IIT-Kanpur**	· BSNL-IITK Telecom Center of Excellence · Samtel Center for Display Technologies (SCDT)
5.	**IIT-Delhi**	· Bharti School of Telecommunication Technology and Management · Airtel IIT Delhi Centre of Excellence in Telecommunications (AICET)
6.	**IIT-Guwahati**	· Society for Applied Microwave Electronic Engineering and Research-SAMEER
7.	**IIT-Roorkee**	· Intel set up a Planet Labs in E&C Dept. · Cisco set up equipment for a Telephony and Security Lab · RailTel IIT Roorkee Centre of Excellence in Telecom (RICET)
8.	**IIT-Gandhinagar**	· Grant from the Underwriters Laboratories Inc (UL) to develop safety initiatives at the Institute. · Ricoh Company Ltd, aided the establishment of a Centre for Design and Innovation at the Institute. · Analog Teaching Lab Setup by Cranes Software International Limited · C2000 Micro Controller Lab Setup by Cranes Software International Limited
9.	**IIT-Patna**	· Elsevier Centre of Excellence for Natural Language Processing · Sushrut-eZDI Research Lab

Question: 5 Industry sponsored research fellowship in the institute

The investment of private sector in R&D activities is a key parameter for commercialisation of technologies and for taking them from the bench to the market. It has been observed that the time for commercialising technologies is shorter in countries where private sector is actively engaged in R&D. One of the factors that reflects such engagements is 'industry sponsored research fellowships' in HEIs. As shown in table 4.8, industries have offered fellowships to almost all IITs (13) thereby promoting industrial research and active long term linkages of the two.

Table 4.8: Industry Sponsored Fellowships in IITs

S. No.	Institute	Industry Partner/ Name of the Fellowship
1.	**IIT-Kharagpur**	· TCS Research Scholar Program · Google India Fellowship · Indian Oil Educational Scholarship · Aditya Birla Scholarship · Singapore Technologies Scholarship in Engineering
2.	**IIT-Bombay**	· OP Jindal Engineering and Management Scholarships · TCS Research Scholar Program · Infosys Fellowship · Intel India PhD Fellowship · Crompton Greaves Research Fellowship Programme
3.	**IIT-Madras**	· Aditya Birla Scholarship · TCS Research Scholar Program · OP Jindal Engineering and Management Scholarships · Singapore Technologies Engineering Scholarship · Nissan Scholarship
4.	**IIT-Kanpur**	· Aditya Birla Scholarship · OP Jindal Engineering and Management Scholarships
5.	**IIT-Delhi**	· OP Jindal Engineering and Management Scholarships
6.	**IIT-Guwahati**	· ABB India Ltd.
7.	**IIT-Roorkee**	· OP Jindal Engineering and Management Scholarships
8.	**IIT-Bhubaneswar**	· WMG (Warwick Manufacturing Group, U.K.)
9.	**IIT-Gandhinagar**	· AIMIL LTD sponsors research at the institute
10.	**IIT-Patna**	· TCS Research Scholar Program
11.	**IIT-Indore**	· TCS Research Scholar Program
12.	**IIT-Mandi**	· TCS Research Scholar Program
13.	**IIT-BHU, Varanasi**	· TCS Research Scholar Program · OP Jindal Engineering and Management Scholarships

Question: 6 Do the students of the institute visit industrial facilities on a regular basis?

Industrial visits form an important part of the curricula and play an essential role in bridging the gap between classroom and the real world. Students learn about "real life" examples of application of science, engineering and business management.

Students from all the IITs involved in the study, visit industrial facilities on a regular basis to get an insight into the practicality and work ecosystem of the industries.

Question: 7 Incentives to faculty members/researchers who have obtained patents/transferred technology?

Providing impetus to the faculty members and researchers for generation of IP (patents, technology transfer primarily) is of utmost significance to advocate research that can support economic prosperity of the nation. Eleven IITs i.e. 73% (Fig. 4.4) provide incentives to the faculty members and researchers to motivate them for undertaking research having societal impact.

The IITs that provide faculty with incentives are IIT-Kharagpur, IIT-Bombay, IIT-Madras, IIT-Kanpur, IIT-Delhi, IIT-Bhubaneswar, IIT-Jodhpur, IIT-Gandhinagar, IIT-Indore, IIT-Mandi and IIT-BHU.

IIT-Guwahati, IIT-Roorkee and IIT-Patna do not have any provision for incentivising their faculty members/researchers who have obtained IP or commercialized technology.

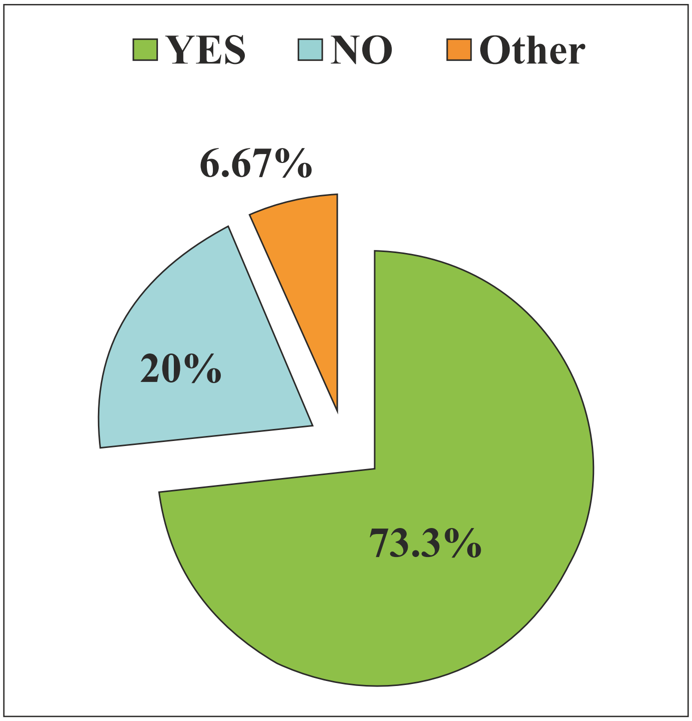

Figure 4.4: Percentage of IITs Providing Incentives to Faculty/Researchers With Patents/Tech. Transfers

Question: 8 Provision of leave to the faculty to take an assignment in the industry?

Paid leaves and sabbaticals are a way of giving time to the faculty and researchers for indulging in extra academic research collaborations. Fourteen IITs have this provision for their faculty members which gives them an opportunity to take assignments with the industry. IIT-Gandhinagar does not give permission to its faculty to take any sabbatical for working with an industry.

Question: 9 Does the institute offer special courses/modules for regular employees of the industry?

In order to attract the industry towards the academic sector, academia can offer certain specific courses or modules for industry employees. These courses will help the industry employees to obtain certification for their professional growth. As observed in table 4.9 out of 15 IITs, 10 provide such special courses. For example FITT in IIT-Delhi has initiated 'Professional Candidate Registration' (PCR) programme through which a number of courses in different fields are offered by the institute in accordance to suitable time slots, for commencing part time post-graduate/Ph.D programme. There are certain online modules as well that can be taken up by industry personnel.

Table 4.9: IITs Offering Special Courses for Industry Personnel

S. No.	Institute	Name of the Courses
1.	**IIT-Kharagpur**	· Continuing Education Programme (CEP)
2.	**IIT-Bombay**	· CEP
3.	**IIT-Madras**	· CEP
4.	**IIT-Kanpur**	· CEP
5.	**IIT-Delhi**	· Professional Candidate Registration (PCR) Programme · CEP
6.	**IIT-Roorkee**	· CEP
7.	**IIT-Bhubaneswar**	· CEP
8.	**IIT-Gandhinagar**	· CEP
9.	**IIT-Ropar**	· External Registration Program (Part-time Ph.D) for Industry Personnel
10.	**IIT-Indore**	· CEP
11.	**IIT-BHU, Varanasi**	· Short Term Courses/Training Programmes

Question: 10 Does the industry use infrastructure resources like instruments, library, legal services, any other of the institute?

A number of HEIs have a large pool of infrastructural resources and facilities that are of world class status. In order to establish effective I-A interface, both academia and industry should develop close collaboration with freedom of exchange of knowledge and resources such as instruments, library and other services. IITs are in the forefront of promoting industrial linkages. As depicted in figure 4.5, 93.33% of the IITs (14) have set up a freedom of resource access for the industries that has lead to strong foundation for endowing I-A linkages. IIT Patna does not have any such provision of resource sharing.

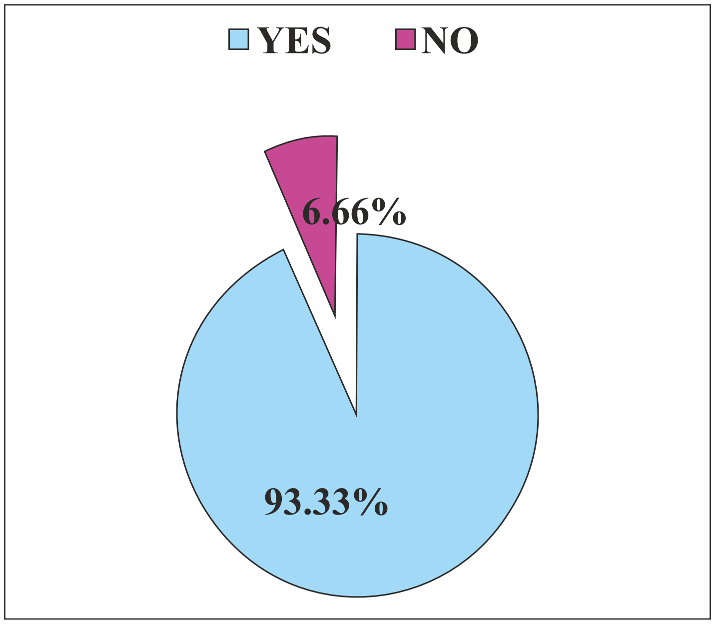

Figure 4.5: Percentage of IITs Sharing Infrastructure with Industries

Question: 11 Does the institute have an IPR Cell/Entrepreneurship Cell/Placement Cell/Technology Transfer Cell/any other?

All IITs have a dedicated cell for IPR management/Entrepreneurship/Technology transfer. Presence of such cells aids in stimulating the process of ideation to commercialization. These cells take responsibility for rendering all kinds of IPR assistance and inductive services like patenting and licensing. Expert mentorship for entrepreneurship and start-ups is also provided by these cells.

Question: 12 Does the institute engage industry personnel for teaching programmes? If yes, are they engaged as: (a) Invited speakers for a few lectures, (b) Guest faculty, (c) Adjunct faculty

In order to proliferate I-A linkages, not only should industry oriented research be undertaken by the academia, industry participation should also be encouraged by inviting speakers for special lectures or as a faculty (guest/adjunct), to bring forward industrial needs, practices and experiences amongst students.

Figure 4.6 and table 4.10 represent the number and percentage respectively, of IITs that engage industry personnel for different teaching programs. Fourteen IITs (93%) invite speakers from the industry to deliver special lectures in the field of their expertise. These lectures are helpful for students and help them in integrating the practical knowledge with theoretical aspects. Ten IITs (67%) and eleven IITs (73%) have tied up with the industry experts to be the guest faculty and adjunct faculty at their institutes, respectively.

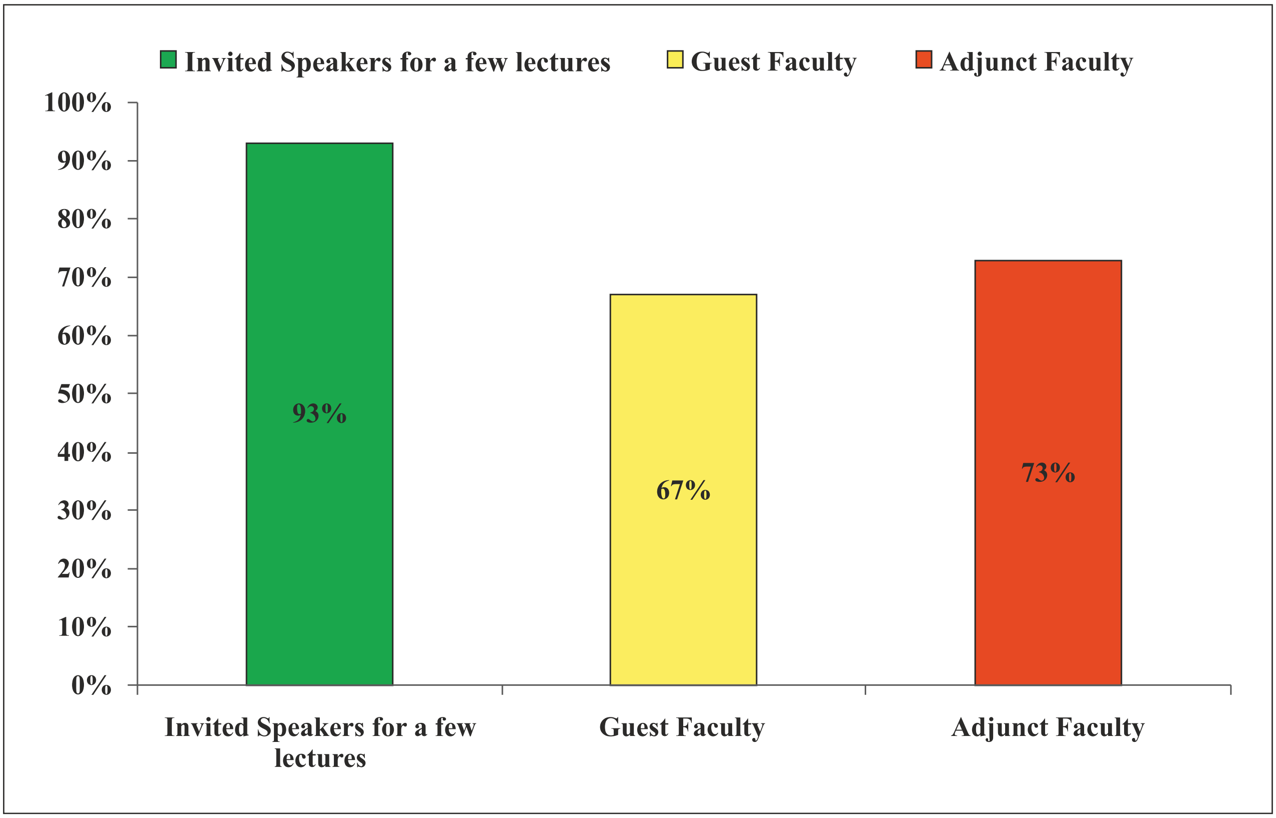

Figure 4.6: Percentage of IITs Engaging Industry Experts in Teaching Programme

Table 4.10: IITs Involving Industry Personnel in Teaching Programs

S. No.	Institute	Invite Speakers for Special Lectures	Guest Faculty	Adjunct Faculty
1.	IIT-Kharagpur	✓	✓	✓
2.	IIT-Bombay	✓	—	✓
3.	IIT-Madras	✓	✓	✓
4.	IIT-Kanpur	✓	✓	✓
5.	IIT-Delhi	✓	✓	✓
6.	IIT-Guwahati	✓	✓	—
7.	IIT-Roorkee	—	—	—
8.	IIT-Bhubaneswar	✓	✓	✓
9.	IIT-Gandhinagar	✓	✓	✓
10	IIT-Patna	✓	✓	✓
11.	IIT-Jodhpur	✓	✓	✓
12.	IIT-Ropar	✓	—	—
13.	IIT-Indore	✓	—	✓
14.	IIT-Mandi	✓	—	—
15.	IIT-BHU, Varanasi	✓	✓	✓

* — – No industry personnel in teaching programmes

Question: 13 Statistics of Patents Filed, Patents Granted, Technology Transfer and MoUs Signed with the Industries, of IITs.

In today's era of knowledge economy, an organization gains trust and competence by means of its IP profile. The physical assets of an institution are of less worth and value as compared to the intangible capital (know-how, innovations, inventions, etc.). IPRs are statutory rights that allow inventors to exploit their inventions for an exclusive time period. IPRs are not only devices/tools to protect one's innovation and creative ideas for generation of revenue but they are also the basis of strong alliances between different stakeholders for the benefit of society and technological development. IITs take special efforts to undertake innovative research leading to the generation of IP.

Table 4.11 enlists the number of patents (filed and granted), technologies commercialized, technologies under process and MoUs with industries of IITs in the last five years. Figure 4.7 (A & B) represents the patents filed and granted of first generation and second generation IITs respectively. Figure 4.8 represents the technologies commercialized and technology commercialization under process by first generation IITs. Second generation IITs are yet to open their account in the parameters of technology commercialization. Figure 4.9 (A & B) depicts the MoUs signed with the industries of the first and second generation IITs respectively.

IITs at Mumbai, Kanpur, Chennai and Delhi are performing exceptionally well in transferring technologies developed at the institute (73, 56, 17 and 15 respectively) to the market. These institutes have also generated significant IP in terms of patent (filed/granted): IIT-Bombay (439/61), IIT-Kanpur (204/09), IIT-Madras (311/24), IIT-Delhi (146/25) and IIT-Kharagpur (231/13), in the last five years (2010-15).

Amongst the second generation IITs, IIT-BHU, IIT-Roorkee, IIT-Ropar, IIT-Bhubaneswar and IIT-Patna have credited themselves with a satisfactory number of patent filings (> 10). IIT-BHU and IIT-Roorkee have been granted 3 patents each.

Another parameter that reflects the successful I-A interface, is number of MoUs signed between industries and institutes. Maximum number of MoUs have been signed by IIT-Bombay (225) followed by IIT-Madras (176), IIT-Kanpur (124) and IIT-Kharagpur (60). Amongst the newer IITs, maximum number of MoUs have been signed by IIT-Gandhinagar and IIT-BHU (14 each) followed by IIT-Jodhpur and IIT-Bhubaneswar (6 each).

Table 4.11: Patents, Technology Transfer and MoU Details 2010 Onwards

S. No.	Institute	Patents		Technology Transfers		MoU with Industries	
		Granted	Filed	Commercialized	Under Process	Signed	Under Process
1.	**IIT-Kharagpur**	13	231	09	02	60	10
2.	**IIT-Bombay**	61	439	73	00	225	00
3.	**IIT-Madras**	24	311	17	05	176	00
4.	**IIT-Kanpur**	09	204	56	00	124	00
5.	**IIT-Delhi**	25	146	15	01	08	03
6.	**IIT-Guwahati**	06	61	04	01	14	00
7.	**IIT-Roorkee**	03	22	00	00	03	00
8.	**IIT-Bhubaneswar**	00	10	00	00	06	00
9.	**IIT-Gandhinagar**	00	04	00	00	14	00
10.	**IIT-Patna**	00	09	00	00	00	00
11.	**IIT-Jodhpur**	00	05	00	00	06	01
12.	**IIT-Ropar**	00	>10	00	00	00	02
13.	**IIT-Indore**	00	07	00	00	02	00
14.	**IIT-Mandi**	00	01	00	00	03	00
15.	**IIT-BHU, Varanasi**	03	09	00	00	14	08
	Total	**144**	**1469**	**174**	**09**	**655**	**24**

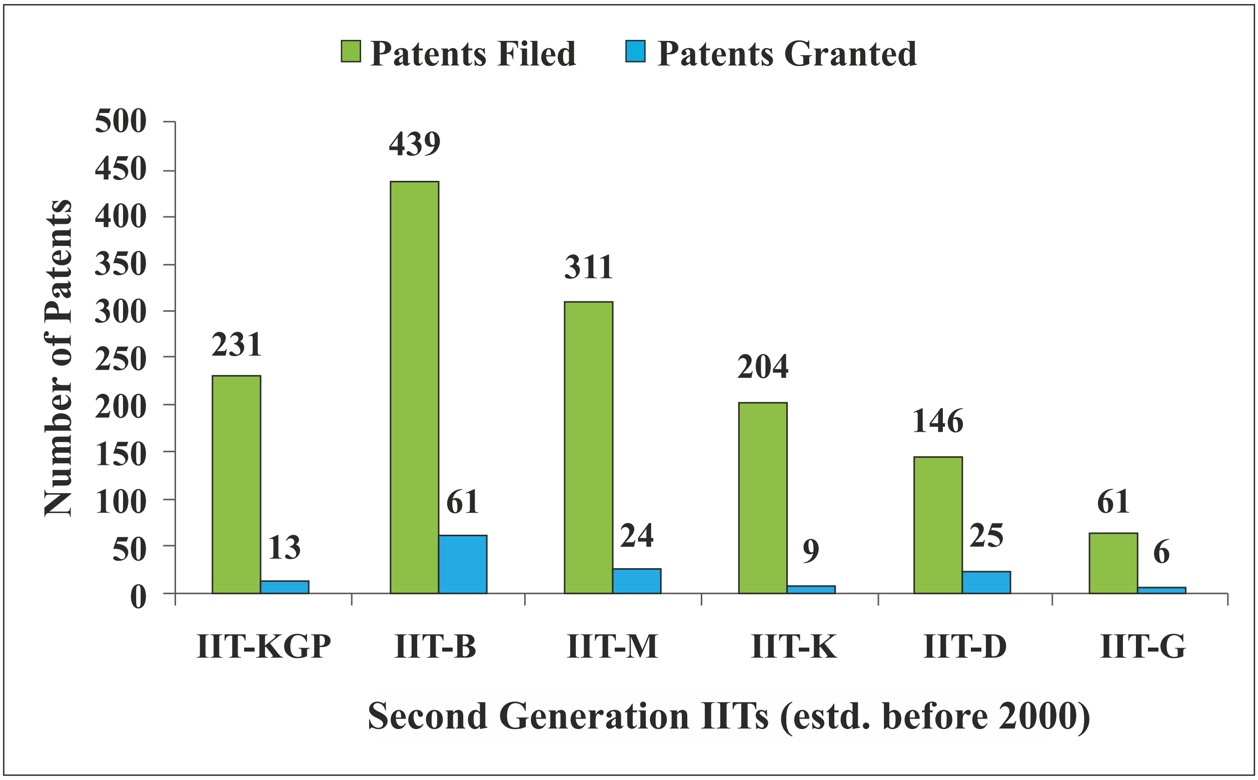

Figure 4.7 (A): Patents Filed/Granted of First Generation IITs

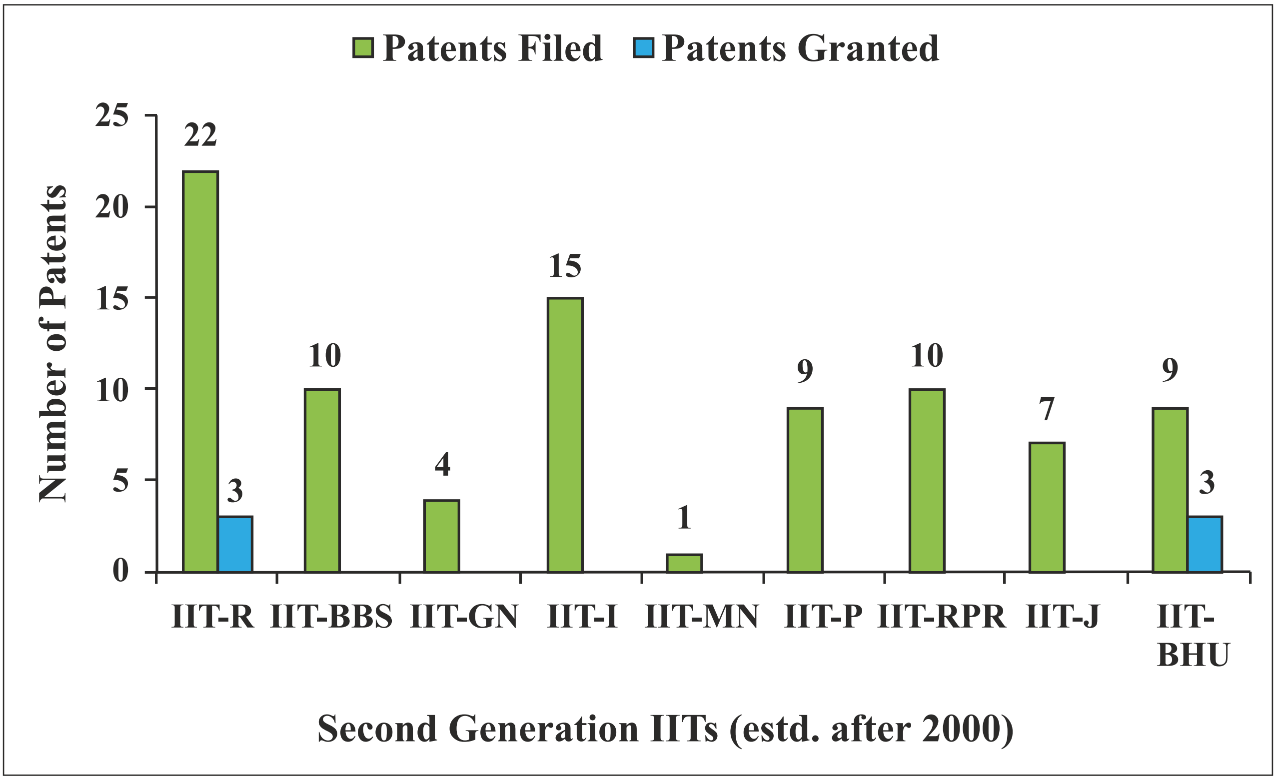

Figure 4.7 (B): Patents Filed/Granted of Second Generation IITs

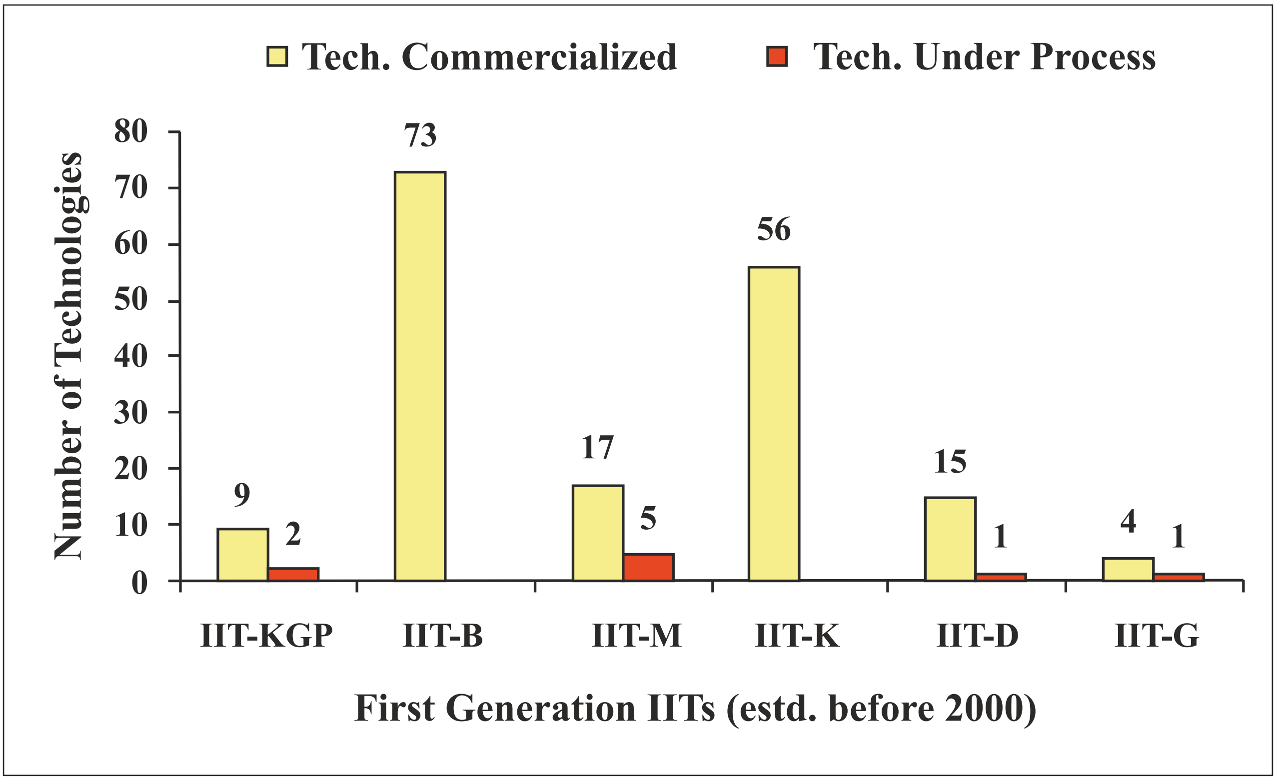

Figure 4.8: Technologies Commercialized/ Under Process of First Generation IITs

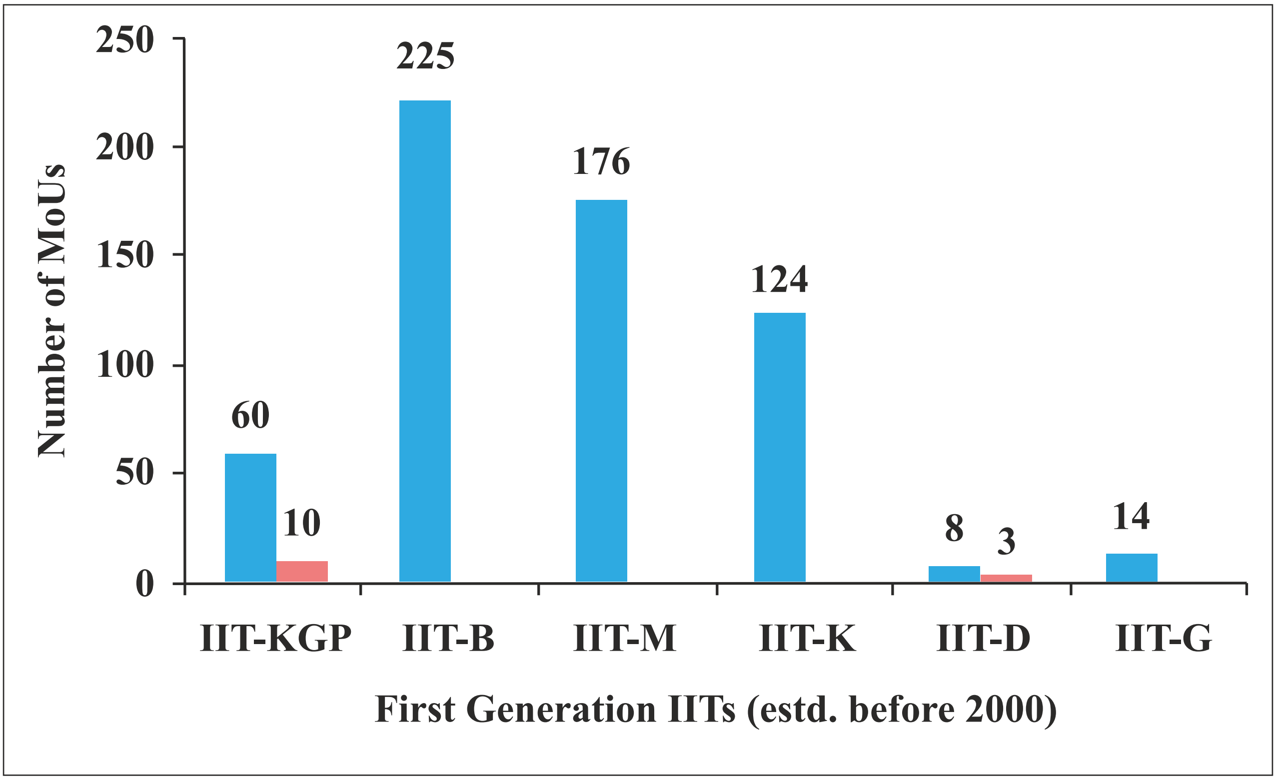

Figure 4.9 (A): Industry-Academia MoUs of IITs (First Generation)

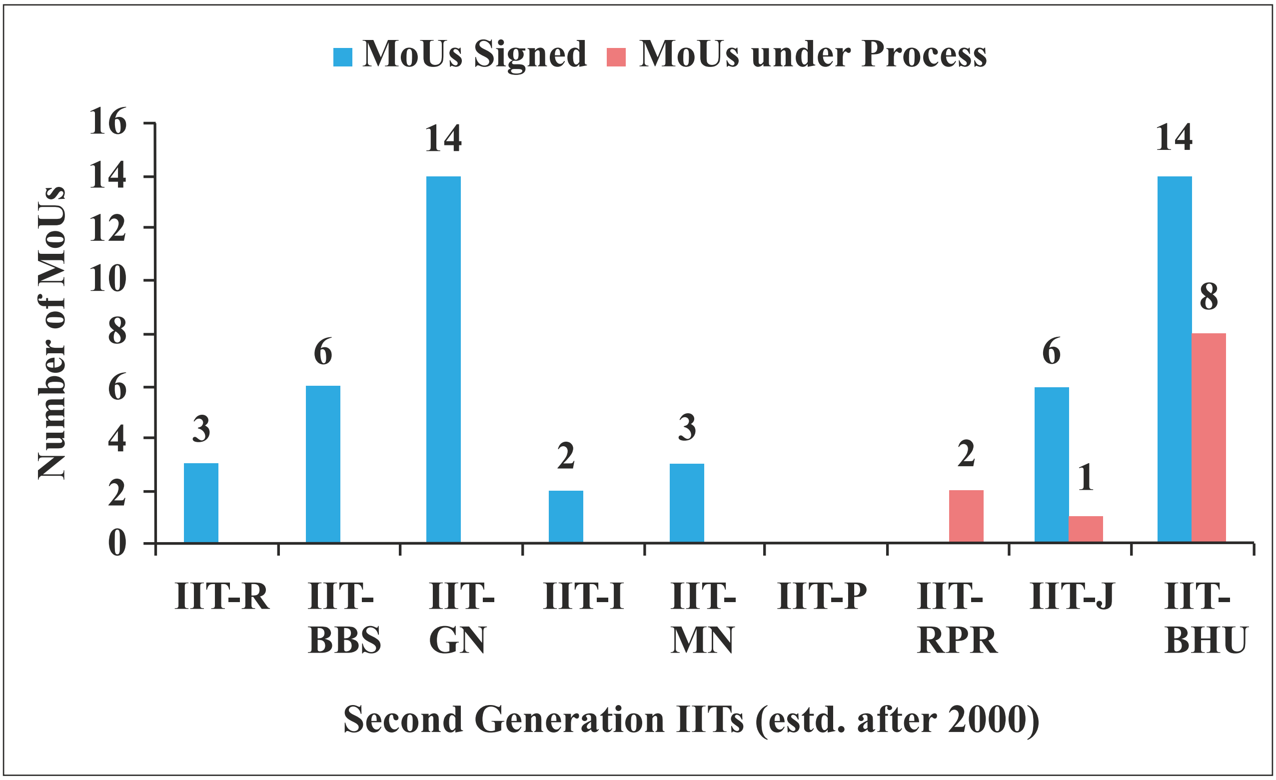

Figure 4.9 (B): Industry-Academia MoUs of IITs (Second Generation)

Question: 14 Organisation of workshops/conferences/seminars in association with the industry?

Workshops, seminars and conferences give an opportunity to the stakeholders of I-A linkages to interact with each other on a single platform. These modes of interaction apprise the entities of the latest developments in each other's fields and the scope for collaboration. Realising the importance of such events, all IITs are actively engaged in organising workshops, conferences and seminars in association with the industry. The industry benefits largely from these events by means of gathering academic expertise for problem solving and betterment of existing technologies.

Question: 15 Factors hampering the growth of Industry-Academia linkages:

a) Lack of common area of interest: 7 of the 15 IITs agree on this factor (46.7%)

b) Lack of co-operation from industry: 6 of the 15 IITs agree on this factor (40%)

c) Intellectual property rights issues: 5 of the 15 IITs agree on this factor (33.3%)

d) Not much weightage given by the institute to develop industrial linkages: 4 of the 15 IITs agree on this factor (26.7%)

e) Lack of incentives for industry driven research: 5 of the 15 IITs agree on this factor (33.3%)

f) Others: 2 (new generation) of the 15 IITs have stated additional factors (13.33%)

- Being new institutes, the priority was given to setting up of laboratories and other infrastructure required for UG/PG teaching.
- Faculty members not yet ready to handle industry relations.

It is observed that most of the IITs (46%) (IIT-Indore, IIT-Delhi, IIT-Madras, IIT-Mandi, IIT-Bombay, IIT-Gandhinagar and IIT-Patna) believe lack of common area of interest to be a major factor that hampers growth of I-A linkages, which can be explained by the lack of awareness of research areas/interests of both the organisations (Fig. 4.10). Therefore, measures should be taken to overcome this barrier by creation of modes such as National Web Portal.

Some of the IITs (IIT-Indore, IIT-Mandi, IIT-Gandhinagar, IIT-Kanpur, IIT-Kharagpur and IIT-Patna) feel that the industry does not come forward for joining hands (40%) and a few of them (IIT-Indore, IIT-Madras, IIT-Gandhinagar, IIT-Kharagpur and IIT-Patna) also agree that the complications related to IPR pose as a bottleneck (33.3%). The issues of lack of confidence in each other and time constraints add to these factors. The lack of incentivisation, as discussed above (Q. 7), by the institute is also a factor that hinders I-A interactions.

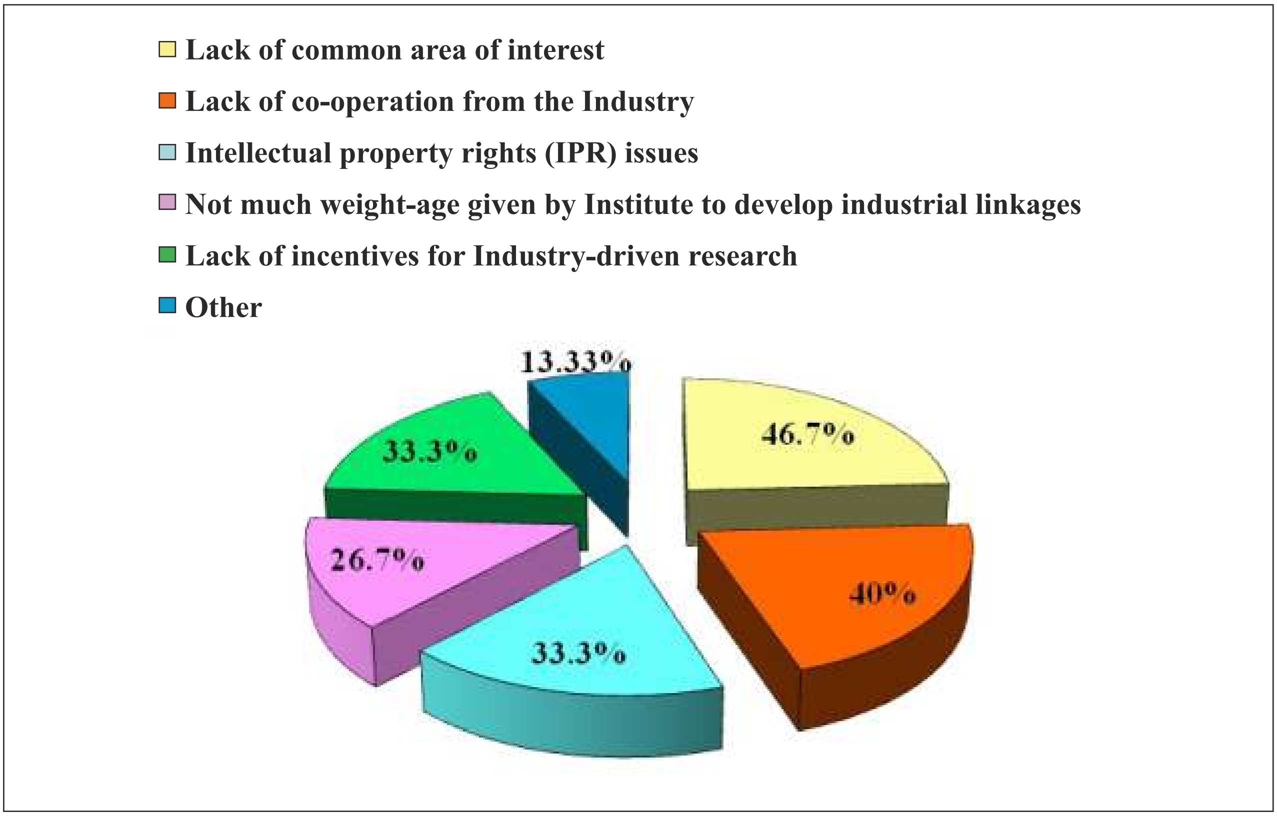

Figure 4.10: Factors Hampering the Growth of I-A Linkages in Institute

Question: 16 Lack of sensitization of Intellectual Property Rights (IPR) in the institute is because of:

Figure 4.11 and table 4.12 represent the factors affecting generation of IP in IITs.

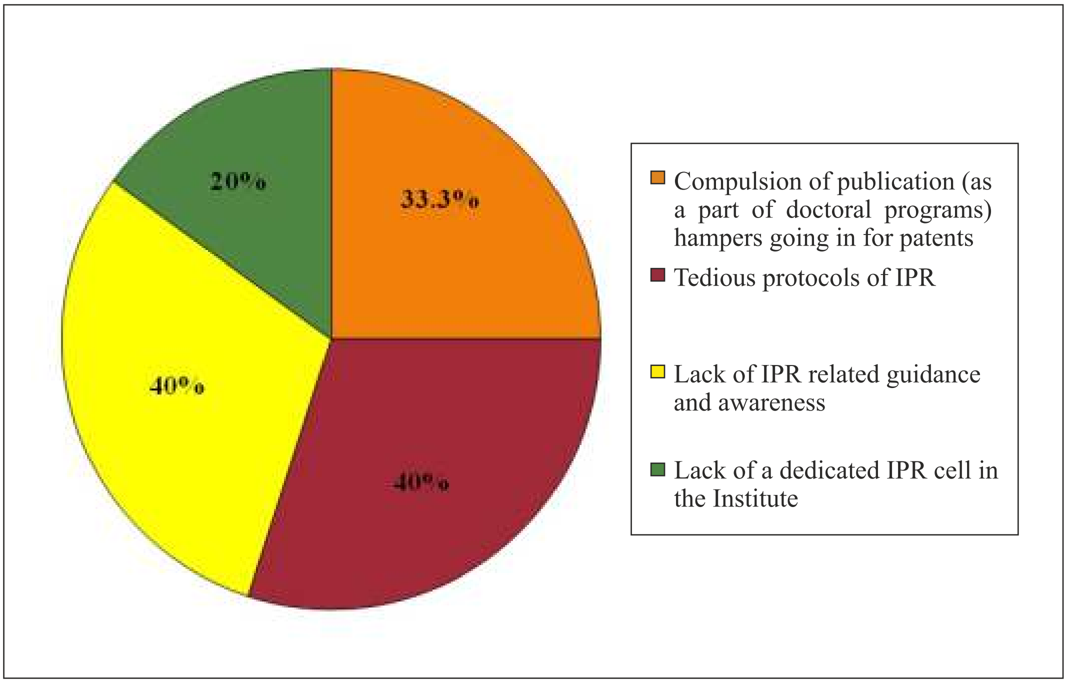

Figure 4.11: Factors Responsible for Lack of Sensitization of IPR in IITs

Table 4.12: Factors Responsible for Lack of Sensitization of IPR in the Institutes

S. No.	Factor	Percentage	Responders
a)	*Compulsion of publication (as a part of doctoral programme) hampers going in for patents*	33.3%	IIT-Mandi, IIT-Gandhinagar, IIT -Kanpur, IIT-Kharagpur and IIT-Patna stated that the academic sector gives more weightage to the publications than to IP.
b)	*Tedious protocols of IPR*	40.0%	6 IITs (IIT-Delhi, IIT-Mandi, IIT -Ropar, IIT-Kharagpur, IIT-Patna, IIT-BHU) agree that filing of IP is a cumbersome process and also involves high finances and time, which is not affordable by every researcher.
c)	*Lack of IPR related guidance and awareness*	40.0%	6 IITs (IIT-Delhi, IIT-Mandi, IIT -Ropar, IIT-Jodhpur, IIT-Patna, IIT-BHU) agree upon the unavailability of appropriate guidance at the right time.
d)	*Lack of dedicated IPR Cell in the institute*	20.0%	IIT-BHU, IIT-Mandi and IIT-Patna.

Question: 17 Barriers preventing the successful technology transfers from the institute to industry:

The successful conversion of academic knowledge into technologies is imperative for achieving global competitiveness in the area of science & technology. Table 4.13 and figure 4.12 highlight the barriers faced by IITs in technology transfers.

Table 4.13: Factors Responsible for Hindering Technology Transfer in Institutes

S. No.	Factor	Percentage	Responders
a)	***Inadequate legal support services***	26.7%	Four IITs (IIT-Mandi, IIT-Ropar, IIT -Kharagpur and IIT-Patna) feel that the lack of legal support is a hampering factor. One of the reasons may be the fact that hiring external legal services requires audit permissions and high financial resources.
b)	***Inadequate technical facilities***	13.3%	Only 2 IITs (IIT-BHU and IIT -Roorkee) feel that unavailability of technical facilities hampers the testing of prototype of a new technology. The unavailability of technical facilities could be credited to lack of funds, lack of technical support and lack of maintenance.
c)	***Others***	46.67%	7 IITs (IIT-Kanpur, IIT-Jodhpur, IIT -Gandhinagar, IIT-Bombay, IIT-Mandi, IIT-Madras, IIT-Delhi) have stated other factors that hamper technology transfers, such as · Lack of govt. support and incentivisation of faculty · Technology developed is not ready for industry · Lack of training to assess the need and market for a technology · Insignificant portfolio of patents in technology domain · Insufficient engagements of faculty with the industry

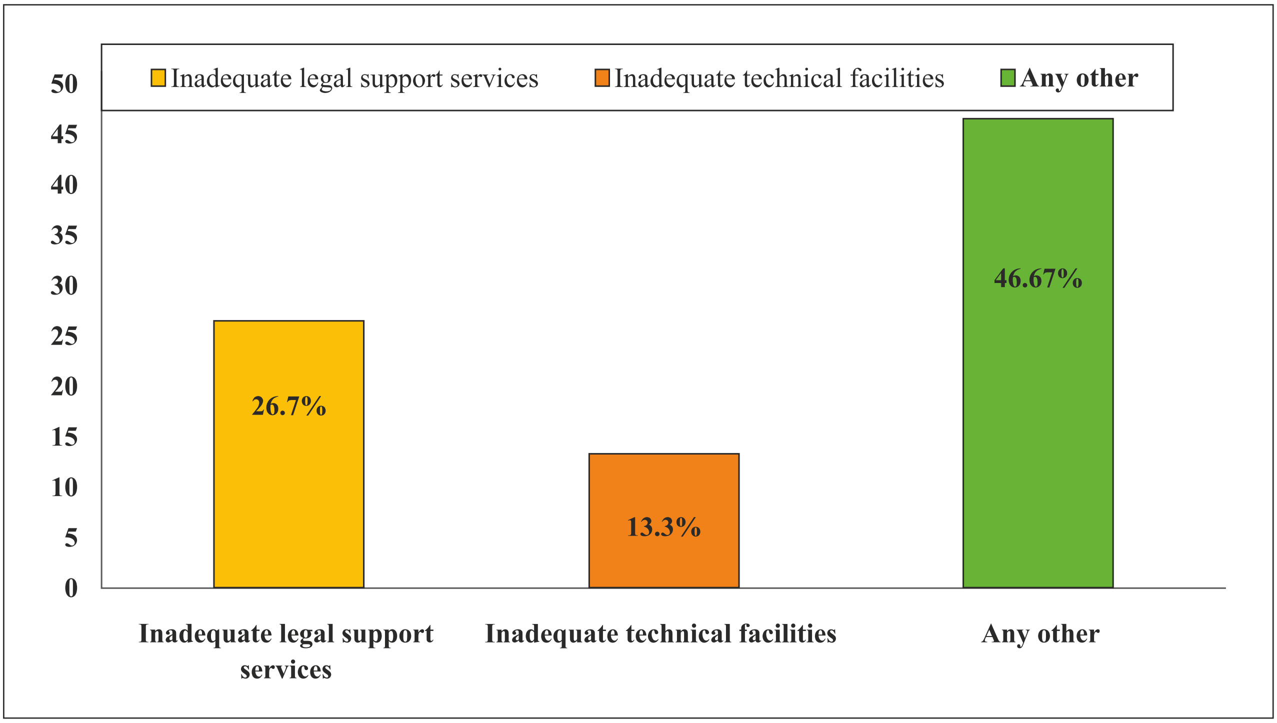

Figure 4.12: Barriers Preventing Successful Technology Transfers from IITs

4.4 Summary

The I-A related Questionnaire was sent to 16 IITs. Two newly established IITs at Tirupati and Palakkad were not included in the study. IIT-Hyderabad did not respond to our Questionnaire, despite repeated reminders. The salient points of the survey are:

- Majority of IITs have adequate presence of industrial sector in the form of members of governing/academic bodies, delivering guest lectures and holding joint workshops/seminars/conferences/R&D activities.
- Out of 15 IITs, 12 IITs provide industrial training to students in the fields of *Engineering,* 7 IITs in *'Life Sciences'* and 4 IITs in *'Business Management'* . Only IIT-Kharagpur has a course in '*Legal Studies'* and imparts practical training as well.
- By and large all the IITs have dedicated I-A Cells, IPR Management Cells and Entrepreneurship Cells.
- Nine IITs have campus research centers set up by the industries. A few of them have been established under PPP mode e.g. Telecom Centers of Excellence.
- Majority of IITs (13) have industry sponsored '*Research Fellowships'* for the students.
- Eleven IITs have a provision for incentivizing faculty members/researchers who convert their innovations into patents/technologies. Three IITs namely, IIT-Guwahati, IIT-Patna

and IIT-Roorkee do not have such provision.

- Except IIT-Gandhinagar, all IITs have a provision for sabbatical-leave for the faculty members willing to take up industrial assignments.
- Eleven IITs have a system of continuing education for the employees of the private sector. These IITs offer courses for the industrial sector that help employees achieve professional growth.
- All IITs are actively engaged in R&D. First generation IITs have excellent record in number of research publications, patents and tech transfers. In the period from 2010-2015, IIT-Bombay is the frontrunner in the parameter of 'Patents Filed/Granted' (439 patents filed, 61 granted) followed by IIT-Madras (311 patents filed, 24 granted). In the last five years, maximum number of technologies have been commercialized by IIT-Bombay, followed by IIT-Kanpur and IIT-Madras. IIT-Bombay is also at the forefront of signing MoUs with the industries (225 MoUs since 2010), followed by IIT-Madras and IIT-Kanpur.
- In the category of 'Factors hampering the growth of I-A linkages in IITs', seven IITs feel 'lack of common area of interest' and 'lack of cooperation from the industry' as the major road blocks. Six IITs are of the view that the industry does not come forward for joining hands with academia for collaborative research. Five IITs believe 'lack of appropriate incentives for industry driven research' and 'the issue of IPR' as dampeners for effective I-A research collaborations. The issues of 'lack of confidence in each other' and 'time constraints' add to these factors.
- With regard to the lack of sensitization of IPR in the institutes, six IITs feel that (a) tedious protocols of IPR and (b) lack of IPR related guidance constrain the faculty members to undertake technology oriented research work. Four IITs believe that the compulsion of publication in doctoral programmes hampers them from going in for IP protection. Seven IITs believe that (a) lack of government support, (b) in appropriate incentivisation to the faculty, (c) inadequate legal services and (d) inadequate technical facilities also pose as bottlenecks for effective tech. transfers and IP generation.

4.5 Conclusion

The industry and academia are two vital sectors for nation building, but have different goals and priorities. Earlier, both sectors were developing independent of each other. However, with changed scenario of the global economy, the hand shake of academia with industry has become an important component for the generation of innovations, for boosting the economy of the nations. Developed countries have already created bridges between academia and industry, whereas developing countries, including India, have just begun to make inroads.

In India, IITs are the flag bearers of I-A relationship in the areas of academics as well as research. The governing bodies as well as academic bodies of IITs have industry personnel on board. The industrial visits by students is a serious business. Industry happily delivers guest lectures. A few industry personnel have been accredited as adjunct-faculty. The creation of 'Industry Chairs' and industry sponsored research project/scholarships/fellowships in IITs is a reflection of the faith of industrial sector in IITs. 'Centres of Excellence' (CoE) in IITs are a shining example of Triple Helix Model for R&D under PPP mode, where intelligentsia in collaboration with industry works on the futuristic innovations for commercial gains or societal value. The funds for the development of infrastructure are primarily provided by the government through funding agencies. These factors along with the presence of I-A Cell, Patent Cell, Entrepreneurship Cell have helped IITs to produce significant number of publications, patents and technologies. In addition, IITs are helping the industrial sector by running dedicated courses for its employees, which help them in gaining promotions.

Universities and national research labs in India have intelligentsia in abundance and are also equipped with reasonable number of equipments, courtesy UGC-SAP, DST-PURSE and TEQIP programmes. Once the missing links for translational research are provided to them, industry would be happy to tie up with scientists from academia and research labs. The extension of I-A linkages to academia and research labs will take the tally of technologies and patents to a higher pedestal, thereby improving the S&T quotient of the nation.

Although the level of I-A interactions in IITs is quite satisfactory, but there is room for improvement. Many of the scientists in IITs feel lack of (a) common area of interest, (b) cooperation from the industry, (c) incentives for industry driven research and (d) IPR knowledge are some of the important factors hampering the growth of I-A collaborative R&D. The first two factors can be addressed by having regular meetings of specific industry associations with the IIT professors. For the last two factors, IITs excelling in the areas of incentivisation of faculty and IPR Cell can act as mentors for other IITs to overcome these deficits.

Appendix

Academic Fields Offered at Different IITs

Institute	Life Sciences	Engineering Sciences	Business Management	Legal Studies
IIT-Kharagpur	✓	✓	✓	✓
IIT-Bombay	✓	✓	✓	—
IIT-Madras	✓	✓	✓	—
IIT-Kanpur	✓	✓	✓	—
IIT-Delhi	✓	✓	✓	—
IIT-Guwahati	✓	✓	—	—
IIT-Roorkee	✓	✓	✓	—
IIT-Bhubaneswar	—	✓	✓	—
IIT-Gandhinagar	✓	✓	✓	—
IIT-Patna	✓	✓	—	—
IIT-Jodhpur	✓	✓	—	—
IIT-Ropar	✓	✓	—	—
IIT-Indore	✓	✓	—	—
IIT-Mandi	✓	✓	—	—
IIT-BHU, Varanasi	✓	✓	—	—
Total	**14**	**15**	**8**	**1**

Source: *http://www.iitkgp.ac.in/, http://www.iitb.ac.in/, https://www.iitm.ac.in/, http://www.iitk.ac.in/, http://www.iitd.ac.in/, http://www.iitg.ac.in/, http://www.iitr.ac.in/, http://www.iitbbs.ac.in/, http://www.iitgn.ac.in/, http://www.iiti.ac.in/, http://www.iitmandi.ac.in/, http://www.iitp.ac.in/, http://www.iitrpr.ac.in/, http://www.iitj.ac.in/, http://www.iitbhu.ac.in/*

Public Private Partnership Models for R&D in India

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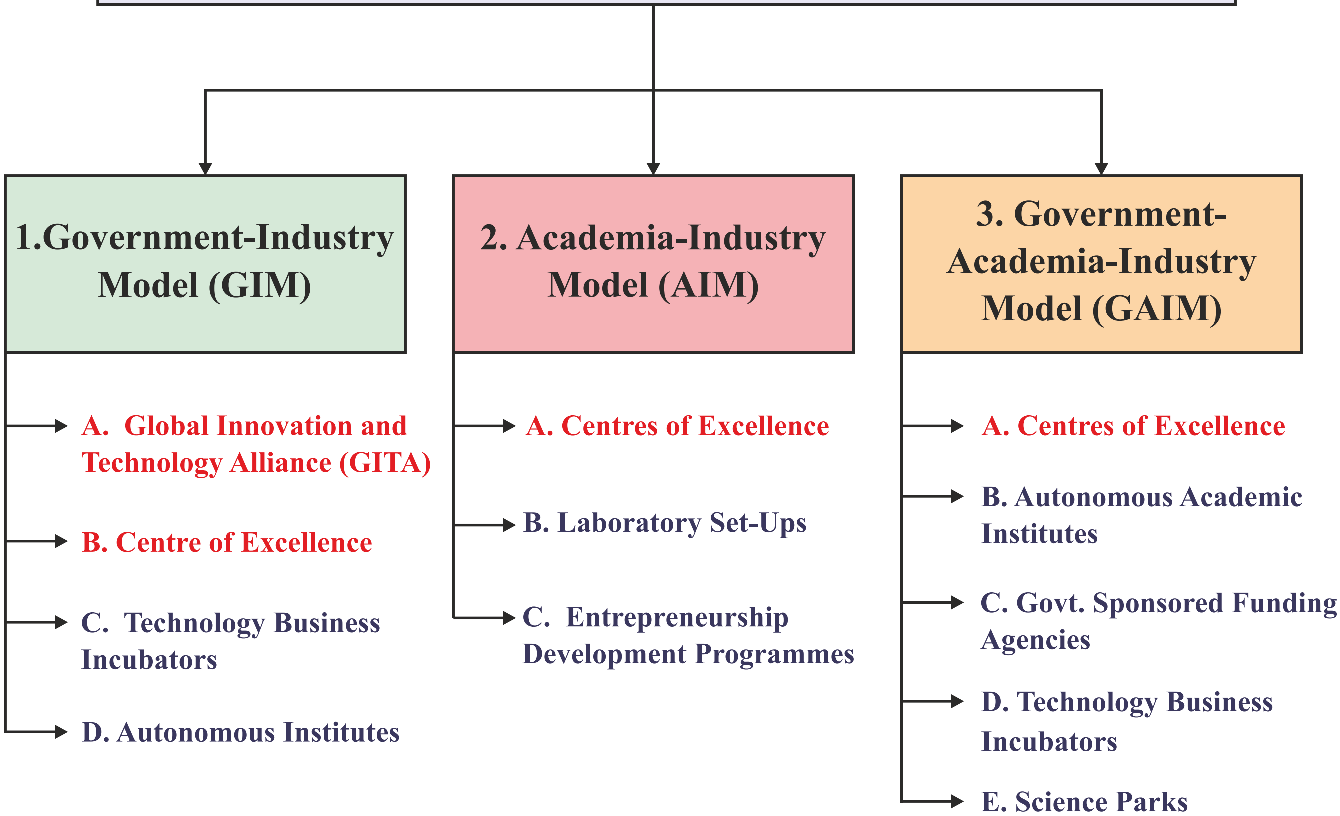
Public Private Partnership (PPP) is a kind of joint venture of the public and private sectors addressing the public needs through proper allocation of resources, risks and returns. The concept of PPP model has been embraced by the nations worldwide as it provides essential capital (which a public sector alone cannot afford) and professional competence in the work culture (focused approach, better management of finances and time bound projects). PPP models have become a phenomenon all around the world, including India, in the fields of infrastructure, transportation and urbanization.

In addition, developed nations like, USA, U.K., Germany, Singapore and S. Korea have also built successful models of PPP for R&D. One of the most successful models of PPP (R&D) is termed as 'Triple Helix Model' in which government-academia-industry come together for strengthening nation's innovation ecosystem. Triple Helix Model has been successfully adopted by many universities like Stanford University (USA), University of California (USA), Birmingham University (U.K.) and Stockholm University (Sweden) for futuristic innovations. In addition to Triple-Helix Model, bipartite models (government-industry or academia-industry) also exist for R&D under PPP mode, such as Cooperative Research Centres (Australia) and Industry/University Cooperative Research Centres (USA).

Realizing the huge benefits (commercial and societal) accruing from industry (private sector)-academia (public sector) strategic partnership in the domain of R&D, the Science, Technology and Innovation (STI)-2013 Policy of India has emphasized the need for promotion of R&D programmes via PPP mode. In India, PPP in R&D is in its infancy. Technically, there are only a few examples of PPP (R&D) e.g. Centres of Excellence (CoEs) in academic institutes and Gobal Innovation and Technology Alliance (GITA) based in New Delhi. But, there are many instances wherein public (government and/or academia) and private (industry) sectors have collaborated with each other in the pursuit of scientific excellence, but are not bound by tight regulations. Taking holistic view of PPP (R&D) in India, the existing PPP in the domain of R&D can be categorized a) Technically Correct-PPP (TC-PPP), and b) In Practice-PPP (IP-PPP) models.

In the present chapter, an overview of the existing PPP (R&D) models is presented. For convenience sake, the R&D programmes and activities under PPP mode have been divided into three models: Govt.-Industry Model (GIM); Academia-Industry Model (AIM) and Govt.-Academia-Industry Model (GAIM). The glimpse of these models is provided in figure 5.1.

Fig 5.1: Existing PPP Models for R&D in India



-----*Sections marked in red fall under TC-PPP Model*

-----*Sections marked in blue fall under IP-PPP Model*

5.1 Government-Industry Model (GIM)

Under GIM, the government partners with industries/industry associations to promote the spirit of scientific fervour, entrepreneurship and research collaborations. The examples of GIM are:

5.1.1 Global Innovation and Technology Alliance (GITA)

5.1.2 Centre of Excellence (CoE)

5.1.3 Technology Business Incubators (TBIs)

5.1.4 Autonomous Institutes

5.1.1. Global Innovation and Technology Alliance (GITA); www. gita.org.in

Public Sector: Department of Science and Technology (DST), GoI
Private Sector: Confederation of Indian Industry (CII)

To stimulate investments in R&D sector, GITA, an innovative pilot project was commenced in 2007 by DST (public sector) in collaboration with CII (private sector). DST and CII hold 51% and 49%

equities respectively. GITA is an industry managed body for promoting vigorous innovation clusters along with managing 'National Innovation Fund' through PPP model. GITA is actively supporting emergence of open source innovations and venture capital industry for social inclusion. It also provides know-how for IP acquisition and licensing social goods (non-exclusive) from the government. GITA is strongly promoting innovation culture by bringing industry and academia together not only in India but globally as well. The innovation ecosystem of GITA is elaborated in figure 5.2.

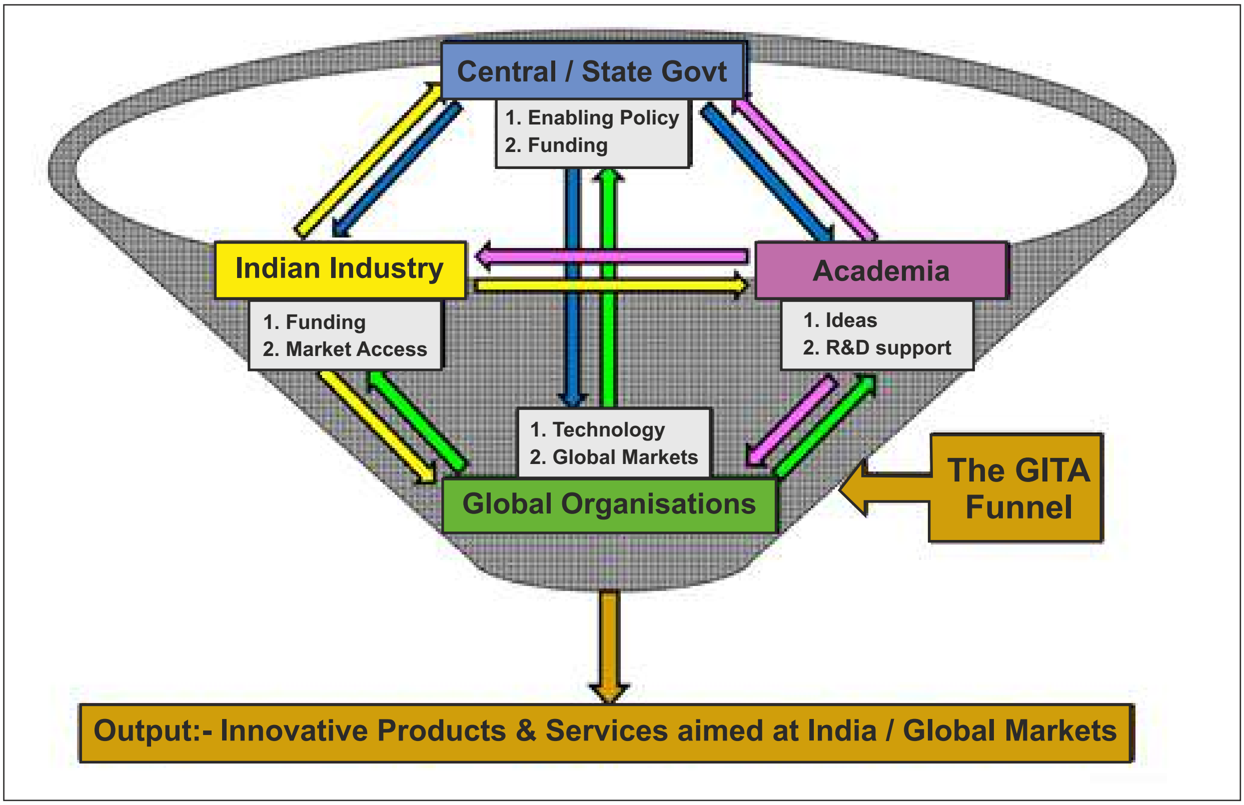


Figure 5.2: GITA Innovation Ecosystem

Source*: www.gita.org.in*

Various programmes of GITA promoting industrial research are listed in table 5.1.

Table 5.1: Industry Linked Programmes of GITA

S. No.	Programme	Brief Details
1.	**Bilateral Programmes**	· **Technology Acquisition and Development Fund** is the scheme launched by DIPP and implemented by GITA. This scheme facilitates applicability of clean and green technologies available to Indian SMEs. · **India U.K. Collaborative Industrial Research Development Programme:** ₹ 1.50 crores grant available to Indian companies

		and up to £ 300,000 to U.K. Companies for joint co-development of industrial R&D and innovation project in the areas of cleantech, use of Electronic System Design and Manufacturing (ESDM) technologies, affordable healthcare to provide solutions to societal challenges.
2.	**Multilateral Programmes**	Multilateral programmes consist of network of foreign entities. Some of the multilateral programmes of GITA are as: · **The Enterprise Europe Network (EEN):** EEN is a European Union initiative with an aim to provide innovation and business support to SMEs in Europe and India. In India, EEN is jointly coordinated by the European Business and Technology Centre (EBTC), GITA, CII, Federation of Indian Export Organizations (FIEO) and the Steinbeis Centre for Technology Transfer India (SCTI). Through this platform, companies which are looking for business improvement and expansion to new markets can use EEN's database of technology offers. · **Innovation Driven Initiative for the Development and Integration of Indian and European Research (INNO INDIGO):** INNO INDIGO is a network between Europe and India, funded by the European Commission (EC) for research and technological development. INNO INDIGO has 11 consortium partners from Europe and 3 from India, namely, CSIR, DBT and GITA. Its main objective is the implementation of transnational Indo-European joint call for proposals in which funding agencies from India, EU member states and associated states can participate.

Source: *www.gita.org.in*

5.1.2 Centre of Excellence (CoE)

The public (government) and private (industry) sectors have together established Centre of Excellence for Internet of Things (CoEIoT) to carry out high-end R&D in IT Sector.

i) **CoEIoT, Bengaluru*;*** www.coe-iot.in

Public Sector: Ministry of Electronics and Information Technology (MeitY), GoI **Private Sector:** National Association of Software and Services Companies (NASSCOM)

CoEIoT was established as a PPP initiative of Ministry of Electronics and IT (MeitY), Education and Research Network (ERNET) India and National Association of Software and Services Companies (NASSCOM). It aims to promote an IoT ecosystem in India. Services provided by CoEIoT are, a) assists in arranging funding from angel investors as well as for mature companies looking to raise funds; b) acceleration for the start-ups; c) mentoring for go-to-market strategy, product management and industry insights from the experts of the industry; d) enterprise connects and e) recruitment support through strategic partnership to find the right kind of technical and non-technical employment

5.1.3 Technology Business Incubators (TBIs)

Public Sector: National Science and Technology Entrepreneurship Development Board (NSTEDB), DST, GoI

Private Sector: Private Organizations

NSTEDB under the aegis of DST, New Delhi has taken impactful initiative 'Institution Mechanisms Building' by building TBIs all over India to incubate indigenous technologies 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 institutes and DST. Each TBI has dedicated thrust area and working with a mandate to build efficient technologies in their respective domains. Each TBI is acting as a role model for enhancing industrial involvement in academic research. A few TBIs are working under PPP mode where government is providing funding and private organization is carrying out research (Table 5.2). Government of Karnataka and Government of Andhra Pradesh have come up with 'Start-Up Policy 2016' and have given special emphasis on creation of incubators under PPP mode.

Table 5.2: Technology Business Incubators (TBIs) Working Under PPP

S. No.	Technology Business Incubator (TBI)	Brief Details
1.	**Technology Business Incubator at Shriram Institute of Industrial Research, Delhi (SRI-TBI)** www.shriraminstitute.org	Established in 2007 in the association with DST, New Delhi and is working with the mandate to promote, develop and encourage budding entrepreneurs in the fields of chemicals, waste management, rubber and plastics, and contributing to the growth of indigenous industries. TBI also provides solution to the entrepreneurs in the field of domestic manufacturing sector.
2.	**Life Science Incubator at IKP Knowledge Park-, Hyderabad** www.ikpknowledgepark.com	IKP Knowledge Park has set up a Life Science Incubator (LSI) with an aim to encourage and nurture start-up companies in pharma and biotech sector. It also provides number of assistance programmes for scientists, entrepreneurs and innovative start-up companies.

A few of other TBIs which fall under in-practice PPP are listed in section 5.3.4.

5.1.4 Autonomous Institutes

Keeping in mind the R&D needs of industries a few research institutes including 'Automotive Research Association of India' (ARAI) and 'Indian Plywood Industries Research and Training Institute' (IPIRTI) have been established by GoI. On the other hand, research institutes like, 'The Energy and Resources Institute' (TERI) and 'Shriram Institute for Industrial Research' (SRI) created by private entities, are utilizing government funding support for their R&D endeavours under PPP mode. A brief information about these institutes is mentioned below.

i) Automotive Research Association of India (ARAI), Pune; *www.araiindia.com*

Public Sector: Ministry of Heavy Industries and Public Enterprises (MoHI&PE)
Private Sector: Automotive Industries

ARAI, a Pune based co-operative industrial research unit was established by the automotive industry in association with the Ministry of Heavy Industries and Public Enterprises (MoHI&PE), GoI in 1966. The governing body of ARAI comprises of 21 members, out of which 18 are from industries. More than 70 industries are affiliated with this institute. ARAI has opened its branches in a couple of Asian countries i.e. China and S. Korea. It is playing an essential role in designing less polluting, safe and more efficient vehicles. It also provides technical assistance in the domains of R&D along with testing, homologation, framing and certification of vehicle regulations. ARAI is accredited with ISO 9001, ISO 14001, Occupational Health and Safety Management (OHSAS) 18001 and National Accreditation Board for Testing and Calibration Laboratories (NABL). The services provided by ARAI are listed in table 5.3.

Table 5.3: Services Offered by ARAI

S. No.	Service	Brief Details
1.	**R&D Services**	Pursuing research in fields, such as powertrain, structural dynamics, safety, electronics, materials, noise, vibration and harshness and computer aided engineering ARAI has successfully developed indigenous LPG and CNG conversion kits for two and three wheelers to meet EURO IV emission norms. ARAI through its research activities in the field of powertrain and electronics has generated key products of industrial importance. Some of the key products are EURO-4 CRDI Diesel Development; CNG HCV for Bus Application; LPG Passenger Car for OEM Application; In-vehicle Duty Cycle and Operation Pattern Recorder and Conversion of Legacy Sensors Data to CAN Messages

2.	**Education and Training**	ARAI has built ARAI academy with an aim to develop eco-friendly research institute for masters, doctoral and professional improvement courses in the field of automotive engineering in collaboration with universities (national and international) like, VIT University, Vellore; VELTEC University, Chennai; College of Engineering Pune; University of Alabama, Birmingham and 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. FID is supported and promoted by MoHI&PE, GoI, ARAI and Association of Indian Forging Industry (AIFI)
4.	**Certification**	ARAI provides certification for vehicles, engines, safety components, genset, agricultural equipments, construction equipments and bus body builders.
5.	**Testing and Calibration**	Under testing and calibration service, ARAI offers testing services to the auto electronics, auto component and IT industry.

Source: *www.araiindia.com*

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. ARAI is credited with 15 granted patents and 18 filed patents along with 25 technology transfers. Now, ARAI is 100% self-sustainable autonomous body. In the last year, ARAI generated revenues worth ₹ 214.41 crores, which were sufficient for meeting all the expenses of the institute including the salaries of 65 employees. Last year, ARAI earned a net profit close to ₹ 20 crores, amounting to 10% of the total revenues generated, after meeting all the expenses of the institute. ARAI is credited with 9.3% year on year growth in its operational income and 57% of its operational income comes from non-certification business which mainly relies on its R&D activities (Annual Report 2014-15). ARAI has strong industrial linkages. It has 73 member industries who are availing different services offered by ARAI. List of important member companies include Ashok Leyland Ltd., Bajaj Auto Ltd., Eicher Motors Ltd., Ford India Pvt. Ltd., General Motors India Pvt. Ltd., Honda Cars India Ltd., Hyundai Motor India Ltd., Kirloskar Oil Engines Ltd., Lombarghini India Pvt. Ltd., Mahindra & Mahindra Ltd., Maruti Suzuki India Ltd., Mercedes-Benz India Pvt. Ltd., Skoda Auto India Pvt. Ltd., Tata Motors Ltd., TVS Motor Co. Ltd., Volkswagen India Pvt. Ltd., and Volvo India Pvt. Ltd.

ii) Indian Plywood Industries Research and Training Institute (IPIRTI); Bengaluru;

www.ipirti.gov.in

Public Sector: Ministry of Environment, Forests and Climate Change (MoEF&CC), GoI
Private Sector: Plywood Industries

IPIRTI is an autonomous body established in 1962, under the Ministry of Environment, Forests and Climate Change (MoEF&CC), 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 organization with a mandate of developing novel eco-friendly technologies for wood industry.

Till date, 68 industries have attained IPIRTI membership. Some of the notable member industries are: ARCL Organics Ltd., Kolkata; Aditya Industries, Navsari; Century Plyboards (I) Ltd., Kolkata; Fine Wood Products Pvt. Ltd., Puducherry; Greenply Industries Ltd., Kolkata; Hero Plywoods & Boards, Thaliparamba; 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 and The Western India Plywoods Ltd., Kannur.

IPIRTI is working with the 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 the field of wood and panel products, such as lignocelluloses and agro residues. The 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

IPIRTI is credited with 5 granted patents and 9 filed patents (Table 5.4). It has carried out 28 in-house projects, 13 sponsored projects and 3 consultancy projects and has successfully transferred 18 technologies to various organizations (Table 5.5).

Table 5.4: List of Patents Granted and Filed to IPIRTI

S. No.	Title	Status
1.	Development of Matchstick from Bamboo	Granted
2.	Bamboo Mat Corrugated Roofing Sheets	Granted
3.	An Improved Process for the Preparation of Water Impermissible Resins	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

Source*: www.ipirti.gov.in*

Table 5.5: Technologies Transferred from IPIRTI

S. No.	Technology	Transferred to
Industries		
1.	Development of 50mm Compreg using Gurjan Species	Indeustch International, Noida, Uttar Pradesh
2.	Manufacture of High Density Bamboo Mat Board	Divine Industries, Mumbai, Maharastra

3.	Manufacture of Bamboo Mat Corrugated Sheet	Brahmaputra Forest Industries, Lakhimpur, Assam
4.	Instruments for Peeling Lathe Adjustments	Kalyan Industries, Yamunanagar, Haryana
5.	Finger Jointing Machine	Lakshmi Industries, Ahmedabad, Gujarat
6.	Light Coloured PF	Shivhari Plywood, Nainital, Uttarakhand
7.	Shuttering Grade Plywood	TATA Coffee Ltd., Mysore, Karnataka
8.	Bamboo Technology (BMT)	Natura Pvt. Ltd., Bengaluru, Karnataka
9.	Bamboo Technology (BMB and BMCS)	Timpack Pvt. Ltd., Byrnihat, Meghalaya
10.	Bamboo Technology (BMB)	Supernatural Plywood, Chandapura, Karnataka
11.	Bamboo Technology (BMB & BMVC)	Cosmicraft Industries, Shillong, Meghalaya
Government Organizations		
12.	Bamboo Technology (BMB & BMVC)	Kerala State Bamboo Corpn., Angamally, Kerala
13.	Bamboo Technology (BMB)	Gramvikas, Berhmapur, Orissa
14.	Bamboo Technology (BMT)	BAIF, Pune, Maharashtra
15.	Coir Tray	Coir Board, Bengaluru, Karnataka
16.	Pine Needle Particle Board	Himachal Pradesh Forest Development Corporation Shimla, Himachal Pradesh
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

***Source**: www.ipirti.gov.in*

IPIRTI has also started various academic programmes including 'Post Graduate Diploma Course in Wood and Panel Products Technology' in association with government agencies and industries to provide education and training in the field of wood and panel industry.

iii) Other Government Supported Organizations for Industrial Development

Many other organizations/institutes have been established by GoI for developing technologies for MSMEs (Table 5.6).

Table 5.6: Organizations/Institutes Established by GoI for Assisting Industrialization of MSMEs

S. No.	Institute	Brief Details
1.	**Mahatma Gandhi Institute for Rural Industrialization, Wardha** *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, Hyderabad** *An organization under Ministry of Micro Small & Medium Enterprises, GoI* http://nimsme.org/	Through its expertise in field of entrepreneurship development, technology development & 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.
3.	**National Small Industries Corporation (NSIC), New Delhi** *GoI enterprise under Ministry of Micro, Small and Medium Enterprise* http://www.nsic.co.in/SCHSERV.ASP	This enterprise is working with the aim to promote growth of MSMEs. It provides financial, technology and marketing support along with consultancy services for MSMEs growth. It has established 106 training cum incubation centres all over India for assisting technology growth of MSMEs.
4.	**Central Manufacturing Technology Institute (CMTI), Bengaluru** http://cmti-india.net/	CMTI is the R&D organization supported by DIPP with an aim to harness technology know-how in the manufacturing sector.
5.	**Central Pulp & Paper Research Institute (CPPRI), Saharanpur** http://www.cppri.org.in/	It is an autonomous body under the aegis of DIPP, working with a mandate of enhancing R&D in pulp and paper industry.
6.	**National Council for Cement and Building Materials (NCB), Faridabad** http://www.ncbindia.com/	Ministry of Commerce and Industry, GoI established this institute for promoting technology development and transfer along with number of industrial services for cement and construction industries.

iv) The Energy and Resources Institute (TERI); New Delhi; *www.teriin.org*

Public Sector: Financial Support from Government Funding Agencies
Private Sector: A Private Research Institute-The Energy and Resources Institute (TERI)

TERI is an autonomous, *not for profit*, independent research institute established in 1974. This institute has immensely contributed towards science and policy research and has attained global recognition for its competent research in the domain of energy, environment and sustainable development.

- **Research and Development**

TERI focuses on research to deliver continuous and worthwhile solutions, in the following major areas:

- Biotechnology and Bioresources
- Energy Environment Technology Development
- Sustainable Development Outreach
- Industrial Energy Efficiency
- Environmental and Industrial Biotechnology
- Social Transformation
- Water Resources
- Sustainable Habitat
- Earth Science and Climate Change
- Knowledge Management

The institute has amassed a number of technologies that carry tremendous capability to minimize the ecological footprints on the natural resources of the country. Nearly 1300 research projects (ongoing/completed) catering to different fields have been funded by various national and international agencies. A few of the effective and economically viable technologies developed along with their beneficiaries are listed in table 5.7.

Table 5.7: Selected Technologies Developed at TERI

S. No.	Technology	Beneficiaries
1.	**Advanced wastewater treatment made affordable**	· Municipalities · Communities (urban and sub urban)
2.	**Oilzapper and Oliovorous-S** Oilzapper (a bacterial consortium that degrades crude oil and oily sludge) Oilivorous-S (contains an additional bacterial strain that makes the former more effective against sludge and crude oil with high-sulphur content).	Approx. 5000 hectares of cropland contaminated with crude oil spills has already been reclaimed and nearly 26000 tonnes of oily sludge has been successfully treated with Oilzapper. A few of the consumers include: Bharat Petroleum Corporation Ltd. (BPCL), Oil and Natural Gas Corporation (ONGC), Oil India Ltd. (OIL), Hindustan Petroleum Corporation Ltd. (HPCL) and Reliance Industries Ltd. (RIL)
3.	**Microbially enhanced oil recovery**	Wells of the ONGC, Gujrat have been revived and are now functioning again.

4.	**Reclamation of abandoned fly ash dumps using Mycorrhizal Technology**	Fly ash dumps near the power plants at Badarpur (Delhi), Korba (Chattisgarh), Vijayawada (Andhra Pradesh) have been revived and today stand green.
5.	**Reclamation of Wastelands contaminated with Chlor Alkali Sludge**	The toxic chemical basin created at the Tata Chemicals Ltd., Mithapur, Gujarat plant has been converted into a green belt.
6.	**Technology to manage distillery effluents**	An effluent loaded site of a distillery in Madhya Pradesh has been treated using mycorrhizae and a few other useful microbes. Technology is called as high-rate transpiration system (HRTS) technology.
7.	**Membrane filtration for sugar manufacturing**	Sugar mill owners e.g. The Simbhaoli Sugar Mills Limited, the venue of the pilot study, has adopted a full-scale juice pre-filtration system that was tested during pilot trials for the removal of suspended solids from clarified juice.
8.	**TERI's enhanced acidification and methanation (TEAM) technology** Converts organic waste dumps into resource centres	· Communities (villages, towns, cities etc.) · Municipal Corporations.
9.	**Natural-gas-based pot and muffle furnaces for glass industry**	Nearly 45 muffle furnace units of the glass industry in the Firozabad, Uttar Pradesh, area have switched over to TERI's design which exhibited substantial reduction in energy consumption as well as emission of pollutants.
10.	**Bollcure-New Bio Pesticide for Cotton Bollworm** A plant extract-based bio pesticide formulation	TERI has filed two national patents and one international PCT application for this technology, which will benefit agriculturalists.

***Source**: http://teriin.org/*

Owing to its vision of developing sustainable technologies/solutions, TERI has successfully developed and transferred a few technologies as listed in table 5.8.

Table 5.8: Successful Technology Transfers by TERI

S. No.	Technology	Name of the Licensee
1.	Plant extract based biopesticide formulation 'Bollcure' against cotton bollworm (*Helicoverpa armigera*)	· Sri Biotech Laboratories India Pvt. Ltd., Hyderabad · Pasura Biotech Pvt. Ltd., Hyderabad · Marrone Bioinnovations Inc., Delaware USA

2.	Mass production of Mycorrhiza biofertilizer	· Cadila Pharmaceuticals Ltd., Ahmedabad · KCP Sugar and Industries Corporation Ltd., Chennai
3.	Improved technology of mass production of Mycorrhiza biofertilizer	· Cadila Pharmaceuticals Ltd., Ahmedabad
4.	Mycorrhiza consortium production	· Majestic Biotech Pvt. Ltd., New Delhi · KCP Sugar and Industries Corporation Ltd., Chennai · Cosme Pharma Pvt. Ltd., Goa · Sarita Ganga Farms Pvt. Ltd., Ahmedabad
5.	Oil Zapper- Bioremediation of polluted sites by petroleum industries/installations using oil zapper technology	· Group of petroleum companies (ONGC, IOC, HP and BP).

Source: *http://deskuenvis.nic.in/biotechinfo.asp/; http://www.teriin.org/events/icom/files/mycorrhizal_tech.pdf; http://www.teriin.org/events/icom/files/BMBD_brochure.pdf*

TERI's strength lies in its research competence and the capacity to develop frugal innovations. The institute specialises in initiating projects that lead to the solutions of specific problems and the technologies developed henceforth, that are socially beneficial and dissemination of intellectual property. TERI's research group has filed nearly 50 patents and 14 technologies are ready to be licensed/transferred (Table 5.9).

Table 5.9: Technologies Ready for Licensing and Technology Transfer

Biomass dryers for cash crops	Bio-remediation of acidic sludges (patent applied)
Production of compacted fuels from crop residues	A process for biomethanation of organic wastes (patent applied)
Arbuscular Mycorrhizae biofertilizer as a natural alternative to chemical fertilizers	A process for storage of vesicular arbuscular mycorrhizae (patent applied)
Thermal applications for silk thread production	A biopesticide based on eucalyptus plant extract (patent applied)
Biomass gasification for heat and power applications for rural, commercial, and industrial applications (upto 150-kW capacity)	A method for preventing deposition in an oil-well bore using microbial means (patent applied)
Microbial nutrients for bio-remediation of oil sludges and contaminated soils	Technology for reclamation of flyash overburdens and alkali-chlor sludge
Ceramic membranes for clarification applications	Technology for reclamation/management of distillery and paper and pulp effluents

Source: *http://www.teriin.org/technology/technology*

v) Shriram Institute for Industrial Research (SRI); New Delhi; *www.shriraminstitute.org*

Public Sector: Financial Support from Government Funding Agencies **Private Sector:** A Contract Research Organization-Shriram Institute for Industrial Research (SRI),

SRI, a self sustaining, independent, *not for profit* multidisciplinary contract research organization was founded by an industrialist, Lala Shriram in 1947. SRI is a unit of society 'Shriram Scientific and Industrial Research Foundation'. SRI is conducting research in many areas (material sciences, analytical sciences, life sciences and irradiation of medical products) keeping in mind the needs of industry. It is committed to innovate, analyse, develop and use technology for generating products and processes. SRI has successfully brought its innovations to the market place through licensing and also support establishment of production units for the interested clients. SRI is an ISO-9001 certified contract research organization and conducts R&D projects, testing, calibration, inspection and environmental protection, irradiation services, toxicology studies and offers services for consultancy.

➢ **Services of SRI**

SRI is engaged in a wide range of R&D activities covering material sciences, analytical science, life sciences and biosciences. Number of services for the industry and academia are offered by SRI. Major service offerings of SRI in various domains are presented in table 5.10.

Table 5.10: Major Services Offered by SRI

S. No.	Services	Brief Details
1.	**Development of new products and its applications**	Major R&D activities include: · Identification of new product, application, process and technology · Improvements in the existing product and process · Scale-up studies to take up development work from lab scale to commercial scale · Cost effective measures either by suggesting alternative route or process of manufacturing of a particular product · Rendering technical help in preparation of product, application and safety data sheet for capturing market **Through its R&D activities ~25 technologies have been developed by materials science division of SRI and has given analytical support to ~108 products.**

2.	**Contract Research**	SRI undertakes time-bound contract research tasks pertaining to identification, development and modification of processes for commercialization of specified product as per the satisfaction of the client. SRI carries out research work on behalf of the multinational companies on signing confidentiality agreement and MoU. They also promote a base for corporate R&D tie-ups as per the mutual interest. The sponsor's interests are taken care, both from confidentiality and intellectual property area.
3.	**Technical Consultancy**	Technical consultancy to the SMEs and budding entrepreneurs to set up the production unit is provided at nominal fees.
4.	**Technology Business Incubator (SRI-TBI)**	SRI-TBI offers number of services to the entrepreneurs to convert their ideas into business reality. This centre is also actively involved in providing solutions to the industrial problems making them market competitive. **SRI-TBI has led to the development of 8 technologies and presently collaborating with ~24 industries.**
5.	**Toxicological Studies**	Various studies undertaken by SRI, as per norms of National and International guidelines are as follows that can be availed by industries or research laboratories: chronic, acute and sub acute toxicology studies; ecotoxicology studies; irritation study; allergic sensitization; reproductive toxicity; carcinogenicity and mutagenecity; biocompatibility study and bio-safety studies
6.	**Microbiological Studies**	SRI undertakes inspection and quality certification for industries which are associated with drugs, pharmaceuticals, cosmetics, raw and processed food and water.

Source: *www.shriraminstitute.org*

SRI has oriented its research towards the progress of industries and scientific fraternity by providing number of services using *state of art* facilities. More than ~1500 industries have availed SRI services in various domains.

5.2. Academia-Industry Model (AIM)

Academic institutions are the store house of intelligentsia which industrial sector is eager to utilize for its on-going and futuristic R&D activities. It has been observed that industries are eager to tie -

up with academic institutions which are performing commendably in the domains of patents, technologies and entrepreneurship. In such institutions, industry has contributed financially for establishing centres of excellence, research/testing laboratories, industry chairs and scholarships/fellowships. Industry also grants many research projects to scientists. The partnership of industries with academia has become more needful and relevant, as they have realized that in order to progress and compete globally, they need to bring scientific innovations in their existing system. Therefore, it is imperative for industry and academia to partner with each other in order to pursue focussed research that can be translated into an innovative product/technology/process. The examples of academia-industry partnership under AIM are as follows:

5.2.1. Centres of Excellence

5.2.2. Research Laboratories

5.2.3 Entrepreneurship Development Programme

5.2.1 Centres of Excellence (CoEs)

Public Sector: Higher Education Institutes (HEIs)
Private Sector: International Business Machines (IBM) Corporation, India

A renowned private software company, International Business Machines (IBM) Corporation, has established nearly 150 Software CoEs in educational institutes all over India. These CoEs are called as ***IBM Software Centre of Excellence;*** http://www-07.ibm.com/in/projectpraviin/coe.html. A few of such CoEs have been established at Guru Nanak Dev University, Amritsar, Punjab; Punjab Agricultural University, Ludhiana, Punjab; Pandit Deendayal Petroleum University, Gandhinagar, Gujarat; Calcutta Institute of Technology, Howrah, West Bengal; University of Petroleum of Petroleum & Energy Studies, Dehradun, Uttarakand and SSG Panjab University Regional Centre, Hoshiarpur Punjab.

5.2.2 Research Laboratories

Public Sector: Higher Education Institutes (HEIs)
Private Sector: Industries

Various industries have set up specialized laboratories/units in academic institutions where industry personnel and academicians (faculty and researchers) together carry out industry oriented research activities (Table 5.11).

Table 5.11: Research Laboratories Established by Private Sector in Higher Education Institutes

Industrial Set up	Academic Institution
· Xilinx FPGA Laboratory · The Tata Infotech Laboratory · Intel Microelectronics Laboratory · Laboratory for Intelligent Internet Research · Tata Consultancy Services Laboratory for VLSI Design and Device Characterization · 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 Electronics and Communication 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
· M. K. Rangnekar Memorial Laboratory · Ramesh Banatwala Memorial Industrial Pharmacy Laboratory · E- Merck Laboratory and Chemistry Laboratory · Nihchal Israni Microbiological Laboratory · Academy of Clinical Excellence	Bombay College of Pharmacy, Mumbai

The investment of private sector in the domain of R&D in public sector is an example of synergy between industry and academia. Initiation of industry funded scholarships, chairs and entrepreneurship development programmes are the example of I-A synergy in domain of R&D.

5.2.3 Entrepreneurship Development Programme

Of late, GoI is vigorously promoting the spirit of entrepreneurship among the young minds. Various ministries have initiated many schemes for the same. Private sector is also actively involved to enhance entrepreneurial culture among the youth of India. Recently, a leading pharmaceutical company, Pfizer Ltd., India has partnered with an industry-academia interface based in IIT-Delhi, known as 'Foundation for Innovation and Technology Transfer' (FITT) to promote R&D and entrepreneurial activities. Pfizer and FITT have co-created an '*Incubation Accelerator'* to promote R&D in pharmaceutical research. A collaborative programme-'*Pfizer IIT Delhi Innovation and IP Program' (PIDIIP)* has been initiated through which support of ~₹ 50 lakhs along with mentor and infrastructure support will be provided to scientists/researchers to transform their entrepreneurial idea to IP.

Other than Pfizer Ltd., several other private organizations have collaborated with FITT to promote innovation in IIT-Delhi. Power System Operation Corporation Limited (POSOCO), a PowerGrid subsidiary company has introduced an award 'POSOCO Power System Award' (PPSA) to encourage innovative/entrepreneurial research in the power systems. ERRICSON India also instituted 'ERRICSON Innovation Awards' to encourage research in field of web designing. A private bank, ICICI, has also collaborated with FITT to start 'ICICI Trinity Programme' to promote innovation and entrepreneurship and consist of 3 phases which are a) ideate, b) prototype and c) be an entrepreneur.

5.3. Government-Academia-Industry Model (GAIM)

The Triple-Helix Model of PPP for R&D, wherein government, academia and industry have joined hands, can be seen in the establishment of CoEs, academic institutes, funding agencies, incubators, accelerators and science parks as mentioned below:

5.3.1. Centres of Excellence

5.3.2 Autonomous Academic Institutes

5.3.3 Government Sponsored Funding Agencies

5.3.4. Technology Business Incubators and Accelerators

5.4.5. Science Parks

5.3.1 Centres of Excellence (CoEs)

i) Telecom Centres of Excellence (TCOEs); *www.tcoe.in*

Public Sector: Department of Telecommunication (DoT), Ministry of Communication (MoC) and Academic Sector (IITs, IIM-Ahmedabad and IISc-Bangalore)

Private Sector: Telecom Industries

TCOEs were conceptualized in 2007 and came into existence in 2008. Various telecom industries became sponsorers for establishing TCOEs in premier institutes in India such as IITs, IIM-Ahmedabad and IISc-Bangalore (Table 5.12). TCOEs are working under PPP mode. These are the perfect examples of academia, industry and government working together to achieve excellence in the field of R&D. They have been created with an objective to promote generation of IPRs, development of new technologies, incubating innovations and entrepreneurship in telecom sector.

Table 5.12: Telecom Centres of Excellence (TCOE) in India

S. No.	TCOE	Research Focus Area
1.	Aircel TCOE at IISc-Bangalore	Information Security and Disaster Management of Telecom Infrastructure
2.	Bharat Sanchar Nigam Ltd. (BSNL) TCOE at IIT-Kanpur	Multimedia and Telecom, Cognitive Radio and Computational Mathematics
3.	Bharti Airtel TCOE at IIT-Delhi	Telecom Technology and Management
4.	Idea Cellular TCOE at IIM-Ahmedabad	Telecom Policy, Regulation and Customer Care
5.	Reliance Communications TCOE at IIT-Madras	Telecom Infrastructure (Active and Passive) and Energy
6.	Tata Teleservices TCOE at IIT-Bombay	Rural Telecom Technology
7.	Vodafone Essar TCOE at IIT-Kharagpur	Next Generation Networks and Technology
8.	RailTel TCOE at IIT-Roorkee	ICT and Broadband Applications

ii) MHRD initiated CoEs under PPP mode

Public Sector: Ministry of Human Resource Development (MHRD), GoI
Private Sector: Industries and Private Organizations

MHRD has also created CoEs under the scheme of teaching 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 CoEs have been created by MHRD in association with industrial sector in different parts of India. As per the desire of MHRD, each CoE is expected to be a collaborative activity between a team of high quality researchers in the institution and researchers or research-users in several companies or organizations on new and emerging technologies, multi-disciplinary and translational research relevant to national development goals (http://mhrd.gov.in/technical-education-13).

5.13: Notable CoEs Created Under Training and Research in Frontier Areas of Science and Technology (FAST)

S. No.	Institute	CoE
1.	IIT- Delhi	Nanoscale Devices and Systems
2.	TERI University-New Delhi	Energy Storage
3.	IISc-Bangalore	Biomolecular Interaction Studies
4.	IISER-Thiruvanathapuram	Computation, Modelling and Stimulations
5.	IIT-Bombay	Urban Science and Engineering
6.	IISER-Pune	Research in Energy and Sustainable Materials
7.	NIT-Rourkela	Tissue Engineering
8.	IIT-Bhubneshwar	Novel Energy Materials (NEM)
9.	IISER-Mohali	Protein Science, Design and Engineering
10.	IIT-Madras	Nonintrusive Diagnostics
11.	IIT-Kanpur	Advanced Computer Research
12.	IISER-Kolkata	Computational Space Science
13.	IIT-Kharagpur	E-Business
14.	IIT-Guwahati	Advanced Molecules and Materials

Source: *http://mhrd.gov.in/sites/upload_files/mhrd/files/List%20of%20Centres%20of%20Excellence.pdf*

iii) CoE in Wireless Technology (CEWiT); *www.cewit.org.in*

Public Sector: Ministry of Communication (MoC), Ministry of Electronics and Information Technology (MeitY) and Academic Sector (IIT-Madras)

Private Sector: Telecom Industries

CEWiT was set up by Ministry of Communication (MoC) and Ministry of Electronics and Information Technology (MeitY), GoI in partnership with the leading Indian telecom industry as an autonomous research organization. It is registered as a society in IIT-Madras and is functioning from IIT-Madras Research Park. CEWiT is working as a partner to various stakeholders, such as industry and government policy makers for strengthening field of wireless communication in India. It is specifically focusing on research in area of 4G/4G-Advanced and 5G technologies. CEWiT also provides consultancy services to IT industry on many areas of the wireless communication technology.

5.3.2 Autonomous Academic Institutes

Recently, MHRD has introduced plans to create Higher Education Institutes (HEIs), like polytechnics and IT related institutes, under PPP mode. The concept of HEIs under PPP mode is not new. Two HEIs, namely Bombay College of Pharmacy, Mumbai (established in 1957) and Institute of Chemical Technology, Mumbai (established in 1933 as one of the university department) were instituted by the government at the growing demand of industry/industry associations. These two institutes are working in close collaboration with industries and have significantly contributed to the R&D industrial growth. A brief about above mentioned institutes is presented below.

i) Indian Institutes of Information Technology (IIITs)

Public Sector: Ministry of Human Resource Development (MHRD), GoI
Private Sector: Industries

MHRD, GoI has introduced plans for the establishment of IIITs with funding support from central government (50% funding), state government (35% funding) and industrial segment (15% funding). A few such institutes have been established, e.g. IIIT-Pune (http://www.isquareit.edu.in/) and IIIT-Hyderabad (https://www.iiit.ac.in/). IIIT-Hyderabad is the first IIIT to be established as a *not for profit* public private partnership (N-PPP) model. A governing council consisting of eminent people from academia, industry and government presides over the governance of the institution.

ii) Polytechnic Colleges

Public Sector: Ministry of Human Resource Development (MHRD), GoI
Private Sector: Industries

The Indian government's mission is to train skilled manpower of at least 500 million persons by 2020. To achieve this goal, MHRD has decided to set up 300 new polytechnics under PPP mode. For each college, the proposed share of MHRD, state government and industry partner will be ₹ 3.00 crores, ₹ 2.00 crores and ₹ 10.00 crores, respectively (http://www.aicte-india.org/downloads/Details_of_the_Scheme_171111.pdf).

iii) Bombay College of Pharmacy; Mumbai; www.bcpindia.org

Public Sector: State Government of Maharashtra
Association: Indian Pharmaceutical Association-Maharashtra State Branch (IPA-MSB)
Private Sector: Pharma Industrial Conglomerates

Bombay College of Pharmacy (BCP) affiliated to University of Mumbai, is one of the premier pharmacy colleges in India, imparting quality pharma 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 (www.bcpindia.org).

BCP has constituted a *'Research Society'* in association with Indian Pharmaceutical Association and is recognized by DSIR. This society manages and co-ordinates various industrial research collaborations for related industries. Research is highly promoted in various domains such as pharmaceutics, pharmacology and toxicology, pharmaceutical chemistry, pharmacognosy and pharmaceutical analysis. 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 terms of industrial trainings, industry sponsored projects, consultancy and faculty exchange.

BCP has been documented as one of the successful I-A linked institutes of the country. Since 2013, this institute has been accredited with the 'Best Industry-Linked Institution in Pharmacy'according to the national survey carried out by AICTE in collaboration with CII. BCP has devised incentives for faculty for carrying out I-A research and consultancy services. Twenty percent of total project cost for research projects and 67% of total consultancy cost is paid to the concerned faculty. Industry linkages of BCP are briefed below:

a) Industry Institute Interaction Cell (IIIC)

BCP has dedicated 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).

b) Industry Representatives in Committees

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 academic curriculum and design of course structure. Eighteen industrialists from notable pharma industries are presently part of BCP's governing body.

Several industries have partnered with BCP for pursuing collaborative research e.g. Pfizer Ltd., Mumbai; Dr. Reddy's Laboratories Ltd., Hyderabad; Novartis India Ltd., Mumbai; Sanofi-Aventis Pharma Ltd., Mumbai; Spectra Clinical Research Center, Hyderabad; Mumbai and Zydus Byk Healthcare Ltd., Mumbai.

c) 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 Dr. Rao VSVV, Vice President, Nektar Therapeutics India Pvt. Ltd.; Dr. Arun Bhatt, President, ClinInvent Research Pvt. Ltd., and Dr. C.N. Potkar, Director, Clinical Research & Regulatory Affairs, Pfizer Ltd.

d) 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. The industrial collaborations of the major departments of BCP are mentioned in table 5.14.

Table 5.14: Industrial Collaborations of Major Departments of BCP

Department	Industrial Collaborators	Details
Pharmacology and Toxicology	Shreya Lifesciences; Yasham P2D; Marico Ltd.; ACTREC; Haffkin Institute; PCP (BDVU)	Faculty Members: 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 Members: 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 Members: 4; Patents: 6 Consultancy Services *(in last 5 Years)*: ~2
Pharmacognosy	Omniactiv; Anazeal; Marico Ltd.	Faculty Members: 2; Patents: 1 Consultancy Services *(in last 5 Years)*: ~3
Pharmaceutical Analysis	Marico Ltd.; Spring Bank Pharmaceuticals Inc.	Faculty Members: 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 (Table 5.15).

Table 5.15: Research Laboratories Created in BCP in Association with Industry

The Vividhlaxi Audyogik Samshodhan Vikas Kendra (VASVIK) Research Wing
M. K. Rangnekar Memorial Laboratory
Bioavailability Centre
Ramesh Banatwala Memorial Industrial Pharmacy Laboratory
E- Merck Laboratory and Chemistry Laboratory
Academy for Clinical Excellence (ACE) in Collaboration with Pfizer Ltd., India-Global Research
Nihchal Israni Microbiological Laboratory

Industries have also promoted 'Research Fellowships' at BCP 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 in the field of pharmaceutical and allied science in BCP and some other pharmaceutical institution in India. In addition, AMRF has also supported BCP for payment of faculty salaries amounting to ₹ 47 lakhs.

MoUs with Industries: BCP has signed MoUs with many industries for providing education, training, consultancy and research projects. Name of industrial collaborators of BCP from 2015-16 are Gattefosse India Pvt. Ltd., Fusion Scientific Laboratories Pvt. Ltd., Pioma Chemicals, Naprod life Sciences Pvt. Ltd., Vinayak Ingredients 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 and BASF SE, Germany.

iv) Institute of Chemical Technology, Mumbai; *www.ictmumbai.edu.in*

Public Sectors: Higher Education Institute (HEI)
Private Sector: Industries

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 intention of enhancing India's capability and 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 ICT in 2008. The institute has been recognized as a premier institute in the domain of I-A collaboration in chemical technology, chemical engineering, pharmaceutical sciences, applied chemistry, bio-processing and biotechnology. The fact that over 80% of its faculty members are working closely with the industry gives a commendable measure of its I-A collaboration.

Recently (2016), ICT Mumbai was ranked as number 2 university, under the National Institutional Ranking Framework (NIRF) of MHRD, (GoI). A brief profile of ICT is provided in table 5.16.

Table 5.16: Brief Profile of ICT, Mumbai

Attributes	Details
Status of University	Deemed University (University under Section 3 of UGC)
Source of Funding	State Government
Faculty Strength	82
Faculty Involved with Industrial Consultancy	80%
Patents Filed (in last 10 years)	310
Research Paper in International Journal (2011-15)	2806
Average Papers per Faculty	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

Source: *www.ictmumbai.edu.in*

a) Centres of Excellence (CoEs)

Three CoEs related to R&D have been established in ICT to promote quality education and research through the support of central agencies. These are:

- DBT-ICT-Centre for Energy Biosciences: The main focus of this Centre is on the development of biofuels from renewable resources to reduce India's increasing reliance on petroleum fuels. The team working in 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 grant received by this Centre from various sources amounts to ₹ 49 crores (approx). This centre also has a dedicated unit for IP management and commercialization. Notable projects undertaken by the Centre are listed in tables 5.17 and 5.18. Patents granted to the centre are listed in table 5.19.

Table 5.17: List of Select Research Projects Undertaken by Centre for Energy Biosciences

S. No.	Title	Funding Agency	Amount (₹) in Lakhs
1.	Green enzymatic fat splitting technology for production of fatty acids and acyl glycerols	DST, India	847.53
2.	Improved production of biogas and bio-CNG from lignocellulosic biomas	MNRE, India	515.61
3.	Centre for energy biosciences: New and extension proposals	DBT, India	1800.00
4.	Transnational approaches to resolving biological bottlenecks in macroalgal biofuel production	DBT-BBSRC (Joint Indo-U.K., Scheme)	471.02
5.	Integrated technologies for economically sustainable bio- based Energy	AISRF Indo-Australia Grand Challenge Program, DST, India	444.00
6.	Mass cultivation of algae for aqua feed	Godrej Agrovet Ltd., Mumbai	115.00

Table 5.18: Inter Institutional Collaborative Projects of Centre for Energy Biosciences

S. No.	Title	Collaboration	Grant (₹) in Lakhs
		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, U.K. Centre for Advanced Research in International Agricultural Development (CARIAD), Bangor University, U.K. Institute of Biological, Environmental and Rural Sciences. Aberystwyth University, U.K.	471.02
3.	Engineering enzymes, bacteria and bioconversion processes for advanced biofuels from waste grain straw	Clostridia Research Group/Life Sciences, University of Nottingham, U.K. Centre for Novel Agricultural Products, Department of Biology, University of York, U.K.	272.08

		Institute for Cell and Molecular Bioscience, Newcastle University, U.K. Faculty Health & life Sciences, Oxford Brookes University, U.K.	
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) 850.60 (DST)
6.	Pilot scale translational facility for value added chemicals from biomass	Privi Biotechnologies (P) Ltd., Mumbai	395.00 (Industry), 390.00 (BIRAC, DBT as a loan), 50.00 (BIRAC, DBT as a grant)
7.	Lignocellulosic ethanol pilot plant to integrated continuous pilot plant	India Glycols Limited, Noida	862.50 (Industry Contribution), 862.50 (BIRAC, DBT as a loan)

Table 5.19: 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	US 8709763 (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 monoacylglycerol from oil	1583/MUM/ 2014	Patent filed; Pilot plant being 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

** L=Lakhs*

- 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 and 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. Notable projects of the centre are presented in table 5.20.

Table 5.20: Important Sponsored Projects (> ₹ 50 lakhs) 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.	Passive decay heat removal system of AHWR	221.00	DAE
3.	Thermal hydraulic studies related to coolants for new generation reactors	80.00	DAE
4.	Characterization of cavitation phenomena and its applications in solid liquid mass transfer operations	88.90	DAE
5.	Transport of actinides and fission products across hollow fibre supported liquid membranes	72.40	DAE

6.	Self assembly of tethered nanoparticles: Macromolecule' for tailored nanomaterials	95.00	DAE
7.	Knowledge based engineering: Improvements in reactor design, heavy water production efficiency, nuclear waste management and development of novel	150.00	DAE
8.	Chemical engineering, education and research	7500.00	DAE

- Centre for Green Technology: Synthetic chemicals are routinely used to make virtually every man-made product, however most of the synthetic chemicals are harmful in nature, therefore 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.

b) Promotion of Research

- Teaching work load remission is provided to the faculty members in order to devote time to research activities.
- Faculties who do not have a Ph. D are encouraged to do Ph. D. Three faculty members have availed this opportunity.
- Provision for 'Sabbatical Leave' for higher research within the country and abroad.
- Many endowment chairs have been created to invite eminent persons from academic and industry, e.g. R.T. Mody Professor of Chemical Technology, Sir Dorabji Tata Reader in Pharmaceutical Chemistry, Darbari Seth Professor of Inorganic Chemical Technology, Bharat Petroleum Distinguished Professor of Chemical Engineering, J.G. Kane Chair of Oil Technology, M. M. Sharma Distinguished Professor of Chemical Engineering, R. A. Mashelkar Chair of Chemical Engineering and many more.
- Instruments/equipments of the institute are available to research scholars 24X7, for performing their research work.

c) Outcomes of Research in ICT-Mumbai

- Publications: Details of the publications by the faculty from 2011-15 are as follows: Number of papers published in peer reviewed journals- 2806, Chapters in books- 29, Books with ISBN- 8, Books edited- 25, Monographs- 6, Number of publications listed in International Database e.g. Web of Science, Scopus, Humanities International Complete and EBSCO host- 2037, Citation Index- 26,498, H-index- 63.
- Patenting and Licensing: ICT-Mumbai has filed/acquired 310 patents in last 10 years of which

189 are during the last 5 years.

- Industry Sponsored Projects: Around 232 industry/corporate houses sponsored projects have been undertaken by ICT Mumbai worth ₹ 84.7 crores.
- Industrial Collaborations: ICT Mumbai has close working relations with both foreign and Indian institutes and industries. A large number of MoUs have been signed to facilitate joint projects and research programmes, faculty and student exchange. Some of the important MoUs are with Bharat Petroleum Corp. Ltd. (BPCL), Reliance Industries Ltd., Hindustan Petroleum Corporation Ltd., Tata Chemicals Ltd., Biotech Consortium India Ltd., GlaxoSmithKline Consumer HealthCare Ltd., lndian Oil Corporation Ltd., Asian Paints Ltd., Godrej industries Ltd., Microsoft Corporation and Coca Cola Ltd.
- Generation of Entrepreneurs: The industry-institute-government relationship fostered by ICT Mumbai has been exemplary and has been acknowledged 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:

  a) Shri. Mukesh D. Ambani (CMD, Reliance Industries Ltd.)

  b) Dr. Dinesh Patel (Chairman, Themis Pharmaceuticals)

  c) Dr. K. Anji Reddy (Chairman, Dr Reddy's Laboratory Ltd.)

  d) Shri. Ashwin S. Dani (Vice Chairman and MD, Asian Paints Ltd.)

  e) Shri. C. J. Bhumkar (Chairman, Soujanya Chemicals)

  f) Shri. C.V. Gogri (Chairman, Aarti Industries and Aarti Group of Companies)

d) Salient Features of Intellectual Property Rights (IPRs) Guidelines of ICT-Mumbai

Research carried out at ICT Mumbai caters to both academic needs 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)*

A few standout features adopted by ICT Mumbai for promotion of IP are as follows:

- In ase of patent filed by the faculty members, if there is no third party involved, the license fee should be shared between the institute and faculty members in the proportion of 30% to the institute and 70% to the faculty members.
- In the case of patent filed by the faculty members, if there is no third party involved, the royalty will be shared in the ratio of 1:4 i.e., 20% to the institute and 80% to the faculty members and the

other inventors.

- The institute will not pay any annual renewal fee for the patent granted. It shall be the responsibility of the pantent holder.

5.3.3 Government Sponsored Autonomous Funding Agencies

A few ministries and GoI have created specialized agencies for promoting investments in R&D from both industrial and academic sector under PPP mode. For example, 'Biotechnology Industry Research Assistance Council' (BIRAC) and 'Biotechnology Consortium India Limited' (BCIL) have been established by Department of Biotechnology (DBT), GoI with a mandate of strengthening Indian biotech sector by bringing industry and academia together and enhancing entrepreneurship in biotech field. CSIR has created 'CSIR-Tech' as a commercialization arm for various academic institutions including R&D institutions and universities by collaborating with potential industries.

i) Biotechnology Industry Research Assistance Council (BIRAC); New Delhi; *www.birac.nic.in*

Public Sector: Government Funding Agencies
Private Sector: Biotech Industries

Government of India through DBT (www.dbtindia.nic.in) 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, Schedule B, Public Sector Enterprise registered under Indian Companies Act 1935. DBT formulated 'National Biotechnology Development Strategy' in 2007 and announced that 30% of its budget will be set aside for PPP via creation of separate organization in order to execute and implement PPP. BIRAC 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 within 5 years of its existence has strongly connected with different stakeholders, both from academia and industry, who are contributing to tremendous growth of biotech sector.

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. Through different programmes of BIRAC, three major domains are addressed which are as, a) Promotion of PPP in biotech sector; b) Bridging I-A collaboration of biotech companies and academic institutes pursuing biotechnology and c) Supporting entrepreneurship culture in India. Programmes/schemes started by BIRAC to address the first two domains are described in table 5.21.

Table 5.21: Industry-Academia Programmes Offered by BIRAC

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. · 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 over 200 companies in diverse fields of biotechnology · Till date has generated 13 products/technologies and 8 early stage technologies.
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. · In totality under this scheme 157 projects have been sponsored · 146 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 · Total products generated:16; Early stage technologies: 17

3.	**Contract Research and Service Scheme (CRS)**	· Scheme started to boost PPP efforts in the country · 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. Presently, 21 academia and 17 industrial partners have received grant of ₹ 28 crores
4.	**University Innovation Cluster (UIC)**	In order to encourage techno-entrepreneurship in Indian education system, BIRAC has created University Innovation Clusters (UICs). 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 and product development to the innovators. Through these centres, industries participation for training, mentoring and sponsored research and networking opportunities is also encouraged. Nearly, 10% of the salaries of the employee of UIC, BIRAC is invested in industrial R&D

Source: *www.birac.nic.in; http://www.birac.nic.in/webcontent/BIRAC_Brochure_march_2016.pdf*

Through the channel of BIRAC, R&D under PPP is widely pursued in Biotechnology. BIRAC has contributed ₹ 677 crores and private sector around ₹ 765 crores in total funding for more than 500 projects in field of biotechnology. Field wise funding contribution of BIRAC and private companies are depicted in figure 5.3.

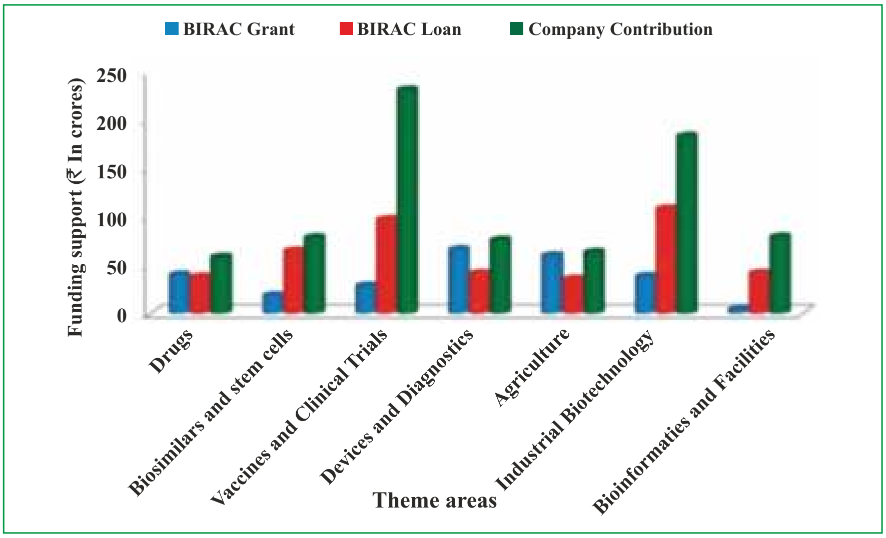


Figure 5.3: PPP Investments in Various Areas of Biotechnology

Source: *http://www.birac.nic.in/webcontent/birac_compendium_2015.pdf*

BIRAC's innovative schemes for funding has greatly enhanced and encouraged industry to collaborate and fund various research projects. BIRAC has actively contributed to collaborations between various stakeholders as presented in figure 5.4.

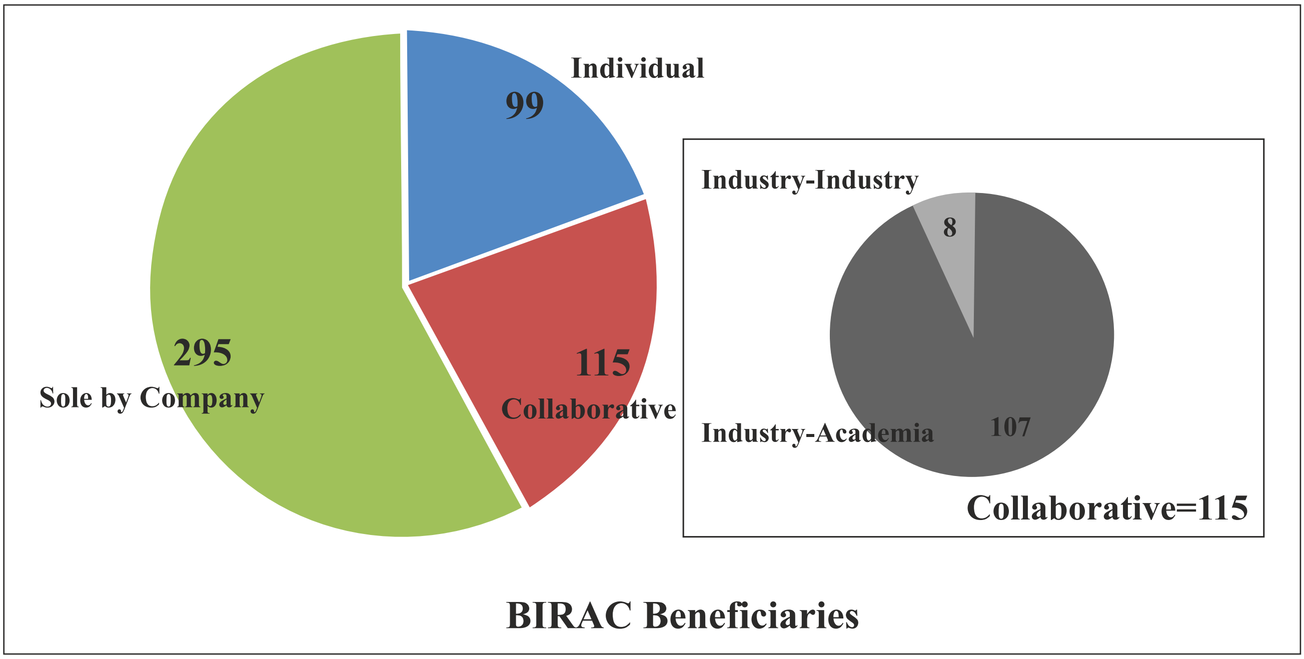


Figure 5.4: BIRAC Beneficiaries

Source: *http://www.birac.nic.in/webcontent/birac_compendium_2015.pdf*

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. BIRAC has brought nearly 30 products/technologies to the market, promoted over 115 I-A research collaborations, supported more than 340 companies and 104 biotech start-ups and generated close to 230 employment opportunities in the field of biotechnology.

ii) Biotechnology Consortium India Limited (BCIL); New Delhi; *www.bcil.nic.in*

Public Sector: Government Funding Agencies
Private Sector: Biotech Industries

BCIL is a public company under Indian Companies Act 1956, instituted by DBT, GoI and All India Financial Institutions in 1990. BCIL is working with a mandate of creating a channel for necessary linkages amongst various stakeholders (government, academic institutes, research institutes, financial institutions and corporates) for accelerating commercialization of technologies in the field of biotechnology. Governance of BCIL composes of senior representatives from DBT, GoI, New Delhi; CSIR, Indian Council of Agricultural Research (ICAR), financial institutions of India [Industrial Development Bank of India (IDBI), Small Industries Development Bank of India (SIDBI), Export

Import Bank of India (EXIM Bank) and North East Development Financial Commission] and biotech industry. BCIL is actively working in the domains of technology management, technology transfer, consultancy, syndication of funds, dissemination of information and training in the biotech sector. It has successfully licensed and transferred technologies from the technology developers, such as scientists and researchers from academic and research institutes to the potential market. BCIL has evolved as a unique platform for networking among all the stakeholders to facilitate commercialization of biotechnology. BCIL has cliental from government, academia and industries as mentioned in table 5.22.

Table 5.22: Cliental of BCIL

Government Agencies	State Government	Corporate	International
▪ Department of Biotechnology (DBT) ▪ Department of Science and Technology (DST) ▪ Ministry of Environment and Forests and Climate Change (MoEF&CC) ▪ Ministry of Agriculture (MoA) ▪ Ministry of Micro, Small & Medium Enterprises (MSME) ▪ Agricultural & Processed Food Products Exports Development Authority (APEDA) ▪ National Biofertilizer Development Center ▪ Ministry of Food	▪ Government of Andhra Pradesh ▪ Government of Assam ▪ Government of Madhya Pradesh ▪ Government of Chhattisgarh ▪ Government of Tamil Nadu ▪ Government of Kerala ▪ Government of Uttar Pradesh ▪ Government of Haryana ▪ Government of Punjab ▪ Government of West Bengal ▪ Government of Orissa	▪ Shanta Biotechniques, Hyderabad ▪ J Mitra & Company, New Delhi ▪ Panacea Biotech Ltd., New Delhi ▪ Bharat Biotech India Ltd., Hyderabad ▪ Biological E. Ltd., Hyderabad ▪ USV Ltd., Mumbai ▪ Zydus Cadial, Ahmedabad ▪ IL& FS, Mumbai ▪ EXPO Mushroom Ltd., Orissa ▪ BASF, Mumbai	▪ United Nations International Development Organization (UNIDO), Vienna ▪ AGBIOS, Canada ▪ Canadian High Commission, Delhi ▪ United Nations Environment Programme (UNEP), Nairobi ▪ World Intellectual Property Organization (WIPO), Geneva ▪ South Asian Association for Regional Cooperation (SAARC), Katmandu ▪ World Bank, Washington ▪ Indo Swiss Collaboration in Biotechnology, Zurich ▪ African Center for Technology Studies, Kenya

Source: *www.bcil.nic.in*

➢ Services Offered by BCIL

BCIL provides number of services for technology management to various stakeholders as listed in table 5.23.

Table 5.23: Services Offered by BCIL

S. No.	Service	Brief Details
1.	**Technology Transfer**	It acts as interface body between technology sources and seekers of the technology, both nationally and internationally. It has developed well knit network of research and academic institutes with number of government agencies and industries for technology sourcing, tie-ups for marketing and looking for joint venture partners. **BCIL has transferred 42 technologies and 27 technologies are available for licensing.**
2.	**IP Facilitation**	BCIL provides a single window service for IPR protection and management in discipline of biotechnology to various stakeholders.
3.	**Project Consultancy**	BCIL provides consultancy services to various stakeholders in project feasibility studies, business plans, design of biotech parks, sectoral studies, market surveys, technical assessment studies, strategic advisory services for new products, diversification plans and investment plans.
4.	**Project Management**	BCIL provides services for administrative, technical and financial management for long term projects. In the following projects, BCIL has provided management services: · National Biodiversity Strategy and Action Plan (NBSAP) · Small Business Innovation Research Initiatives (SBIRI) · Biotechnology Industry Partnership Programme (BIPP)
5.	**Certification Services**	DBT, GoI has recognized BCIL as National Certification System for Tissue Culture Raised Plants Management Cell for assisting DBT to provide certification in field of tissue culture. It is also assisting in recognizing tissue culture production facilities and accrediting test laboratories.
6.	**Biosafety**	It provides capacity building support in the field of biosafety associated with Genetically Modified Organisms (GMOs). It helps in designing and documenting key policy issues in biotech biosafety areas.
7.	**Human Resource Management and Information Services**	BCIL provides information services and human resource management by assisting in collecting information, analysis and dissemination

***Source**: www.bcil.nic.in*

The technologies transferred by BCIL to industries are listed in table 5.24.

Table 5.24: Technologies Transferred by BCIL 2010 Onwards to Industries

S. No.	Year	Technology Title	Technology Source	Licensee
1.	2010	Plant Extract Based Biopesticide Formulation 'bollcure' Against Cotton Bollworm (*Helicoverpa armigera*)	The Energy and Resources Institute (TERI), New Delhi	Marrone Bioinnovations Inc., Delaware US
2.	2011	Quantitative Detection of Reproductive Hormones	National Institute for Research in Reproductive Health, Mumbai	HLL Lifecare Ltd., Trivandrum
3.	2012	Chlamydia Diagnostic kit	National Institute of Pathology, Delhi	Accurex Biomedical Pvt. Ltd.
4.	2012	Fecal Incontinence Management Device	AIIMS and IIT-Delhi	Consure Medical Pvt. Ltd., New Delhi
5.	2012	Neonatal Resuscitation Device	AIIMS and IIT-Delhi	Windmill Health Technologies Pvt. Ltd., New Delhi
6.	2013	Limb-Immobilisation Device	AIIMS and IIT-Delhi	HLL Lifecare Ltd., Kerala
7.	2013	Patient Transfer Device	AIIMS and IIT-Delhi	MGM Associates, New Delhi
8.	2013	Auditory Impairment Screening Device	AIIMS and IIT-Delhi	Sohum Innovation Labs Pvt. Ltd., Bhopal
9.	2013	Soft Tissue Biopsy Device	AIIMS and IIT-Delhi	IndioLabs Pvt. Ltd., Bangalore
10.	2013	Device for Concurrent Biopsy and Hemostasis	AIIMS and IIT-Delhi	IndioLabs Pvt. Ltd., Bangalore
11.	2013	Abdominal Paracentesis Device	AIIMS and IIT-Delhi	Mecmaan Healthcare Pvt. Ltd., Bhahadurgarh
12.	2013	Assistive Device for NG Tube Deployment	AIIMS and IIT-Delhi	Mecmaan Healthcare Pvt. Ltd., Bhahadurgarh
13.	2013	Device/Kit for Pleural Tapping	AIIMS and IIT-Delhi	Mecmaan Healthcare Pvt. Ltd., Bhahadurgarh
14.	2013	Device for Foreign Body Removal	AIIMS and IIT-Delhi	Innaccel Consulting Services Pvt. Ltd., Bangalore

15.	2014	Portable Device for Hand Sanitization	AIIMS and IIT-Delhi	Observe Design Pvt. Ltd., New Delhi
16.	2014	Feto-Maternal Monitoring Device	AIIMS and IIT-Delhi	Brun Health Pvt. Ltd., Telangana
17.	2015	A Breathable and Customized Cast for Immobilization of Fractured Limb	AIIMS and IIT-Delhi	JC Orthoheal Pvt. Ltd., Gujarat

***Source**: www.bcil.nic.in*

BCIL has also created 'Biotechnology Club' for various stakeholders to get regular update of major development in biotech sector. Members get information on various funding schemes, technologies available for licensing and reports on biotechnology in form of news updates and periodicals.

iii) CSIR-Tech Private Limited (CTPL), Pune; www.csirtech.com

Public Sectors: Council of Scientific and Industrial Research (CSIR) and State Bank of India (SBI)

Private Sector: Industries

Business: Venture Centre (*Registered as Entrepreneurship Development Center under The Companies Act 1956 as a Section 25 Company*), Pune

CSIR-Tech is a Pune based private limited company established in 2011. The major partners of CSIR-Tech are CSIR, State Bank of India and Venture Centre (a technology business incubator). It is located in the Innovation Park of National Chemical Laboratory (NCL), Pune. 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 works closely with R&D institutions in India such as the CSIR, IITs, DAE, DST, DBT and a few private R&D labs. CSIR-Tech represents over 9,000 of the 25,000 plus scientists working in public-funded R&D labs across India. CSIR-Tech is governed by a board of directors comprising of chairman (1), CEO (1) and members (8) from industries, banking sector and research organizations. Day to day functioning of CSIR-Tech is in the hands of CEO and its team comprising of 10 members which are Venture Consultant (1), Chief Business Officer (1), Technology Transfer Associates (3), Technology Transfer Analysts (3) and Consultants (2).

CSIR-Tech provides industry advisory services and government advisory services that includes technology scouting, R&D partner search, market research and consulting, open innovation, technology/IP evaluation capacity building, research, S&T development, opportunity identification, market penetration, technology de-risking, synthesis, aggregation and agreements, business planning and raising finances and virtual business incubation support

CSIR-Tech offers innovative technologies and know-how from recognized R&D labs and academic institutes. The technology offerings are in biological, chemical, environment, earth sciences, physical, and information sciences. Number of technology transfer portfolio of CSIR-Tech in various sectors is over 900 (www.csirtech.com) and the notables ones are: Chemicals (174), Drug discovery & Therapeutics (143), Clean Tech (92), Food and Nutrition (70), Healthcare (66), Agriculture (66) and many more.

5.3.4 Technology Business Incubators (TBIs)

Public Sector: National Science and Technology Entrepreneurship Development Board (NSTEDB), DST, GoI

Private Sector: Private Organizations

GoI has floated various schemes to promote PPP in R&D domain. One of the most impactful schemes was creation of TBIs in various educational institutes and industrial set ups. TBIs are the entities that were created for enhancing MSMEs growth and entrepreneurship culture in India. A brief detail of TBIs is mentioned in section 5.1.2. Examples of TBI under GAIM model are described below:

Table 5.25: TBIs Established Under PPP Mode

S. No.	Private Organizations	R&D under PPP mode
1.	**MITCON Biotechnology and Pharmaceutical Centre, MITCON Consultancy and Engineering Services Ltd., Pune** http://www.mitconbiopharma.com/	MITCON Biotechnology and Pharmaceutical Center is one of the TBIs financially supported by DST, GoI. The incubator consists of developed world class facility mainly for biofertilizers, microbiology, genetic engineering, plant tissue culture, fermentation technology and bioinformatics. The incubator supports various business activities with an objective to commercialize biotechnology via product support, consultancy and training. The centre also offers number of industry oriented biotechnology, clinical research training and academic courses.
2.	**BITS Pilani Technology Business Incubator, BITS, Pilani** http://www.bits-pilani.ac.in/pilani/technologybusiness/TechnologyBusinessIncubator	DST established TBI in private academic institute-BITS, Pilani in field of embedded systems and VLSI design. It has also created Center for Entrepreneurial Leadership (CEL) with an aim to boost entrepreneurship. The institute regularly invites various entrepreneurs or MSMEs to avail TBI services for product development and commercialization.

3.	**Manipal University Technology Business Incubator (MUTBI), Manipal University, Manipal** http://manipal.edu/mit/mit-experience/business-incubation-centre.html	DST created TBI in Manipal University. It is nurturing innovative and entrepreneurial skills among faculty and students of the Manipal University, as well as people of the region. It is playing significant role in strengthening start-ups and MSMEs in the region. This TBI is playing catalytic role in networking among academic/R&D institutions and industries.

5.3.5 Science Parks

Public Sector: National Science and Technology Entrepreneurship Development Board (NSTEDB), DST, GoI

Private Sector: Private Organizations

Science, Technology and Entrepreneurship Parks (STEPs) have been instituted by NSTEDB with a mandate of creating an environment for entrepreneurship and innovation. STEPs are working with an objective of forging linkages among academic/R&D institutions and industry to promote innovative enterprises in the country. So far, 15 STEPs have been created in different parts of the country. They have ~788 units with annual turnover of ~₹ 130 crores and employment for 5000 people. Creation of STEPs has led to generation of 100 new products and technologies. Many science parks are proposed by government and industry to be instituted under PPP mode in near future, such as Life Science Park in Visakhapatnam and Biotechnology Park in Indore. Under this scheme various private organizations and academic institutions are funded for setting up science parks. List of private organizations which were supported by government for establishing STEPs are described below.

Table 5.26: STEPs Established Under PPP Mode

S. No.	Private Organizations	R&D under PPP mode
1.	**Science and Technology Entrepreneur's Park (STEP) at IIT Kharagpur, 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.
2.	**Birla Institute of Technology- Science and Technology Entrepreneurs' Park (BIT-STEP), Ranchi**	It is the first STEP approved and established by NSTEBD, DST, GoI for promoting entrepreneurship and innovation in the country through services for education, research, training and finance management.

	http://new.bitmesra.ac.in/	Presently, 15 industries are running successfully under BIT-STEP, providing employment to about 300 people.
3.	**Thapar Institute of Engineering and Technology University-Science and Technology Entrepreneur's Park, Patiala** http://www.thapar.edu/ index.php/science-technology-entrepreneur-s-park-step	It was established as a joint venture between the NSTEDB, DST, GoI and Thapar University Institute of Engineering and Technology for business incubation that has emerged as a nursery for entrepreneurs and a launch pad for MSMEs. STEP is playing the role of a catalyst for change in the MSME sector by tapping new business opportunities through commercialisation and transfer of technology.It has incubated 25 companies, out of which 10 have been set up as independent ventures. It has conducted 16 farmers' meets and 76 entrepreneurship development programmes It has also started hands-on training for students, farmers, NGOs, entrepreneurs and industrialists.

5.4 Summary

The existing PPP models (R&D) fall under two categories: Technically Correct PPP (TC-PPP) model and In-Practice PPP (IN-PPP) model. In the present chapter an overview of existing PPP (R&D) has been placed under three models as: A) Government-Industry Model (GIM); B) Academia-Industry Model (AIM) and C) Government-Academia-Industry Model (GAIM).

A: GIM

GIM has four different categories: a) Global Innovation and Technology Alliance (GITA); b) Centre of Excellence (CoE); c) Technology Business Incubators (TBIs) and d) Autonomous Institutes.

a) Global Innovation and Technology Alliance (GITA): DST and CII together instituted a joint venture *not for profit* company, GITA for catalyzing innovation and investment in science and technology. DST and CII hold 51% and 49% equities respectively in this company. GITA is industry managed body working for enhancing innovation ecosystem in India by creating scientific co-operations at global level through bilateral and multilateral programmes.

b) Centre of Excellence (CoE): Government and private sectors have together created CoE to address the societal and industrial needs, e.g. **'Centre of Excellence for Internet of Things'** (CoEIoT) in New Delhi was created under PPP mode to carry R&D activities in IT Sector.

c) Technology Business Incubators (TBIs): With financial assistance from government organizations, private sector has established TBIs. e.g. TBI in **'Shriram Institute of Industrial Research'** in Delhi and TBI in **'IKP Knowledge Park'** in Hyderabad to boost up R&D activities, encouraging growth of MSMEs and entrepreneurship culture in India.

d) **Autonomous Institutes:**

(i) **Automobile Research Association of India (ARAI),** Pune was established as autonomous industrial research unit by Ministry of Heavy Industries and Public Enterprises, GoI to address the R&D problems of the automobile sector. It is a self sustainable institute. The institute carries out R&D activities, training, testing and standardization services for automobile industries. In the year 2014-15, ARAI generated revenues worth ₹ 214.41 crores and more than 50% of the income came from R&D activities. Nearly, 10% of the revenues, amounting to ₹ 20 crores, were termed as surplus after accounting for all the expenses including the salaries and pensions of the employees. ARAI is credited with 15 granted patents and 18 filed patents. Out of the 21 members of the governing body of ARAI, 18 belong to industrial sectors. More than 70 industries are members of ARAI.

(ii) **Indian Plywood Industries Research and Training Institute (IPIRTI),** Bengaluru, was created by Ministry of Environment, Forests and Climate Change, GoI in association with plywood industries. The institute carries out R&D activities, training, testing and standardization services for plywood industry. It is credited with 5 granted patents and 9 filed patents. It has carried out 28 in-house projects for collaborating industries, 13 sponsored projects and 3 consultancy projects of industries.

(iii) **Other Government Initiated Organizations:** A few of other ministries have created dedicated institutes that are working for industrial R&D. Ministry of Micro, Small and Medium Enterprises (MSME) established institutes like, **'Mahatma Gandhi Institute for Rural Industrialization' (MGIRI), 'National Institute for Micro, Small and Medium Enterprises' (NIMSME)** and **'National Small Industries Corporation' (NSIC)** for assisting development of MSMEs in India. Department of Industrial Policy and Promotion (DIPP) has supported various autonomous institutions, 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.

(iv) **The Energy and Resources Institute** (TERI), New Delhi is an autonomous, *not for profit* research institute. TERI is pursuing research in nearly 30 different fields with ~1300 ongoing projects (industry sponsored and government sponsored) and has generated nearly 50 patents and 14 technologies. TERI has built strong collaborative partnerships and networks with objective of knowledge sharing, enhancing technological capabilities and fostering innovations.

(v) **Shriram Institute for Industrial Research** (SRI), Delhi is self sustaining, independent, *not for profit* contract research organization (CRO). SRI is one of its kind institutes in India pursuing industrial research and is bridging connections between industry, regulatory agencies, consumer organizations, academia and policy makers. SRI is actively involved in developing new products and processes. SRI has developed ~25 technologies and has supported ~108 products. SRI is linked with ~1500 industries, which avail services, such as technical consultancy, contract research, calibration and analytical method development, certification and quality assurance.

B: AIM

AIM has three categories: a) Centres of Excellence (CoEs); b) Research Laboratories and c) Entrepreneurship Development Programmes.

a) **Centres of Excellence (CoEs): 'IBM-Software CoE'** is the classical example of academia-industry partnership for pursuing research as per needs of the industry.

b) **Research Laboratories:** Industries have set up **'Research Laboratories'**, introduced **'Scholarships'** and **'Fellowships'** and sponsored **'Industry-Chairs'** in Higher Education Institutes (HEIs). These steps undertaken by industries can be considered as successful examples of PPP. Amongst HEIs, IITs are leading in above mentioned I-A initiatives.

c) **Entrepreneurship Development Programmes:** Industry has also supported creation of dedicated programmes in academia, such as **'Pfizer-IIT Delhi Innovation and IP Programme' (PIDIIP)** at IIT Delhi, for assisting R&D activities and technology development and deployment from the academia to the industry along with enhancing entrepreneurship culture.

C: GAIM

GAIM has five categories; a) Centres of Excellence (CoEs); b) Autonomous Academic Institutes; c) Govt. Sponsored Funding Agencies; d) Technology Business Incubators (TBIs) and e) Science Parks.

a) **Centres of Excellence: 'Telecom Centres of Excellence' (TCOEs)** in IITs, IIM-Ahmedabad and IISc-Bangalore are perfect examples of academia, industry and government working together to achieve excellence in R&D. MHRD in collaboration with private sector has also established 36 CoEs in various academic institutes. **'Centre of Excellence in Wireless Technology'** (CEWiT) in Chennai was set up under PPP mode by Ministry of Communication, IIT Madras and Telecom industry.

b) **Autonomous Academic Institutes:**

(i) Many **'Indian Institute of Information Technology' (IIIT)** have been planned by MHRD to be built under PPP mode. Two IIITs, IIIT-Hyderabad and IIIT-Pune have been established as *not for profit*-Public Private Partnership (N-PPP) mode with funding from central government (50%), state government (35%) and industry (15%).

(ii) **Polytechnic Colleges** have also been planned to be established under PPP mode with share of MHRD (₹ 3 crores), state government (₹ 2 crores) and industry (₹ 10 crores)

(iii) Bombay College of Pharmacy (BCP), Mumbai was established with financial support of industry and central and state governments. BCP has a dedicated 'Industry Institute Interaction Cell' that coordinates with industries. Industry representatives are part of governing body and curriculum design committee of BCP. BCP has undertaken more than 300 industrial R&D projects. In last four years (2012 onwards), BCP has carried out 81 industrial projects.

(iv) Institute of Chemical Technology (ICT), Mumbai, now a deemed university, has created a strong network with chemical industries for pursuing collaborated research. 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 scientists actually enhance their salaries through the consultation fees paid by the collaborating industry. During the last 10 years, ICT-Mumbai has filed 310 patents and published 382 international publications.

c) Govt. Sponsored Autonomous Funding Agencies:

(i) Biotechnology Industry Research Assistance Council (BIRAC), New Delhi provides funding support in the form of grants to SMEs in order to stimulate R&D activities and promoting innovation amongst SMEs. 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 [Small Business Innovation Research Initiative (SBIRI), Biotechology Industry Partnership Programme (BIPP) and Contract Research and Service Scheme (CRS)] has led to 121 collaborative projects, out of which 108 were Industry-Acadima projects and 13 were Industry-Industry projects.

(ii) Biotechnology Consortium India Limited (BCIL), New Delhi is a public company registered under Indian Companies Act 1956, established in 1990. BCIL was instituted by DBT and all India financial institutions. It is working for assisting government, entrepreneurs, academicians and industrialists in technology commercialization in the field of biotechnology. BCIL has transferred 42 technologies from research and academic institutes to the market. Twenty Seven technologies are available for licensing.

(iii) CSIR-Tech Private Limited (CTPL), Pune is for-profit 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.

d) Technology Business Incubators (TBIs): With financial assistance from government organizations a few of TBIs have been established in private sector e.g. **'MITCON Consultancy and**

Engineering Services Limited', Pune and private academic institutes like, **'BITS'**, Pilani and **'Manipal University'**, Manipal.

e) **Science Parks:** With financial assistance from government organization, science parks are being established in private sector e.g. **'Science and Technology Entrepreneur's Park'** (STEP) at IIT Kharagpur; STEP in **'Thapar Institute of Engineering and Technology University'**, Patiala and **'Birla Institute of Technology'**, Ranchi and they have catalyzed the Government-Academia-Industry Partnership in promoting R&D activities and technology development under PPP mode.

5.5 Conclusion

The R&D activities of the public and private sectors have generally remained disconnected from each other, thereby creating a large gap in technology development and technology deployment. This statement along with the limited financial resources of the public sector calls for a PPP for R&D to strengthen Indian Innovation ecosystem. India has begun PPP in various sectors (infrastructure, transport and urbanization). However, PPP model for R&D has yet to gain a firm footing, though the benefits accruing from this strategic partnership are huge for the nation's economy and addressing societal needs.

Existing PPP (R&D) models in India fall under two categories a) Technically Correct PPP (TC-PPP) where public and private sector have fixed responsibilities and b) In-Practice PPP (IP-PPP) where public and private sector are working in close collaboration with no defined roles and responsibilities. The 'Centres of Excellence' (CoEs) in the academic sector and 'Global Innovation and Technological Alliance' (GITA), a R&D promoting organization are examples of TC-PPP for R&D. Whereas, creation of autonomous research and academic institutes, technology business incubators and science parks are examples of IP-PPP for R&D.

Based on the involvement of government, academia and industry, the PPP (R&D) models fall under any of the three classes, Government-Industry Model (GIM); Academia-Industry Model (AIM) and Government-Academia-Industry Model (GAIM). Each model has successful examples which can be replicated in HEIs and R&D institutions for the promotion of innovative research.

GITA is an example of GIM. It is jointly promoted by TDB, (DST, GoI) and CII. It is an innovative platform of government and industry through which industrial investments are encouraged for innovative technology development and commercialization. GITA supports technology partnerships between HEIs/R&D institutions and industry not only in India but also across the globe. Creation of such collaborative body for various industrial sectors can revolutionize technological growth of Indian industry through bilateral and multilateral technological support that can lead to reduced dependence on foreign technologies.

The most successful model of PPP for R&D is exemplified by the establishment of CoEs by the private sector in HEIs (public sector). More than 100 CoEs have been created in IITs, Central/State universities and R&D institutes adopting AIM or GAIM models. These research centres are highly productive as they cater to a specific R&D objectives as laid down by the industry. It is suggested that government should come out with a policy for stimulating private sector for investment in setting up CoEs in R&D promoting institutes. Government may allow a part of CSR fund to be used by the private sector for establishing CoEs in the public institute of higher learning.

The Industry-Academia Model (AIM) has been successfully adopted by ARAI. This institute was setup by the public sector (MoHI&PE, GoI) and private sector (automobile industry), which is intimately associated with its governance and utilizes its services for various purposes including R&D. ARAI have become financially independent and generates more than 50% of total revenues by way of technology-transfers, licensing of patents and consultancy. ARAI modal of governance can act as a template for setting up more R&D institutes catering to the industrial sector.

Two Mumbai based HEIs namely, Institute of Chemical Technology (ICT) and Bombay College of Pharmacy (BCP), are excellent examples of I-A linkages/partnerships and can be placed in GAIM. These institutions were set up by the government with the involvement of respective industrial associations. The industry is deeply embedded in their governance, setting up of industry sponsored laboratories, CoEs, scholarships, fellowships and chairs. These institutes have also developed robust network with industries for pursuing need based research under collaborative mode. Both academic institutes have been rated as number one in terms of industry-academia linkages by CII-AICTE survey for the last three years. The public-private R&D ecosystem of these institutes can be used as a template for the upcoming HEIs i.e., IIITs and Polytechnic Colleges being set up by MHRD under PPP mode for addressing the industrial needs.

The research funding agencies of India are also contributing towards the promotion of R&D under PPP mode. One such example is an autonomous, Section 25 Company called BIRAC, created by DBT, GoI as I-A interface to pursue targeted research in the field of biotechnology. BIRAC acts as a platform for public and private sectors (primarily MSMEs) to jointly invest in R&D for beneficial outcomes. BIRAC has introduced many schemes which fall under AIM or GAIM. In BIRAC programmes, the investment of private sector (₹ 765 crores) is much more than the public sector (₹ 677 crores). In a short span of 5 years, BIRAC has brought out 29 innovative biotech products to the market and also funded nearly 115 industry-academia research projects. The other funding agencies such as ICAR, ICMR, CSIR, DRDO, MeitY, etc., can take a cue from BIRAC to set up dedicated I-A R&D promoting agencies.

Of late, government has started investing in setting up Technology Business Incubators (TBIs) and Science Parks for bringing private and public sectors under one umbrella. These models are well established in other countries for bringing together public and private players to work collectively or individually for futuristic innovative technologies. These places are promoting young minds to give wings to their entrepreneurial ideas. For these models (TBIs and Science Parks) to succeed, it is imperative that 'outreach awareness programmes' are given a top priority by the government for promotion of such programmes.

Table 6.1: IPR Related Activity Domains of WIPO

S. No.	Area of Work	Brief Details
1.	**IP Protection and Services**	***International Patent System via Patent Cooperation Treaty (PCT)***: assists in seeking patent protection simultaneously in many countries throughout the world by filing one international patent. 148 countries have signed PCT agreement. ***Madrid-The International Trademark System***: It is one stop solution for registering and managing trademarks worldwide. It comprise of 97 member states. ***Hague-The International Design System***: It is an international registration of industrial designs over 65 territories under one application. ***Lisbon-International Registration of Appellations of Origin***: Through single registration protection for an appellation of origin is provided.
2.	**Designing Policies**	For designing IPR policies, WIPO has developed number of negotiating bodies which are as: **a) Governing Bodies:** WIPO assemblies **b) Permanent Committees**: Programme and Budget Committee, Committee on Development and IP, Intergovernmental Committee on IP and Genetic Resources, Traditional Knowledge and Folklore (Inter Governmental Committee), Advisory Committee on Enforcement **c) Standing Committees**: Standing Committee on the Laws of Patents (SCP), Law of Trademarks, Industrial Designs and Geographical Indications (Standing Committee on the Law and Trademarks), Copyrights and Related Rights (Standing Committee on Copy Rights and Related Rights), WIPO standards (Committee on WIPO Standards) These bodies are responsible for designing polices for IPR for its member states.
3.	**Development and Global Cooperation**	WIPO works in collaboration with the governments of member states along with its public and private sectors/organizations to sensitize them about the benefits accruing from generation of IPRs. Some of the co-operations are mentioned below: · Regional Bureaus for Africa; Arab countries; Asia and the Pacific; Latin America and the Caribbean · Division for Least Developed Countries (LDCs) · Department for Transition and Developed Countries · South-South Cooperation

Source: *www.wipo.int*

Based on the WIPO Report 2015, a comparative study of five Asian countries i.e. Singapore, Japan, S. Korea, China and India has been carried out (Table 6.2). China, Japan and S. Korea are performing exceedingly well in the parameters of *IP filing* in the 'residents category' as well as 'residents & abroad category'. All the three nations are in top five economies of the world, with China occupying first ranking. India's global ranking is satisfactory as it has been ranked 11 and 14 in the categories of 'residents' and 'resident & abroad'. However, Singapore needs to improve its ranking in both the categories.

In the parameter of *'number of filing of patent applications'*, China is far ahead of other four countries with over 9,00, 000 patent applications filed in its patent office. This number is 24 fold more than the applications filed in Indian Patent Office (IPO) (42,854). Interestingly, the sum total of all the four nations (Japan, S. Korea, Singapore and India) makes up only two-third of the total patent applications filed by China.

Table 6.2: Global Rankings of Asian Countries Based on WIPO Report 2015

S. No.	Indicators		Global Rankings				
			Singapore	**Japan**	**S. Korea**	**China**	**India**
1.	**IP Filing Rankings*** **(resident & abroad)**	Patents	26	3	4	1	14
2.	**IP Filing Rankings**** **(residents)**	Patents	30	3	4	1	11
3.	**Number of Patent Applications by Office of the Country**	Total	10,312	3,25,989	2,10,292	9,28,177	42,854
		Residents	1,303	2,65,959	1,64,073	8,01,135	12,040
		Non-residents	9,009	60,030	46,219	1,27,042	30,814

* Out of 100 economies, **out of 80 economies

Source: *World Intellectual Property Indicators (www.wipo.int/ipstats, http://www.wipo.int)*

6.3 Patent Regime in India Based on IPO Indicators

In India, the main body looking after IPRs is the office of CGPDTM (http://www.ipindia.nic.in/) located in Mumbai. This office is a subordinate office of the Department of Industrial Policy & Promotion (DIPP), which comes under the Ministry of Commerce and Industry (Fig. 6.1).

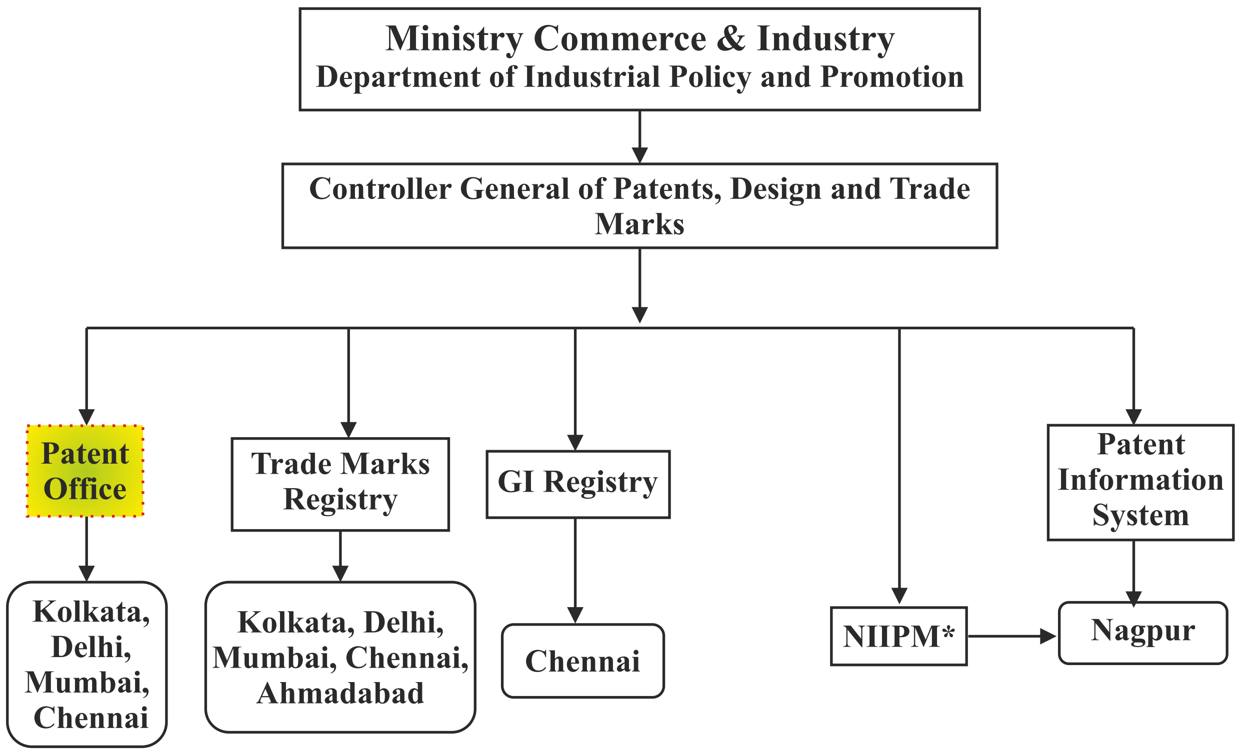


Figure 6.1: Organizational Structure of Patent Regime in India

**National Institute of Intellectual Property Management*

6.3.1 Patent Applications

Table 6.3 throws light on the trend of patents filed/granted in India in the last five years. A big jump in the number of patents filed (43,197) was observed in the time period 2011-12 over the preceding year i.e. 2010-11 (39,400). In the subsequent year (2012-13), a marginal increase of 477 patents filed was observed, taking the total tally to 43,674. However, in the following two years (2013-15), a slight decrease was observed in the number of patents filed. In the category of patents granted, 7,509 patents were granted in 2010-11, which is the highest score in the last five years. Following three years saw a significant decline of nearly 20%. However, last year (2014-15) the figure showed a remarkable recovery as 5,978 patents were granted by the IPO. In the other two categories total number of patents examined, and disposal of request for patent examination (granted, refused, abandoned), by and large an increasing trend was observed, suggesting improvement in the functioning of the IPO. Compared to 11,208 patents examined in 2010-11, more than double the number were examined in 2014-15.

Table 6.3: Trend in Patent Applications in India

Year	2010-11	2011-12	2012-13	2013-14	2014-15
Filed	39,400	43,197	43,674	42,951	42,763
Examined	11,208	11,031	12,268	18,615	22,631
Granted	7,509	4,381	4,126	4,227	5,978
Disposal of request for examination (Granted + Refused + Abandoned)	12,851	8,488	9,027	11,411	14,316

***Source**: IPO Annual Report 2014-15*

6.3.2 Applications Filed by Indian Applicants

Figures 6.2 & 6.3 depict the number of patents filed and granted in India in various fields of industrial sector. Mechanical sector leads the list with 10,031 filed-patents, amounting to 23% of the total filed patents. Second ranking is held by Chemical (6,454), followed by Computers/Electronics (4,285) & Electrical (4,031), Drugs (2,640) and Biotechnology (1,035) sectors.

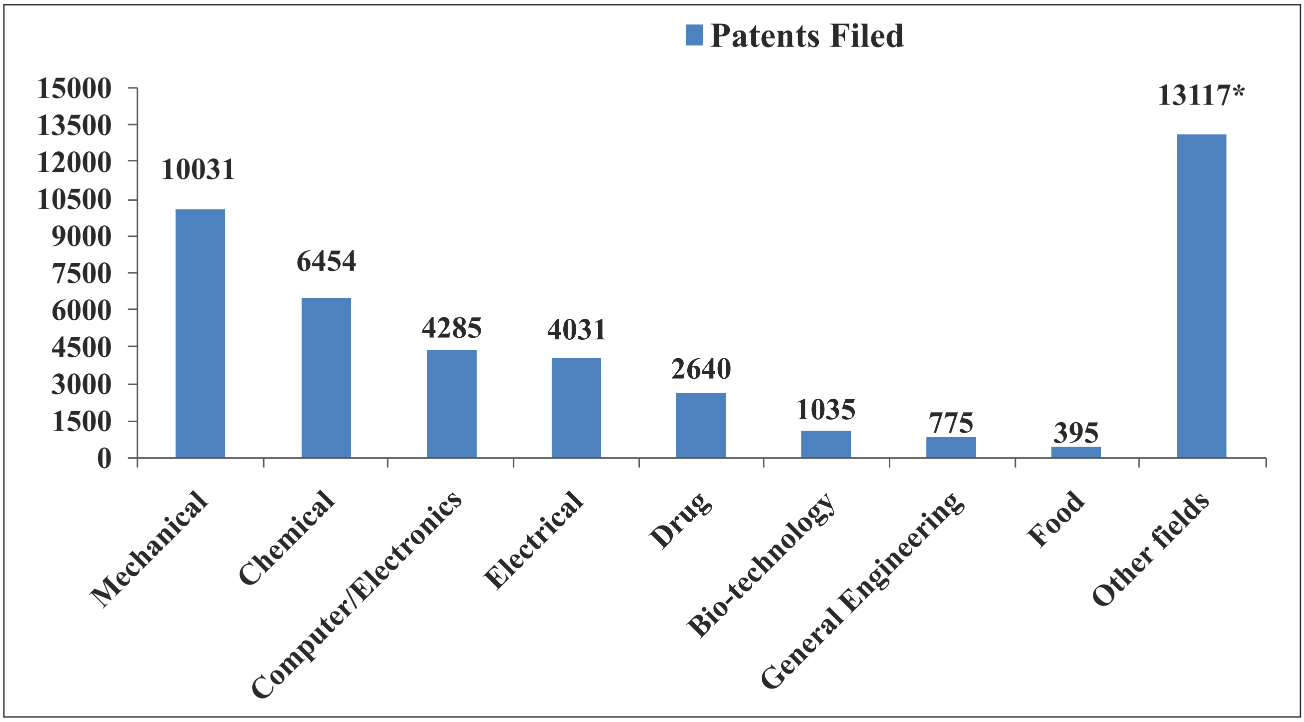


Figure 6.2: Number of Patent Applications Filed in 2014-15 Under Major Fields of Inventions

** Others – Bio-Medical, Bio-Chemistry, Communication, Physics, Civil, Textile, Metallurgy/Material Science, Agriculture Engineering, Polymer Science/Technology, Micro-Biology, Agrochemical, Traditional Knowledge BIO/CHEM/MECH*

***Source**: IPO Annual Report 2014-15*

In the patent granted category, top six rankings of industrial sectors are the same as for patent filed category. However, there is change in the sequence of ranking. Chemical sector (1,533) has replaced Mechanical sector (1,047) as number one ranked industrial sector followed by Computer/Electronic (835), Drugs (389), Electrical (376) and Biotechnology (262) sectors.

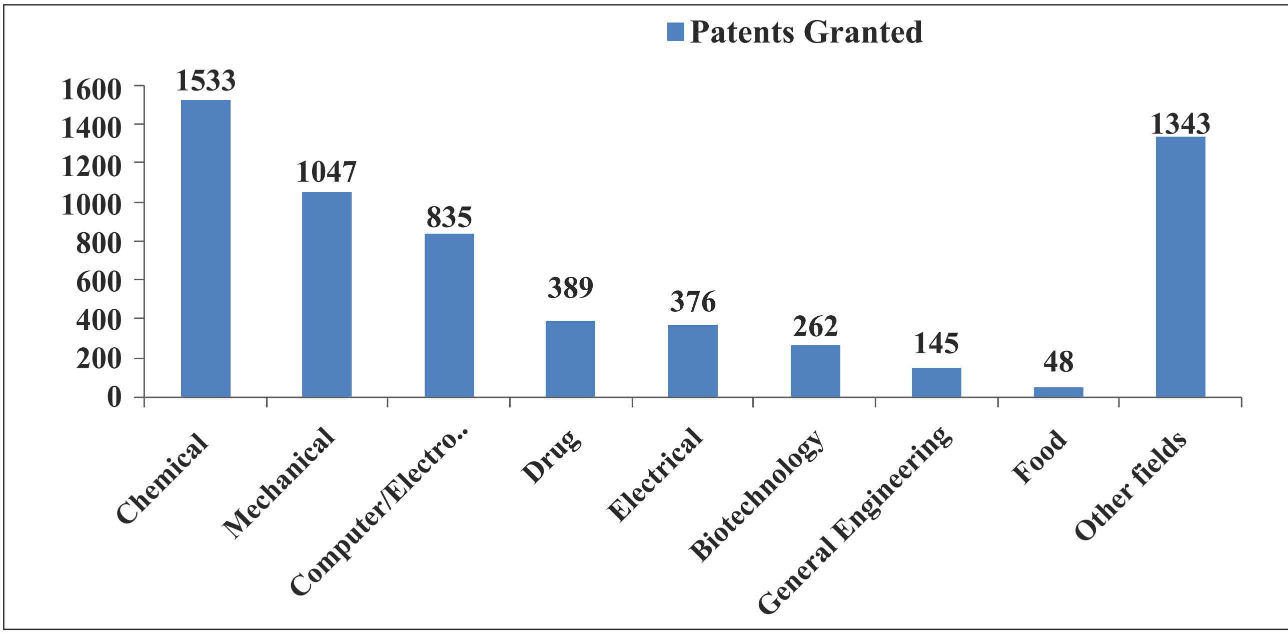


Figure 6.3: Number of Patents Granted in 2014-15 Under Major Fields of Inventions

** Others – Bio-Medical, Bio-Chemistry, Communication, Physics, Civil, Textile, Metallurgy/Material Science, Agriculture Engineering, Polymer Science/Technology, Micro-Biology, Agrochemical*

***Source**: IPO Annual Report 2014-15*

Analyzing the data on the basis of state wise categorization of ordinary patents filed (Fig. 6.4), Maharashtra (3,193) occupies first position followed by Karnataka (2,102), Tamil Nadu (1,412) and Delhi (1,099). In fact, out of 29 states, and 7 union territories, these four states account for 65% of the total ordinary patents filed with IPO *(data for Lakshadweep is not available)*. As per IPO data, out of a total of 42,763 patents filed, only 12,071 patent applications (ordinary, convention and PCT) were filed by Indians, and 31,692 were filed by foreign applicants. In other words, 72% applications were filed by foreign applicants and only 28% were filed by Indian applicants.

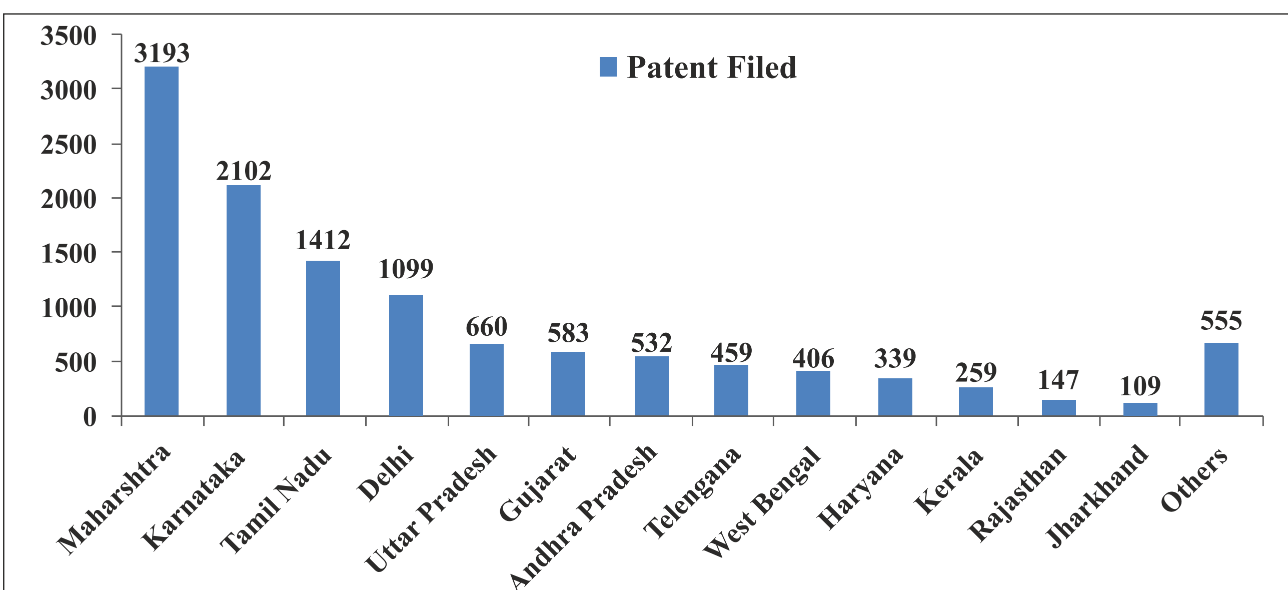


Figure 6.4: Patents Filed (Ordinary) in the Year 2014-15 (>100 applications Filed)

***Source**: IPO Annual Report 2014-15*

Table 6.4: Other States of Fig. 6.4 Comprise of Applications Filed (<100)

S. No.	State/Union Territory	Ordinary (2014-15)	S. No.	State/Union Territory	Ordinary (2014-15)
1.	Madhya Pradesh	**98**	12.	Pondicherry	**16**
2.	Punjab	**97**	13.	Tripura	**8**
3.	Orissa	**88**	14.	Manipur	**5**
4.	Uttaranchal	**61**	15.	Dadra & Nagar Haveli	**2**
5.	Assam	**46**	16.	Arunachal Pradesh	**1**
6.	Bihar	**31**	17.	Sikkim	**1**
7.	Chhattisgarh	**28**	18.	Meghalaya	**0**
8.	Chandigarh	**24**	19.	Mizoram	**0**
9.	Jammu & Kashmir	**17**	20.	Nagaland	**0**
10.	Himachal Pradesh	**16**	21.	Andaman & Nicobar	**0**
11.	Goa	**16**	22.	Daman & Diu	**0**

***Source**: IPO Annual Report 2014-15*

In the domain of scientific and R&D organizations (Table 6.5), first ten organizations filed 870 patents in 2014-15, with CSIR filing maximum number of patents (315), followed by DRDO (98) and ICAR (68). Out of top ten organizations, seven belong to public sector. Three private sector companies namely, GHR Labs and Research Centre, Nagpur (31), GSP Crop Science Pvt. Ltd., Maharashtra (23) and Hetero Research Foundation, Hyderabad (22) occupy fourth, sixth and seventh rankings respectively.

Table 6.5: Top 10 Indian Applicants for Patents from Scientific and Research & Development Organizations

S. No.	Name of Scientific and Research & Development Organization	Applications Filed
1.	Council of Scientific & Industrial Research (CSIR), New Delhi	315
2.	Defence Research & Development Organisation (DRDO), New Delhi	98
3.	Indian Council of Agricultural Research (ICAR), New Delhi	68
4.	GHR Labs and Research Centre, Nagpur	31
5.	Department of Biotechnology (DBT), New Delhi	23
6.	GSP Crop Science Pvt. Ltd., Ahmedabad	23
7.	Hetero Research Foundation, Hyderabad,	22
8.	Rotary Wing Research & Design Centre Hindustan Aeronautics Ltd., Bengaluru	22
9.	Centre for Development of Advanced Computing (C-DAC), Pune	20
10.	Department of Electronics and Information Technology (DeitY), New Delhi	18

***Source**: IPO Annual Report 2014-15*

Table 6.6 lists the top ten Higher Education Institutes (HEIs) of India in the area of patent filing for the year 2014-15. IITs continue to occupy the first position. Surprisingly, Janardan Rai Nagar Rajasthan Vidyapeeth (Deemed) University, a new entrant has relegated IISc-Bangalore to third spot even though it showed an increase of nearly 43% over the preceding year i.e. 2013-14. Amity University has slipped to 4th position with a decline in filing as compared to 2013-14 time period. In an interesting observation, eight out of top ten patent filing institutes belong to private sector. Only two institutes i.e. IITs and IISc-Bangalore belong to public sector. However, these two public institutes comprise of 61.48 percent of the total patents filed by top HEIs mentioned in table 6.6.

Table 6.6: Top 10 Indian Applicants for Patents from Institutes and Universities

S. No.	Name of Institute/University	Applications Filed
1.	Indian Institute of Technology (Collective)	337
2.	Janardan Rai Nagar Rajasthan Vidyapeeth (Deemed) University, Udaipur	53
3.	Indian Institute of Science, Bangalore	46
4.	Amity University, Noida	43
5.	Sandip Foundations: Sandip Institute of Technology & Research Centre, Mumbai	33
6.	Hindustan Institute of Technology & Science, Chennai	31
7.	SAL Institute of Technology & Engineering Research, Ahmedabad	22
8.	Sandip Foundations: Sandip Institute of Engineering and Management, Mumbai	21
9.	Siddaganga Institute of Technology an Institution of Sree Siddaganga Education Society, Tomakuru, Karnataka	19
10.	Karpagam University, Coimbatore.	18

***Source**: IPO Annual Report 2014-15*

Amongst the top 5 Indian patentees (Table 6.7), four belong to public sector i.e. CSIR (66). BHEL (56), IITs (30) and Tata Motors Limited (26). They occupy first, second, fourth and fifth position. Third position is occupied by a private company i.e. Samsung R&D Institute India Bangalore Private Limited, Bengaluru.

Table 6.7: Top 5 Indian Patentees (2014-15)

S. No.	Name of Organization	Patents Granted
1.	Council of Scientific & Industrial Research, New Delhi	66
2.	Bharat Heavy Electricals Limited, New Delhi	56
3.	Samsung R&D Institute India Bangalore Private Limited, Bengaluru	56
4.	Indian Institute of Technology (Collective)	30
5.	Tata Motors Limited, Mumbai	26

***Source**: IPO Annual Report 2014-15*

As far as top 5 foreign resident patentees are concerned (Table 6.8), Gm Global Technology Operations INC, a US company providing services for engineering and construction industries, is ranked at the top with 267 patents (granted). Second rank is held by Qualcomm Incorporated (205), an American based semiconductor and telecommunications equipment company. Third place is secured by Telefonaktiebolaget Lm Ericsson (Publ) (94 granted patents), a Sweden based company which provides software, equipments and services for communication technology. Fourth position (87 granted patents) is occupied by a consumer electronics company, known as LG Electronics, which is a S. Korean company. Fifth place is secured by Netherlands based company known as Koninklijke Philips Electronics N. V., which focuses in lighting, health care and electronics.

Table 6.8: Top 5 Foreign Resident Patentees (2014-15)

S. No.	Name of Applicant	Patents Granted
1.	Gm Global Technology Operations Inc, U.S.A	267
2.	Qualcomm Incorporated, U.S.A	205
3.	Telefonaktiebolaget Lm Ericsson (Publ), Sweden	94
4.	LG Electronics, S. Korea	87
5.	Koninklijke Philips Electronics N. V., Netherlands.	61

***Source**: IPO Annual Report 2014-15*

In the field of information technology (Table 6.9), Samsung R&D Institute India Bangalore Private Limited (233) occupied the first place in the year 2014-15 which is a mobile telecommunication company, while, next four positions are occupied by public sector organizations i.e. Tata Consultancy Services Limited (147), a consulting and business solutions software company; Wipro Limited (117), an information technology services provider; Hindustan Aeronautics Limited (57) and lastly, IITs (Collective) with 50 applications filed in the year 2014-15.

Table 6.9: Top 5 Indian Applicants for Patents in the Field of Information Technology

S. No.	Name of Company	Applications Filed
1.	Samsung R&D Institute India-Bangalore Private Limited, Bengaluru	233
2.	Tata Consultancy Services Limited, Mumbai	147
3.	Wipro Limited, Bengaluru	117
4.	Hindustan Aeronautics Limited, Bengaluru	57
5.	Indian Institute of Technology (Collective)	50

***Source**: IPO Annual Report 2014-15*

6.3.3 Patent Cooperation Treaty (PCT): National Phase Applications

The majority of foreign patent applications filed in India were through the PCT national phase route. The number of such applications filed during 2014-15 was 26,057, which show 3.77% decrease in comparison with the previous year (2013-14) figure of 27,078 applications. The top five countries filing patents, through PCT national phase route are USA (8,237), Japan (4,388), Germany (2,581), Netherlands (1,267) and Switzerland (1,252). Many other countries including France (1,236), United Kingdom (973), China (874), Sweden (835) and others are mentioned in figure 6.5.

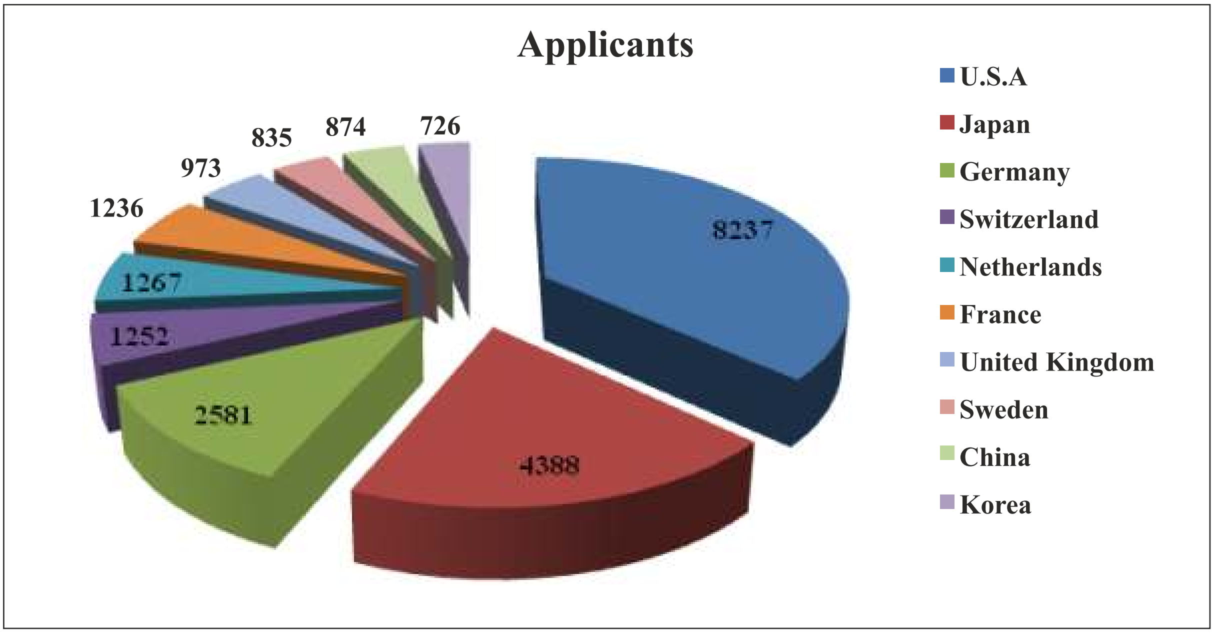


Figure: 6.5 Top Ten Applicants for PCT National Phase (Country-Wise)

Source*: IPO Annual Report 2014-15*

6.3.4 Top Ten Foreign Resident Applicants

The following table (Table 6.10) provides a list of top 10 foreign resident applicants who filed patent applications during 2014-15. It is observed that Qualcomm Incorporated, a wireless technology producer continued to be on the top of the list with 1,214 applications. It was followed by a consumer electronics company, Koninklijke Philips N.V. (805), a network and telecom company, Telefonaktiebolaget LM Ericsson (449) and Samsung Electronics Co. Ltd. (379) which are at 2nd, 3rd and 4th position respectively. Fifth position is secured by a chemical producer company BASF SE, which is a Germany based company. Honda Motor Co. Ltd. is at 6th position with 280 applications filed, Siemens Aktiengesells Schaft a power generation technology company (277), General Electric Company (276) which is a consumer electronics and software company, steel product producer company, JFE Steel Corporation (230) and Sony Corporation (218), a consumer electronics company, are at 7th, 8th, 9th and 10th positions respectively.

Table 6.10: Top Ten Foreign Resident Applicants

S. No.	Name of Organisation	Number of Applications
1.	Qualcomm Incorporated, USA	1,214
2.	Koninklijke Philips N.V., Amsterdam	805
3.	Telefonaktiebolaget Lm Ericsson (Publ), Sweden	449
4.	Samsung Electronics Co. Ltd, S. Korea	379
5.	BASF SE, Germany	297
6.	Honda Motor Co. Ltd. Japan	280
7.	Siemens Aktiengesells Schaft, Germany	277
8.	General Electric Company, USA	276
9.	JFE Steel Corporation, Japan	230
10.	Sony Corporation, Japan	218

***Source**: IPO Annual Report 2014-15*

6.3.5 Revenue Generated

During the time period 2010-14, the revenues generated by the patent office, as fee for patent-application processing, ranged between ₹ 159-180 crores. Surprisingly, last year's (2014-15) earnings jumped to ₹ 374 crores (Fig. 6.6) which were 98.93% more than the amount (₹ 188 crores) accrued in the previous year (2013-14). The trend of revenue generated and revenue expended are shown in the form of bar diagrams in figures 6.6. & 6.7 respectively.

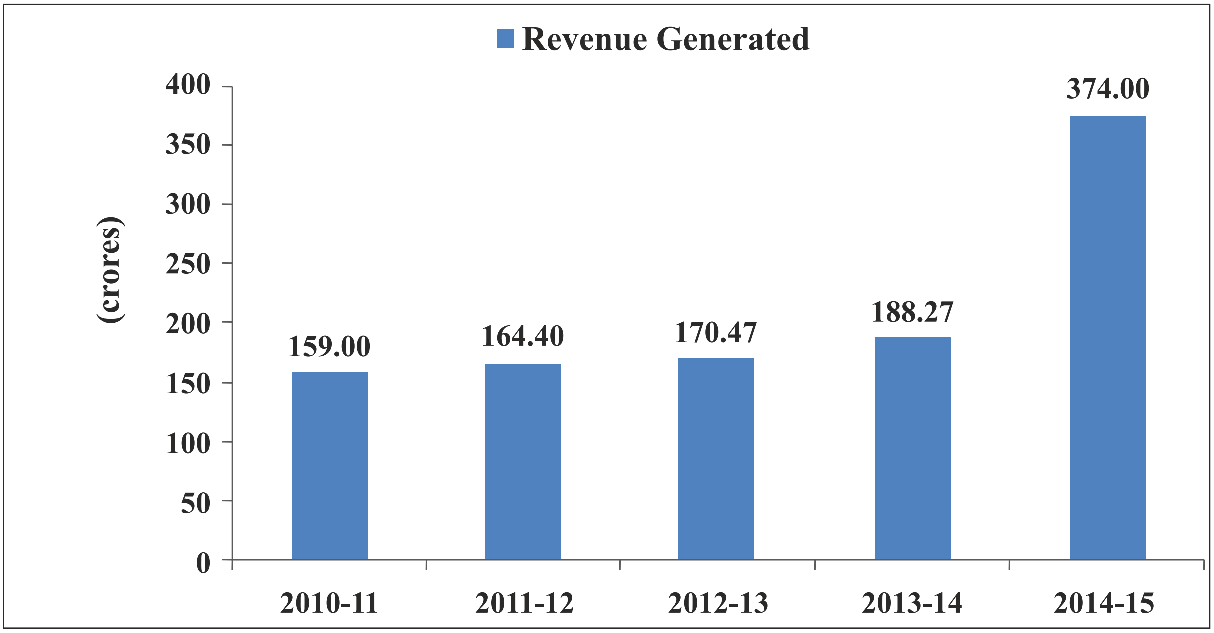


Figure 6.6: Revenue Generated by Indian Patent Office

***Source:** IPO Annual Reports*

6.3.6 Revenue Expended

During the time period 2010-15, the non-plan expenditure with regard to IP administration hovered around ₹ 25 ± 1.5 crores (Fig. 6.7). Maximum expenditure (₹ 26.82 crores) was incurred in 2013-14. Despite of peer expenditure, IP office accrued gross profit of 93% in the year 2014-15, whereas, it was 85% in the year 2013-14 and 84% in the year 2012-13.

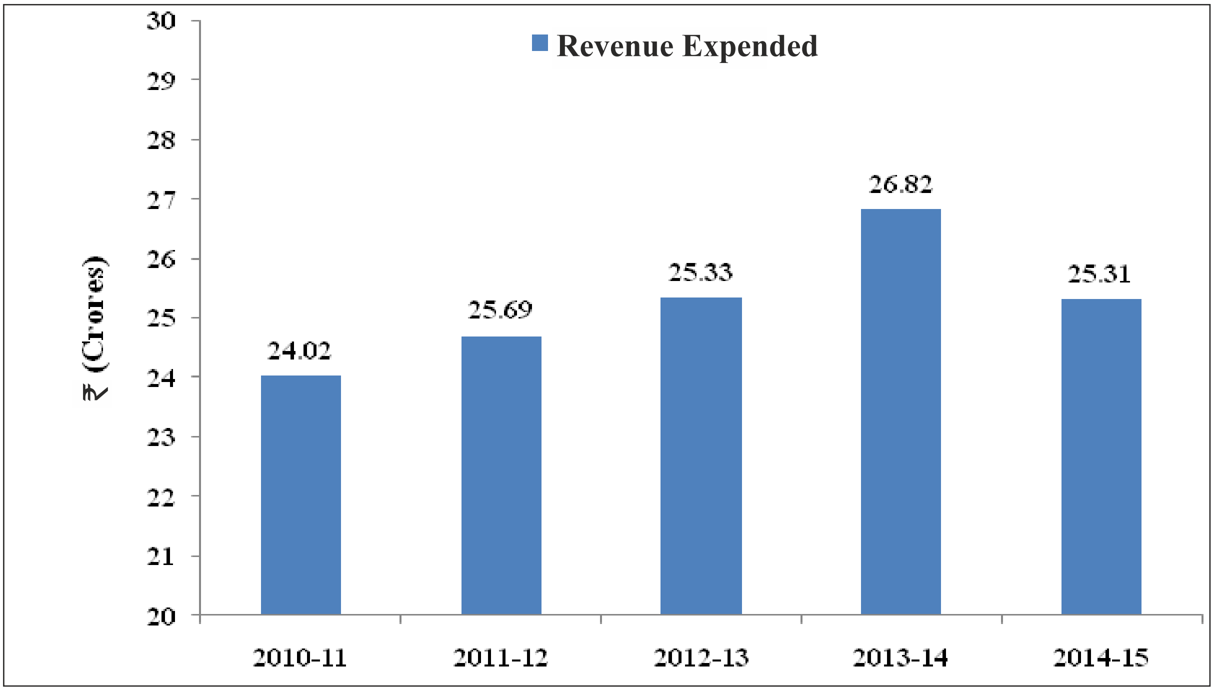


Figure 6.7: Expenditure on Patents by Indian Patent Office

Source: *IPO Annual Reports*

6.4 Patent Ecosystem of India

There are few agencies in India which are promoting, developing and funding patents (Fig. 6.8) In addition DST has created Patent Information Centres (PICs) in 20 states under TIFAC which further have their nodal agencies in different universities of India. For example Punjab State Council for Science & Technology (PSCST), Chandigarh which is one of the 19 PICs has its nodal agency in Panjab University, Chandigarh i.e. Centre for Institute Industry Partnership Program (CIIPP). Continuous efforts are being made by GoI to develop a strong IPRs regime.

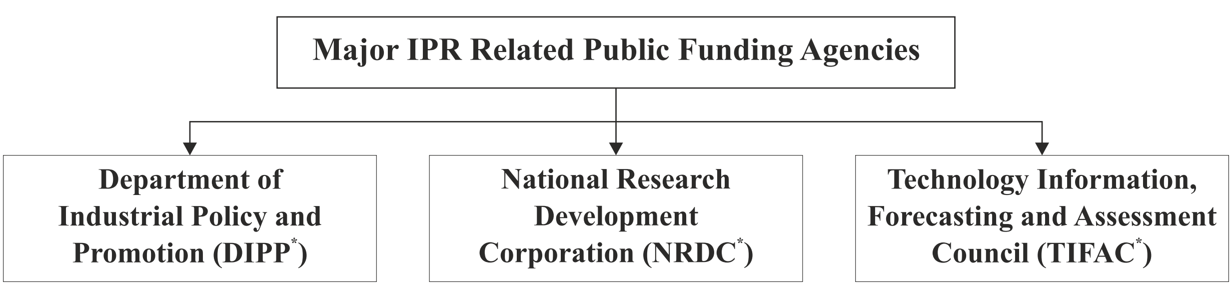


Figure 6.8: IPR Related Public Funding Agencies in India

**Details of these funding agencies are mentioned in the chapter-2*

6.5 National IPR Policy, 2016

(http://dipp.nic.in/English/Schemes /Intellectual_ Property_Rights/National_IPR_Policy_08.08.2016.pdf).

A National Intellectual Property Rights policy has been issued by DIPP on 12th May 2016, which comprises of seven objectives as mentioned below. The following objectives 2 & 5 have been taken as it is from National IPR Policy, 2016.

1. **IPR Awareness: Outreach and Promotion**-To create public awareness about the economic, social and cultural benefits of IPRs among all sections of society.
2. **Generation of IPRs** - To stimulate the generation of IPRs.
3. **Legal and Legislative Framework**-To have strong and effective IPR laws which balance the interests of rights owners with larger public interest.
4. **Administration and Management** - To modernize and strengthen service oriented IPR administration.
5. **Commercialization of IPRs** - Get value for IPRs through commercialization.
6. **Enforcement and Adjudication**-To strengthen the enforcement and adjudicatory mechanisms for combating IPR infringements.
7. **Human Capital Development**-To strengthen and expand human resources, institutions and capacities for teaching, training, research and skill building in IPRs.

Out of these seven objectives 2 and 5 have direct relevance to R&D. The details of these two objectives are mentioned below:

Objective 2: Generation of IPRs - In India, the number of patents filing has increased in the last few years, but the percentage of filing by Indians is relatively low. India has a huge talent pool of scientific and technological talent spread over R&D institutions, enterprises, universities and technical institutes. There is a need to tap this productive knowledge resource and stimulate the creation of IP assets. The steps to be taken to attain this objective are outlined below:

2.1. Use the campaign "Creative India; Innovative India" to propagate the value of creativity and innovation, and the resultant benefit to the public; to create a mindset and culture that encourages knowledge generation and its application through IP.

2.2. Carry out a comprehensive IP audit or base line survey in various sectors in cooperation with stakeholders to assess and evaluate areas of strength and potential, prioritize target groups of inventors and creators, develop specific programs to address their needs, provide resources to enable them to create IP assets and utilize them for their own and social benefit.

2.3. Undertake studies to assess the contribution of IP content in different industries on the economy, employment, exports and technology transfer.

2.4. Focus on improving IPR output of National Research Laboratories, Universities, Technology Institutions and other researchers by encouraging and facilitating the acquisition of Intellectual Property Rights by them.

2.5. Encourage researchers in public funded academic and R&D institutions in IPR creation by linking it with research funding & career progression.

2.6. Encourage researchers in public funded academic and R&D institutions by having uniform guidelines for division of royalties between the organizations and individual researchers and innovators.

2.7. Include IP creation as a key performance metric for public funded R&D entities as well as Technology Institutions, and gradually extend such evaluation from Tier-1 to Tier-2 Institutions.

2.8. Provide guidance to researchers and innovators about national priority areas to focus on, for instance in energy and food security, healthcare and agriculture, as well as specific sectors such as biotechnology, data analytics, nanotechnology, new materials and ICT.

2.9. Encourage public funded R&D institutes and industry to develop affordable drugs relating to neglected diseases.

2.10. Encourage R&D including open source based research such as Open Source Drug Discovery (OSDD) by the Council of Scientific and Industrial Research (CSIR) for new inventions for prevention, diagnosis and treatment of diseases, especially those that are life threatening and those that have high incidence in India.

2.11. Establish and strengthen IP facilitation centers as nodal points especially in industrial and innovation university clusters.

2.12. Create an industry-academia interface for encouraging cross-fertilization of ideas and IPR-driven research and innovation in jointly identified areas.

2.13. Stimulate large corporations, both Indian and foreign, that have R&D operations, to create, protect and utilize IPRs in India.

2.14. Improve awareness of the value of copyright for creators, the importance of their economic and moral rights.

2.15. Introduce support systems for MSMEs, start-ups and grass root innovators to reduce transaction costs linked to IP creation for the entire value chain from IPR generation to commercialization, including schemes to facilitate domestic IPR filings.

2.16. Consider incentives to promote R&D, including the following steps:

2.16.1. Promote R&D through tax benefits available under various laws, through simplification of procedures for availing direct and indirect tax benefits.

2.16.2. Consider financial support for a limited period on sale and export of products based on

IPRs generated from public funded research.

2.16.3. Creation of an effective and simple loan guarantee scheme in order to encourage start-ups and cover the risk of genuine failures in commercialization based on IPRs as mortgage-able assets.

2.17. Promote 'infusion of funds to public R&D units' as a part of Corporate Social Responsibility to foster a culture of open innovation.

2.18. Provide special incentives for creation of IPRs in green technologies and manufacture of energy efficient equipment.

2.19. The ambit of Traditional Knowledge Digital Library (TKDL) should also be expanded to include other fields besides Ayurveda, Yoga, Unani and Siddha.

2.20. Public research institutions should be allowed access to TKDL for further R&D, while the possibility of using TKDL for further R&D by private sector may also be explored, provided necessary safeguards are in place to prevent misappropriation.

2.21. Document oral traditional knowledge, taking care that the integrity of the said knowledge is preserved and traditional ways of life of communities are not compromised.

2.22. Introduce IPRs as part of academic curriculum in educational institutions, especially universities, law and technical institutions.

2.23. Increase awareness of international mechanisms and treaties (e.g. PCT, Madrid, Hague) to encourage creation and protection of IPRs by Indian individuals and entities in global markets.

2.24. Encourage and incentivize IP generation and utilization among students at all levels, use awareness programs and educational materials to inculcate an appreciation for the value of IP.

2.25. Encourage innovations in the agriculture and pisciculture sector through application of IP for higher sustainable agricultural production.

2.26. Encourage the registration of Geographical Indications (GIs) through support institutions; assist GI producers to define and maintain acceptable quality standards, and providing better marketability.

2.27. Encourage creation of design related IP rights by identifying, nurturing and promoting the aspects of innovation protectable under the design law and educating designers to utilize and benefit from their designs; involve the NIDs, NIFTs and others institutions in sensitization campaigns.

2.28. IPR generation for ICT technologies, including those relating to cyber security for India, will be encouraged.

2.29. Take steps to increase domestic filings of patent applications.

2.30. Promote India's rich heritage of traditional knowledge with the effective involvement and participation of the holders of such knowledge. Traditional knowledge holders will be provided necessary support and incentives for furthering the knowledge systems that they have nurtured from the dawn of our civilization.

Objective 5: Commercialization of IPRs - The economic rewards and value for the owners of IP rights comes only from the commercialization of their IPRs. A planned effort should be made for capitalizing the existing IP assets in the country. Entrepreneurship should be encouraged so that the financial value of IPRs may be comprehended. Existing mechanisms including accelerators and incubators set up to promote entrepreneurship should be enlarged with IP-oriented services. Financing is a major barrier for entrepreneurs and therefore it is necessary to connect IP creators and investors. Another barrier faced is valuation of IP and assessment of the potential of the IPRs for the marketing purpose. There is a critical need to take stock of existing IP funding by different government departments and bodies like BIRAC, TIFAC and NRDC and take measures to centralize the same, scaling up successful models while avoiding duplication of efforts. Public-funded research laboratories, academia and other institutions should stimulate commercialization of their research outcomes. They ought to be suitably state-supported in the development and distribution of their IPRs. While certain bigger organizations have the intent and capabilities to commercialize their technologies/ IPRs, several others do not. Hence, it becomes imperative to establish facilitative mechanisms that can address such limitations, especially in terms of academic institutions, individual innovators and MSMEs. Another effective ways of achieving this would be by synergizing the activities of IP facilitation centres with the industrial clusters. Efforts should be made for the creation of a public platform to function as a common database of IPRs which can help creators and innovators connect to buyers, potential users and funding institutions. It would also be helpful in scouting the technology landscape to identify white spaces and thereby help promotion of innovative activities in uncovered areas. Significant potential for innovation exists in new and emerging technologies like nano-technology, agri-biotech, life sciences, biotechnology, green technologies, space technologies, telecommunications, new materials etc. The steps to be taken towards attaining this objective are outlined below:

5.1. Cell for IPR Promotion and Management (CIPAM) shall also undertake the following tasks:

5.1.1. Provide a platform for IPR owners and users of IPRs by acting as a facilitator for creators and innovators to be connected with potential users, buyers and funding agencies.

5.1.2. Undertake a study to examine the feasibility of an IPR Exchange.

5.1.3. Establish links among different organizations for exchange of information and ideas as also to develop promotional/educational products and services.

5.1.4. Facilitate access to databases on Indian IP and global databases of creators/ innovators, market analysts, funding agencies, IP intermediaries.

5.1.5.Study and facilitate implementation of best practices for promotion and commercialization of IP within the country and outside.

5.1.6. Promote public sector initiatives for IPR commercialization.

5.2. Promote licensing and technology transfer for IPRs; devising suitable contractual and licensing guidelines to enable commercialization of IPRs; promote patent pooling and cross licensing to create IPR based products and services.

5.3. Provide support for MSMEs, Individual Inventors and Innovators from the informal sectors with enablers like facilitation centers for single window services to help them commercialize their IPRs.

5.4. Incentivize Indian inventors, MSMEs, start-ups to acquire and commercialize IPRs in other countries also.

5.5. Examine availability of Standard Essential Patents (SEPs) on Fair, Reasonable and Non-Discriminatory (FRAND) terms.

5.6. Identify opportunities for marketing Indian IPR-based products, especially GIs, and services to a global audience.

5.7. Promote collaborative IP generation and commercialization efforts between R&D institutions, industry, academia and funding agencies.

5.8. Ensure enhanced access to affordable medicines and other healthcare solutions by (a) encouraging cross-sector partnerships between public sector, private sector, universities and NGOs; (b) promoting novel licensing models, and (c) developing novel technology platforms.

5.9. Streamline regulatory processes to ensure timely approval for manufacturing and marketing of drugs while maintaining safety and efficacy standards.

5.10. Make efforts to reduce dependency on active pharmaceutical ingredients (API) imports, including incentivizing manufacture of APIs in India and revitalizing public sector undertakings in health care sector.

5.11. Support the financial aspects of IPR commercialization by:

5.11.1. Enabling valuation of IP rights as intangible assets by application of appropriate methodologies and guidelines; facilitating securitization of IP rights and their use as collateral by creation of enabling legislative, administrative and market framework.

5.11.2. Facilitating investments in IP driven industries and services through the proposed IP Exchange for bringing investors/ funding agencies and IP owners/users together.

5.11.3. Providing financial support to the less empowered groups of IP owners or creators like farmers, weavers, artisans, craftsmen, artists etc. through financial institutions like rural banks or cooperative banks offering IP friendly loans.

5.11.4. Providing financial support for development and commercialization of IP assets through links with financial institutions including banks, venture capital funds, angel funds, crowd funding mechanisms.

5.11.5. Utilizing Technology Acquisition and Development Fund under the Manufacturing Policy for licensing or procuring patented technologies.

5.11.6. Taking stock of all IP funding by the Government and suggesting measures to consolidate the same to the extent possible; scaling up the funding as needed and avoiding duplication; enhancing the visibility of IP and innovation related funds so that utilization is increased; performance based evaluation for continued funding.

5.12. Promote use of Free and Open Source Software along with adoption of open standards; possibility of creating Indian standard operating environments will be examined.

5.13. Promote going-to-market activities by:

5.13.1. Creating mechanisms to help MSMEs and research institutions to validate pilots and scale up through market testing.

5.13.2. Providing seed funding for marketing activities such as participating in trade fairs, industry standards bodies and other forums.

5.13.3. Providing guidance and support to IPR owners about commercial opportunities of e-commerce through Internet and mobile platforms.

5.13.4. Encouraging enterprises to create brand equity from their IP rights, such as trademarks and Gis.

6.6 Summary

- This chapter provides a vision of patent status of India for which data has been taken from World Intellectual Property Organization (WIPO) Report-2015, and Indian Patent Office (IPO) Annual Report 2014-15.
- As per WIPO Report-2015, the global ranking of India is 11 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 in these indicators. During the time period 2014-15, the total number of patent applications received by IPO was 42,854 filed (residents + abroad), whereas China, Japan and S. Korea received 9, 28,177; 3, 25,989 and 2, 10,292 applications respectively.
- As per IPO Report 2014-15, the number of total patent applications (resident + abroad) filed with IPO ranged from 39,400 to 43,197 during the time period 2010-15. For the same period, the number of patents granted ranged from 4,126 to 7,509.
- As per latest report (2014-15), IPO received 42,763 patent applications and granted 5,978 patents.

- Categorizing the filed patents based on the field of invention, Mechanical (10,031) tops the ranking, followed by Chemical (6,454), Computer/Electronics (4,285) and Electrical (4,031). However, in the category of patents granted, the top ranking sequence is as follows: Chemical (1,533), Mechanical (1,047), Computer/Electronics (835) and Drugs (389). This data is for the time period 2014-15.
- State wise categorization of patents filed indicates that Maharashtra (3,193) leads the pack, followed by (Karnataka (2,102), Tamil Nadu (1,412), Delhi (1,099) and Uttar Pradesh (660). Top four states (Maharashtra, Karnataka, Tamil Nadu and Delhi) account for 65% of the total ordinary patents filed in 2014-15. No patent was filed by Meghalaya, Mizoram, Nagaland, Andaman & Nicobar, and Daman & Diu.
- IITs (337) are top Indian applicants from *institutes/universities* in the parameter of number of patents filed during 2014-15. Amongst the top ten rankings, two belong to public sector and eight belong to private sector. JRNR Vidyapeeth (Deemed university) Udaipur tops the ranking (2) in the private sector.
- Amongst the top ten rankings, CSIR (315) tops the list in the category of *scientific and research organizations* in the parameter of number of patents filed during 2014-15. Amongst the top ten rankings, seven belong to public sector and three to private sector. GHR Labs and Research Centre, Nagpur tops the ranking (4) in the private sector.
- Amongst the top five Indian patentees, four belong to the public sector i.e. CSIR (66). BHEL (56), IITs (30) and Tata Motors Limited (26). They occupy first, second, fourth and fifth rankings. Third position is occupied by a Bangalore based private company i.e. Samsung R&D Institute India Bangalore Pvt. Ltd.
- Amongst the top five foreign resident patentees, two are US companies i.e. Gm Global Technology Operations (267 patents granted) and Qualcomm Incorporated (205 patents granted). Other three foreign resident patentees are companies from Sweden, S. Korea and Netherlands.
- In 2014-15, 26,057 patents were filed in India through PCT national phase. USA is at the top followed by Japan and Germany. These countries filed 8,237, 4,388 and 2,581 patents respectively. Amongst the companies, Qualcomm Incorporated (USA) filed 1,214 patents followed by Koninklijke Philips N V., Netherlands (805) and Telefonaktiebolaget Lm Ericsson (Publ), Sweden (449).
- In 2015, IPO generated revenue of ₹ 374 crores which was ₹ 186.73 crores more revenue as compared to previous year.
- A portion of the National IPR Policy, 2016, dealing with education and R&D has been included in the chapter.

6.7 Conclusion

The patent data discussed in this chapter clearly indicates the poor status of patent regime in India *vis-a-vis* other Asian countries like China, Japan, and S. Korea. India lags behind these countries in the parameter of filed-patents under 'Residents' category, thus indicating the poor level of R&D being carried out in the research labs (of India). Going deeper into the root cause of this, one finds that India's ranking in the indicator of 'Publications' is quite impressive. It has been globally ranked 5th by SJR-International Science Ranking (2015). However, the ranking takes a nosedive (47) in the indicator, 'Intellectual Property Rights'. The last two statements indicate that science in India is publication-centric.

A strong intervention is required to convert research into innovative products leading to a patent/technology. The scientists need to be made aware of the benefits of patents. The government policies on IP should lay more emphasis on awareness and introduction of IP related courses in Higher Education Institutes and National Research Laboratories. The National IPR Policy-2016 of India has stressed upon making Indian researchers and scientists as IPR savvy. To achieve this goal, DIPP has created a special body i.e., Cell for IPR Promotion and Management (CIPAM), which has been entrusted with the responsibility of creating awareness about IPRs amongst the students and scientists of India by delivering lectures at various places i.e., schools, colleges, universities and R&D institutes. It is a welcome step and will certainly stimulate IPR awareness in India. However, mere awareness of IPRs by delivering lectures may not bring desired results. These lectures will stir up a desire to patent innovative ideas/research, but the researchers/scientists would need the presence of an IPR expert, who can hand hold them in the initial phase of *prior art research* and patent filing process. Thus, it will be prudent if couple of scientists/professors of each institute are empowered with reasonable amount of IPR knowledge/information, so that anybody in the institute having IPR related problem can approach them. In order to empower a few scientists of each institute with basic knowledge of IPR, it is suggested that MHRD or DIPP or TIFAC may set up 'IPR Academies' all over India. These academies may preferably be established in the universities. It is suggested that five universities, each located in northern, southern, western , eastern and central part of India, be designated as nodal centres of IPRs, which will run the *'Train the Trainers'* programme. To make these centres self sustainable; they may be allowed to run short term 'Certificate' and 'Diploma' and 'Advanced' courses on IPR, which are open to everybody from public sector or private sector. Also, the universities and research laboratories should have dedicated ‘IPR Cells’ which should be well conversant with patent laws, patent searching and patent filing processes. TIFAC, an organization under DST, has established Patent Information Centres(PICs) in many states of India. These PICs have set up nodal centres at a few places, primarily in the universities for spreading awareness about IP. It is suggested that more nodal centres be set up in public as well as private universities. The science departments of universities may be mandated to introduce IPR courses, such as (a) 'Certificate Course in IPR', for under-graduates; (b) 'Diploma Course in IPR' for post-graduates and (c) 'Advanced Course in IPR' for Ph.D research scholars. It is also suggested that a *prior-art search* of the patents should be carried out before the start of Ph.D research work, especially in the area of applied sciences. This effort will certainly help the scholar to understand whether his/her research work would lead to some novelty or would just be a repetition of research already taken place. Many times, it has been observed that the outcome of a Ph.D thesis has no novelty, as claimed by the scholar, because the information already exists. Such scenario results only in low or zero impact publication along with drain of the public money.

Various government organizations, such as CSIR, ICMR, ICAR, DST, DBT and many more have established over 300 R&D institutes/centres in which over 25,000 scientists are pushing the frontiers of science as evidenced by thousands of research publications on annual basis. However, their patent generation quotient is below par as listed in table 6.11.

Table 6.11: Patents of Select R&D Organizations (2013-15)

S. No.	Organisation	Patents Filed*	Number of Research Labs/Units/Centres**
1.	CSIR	784	• Labs-38 • Units-5 • Outreach Centres-39
2.	ICMR	39	• Institutes-22 • Units-5 • Regional Centres-5
3.	ICAR	207	• 101 Institutes-101 • Agricultural Universities-71
4.	DBT	85	• Autonomous Institutions-15 • PSUs-3
5.	DST#	87	• Autonomous S&T Institutes-20 • Professional Bodies-5
6.	ISRO***	39	• Centres-42
7.	DRDO***	287	• Laboratories-60

**Annual Reports (2013-15) of Office of the Controller General of Patents, Designs & Trade Marks*
***http://www.csir.res.in/, http://icmr.nic.in/, http://www.icar.org.in/, http://www.isro.gov.in/, http://www.drdo.gov.in/, http://www.dbtindia.nic.in/, http://www.dst.gov.in/*
**** ISRO and DRDO lay more emphasis on technologies than patents.*
#From DST Sponsored Projects (http://www.tifac.org.in/)

The need of the hour is to replace *publication centric* approach with *patent centric* approach of the organizations/scientists. Though, it seems a difficult proposition but certainly not impossible. The biggest challenge is to change the mindset of scientists and creation of Translational Research Ecosystem (TRE) in the institutes. The incentivization of the scientists and institutes will certainly stimulate generation of patents/technologies which could be used for commercial purposes and/or societal uplift.

In the field of engineering, India has a well developed R&D infrastructure and scientific intellect which are responsible for large number of patents in the fields of mechanical, chemical, computers, electronics and electrical. The organizations like CSIR, ICAR and ICMR have also many R&D institutes and large pool of scientists. They can take cue from the TRE of IITs and add to the patent-kitty of India.

Feedback from Select Scientists Engaged in Industry-Academia Research Projects

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7.1 Introduction

In the present era of knowledge economy, a productive interface between academia and industry is a critical requirement. Universities and industries, which, for long have been operating in separate domains, are rapidly inching closer to each other to create synergies. The strong economies of the world have realized the importance of a robust bridge between the academia and the industry. Many novel innovations (technologies/products) in these economies are the result of a warm handshake between the academia and industry. Indian Industries, after the liberalization in 1990s have become marginally more aware of the vital linkage between the education system, business and corporate productivity. Even with this awareness, its engagement with academia is tentative and ritualistic rather than real. However, there are quite a few examples of scientists who have successfully carried out Industry-Academia (I-A) research projects.

DST-CPR initiated the task of studying I-A collaborative projects being carried out in Higher Education Institutes (HEIs) of India. The Centre contacted scientists working in universities, technical institutes like Indian Institute of Technology (IIT), Institute of Chemical Technology (ICT) and medical research institute such as All India Institute of Medical Sciences (AIIMS) and industry representatives to understand the mechanics and challenges involved in delivering I-A collaborative research work. The Centre prepared a detailed I-A Proforma to be filled in by scientists having practical experience of handling I-A collaborative projects. The Proforma also sought suggestions and hindrances faced by the scientists while pursuing I-A collaborative research projects. In total 18 select scientists from all over India were requested to fill I-A proforma for I-A case study. Out of these, 8 scientists filled the I-A proforma (Section 7.2). Four eminent scientists could not send the filled proforma, but Prof. Tewari (Coordinator, DST-CPR at PU, Chandigarh) met them personally and noted down their suggestions for improving I-A interactions. These scientists are:

- Prof. G. D. Yadav, Vice Chancellor, ICT, Mumbai.
- Prof. A. Jhunjhunwala, Chairman, Rural Technology and Business Incubator (RTBI), IIT- Madras, Chennai.
- Prof. T. Pradeep, Head, DST-Unit of Nanoscience, IIT, Madras, Chennai
- Prof. Balram Bhargava, Exec. Director, Stanford-India Biodesign, AIIMS, New Delhi.

Prof. G.D. Yadav emphasized (a) the need for incentivizing university faculty indulging in I-A activities and (b) effective short term industry-projects for both under and post-graduate students of basic and applied sciences.

Prof. A. Jhunjhunwala suggested that government should promote entrepreneurship programme in HEIs, universities, IITs as well as research centres. He was also of the opinion that Small and Medium -Sized Enterprises (SMEs) and Ministry of Micro, Small and Medium Enterprises (MSME) should be encouraged by the government to indulge in R&D activities as large companies are good at scaling up products and are not interested in serious R&D.

Prof. T. Pradeep called for upgrading research eco system in HEIs, especially the instrumentation facilities.

Prof. Bhargava stated that India has huge potential for innovative research in the field of Bio-Medical Engineering. In a short span, the collaboration of AIIMS doctors with Engineering faculty of IIT has resulted in many successful start-ups and entrepreneurs coming out of Stanford Biodesign Centre. He recommended the setting up of similar Centres in research oriented hospitals like PGIMER, Chandigarh and Medical Colleges in Delhi, Lukhnow and Chandigarh.

This chapter has been divided into 5 sections: (7.2-7.6) and are discussed below:

7.2: List of Select Scientists who have Carried Out Successful I-A Collaborative Research Projects in India are mention below:

S. No.	Academician	Industry Counterpart
1.	Prof. V.B. Patravale Institute of Chemical Technology (ICT), Mumbai	Shri. Dhirajlal Kothadia Sahajanand Medical Technologies Pvt. Ltd., Surat
2.	Prof. O.P. Katare Panjab University, Chandigarh	IPCA Labs Pvt. Ltd., Mumbai
3.	Prof. Neelima Kshirsagar Seth GS Medical College and KEM Hospital, Mumbai	Dr. J.N. Verma Founder and Managing Director Lifecare Innovations Pvt. Ltd., Gurgaon
4.	Prof. Shantanu Roy IIT-Delhi, New Delhi	Thermax Pvt. Ltd., Pune
5.	Dr. Sunil Jha IIT-Delhi, New Delhi	BSES Yamuna Power Ltd., New Delhi
6.	Prof. R.K. Saxena University of Delhi, New Delhi	Tata Chemical Ltd., Pune

7.	Prof. Dinesh Goyal Thapar University, Patiala	Goetze India Pvt. Ltd., Patiala
8.	Prof. K. Sankaran Anna University, Chennai	TMI Systems, Bangalore

7.3 Brief Profile of the Scientists Included in Case Studies

Successful I-A interface is characterized by collaborative and interactive programmes between industrial sector and academic institutions. Intensification of interdependence between academia and industry is need of the hour in order to fulfil innovation and sustenance demands of the country. There is a need of paradigm shift in the approach and attitude of industrial sector and academic sector for achieving mutually constructive objectives i.e. to promote technological innovations/products leading to economic development of the nation. Despite various government initiatives, there is ambiguity whether I-A interaction is partial in nature or there is considerable relationship. In order to understand the extent of I-A interaction, the present study was carried out.

To begin with, our centre tends to take inputs/feedbacks from scientists working in universities both public and private universities, technical institutes like IITs and ICT and industry representatives who are pursuing research in different sectors such as pharma, engineering and biotech sector. Keeping this in mind, in the present study, two scientists namely Prof. V.B. Patravale working in ICT, Mumbai and Prof. O.P. Katare from Panjab University, Chandigarh and one industrialist Dr. J.N. Verma co-founder of Lifecare Innovations are carrying out research in the field of pharma sector. On the other hand, 2 scientists, Prof. Shantanu Roy and Prof. Sunil Jha were selected, working in a premier institute of national importance IIT-Delhi and carrying out research in the field of engineering sciences. Another promising field in which India's present research is rapidly progressing is biotechnology. Hence, 3 scientists namely Prof R. K saxena from University of Delhi, New Delhi; Prof. Dinesh Goyal from Thapar University, Patiala and Prof. K. Sankaran from Anna University, Chennai, engaged in the field of applied microbiology and biochemistry were considered for reviewing their I-A collaborative experience.

In this section we present brief details of select scientists in terms of their publications, patent profiles, technologies developed and transferred and awards and accreditations that they have received for their industry oriented research.

7.3.1 Scientists from Pharma Sector:

i) ***Prof. V. B. Patravale (Pharmaceutical Sciences)***

Prof. V.B. Patravale is a professor in the Department of Pharmaceuticals Sciences and Technology at ICT, Mumbai, which has been rated as a top industry-academia linked institute of India (AICTE-CII Survey, 2015). She has been credited with 72 research publications till date, has been granted 4 national patents and has filed 16 national and 6 international patents. Prof. Patravale is actively engaged in industrial collaboration and has handled 19 I-A collaborative projects, 10 technologies transferred and has developed almost 30 industrial products. Moreover she has provided a number of consultancy services to the industrial units such as Cadila Pharma, Sahajannand Medical Technologies, Kamani Oils, Yuva cosmetics and Charbhuja Trading Agency. She has been accredited with various industry related awards. She is the recipient of the prestigious OPPI Woman Scientist Award 2015 from the organization of pharmaceutical products of India. In the same year she received Vividhlaxci Audyogik Samshodhan Vikas Kendra (VASVIK) award from its Apex committee. In the year 2013, Smt. Chandaben Mohanbhai Patel Industrial Research Awards for Women Scientist was awarded to Prof. Patravale. She is the grant awardee for Bill and Melinda Gates Foundation for developing “Nanovaccine for Brucellosis using Green Technology”. Prof. Patravale has strongly contributed to the innovations of industrial importance in the field of pharma sector and has been closely associated with the pharmaceutical industrial segment of India.

ii) ***Prof. O.P. Katare (Liposomal Technology and Drug Development)***

Prof. O.P Katare is a professor in University Institute of Pharmaceutical Sciences, Panjab University, Chandigarh. He is working in the field of liposome technology and has been developing novel drug delivery systems including nanoparticles for tropical pharmaceutical products. He is credited with 112 publications, has been granted 3 national and 4 international patents and has filed 15 patents (9 national and 6 international). He has carried out more than 10 I-A research projects, transferred 3 technologies to industrial sector and developed 3 industrial products. Prof. Katare has been acknowledged for his innovative and industry linked research by DBT and has been awarded the Technology National Award 2007 by the former President of India, late Dr. A.P.J Abdul Kalam. He has also received the prestigious OPPI Scientist Industry Awards in 2011 by GlaxoSmithKline to honor his innovations in the pharmaceutical sector. He received the best patent award from Indian Association of Biomedical Scientists for the development of psorisome. On the international front, he has been a founder member and expert on the scientific board of International

Phospholipd Research Centre at Heidelberg, Germany. He has been actively associated with industry oriented research and has successfully transferred his technology to industry.

iii) Dr J.N. Verma (Drug Development)

Dr J.N. Verma is the co-founder and managing director of Lifecare Innovations Pvt. Ltd., located in Gurgaon and has excelled in his research in the field of drug development with focus on controlled release of pharmaceuticals viz-a-viz liposomal drugs and nano drugs. He is credited with 22 research publications, has been granted 1 national and 6 international patents and has filed 3 national and 17 international patents. He has been actively involved with academia and till date has carried out 15 I-A collaborative research works. He has commercialized 6 technologies translated from academia and has developed a total of 8 products. He has also been honored for his industrial research and active involvement with academic sector by the government of India. He has received great honour and has been conferred with numerous awards. Some of them are as follows: Innovation in Medical Sciences and Technology from Indian Council of Medical Research (ICMR, 2015); Vigyan Ratna Award (2012, 2007); National Award from Department of Scientific and Industrial Research (DSIR, 2006), Department of Biotechnology (DBT, 2004, 2006) and Technology Development Board (TDB, 2008). Dr. Verma is amongst those industrialists who have shown trust in the academia of our country and have immensely benefitted from I-A collaborations.

7.3.2 Scientists from Engineering Sector

i) Prof. Shantanu Roy (Computational Fluid Dynamics)

Prof. Roy is a professor in the Department of Chemical Engineering, IIT-Delhi. He is pursuing his research in the field of multiphase reactors, chemical reaction engineering and modeling, and computational fluid mechanics. He is credited with more than 70 publications and has been granted 3 international patents and has filed one international patent. He has been actively involved in more than 20 I-A research projects. He provides consultancy services to various industries and is a member of scientific advisory committee of Ministry of Petroleum and Natural Gas. He also provides services as an expert in several DST-TIFAC Committees for technology projection. He has been awarded with the DuPont Young Faculty Award 2004 by DuPont Chemical Company, USA for pursuing industry oriented research.

ii) Dr Sunil Jha (Automation in Manufacturing Process)

Dr Jha is an associate professor in the Department of Mechanical Engineering, IIT-Delhi. He is working in the field of manufacturing processes, mechanatronics and automation. He is credited with 20 publications and has filed 4 national patents. He has handled 7 I-A collaborative research products and has contributed towards transfer of 3 technologies and development of 4 industrial products. He is also actively involved with a number of industries for providing consultancy services in the domain of product designing.

7.3.3 Scientists from Biotechnology Sector

i) ***Prof. R.K. Saxena (Applied Microbiology)***

Prof. Saxena was a professor in University of Delhi in the Department of Microbiology. His major area of research work is industrial microbiology. He has published over 175 research publications and has been granted 2 national patents and has filed 12 national and one international patent. He has handled 3 major and 1 minor I-A research projects. Till date Prof. Saxena has contributed to the development of 8 industrial products which are under industrial negotiation for commercialization. Prof. Saxena has been awarded with young Indian Next Practices Award (2011) by DST and Indian Innovation Initiative (2011) by CII. Prof. Saxena was also coordinator of Innovation, Incubation and Technology Development Cell of University of Delhi and has strongly contributed to the strengthening I-A collaborations in the University.

ii) ***Prof. Dinesh Goyal (Applied Microbiology)***

Prof. Goyal is working in the Department of Biotechnology at Thapar University. He is working in the field of applied microbiology and biotechnology. He is credited with 80 publications and one national patent. He has been actively engaged in 4 I-A research projects, has transferred 3 technologies to industry and has developed 5 industrial products. He is actively involved in providing consultancy services to various industries. He has also been heading the Science Technology Entrepreneurship Park of Thapar University to promote technology development, attract industries and promote entrepreneurship culture in the University.

iii) ***Prof. K. Sankaran (Biochemistry)***

Prof. Sankaran is working as professor in Centre for Biotechnology, Anna University, Chennai. He is credited with 40 research publications and has been granted 1 international patent and has filed 9 national and 2 international patents. He has transferred 2 technologies to the industry and has developed 2 industrial products. He has been actively involved in providing consultancy services to Shree Kamdhenu Electronics Pvt. Ltd., and has been associated with field validation services along with Trivitron Healthcare for uropathogenic antibiogram device. He has been involved with a number of I-A collaborative projects and is delivering them successfully under required time frame and industrial requirements.

Brief profiles and achievements of academicians (7) and industrialist (1) are presented in table 7.1:

Table 7.1: Brief Profile of Select Scientists who Successfully Delivered I-A Collaborative Research Projects

S. No.	Name	Broad Area of Research	Res. Papers	Patents		I-A Projects	Tech. Transfer	Industrial Products Developed	Consultancy and Industry Related Awards
				Filed	Granted				
1.	Prof. V.B. Patravale	Pharmaceutical Sciences and Technology	72	22	4	19	10	30	**Consultancy**: Cadila Pharma, Sahajananad Medical Tecghnologies, Kamani Oils, Yuva Cosmetics, Charbhuja Trading Agency **Award**: OPPI Women Scientist Award 2015, Smt. Chandaben Mohanbhai Patel Industrial Research Award for Women Scientist 2013
2.	Prof. O.P. Katare	Liposome Technology and Drug Delivery	112	15	7	>10	3	3	**Award**: DBT Technology National Award 2007, OPPI Scientist Industry Award 2011, Best Patent Award by Indian Association of Biomedical Scientists (IABMS, Chennai)
3.	Dr. J. N. Verma	Drug Development	22	20	7	15	6	8	**Award**: Haryana Vigyan Ratna Award 2012, Vishnu Kamal Award 2009, National Award-Technology Development Board 2008, Vigyan Ratna Award 2007, Scientist of the Year 2003
4.	Prof. Shantanu Roy	Computational Fluid Mechanics	>70	1	3	>20	-	-	**Consultancy:** Scientific Advisory Committee of Ministry of Petroleum and Natural Gas, DST-TIFAC Committee Expert Member **Award**: DuPont Young Faculty Award 2004
5.	Dr. Sunil Jha	Manufacturing Processes, Automation	20	4	-	7	3	4	
6.	Prof. R.K. Saxena	Industrial Microbiology	175	13	2	4	-	8	**Award:** Young Indian Next Practices Award in i3 National Fair 2011, Indian Innovation Initiative Award 2011
7.	Prof. Dinesh Goyal	Applied Microbiology and Biotechnology	80	1	1	4	3	5	
8.	Prof. K. Sankaran	Biochemistry	40	11	1	-	2	2	**Consultancy**: Shree Kamdhenu Electronics Pvt. Ltd. and Trivitron Healthcare, Chennai

7.4 Details of I-A Collaborative Projects Carried out by Select Scientists

i) Prof. V.B. Patravale, ICT, Mumbai

Title	Development of Novel Drug Eluting Coronary Stents
Duration	2006-15 (9 years)
Finances	Industry, ICT and government financed the project in 3 stages of product development: 17,00,000 (stage-I) + 2,69,376 (stage-II) + 7,21,355 (stage-III)
Manpower	3 JRF and 1 Res. Assistant
Responsibilities	*Academia*: Concept development, product development and optimization, *in vitro* characterization, *ex vivo* studies. *Industry*: Concept development, patent filing, scale-up, preclinical and clinical studies, product approval from authorities and marketing. *Other Organization*: PM's Fellowship Schemes for Doctoral Research (Government of India) for awarding JRF
Approach for Initiating Collaborative Work	Industry approached Prof. Patravale for consultancy. After joining as a consultant, the work was then taken ahead as additional collaborative projects.
Stage at which Industry Involved	Industry was involved at every stage of the project
IP Status	Not disclosed
Institute Gain	· 25% of the project cost was received by institute as institutional share · 33% of the consultancy cost was received by institute as institutional share · Empowering image of institute in industrial sector as promising academic collaborator
Scientist Gain	· Inventorship in the patents filed from the research work. · Financial support to conduct research · Publications · Recognition in industrial arena · Achieving scientific excellence
Industry Gain	· Research support and expertise to develop and optimize the product · Cost effective product development · Fulfillment of social responsibility
Market Impact	· Global market entry (over 40 countries) with the superior coronary stents and 1^{st} in India to receive European Conformity (CE) mark · The regulatory authorities (India) not only approved the products but also increased the shelf life from initial 1 year to 2.5 years for SupraFLEX® in year 2015 · More than 3.5 lakh stents implanted till date · Revenue of ~ 50 crores was generated in year 2013-14 · Better market opportunity for products under development
Societal Impact	Superior product with respect to biocompatibility and restenosis rate was available for patients. Cost effective treatment modality with high efficacy for patients (almost 25% cost reduction than the competitor product)
Profit Sharing	Profits not shared with collaborator/institute
Outcome	Currently, 4 coronary stents are being marketed in India (First to receive CE mark) and abroad under the trade names Infinnium™, Supralimus™, Supralimuscore™, Everoflex™ Other stents under development: S-Link and Supraflex.

ii) Prof. O.P. Katare

Title	Development and Scale-up of Some Novel Liposomal Products
Duration	There are different modules viz. Life long, time bound and case bound (continuing from 2004)
Finances	5, 10, 000 (Industry and Panjab University)
Manpower	4 JRF
Responsibilities	*Academia*: Concept formation, hypothesis testing, generation of scientific lab-scale data and scientific evidences, varied techniques for analysis, pre-formulation, formulation development, characterization and standardization, stability issues and assessment, package development, product technology information. *Industry*: Scale-up and tech-transfer issues, development of Standard Operating Procedures (SOPs) (Joint efforts), filling all the gaps to fulfil the regulatory requirements, funding supports for materials and outsourcing, fellowship for scholars and support for lab assistance and patent filing. *Other organization*: Funds support from agencies like UGC, AICTE, DBT and DST for infrastructure and high cost instruments.
Approach for Initiating Collaborative Work	Industry approached only in all cases. (In case of vice versa, it was failure)
Stage at which Industry Involved	Right in the beginning at the conceptual level
IP Status	University shared with innovator the royalty amount, i.e. 2% of ex-factory price which was then distributed 50:50 between the university and investigators.
Institute Gain	· Based on the achievements, the institute and the university fetched so many high-funding projects likes DST-INSPIRE, DST-Policy Centre for Policy Research, UGC-NanoSci projects (worth crores of rupees). · It helped University in ranking by different agencies like NAAC. · Generating finances through Centre for Industry Institute Partnership.
Scientist Gain	· Enhancement in the employability of scholars. They were quickly absorbed in the high growth or top performing pharma industries like Sun Pharma, Lupin, IPCA and others. · Image or brand building at individual level and organizational levels both the investigators and university gained lots of advantages in this regard. · Financial support for procurement of materials and outsourcing that saves lots of time. · Generated IPR with the support of industries which is often ignored in the conventional lines of practice at the University level.
Industry Gain	Novel pharmaceutical products with an edge over other products hence, the market advantages.
Market Impact	Products have been appreciated by the doctors and gradually catching up in the market.
Societal Impact	Helped suffering society
Profit Sharing	University shared with innovator the royalty amount, i.e. 2% of ex-factory price which was then distributed 50:50 between the university and investigators.
Outcome	Liposome and nano-tech based novel pharma products for dermatological disorders like Psoriasis, Eczema and Fungal infection stability solutions

iii) Dr J. N . Verma

Title	Scale-Up Process Development for Production of Liposomal Amphotericin B, Awareness Program and Clinical Performance Trials
Duration	16 months
Finances	Lifecare Innovations Pvt. Ltd., 99.76 lakhs (66.61%) DSIR under PATSER 50.00 lakhs (33.39%)
Manpower	Not disclosed
Responsibilities	*Academia*: Development of lab scale technology (*prior to this project*). *Industry*: Innovations and developments to make the product-Liposomal Amphotericin B patient worthy and commercializable; with cold-chain compatible packing to maintain uninterrupted cold-chain from production to patients' bed-side. *Other organization*: DSIR funded industry for this project for 16 months; DBT funded academic institutions before this project
Approach for Initiating Collaborative Work	In 1990s, Dr J.N.Verma was the only known liposome technologist in Indian industry credited with discovery, development and commercialization of Asia's 1st liposomal product-a Liposome Agglutination Test for immunodiagnosis of Syphilis. Various government agencies viz. DBT, NRDC and DSIR identified Dr Verma and committed support for creating the company Lifecare Innovation to absorb DBT technology, carry out translational research and commercialization of life-saving drug for treatment of life-threatening fungal and leishmanial infections. Dr Verma approached academia for collaborative research.
Stage at which Industry Involved	Dr J.N. Verma being a liposome technologist was in touch with Dr B.K. Bachhawat and Dr Neelima Kshirsagar since 1991 and was regularly interacting with their research groups. Dr Verma played a pivotal role in establishing liposome technology in the industry in India and was involved in the project at different levels before the completion of clinical trials.
IP Status	IP was assigned to the industry and the institution was paid the royalty.
Institute Gain	The institutions KEM Hospital Mumbai, DBT and DSIR received royalties and DSIR's investment as Programme Aimed at Technology Self Reliance (PATSER) grant along with interest was returned by Lifecare Innovations.
Scientist Gain	Scientists were benefitted by unprecedented recognition. In addition to other honors and awards Dr Kshirsagar was conferred with B.C. Roy Award.
Industry Gain	Dr Verma though in the industry as the founder and managing director is also involved in the project as a scientist. Without Dr Verma's pioneering initiatives as a liposome technologist and his determined pursuit in a country that was not the most conducive for technopreneurship, this project would have been buried as a project report in the archives of DBT as no company wanted to invest in this project perceived to be very risky.

	Industry got an opportunity to establish commercial production of Novel Drug Delivery Systems (NDDS) based controlled release drugs viz. liposomal and nano-drugs. Today Lifecare Innovations has forged several collaborations both within and outside India and has become inspiring example of technology led enterprise engaged in discovery and development of novel drugs.
Market Impact	Amphotericin B due to its overwhelming toxicity particularly nephrotoxicity is referred to as *Ampho-the-terrible*. With not even single other broad-spectrum anti-fungal drug discovered, Amphotericin B despite nephrotoxicity to $2/3^{rd}$ of the patients administered with the drug, continued to be the only hope for invasive and systemic fungal infections. FUNGISOME™-*Ampho-the-terrific* safer than any other anti-fungal drug in the world has rekindled hope that liposomes can help mitigate doses limiting toxicities. Consequent to FUNGISOME™, number of companies are now engaged in developing liposomal formulations of Amphotericin B and other drugs. New business of several hundred crores of liposomal drugs has developed in India alone. Following success of FUNGISOME™, Lifecare Innovations has developed and commercialized five lipid and liposomal formulations for treatment of fungal and leishmanial infections and psoriasis
Societal Impact	Prior to FUNGISOME™, Liposomal Amphotericin B was unaffordable by most Indians. Imported Liposomal Amphotericin B was mostly prescribed in defence hospitals. Now because of success of this project and consequent availability of FUNGISOME™, number of lives are saved every day.
Profit Sharing	Institution was paid royalty
Outcome	FUNGISOME™-the only indigenous drug and superior to imported Liposomal Amphotericin B (i.v.) was innovated, commercialized and made available throughout India and became preferred Liposomal Amphotericin B (i.v.) of most of the premier hospitals in India including-AIIMS, New Delhi; PGIMER Chandigarh; Sanjay Gandhi Post Graduate Institute of Medical Sciences (SGPGIMS), Lucknow; Christian Medical College (CMC), Vellore; Tata Memorial Hospital, Mumbai; Medanta-the Medicity, Gurgaon; Apollo Group of Hospitals, New Delhi and other Defense Hospitals. The daily dose cost, success rate and nephrotoxicity of FUNGISOME™ were 5900, whereas of the imported AmBisome were 60,000, respectively. Prior to FUNGISOME, only 1% of the patients needing Amphotericin B could afford its nephrosafe Liposomal formulation whereas within 3 years of FUNGISOME launch, FUNGISOME alone catered to estimated 16% of the patients needing Amphotericin B (i.v.) Today FUNGISOME is emerging as drug of choice in several countries. It has been launched in Latin America under the brand name AmBullet®.

iv) **Prof. Shantanu Roy**

Title	Flow Studies, Mixing Pattern and Modeling of Rotary Bioreactor
Duration	2 years
Finances	Industry ~ 60 lakhs; Ministry of Human Resource Development (MHRD; 25 lakhs); DST (37 lakhs); Board of Research in Nuclear Sciences (BRNS ; 20 lakhs); IIT (~ 30 lakhs).
Manpower	1 SRF, 1 Project Assistant
Responsibilities	*Academia*: Conduct of in-house (in IIT) experiments, establishing the experimental protocol and conduct of experiments, collection and analysis of data and modelling of flow phenomena. *Industry*: Design of experimental unit, fabrication and installation. Providing logistical and manpower support for scientists from IIT and BARC. *Other organization*: BRNS, DAE supported part of the developmental effort in IIT in general (not specific to the current project).
Approach for Initiating Collaborative Work	Industry approached scientist.
Stage at which Industry Involved	From beginning
IP Status	IP was not shared amongst the collaborators/institute/industry. The IP was mostly in form of knowhow. The specific details of the technology were not disclosed but the use of the experimental technique in this setting, which was novel and other significant accomplishments, have been published.
Institute Gain	· Technical success · Training of students in a particular technology that has been developed in-house
Scientist Gain	This is now considered as a case study of industrial radio tracing by the International Atomic Energy Agency (IAEA), of which the PI is a technical expert.
Industry Gain	Product/technology is successfully commercialized and utilized by industry
Market Impact	It is substantial business of the "Water and Waste Solutions" division of Industry. The product is sold under the commercial name "BioCask". The I-A project in question provided a crucial step in commercialization of this technology.
Societal Impact	The product/technology that has been developed is an important technology for end-to-end wastewater and sludge treatment solution. It is commercially viable and used in various urban and rural centres.
Profit Sharing	No profit sharing
Outcome	The technology for flow imaging developed at IIT-Delhi was never used in the industry directly. It was a challenge to do so, and this is the first ever (anywhere in the world) successful demonstration and use of this technique in the industry. The suspected problems were fully addressed and specific recommendations were made. Some minor design changes and major operational changes were made. Good efficiency was ensured and product/technology is a success in the market.

v) **Prof. Sunil Jha**

Title	Solar Power Operated Water Pump
Duration	3 Months
Finances	Industry: 6.50 Lakhs
Manpower	Nil
Responsibilities	*Academia*: To design efficient Solar operated irrigation pumping system. *Industry*: To provide specifications of the requirement.
Approach for Initiating Collaborative Work	Industry approached
Stage at which Industry Involved	Since beginning of the project
IP Status	IP shared amongst the collaborator/institute/industry by 50-50.
Institute Gain	Technology know-how
Scientist Gain	Get to know about the *state of art* of technologies in solar water pumping.
Industry Gain	Get commercial product developed in very short time.
Market Impact	BSES Yamuna Power Ltd. successfully commercialized and installed more than 60 such pumps in Delhi.
Societal Impact	Improved the water supply by reducing power dependency and cost.
Profit Sharing	No profit sharing with institute.
Outcome	Technology for solar water pumping for farmers, schools and hospitals.

vi) **Prof. R.K. Saxena**

Title	Enzymatic Synthesis of Xylitol from Hemicellulose from Tata Chemicals Limited (TCL).
Duration	2 years
Finances	100% financial support by the industry
Manpower	2 JRF
Responsibilities	*Academia*: Sole responsibility of the academia *Industry*: Filing of the patents and subsequent commercialization *Other organization*: Nil
Approach for Initiating Collaborative Work	Industry approached
Stage at which Industry Involved	Right from the beginning
IP Status	Joint patents
Institute Gain	Infrastructural support and industrial relation (university-industry interaction)
Scientist Gain	A new dimension of industrial requirement were explored and investigated

Industry Gain	Industrial processes of bio molecules required by the industry were developed.
Market Impact	Details are with the industry
Societal Impact	Industry provided jobs, based on the work carried out
Profit Sharing	-
Outcome	The 2 products i.e. xylitol and propanedial were developed at the pilot plant 2 students working for these projects were awarded Ph. D degree from University of Delhi. 13 research paper were published

***vii)* Prof. Dinesh Goyal**

Title	Utilization of Waste Biomass for Removal of Heavy Metals from Industrial Effluents
Duration	2005-2008 (3 years)
Finances	CSIR, New Delhi: 20 lakhs
Manpower	2 JRF
Responsibilities	*Academia*: Project co-ordination and management with participating agencies and data generation laboratory work and basic data generation *Industry*: Logistic support at the unit, sample analysis and pilot scale trial *Other organization*: CSIR-project monitoring
Approach for Initiating Collaborative Work	Scientist approached the industry
Stage at which Industry Involved	Towards the completion for pilot scale trials
IP Status	IP shared amongst the collaborators/institute/industry: Equally between University and CSIR
Institute Gain	All deliverables were met, 2 Ph.D and 10 M.Sc were awarded, 12 publications in reputed journals.
Scientist Gain	One patent granted No. 244750: A process for chromium VI removal from industrial effluents by waste biomass Date of publication 24.12.2010; Journal No. 52/2010; Inventor: Ahluwalia AS and Goyal Dinesh
Industry Gain	The industry made trial and used it for environmental clearance and maintenance in removing chromium from waste water.
Market Impact	Not ascertained
Societal Impact	Not ascertained
Profit Sharing	Never estimated
Outcome	In this process bio sorbent is manufactured from microbial waste biomass, originating as waste by-product from pharmaceutical industries, such as microbial waste biomass comprising of fungus *Penicillium* sp./*Pischia* sp./*Rhizopus* sp./ *Aspergillus* sp., used in fermentative production of antibiotics.

viii) **Prof. K. Sankaran**

Title	Instrumentation for Long Term Monitoring of Neuromuscular and Cardiovascular Status for Diagnosis, Therapy and Rehabilitation
Duration	3 years
Finances	Total project Amount = 41,33,000 Source of finances: DST, New Delhi
Manpower	2 SRF
Responsibilities	*Academia*: Technology development *Industry*: Field validation and commercialization *Other organization* : DST for funding
Approach for Initiating Collaborative Work	The scientist approached the industry
Stage at which Industry Involved	During the validation stage
IP Status	IP shared amongst the collaborators/institute/industry: 50:50
Institute Gain	The institute gets the share as stipulated by the sub-committee from the one-time technology transfer fee and royalty.
Scientist Gain	Inventor reward was given to the scientist from the one-time technology transfer fee collected from the industry and also the scientist will be given his share from the revenue generated in the form of royalty on selling of every unit.
Market Impact	Unknown, as the product has not hit the market yet.
Societal Impact	Unknown, as the product has not hit the market yet.
Outcome	Multi-channel synchronous wireless data acquisition; bladder pressure monitoring and extension for cystometrogram system. Standards compliance testing and certification of the product. The project was successfully technology transferred.

7.5 Feedback from Scientists for Strengthening I-A Collaborations in India

i) Prof. V.B. Patravale

Hindrances:

Lack of infrastructure and facilities at institute end required extensive outsourcing in formative years. However the infrastructure was built up as per requirements in later years with the support of government and private industrial grants.

Suggestions:

- Rules and regulations for collaborative projects/consultancy and technology transfer should be properly defined (as these rules are properly and clearly defined at ICT the execution of collaborative project and technology transfer was extremely swift and convenient)
- Patent cell within the institute can help the researchers scan micro patents at faster pace rather than being dependent.
- Patent royalty clause should be inbuilt and a specific percentage defined by the institution.
- Confidentiality agreement and MoU should be critically drafted, safeguarding the interest of both the sides.

	· Follow up mechanism for milestone payments should be automatically built in the system. No reminders from collaborators to central accounts should be necessary. · No maintenance grant comes from government/institute which at times is necessary for smooth functioning of the project.	
ii)	**Prof. O.P. Katare**	
	Hindrances: · University Infrastructure: a) Lack of sufficient space and laboratory facilities, b) Equipments and maintenance · Retention of technology-trained scholars: This means that to carry on the efforts to the level of translation (scale-up), it needs well-equipped personnel. But, there is no provision to retain them for such industrial projects will leave after his/her Ph.D and the final work will then be left incomplete. · Bureaucratic hindrances in utilizing private funds: There are lots of objections to clear the bills by audit department. **Suggestions** · Centre for Industry Institute Partnership should be given complete autonomy, especially in utilizing personal funds. · University should look to address the specific or individualized challenges which may be different from project to project. · The researchers should be given incentives. · To retain the scholars/post-Ph.D, there should be a provision to administer the support without delay. · Also, in order to attract industry, the clouse of service tax (which is getting on funding organization) be erased.	
iii)	**Dr J. N. Verma**	
	Hindrances: · Non-availability of affordable land in and around Delhi. No start-up or entrepreneur led enterprise can afford any land. After 15 years also, we do not have land because of affordability. Make in India is reduced to only a slogan as no one in the country knows "make where in India". · Adequate financial support. If the financial support is not complete, the innovators are forced to depend on financers. Often these financers become impediments for the fruition of the project. · Regulatory Agencies, particularly Drugs Controller General (India) [DCGI]/Central Drugs Standard Control Organization (CDSCO) do not work in time-bound manner, have no experience in dealing with new drugs, have no motivation to support innovation, have no appreciation of eroding patent life because of delays caused by them. Unless there are punitive actions and accountability against DCGI/CDSCO officials and State Drugs Controller Indian healthcare industry cannot progress. R&D alone cannot address unmet medical needs of the country and humanity. There should be time bound	

procedures for all licenses, permissions and delays should not be allowed to be caused on frivolous grounds. Non-response should also not be allowed.

- Bureaucratic Harassment: We faced serious problems with excise department as despite clearly classified as excise free, they charged excise on our first batch of product for which we had to stop salaries. Though we won the case, but wrongly charged excise duty was never returned. On subsequent batches they stopped only when we said that we will stop manufacturing and hold a press conference making excise department responsible for the deaths for the want of life-saving drug. Pollution Control Board harassment and delays are very common.
- Power tariff and uninterrupted power supply to ensure Good Manufacturing Practices (GMP) and seamless Cold Chain. Special status shall be given to healthcare industry to provide uninterrupted power and incentivized tariff.
- The government should promise and implement 'Minimum Purchase' of products manufactured through the support of government grant if they have been tested and their safety and efficacy is established through clinical trials. Though there is an order of MSME to procure minimum 25% from MSMEs. Procurement, hospitals in the country do not follow it and in fact several Hospitals have enforced in their 'Terms and Conditions for Tenders and Rate Contracts' a prohibitive minimum turnover clause to prevent participation of start-ups in tenders.
- If a superior product has been developed and commercialized in India, inferior imports shall be banned. Our product is known world over to be most safe and most effective of all Liposomal Amphotericin B in the world, but continue to allow inferior imports of very high value drug.
- If a product has been developed and manufactured with government support in India, that product should be compulsorily purchased from all government organization. This is not being followed. Government of India or the state government never purchased even one vial of Fungisome for Kala-Azar control programs.

Suggestions

- Indian pharmaceutical industry is 'Generics and Similar Centric'. Because of the huge investments involved in development, clinical trials and international norms of GMP compliance, complexed by 15-20 years of development time, return on investments and reinvestable returns are not possible. To promote the drugs discovery and development, National Pharmaceutical Pricing Authority should be abolished. Similarly, Department of Pharmaceuticals has no role is either promotion of research or industry and thus should be abolished.
- Because of the long durations involved in pre-clinical regulatory toxicity and phase I to phase III clinical trials, most of the IP life of 20 years is eroded and leaves no commercial viability to get returns on investment, there should be a minimum of 15 years of post-commercialization patent life. In the absence of this provision, industry is not interested to develop products in collaboration with academic institutions.

- When the technology originates in the academic institution, there is pressure of publication from both students and faculty as the publications are parameter for their performance evaluation. There is little realization that the World has transitioned from '*publish or perish*' to '*publish and perish*'. In such technologies industry cannot invest. Thus a system needs to evolve for granting higher credits for patents in comparison to publication. For example, 1 patent filed in India should be credited as 1 publication; Patent Co-operation Treaty (PCT) filed should be equivalent to 2 publications; an Indian patent granted should be equal to 2 publications and a high value foreign patent granted should be equivalent to 2-4 publication. This is just an indication. The system should be evolved with critical evaluation of the formula.
- Young scientists shall be encouraged for entrepreneurship to take up commercialization of their work and continue collaboration with their alma mater. This will also maximize translation of research into commerce. These young scientists shall be supported with a corruption free support system as part of institution's entrepreneurship cell.
- R&D funding to the MSMEs shall be provided as risk sharing grant such as PATSER. Under PATSER scheme, no money was returnable by the company in the event of failure. However, on successful commercialization, 1.3 times the grant amount was returnable over five years, starting one year after commercialization.
- Masters Degree program in relevant field shall have courses on documentation of R&D data, intellectual property, regulatory affairs, entrepreneurship and business management.
- There should be government funded Contract Research Organizations (CROs) in institution-industry collaboration clusters possibly linked to entrepreneurship cells of the institution.
- Collaborations with hospitals and doctors is a unique requirement of healthcare industry. Medical doctors in the country mostly respond with 'so what do I get out of this collaboration'. R&D contributions must be a part of performance appraisal of doctors in both teaching and non-teaching hospitals.
- For sanction of R&D grant to an academic, norms shall be laid down to assess applicability/commercialization of their earlier funded work as qualifying criterion to optimize usefulness of government's R&D spending.

iv) Prof. Shantanu Roy

Hindrances:

Nothing in particular. Very good cooperation from industry, who very well championed the cause of incorporating high-end research into crucial parts of their technology.

Suggestions:

- Major public sectors in India have a mandate for research and development, and part of that is joint development with academia. However what plagues success in many cases is that the middle-level management in such major public sectors, who have a direct knowledge of technical challenges and problems (where academia can help), have hardly any decision-making powers. Most of the R&D decisions are taken by top management, and many of the professionals occupying such positions either do not have experience of R&D, or are too busy and disinterested in R&D, let alone interactions with academia.

- They would be present for industry-academia programmes and photo-ops, but since they have very little direct experience or requirement of research-based solutions, the whole effort ends up being cash sink with little positive results. There is need to have the people who are actually working on research to also be decision makers in terms of budgets, spending and setting directions for R&D.
- Also many public sectors have to abide by archaic laws of using 'proven and demonstrated technologies' when they are in the process of design and commercializing a plant. Since new technologies would never by demonstrated, by definition, hence the incentive to go for new technologies developed under I-A interactions is small. Thus, an ecosystem in which new technologies developed indigenously is encouraged, is required. This will have obvious conflicts with risk assessment that companies will make and this has to be addressed.
- In private sectors in India, the problem is two-fold. There are several companies who 'feel the need' for research based solutions, but are too small to afford major projects. They understand the challenges very well, are doing very good work on their own, but they are not part of an 'ecosystem' in which they can freely interact with academia. Maybe the government needs to create an environment, not only in terms of funding but also in terms of 'access', to support such companies to interact freely with academia.
- For large private sector companies in India, the challenges to develop and commercialize technology indigenously are too many. So most of them decide to 'buy-out' technology from known vendors (usually themselves major multinational companies), while the incentive towards indigenous development is low.
- One other aspect is that major technology vendors provide guarantees on technology when deployed. For a private (or even public sector) company that is a major requirement. Even if we do have new technologies and patents coming out of I-A relationships within the country, usually lack of an ecosystem which ensures guarantees and troubleshooting support deterrent for going in for new technologies. Thus, it is important that some sort of undertaking on guarantee of technologies and troubleshooting support, should be provided.

v) Dr Sunil Jha

Hindrances:

Problem in getting good manpower for short term projects.

Suggestions:

- A dedicated team in industry should be identified at the commencement of the project that will interact on regular basis with the Institute.

- Project investigators at institutes should be very clear about the deliverables of the project and work with clear focus in that direction.
- Institute should provide sufficient support to the PI for execution of the project in terms of space and other infrastructure. Because of space required for execution of the industrial consulting projects, institutes normally discourage projects which require space.
- There should be regular meets in institutes with different sectors of industry where industry can share their problems. Institute should maintain a website where industries can post their problems and the same information should be visible to all faculty members.

vi) Prof. R.K. Saxena

Suggestions:

- For applied research of national importance being carried out in public funded institutes, the industry should be involved from the very beginning of the research project. Government should give additional incentives to industries working on research projects of national importance.
- Each research institute should have a dedicated I-A Centre to look after I-A linkages, IPR management, entrepreneurship, technology development and technology transfer.
- Government should encourage setting up research facilities and scale up facilities on the campus under PPP mode.
- Technology developed by scientist/teacher and transferred to an industry should be given academic weight age and incentives to the scientist/teacher.

vii) Prof. Dinesh Goyal

Hindrances:

- Industry is not willing to spend even a single penny in exploratory research. If scientist has anything which is certified and proven technology or concept then only they will come forward that too if it leads to huge profits and money making. The industrial R&D is not at all strong in our country and they do not want to invest in that.
- While conducting trials at industry, there was least interest of industry people and it was only through personal contacts and our interest in doing something meaningful from academic point of view, we could attempt successfully. After completion of work reports were given to them and recommendations were explained, they never turned back to us for any further assistance.
- Fruits of science reach to society with a great difficulty and sometimes the new concept and new technology die off in between. People even after realizing its potential benefits are not able to accept, propagate and commercialize. Government support is necessary in this regard and all different wings of central and state government must come together to realize and implement immediately anything that relates to environment friendly green technologies, best practices in agriculture and environment protection.
- Indian industry has less faith in Indian scientific community.

- We nurture innovations, but it is half way and do not go further, or cannot go further, or there is no mechanism whereby, it can be taken further towards its successful implementation and realization by the society. Scientists and researchers leave in between because of several reasons.

Suggestions:

- Industry must actively work with researchers for working out new concepts and finally cost benefits analysis so that product or process is acceptable by the industry.
- Provide incentives to the working teams for successful implementations.
- The findings generally remain in thesis/dissertation for years and we keep reinventing the wheels. More collaboration between industry and academia is necessary.
- Industry needs to realize that they can get enormous benefits from this I-A partnership in modifying their processes in a cost effective manner, using academia which is actually a center for knowledge creation.
- This knowledge can be protected as well as utilized by them for greater returns. Industry, academia and government to facilitate this and making aware of available technologies which can be commercialized or results of R&D are accepted by the end users.
- Patenting is very slow process in India, by the time patent is awarded everything vanishes.
- Fast patenting and its commercialization or adoption by the industry is very much required. Due to this reason publishing the work in Science Citation Index Impact Factor Journals only remains as an alternative.

7.6 Hindrances and Recommendations

7.6.1 Hindrances:

1. **Limited research infrastructural set up**: e.g. research space, facilities like GMP, animal laboratory, tissue culture laboratory, scale-up facilities, commercialization of lab. research and lack of maintenance grant for existing instruments.
2. **Lack of industry funding**: Lack of funding from industry for basic and applied research. Industry becomes interested only when final product/technology is ready.
3. **Lack of skilled manpower**: Getting good manpower for short term projects is very difficult.
4. **Lack of 'complete set up' for taking laboratory research to commercialization stage.** i.e. assistance needed for IPR, interaction with industry, royalty clause, steps involved in scale-up and taking product to market/society.
5. **Regulatory framework**: Regulatory bodies should act fast on technologies developed under I-A collaborative mode to avoid deadlock of technologies as industry gets put off by lengthy regulatory framework. Hence, slow regulatory framework for approving the valuable product act as barrier for commercializing the technology leading to descent in I-A

interface in country.

6. **Bureaucratic hindrances**: For utilization of private funds, university administration and audit branch raise lot of objections, which sometimes are trivial in nature.
7. **Government policies**: Government policy regarding minimum purchase of superior product developed in the country is not followed properly. It discourages the industry counterparts who face the music of losses from the product developed.

7.6.2 Recommendations:

1. **Creation of a dedicated I-A cell**: Each university doing research should have a dedicated I-A cell. Its responsibilities include proper rules and regulations for collaborative research via creation of dedicated I-A cell addressing following issues. This responsibility should be taken by dedicated I-A cell in the academic institute to deal with all the issues pertaining to the I-A collaborations including creation of patent cell that will be in charge of patent filling and protecting IP.

a) Framing of proper rules and regulations for collaborative I-A research e.g. IP share, profit share, time and finance involvement at each stage, confidentiality agreement and MoU

b) Assist researchers in patent search, IPR issues, technology development/transfer and finding suitable industry for tie ups with scientists

c) Holding I-A meets on regular basis

d) Look out for I-A programmes from funding agencies

2. **Maintenance grant**: Government should set aside special instrument maintenance grant and grants for maintaining research facilities, tissue culture facility, and animal laboratory facility.
3. **Facilities under PPP mode**: Government should encourage setting up research facilities and scale up facilities on the campus under PPP mode such as creation of centre for excellence in collaboration with industrial sector to promote dedicated advanced research in particular field.
4. **I-A website**: Institute should have a I-A website mentioning the applied research, patents, technologies developed/transferred, consultancy work taken up by scientist. Website should also have a portal where industries can post their problems and the same information should be visible to all faculty members.
5. **Dedicated managing body**: Top management of universities should be run by scientists having ample experience in the area of R&D.
6. **Extended patent protection**: In India, time taken from filing a patent to commercialization of technology is too long. In biology related I-A project (e.g. Pre-Clinical Regulatory Toxicity and Phase I to Phase III Clinical Trials) most of the IP life of 20 years is eroded and leaves no commercial viability to get returns on the investment. Rules/regulations should be

amended so that there is minimum of 15 years of post-commercialization patent life. In the absence of this provision, industry is not interested to develop products in collaboration with academic institutions.

7. **Retention of expertise**: To retain post-Ph.D research scholars, there should be a provision of support without delay.
8. **Minimum purchase scheme**: The government should promise and implement 'Minimum Purchase' of products manufactured through the support of government grant. Though there is an order of MSME to procure minimum 25% from MSMEs in government procurement, this practice is not being followed.
9. **Promotion of self-product**: If a superior product has been developed and commercialized in India, inferior imports should be banned.
10. **Credits for patenting the research**: When the technology originates in the academic institution, there is pressure of publication from both students and faculty as the publications are parameter for their performance evaluation. There is little realization that the world has transitioned from '*publish or perish*' to '*publish and perish*'. In such technologies industry cannot invest. Thus, a system needs to be evolved for granting higher credits for patents in comparison to publication. For e.g. 1 patent filed in India should be credited as 1 publication; PCT filed should be equivalent to 2 publications; an Indian patent granted should be equal to 2 publications and a high value foreign patent granted should be equivalent to 2-4 publication. This is just an indication. The system should be evolved with critical evaluation of the formula.
11. **Promoting entrepreneurship**: Young scientists should be encouraged for entrepreneurship to take up commercialization of their work and continue collaboration with their alma mater. This will also maximize translation of research into commerce. These young scientists will be supported with a corruption free support system as part of institution's entrepreneur cell.
12. **Accessibility to risk sharing grant**: To encourage R&D by small businesses, government should provide financial guarantee, as is the case in Germany.
13. **Commencing dedicated courses**: Masters degree program in relevant field should have courses on documentation of R&D data, intellectual property, regulatory affairs, entrepreneurship, and business management.
14. **Creation of interlinked CROs**: There should be government funded CROs in institution-industry collaboration clusters possibly linked to entrepreneurship cells of the institution.
15. **Assessment of R&D funding**: For sanction of R&D grant to academic, norms should be laid down to assess applicability/commercialization of their earlier funded work as qualifying criterion to optimize usefulness of government's R&D spending.

DST- Centre for Policy Research at Panjab University, Chandigarh

Proforma for Industry-Academia (I-A) Case Study

Section A - *(Personal Information)*

1. Name:
2. Date of Birth:
3. Present Position:
4. Complete Postal Address:
5. Mobile/Landline #:
6. Email:
7. Highest Academic Qualification:
8. Broad Area of Research:
9. Research papers (Nos. only):
10. Patents (Filed): National- ; International-

    Granted (Granted): National- ; International-
11. No. of Industry-Academia (I-A) research projects handled:
12. No. of Technologies transferred:
13. No. of Industrial product(s) developed:
14. Any other industry related activity (consultancy etc.):
15. Industry Related awards/ honours:

Section B- *(Project Related Information)*

1. Title of I-A Collaborative Research:
2. Name and Address of Collaborative Industry:
3. Name & Address of other Collaborators (if any):
4. Genesis of the Project:

5. Duration of the Project:
6. Amount and source of finances of the project. *(Pl provide percentage of cost sharing):*
7. Manpower (*JRF/SRF/Res. Assistant/Project Assistant*) hired for the project.
8. Distribution of Responsibilities:

   (I) Academia:

   (ii) Industry:

   (iii) Other organization (if any, like DST/DBT etc.):

9. Deliverables:
10. Outcome of the project:
11. Whether scientist(s) approached the industry or vice versa:
12. At what stage was industry involved in the project:
13. How was the scientist(s) benefitted by this collaborative project:
14. How was the institute(s) benefitted by this collaborative project:
15. How was the industry benefitted by this collaborative project:
16. What is the market impact of the outcome of this project:
17. What is the societal-impact of the outcome of this project:
18. Whether any incentive to the scientist(s) was provided by the institute:
19. How was the Intellectual Property (IP) shared amongst the collaborators/institute/industry:
20. How were the profits shared by the collaborators/institute/industry:

Section C -*(Feedback & Suggestions)*

1. Please list the hindrances faced during the conduct of I-A research collaboration:
2. Kindly provide suggestions that will make I-A interactions more simple and fruitful:

Industry-Academia Interaction: Bridging the Gap for the Benefit of Society

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8.1 Introduction

Globally, the importance of Industry-Academia (I-A) interactions have been well recognized and many high-end technologies have been produced due to fruitful collaboration between these two partners. For India, I-A interface is very crucial and this is one of the areas where focus should be given to enhance synergy between academia and corporate sector for translating research and development (R&D) output for the benefit of society. It is a known fact that both the sectors work in isolation and there is a weak interaction between industry and academia. The I-A connect is not a simple relationship but is more complex because of the divergence in the objectives and ultimate goals. In order to enhance technology oriented R&D in universities and R&D institutes, government is floating many programmes/schemes to bring industry and academia closer and work in tandem for the economic and societal upliftment of the nation. This partnership can provide path-breaking discoveries and technological innovation leading to an improvement in productivity. An ecosystem needs to be built for I-A connect and aggressive interactions between them to achieve beneficial results for the society.

8.1.1 Modes of Industry-Academia Interface

A broad range of I-A interactions spanning from simple consultancies to in-depth research programmes can be devised. The industries in the recent times have shown interest in the activities of the academic institutions to incubate the knowledge they need. This collaboration indeed has led to number of changes among the industry and transformed its business mode. There are many existing best practices to enhance synergy between academia and corporate sector. Some of them are:-

1. Industry scientists to give guest lecturers in academic institutions on technology commercialization, industry needs and market demand.
2. Industry suggestions taken in setting-up curriculum/syllabus for students.
3. Joint seminars by academia and industry for students and executives.
4. Consulting on management related issues on bringing newer technologies/products to the market with academia's advice.

5. Academia generates new ideas and act as incubators to new businesses.
6. Inclusion of industrial experts in governing council and board of studies of academic institute.
7. Funding academic and applied research by industry.
8. Industry providing financial and infrastructural support to the academia for its new ideas/technology development at laboratory level.

8.1.2 Status of Industry-Academia Interactions

In the recent times the I-A interactions/linkages in India are growing but at a much slower pace as when compared to other parts of the world. Top technological institutions like Indian Institute of Technologies (IITs), are having the highest linkages with industry. One of the reasons may be availability of Technology Business Incubators (TBI's) inside IIT's. IITs have a score of 70% industry linkages, whereas involvement of universities with industry is dramatically very low about 5-10% only. There is very little institutional relationship between industry and universities hence they go for personalized interactions. In a move to encourage I-A collaboration in higher educational institutions, the University Grants Commission (UGC), an apex regulatory authority for Indian universities, has asked all the universities and their affiliated colleges to set up University-Industry Inter-Linkage Centres (UILCs). Definitely, this will improve the academic environment in the university system by promoting collaboration and formal linkages with other universities, national laboratories, institutes of national importance and industrial R&D laboratories in all branches of knowledge through programme of teaching, training and research. This step must encourage non university institutions and industries to get benefited from the expertise in the university system.

Based on a survey involving more than 140 start-ups and larger firms, an empirical assessment on the sustainability of university-industry research collaboration was done and it listed many benefits for industry accruing from I-A collaborations, as mentioned in table 8.1 [1].

Table 8.1: Benefits of Industry-Academia Collaborations for Industry

S. No.	Benefits in Collaborating with Academic Institute	Rate of Benefit in Scale of 1-5
1.	Gaining access to new research	4.01
2.	Development of new product/process	3.74
3.	Maintaining relationship with university	3.61
4.	Developing new patents	3.37
5.	Solving problems related to developing a novel technology	3.15
6.	Improving the product quality	2.38
7.	Re-orienting the R&D agenda	2.34
8.	Recruitment of scientists	1.75

From the above table, it is clear that through I-A collaborations industries enhance development of new products though an increased access to new basic and applied research of academic institutes. Once these technologies are scaled to pilot and commercialization level, industry derives multiple benefits such as reduced reliance on foreign technology, improvement in industrial operations, enhancement in quality and competitiveness, and reduction on internal R&D expenditure. In addition, industry chooses and acquires technologies which are patented as per the market demand. They will simultaneously expand their manpower, infrastructure and also will be in a position to file newer patents. They have multilateral collaborations empowering/positioning them in setting up a translational industry technology platforms for the betterment of society.

In reverse order, the academia gains much needed additional financial resources through these collaborations and opens up avenues to orient their minds towards technology development, technology management, and patentability i.e., thinking/going for patents rather than publishing the research data. The research students in research/academic institute get exposure to industrial training and skill development. Further the outcome of fundamental research gets translated into public benefit, The critical journey of delivering academic/research discoveries to the market place is accomplished. Some benefits for academic institute for collaborating with industry are listed in table 8.2 [1].

Table 8.2: Benefits of Industry-Academia Collaborations for Academia

S. No.	Benefits in Collaborating with Industry	Rate of Benefit in Scale of 1-5
1.	Acquired funds for research assistance and lab equipments	3.87
2.	Gained insights into one's own academic research	3.82
3.	Supplemented funds for one's own academic research	3.55
4.	Field tested one's own theory and research	3.50
5.	Acquired practical knowledge useful for teaching	3.04
6.	Create student internships and job placement opportunities	2.97
7.	Led to patentable inventions	2.55
8.	Created business opportunities	2.14

8.1.3 Inhibiting Factors for a Fruitful Collaboration

The industry in the recent times has shown interest in the activities of the academic institutions to incubate the knowledge they need. Generally, an academician focuses his activities on intellectually profound and challenging problems. Academic researchers exhibit strong preference towards knowledge creation in specialized niche areas and thus have strong competence for taking up technology development initiatives and process and product development. Whereas, industrial needs and expectations from academia on industry-related problems is to discover a range of feasible options in a limited time frame as industry can't work at the pace in which academician works due to several market dynamics. From the industry's side as well as from academia's side, there are various inhibiting factors for a fruitful collaboration.

Industry is always oriented towards enhancing revenue generation by making profits. Due to high competition in the marketplace, they need to improve their existing product/process/mechanism. A knowledge or technology based innovation can help them a lot while scaling-up or launching new products. But, the industry faces problems while going through some collaboration with academia. Academia has a lot of resource potential but due to lack of awareness, industry fears to interact with them. High consultation fee or expensive professional experts' advice may be one of the reasons. Indian industry mostly depends on foreign technologies rather than indigenous technologies which are available at low cost. Industry hesitates in initiating agreement for technical collaboration with academia due to many compulsions. Sometimes while interacting with academia, industry faces bad experience due to their concern to keep problems and inventions confidential. In a competitive edge, industries do not want to share their strengths and weaknesses with academia and live in fear even to disclose the problems being faced. Industry loses their faith in academia as professional experts in academia sometimes are not able to fulfil industry's expectations like timely solutions of problems related to market driven demands.

In general, scientists/faculties in the Indian universities/institutions are more attracted towards teaching, laboratory research, and publications. They feel more comfort in collaboration with other labs or institutions for advancing their research but are reluctant to work on inter-disciplinary collaborative research with the objective to solve specific problems. There is lack of interest or enthusiasm towards applied research, technology transfer or research to solve society related problems. It seems that they do not want to leave their comfort zone of teaching. Sometimes, even they don't want to share their strengths of research to industry. In the academic system there is a chronic lack of specialized technical infrastructure and critical mass of experts. Sometimes scientists/faculties are overloaded with teaching and other administrative/institutional responsibilities. At university/institution level, internal policies and lengthy procedures discourage academicians to attempt such collaboration with industry. They are sluggish to get into translational mode of research leading to products/process/technologies and work towards inter-disciplinary research areas.

8.2 Suitable Model for Industry-Academia Connect

A suitable model for I-A collaboration at the Indian scenario has always been a topic of discussion, [2-5] however, there is no concurrence on any widely accepted model for I-A interactions in India. Apart from this, another important challenge is to keep abreast with the incessant changes in the industrial as well as academic sectors. Khokhar *et al*., [6] explained a case study of Foundation for Innovation and Technology Transfer (FITT), established at IIT Delhi as an industrial interface organization. The FITT runs a large numbers of programmes such as technology incubation facilitation centres, courses for knowledge augmentation, entrepreneurship, start-ups, business management and corporate partnership of industrial sector. According to this study, in the past two decades, FITT has promoted the Intellectual Property Right (IPR) prominence of IIT-Delhi by filing more than 200 IPR applications. It has aided the licensing of approximately 40 technologies developed in the institute in the last 10 years. Apart from this, close to 15 spin-offs have graduated and another 15 start-up companies are current residents at the incubation facility of FITT. This I-A interface has grown into a successful self-sustaining centre having plenty of financial reserves. The establishment of centers like FITT in various universities across India will act as a catalyst for enhanced I-A activities, which will culminate into increased number of technologies/products/patents and thus contributing to technological advancements and strengthening of the economy of nation. A consistent I-A interaction is very critical for enhancing the financial resources of universities as well as facilitating regular changes in the curriculum matching the changing needs of the industrial sector [5].

Ministry of Science and Technology, Government of India (GoI) promotes such academia-industry connects through several programmes like, Prime Minister's Fellowship Scheme for Doctoral Research, Global Innovation & Technology Alliance (GITA), Biotech Ignition Grants (BIG), Small Business Innovation Research Initiative (SBIRI), Biotech Industry Partnership Program (BIPP) and other schemes of Biotechnology Industry Research Assistance Council (BIRAC) of Department of Biotechnology (DBT). Department of Science and Technology (DST) itself promotes academia-industry joint projects though its various programme like Technology Development and Transfer, and Technology Development Board. DST also encourages TBIs to collaborate with an industry, an academic institution and with other institutions of repute focusing on innovation, research, commercialization and start-up promotion. Through various schemes/programmes, the government's main role is to incentivize the industry to invest more in this sector and convince them of the long-term benefits that it will bring to their business and the nation.

Department of Scientific & Industrial Research (DSIR), with a mandate of promoting industrial research, supporting indigenous technology development and faster commercialization, is the nodal agency under Ministry of Science and Technology, GoI, New Delhi for granting recognition to In-house R&D units in the Industry. Through DSIR recognition, industries pursuing research and innovation practices can avail fiscal incentives from the government. The major incentive is 200% weighted tax deduction on R&D expenditure incurred by the approved companies in their In-house units; customs and excise duty exemption for all R&D related imports and domestic purchases. Three years central excise waiver for products developed and patented subject to some conditions given therein. Through various schemes namely Promoting Innovations in Individuals, Start-ups and MSMEs (PRISM), DSIR support individual innovators, societies or trusts leading to development of state-of-art new technology solutions.

Under the another scheme of DSIR, Patent Acquisition and Collaborative Research and Technology Development (PACE), Indian industries are supported to acquire patented technology at an early stage (within the country or overseas) on an exclusive as well as non-exclusive basis, add value to the acquired technology either independently or in collaboration with public funded research institutions in India or abroad for exploitation in Indian/foreign markets and develop innovative and socially relevant products for public consumption.

India faces a problem of low investment by private sector in R&D. While public investment meet nearly global benchmarks of 0.07% of Gross domestic Product (GDP) of India, private sector engagement into R&D are significantly lower than those in developed and other emerging economies. The reasons for low involvement of private sector in scientific research lies in the nature of private sector in India, which is mainly in the small and medium scale bracket, as well as the lack of government incentives for private companies to invest in R&D. As published in the report '*White Paper on Stimulation of Private Sector into Research and Development in India*', by the Joint Committee of industry and government in 2013, private sector investments in R&D is essential for promoting technological advancements in the country. Science Technology and Innovation (STI) Policy (2013) also stressed on the need of engagement of private sector into research domain. It was also suggested by the Prime Minister's Council on Trade & Industry to promote Public Private Partnership (PPP) especially in R&D. Major industry associations like the Confederation of Indian Industry (CII), the Federation of Indian Chambers of Commerce and Industry (FICCI), etc. took proactive steps to increase the involvement of Indian industry in R&D efforts done in academia. In order to provide ease of doing business and accelerate the pace of foreign investment in the country, recently GoI took several measures to open new sectors for Foreign Direct Investment (FDI), to increase the sectoral limit of existing sectors and simplifying other conditions of the FDI policy.

8.2.1 Factors Responsible for Fruitful I-A Connect in the Indian Scenario

Based on the several studies, [2-5], different types of collaboration may be formulated to strengthen I-A interaction in the Indian Scenario. This includes, (i) Encouragement of efficient work-flow, (ii) Setting-up of interface structures, (iii) Intensifying collaboration in R&D, (vi) Bilateral program of mobility of S&T professionals, (v) Facilitating flow of technology from lab to market access, and (vi) Fostering PPP

(i) Encouragement of efficient work-flow: Research capabilities of academia may be boosted through several measures including constitution of a research chair, providing suitable incentives, establishing centre of excellence and relevance, student internship, organising annual S&T festival, diffusion of knowledge, etc. Involvement of experts/retired teachers/scientist as mentor may be an important step to encourage the students to make their career in science. Attracting Indian diaspora and best talents to make a faculty pool for universities/research laboratories, an efficient work flow may be encouraged.

(ii) Creation of common research facility/infrastructures: A world-class R&D infrastructure is one of the important and essential requirement for cutting-edge research. Together industry and academia may come forward to establish a common centre for applied research, R&D labs in consortia model, R&D centers housing common facilities/instruments, entrepreneurship development and technology incubation cells. Such joint and collaborative centre may facilitate both the players to advance their R&D activities and commercialization of R&D products.

(iii) Intensifying collaboration in R&D: A strong partnership between industry and academia for a mutual interest of promoting applied research is essential to accelerate the collaborative R&D activities for the benefit of the society.

(iv) Bilateral program of mobility of S&T professionals: The government should formulate a scheme/program to encourage mobility of S&T professionals among academia and industries.

(v) Facilitating flow of technology from lab to market access: Though a policy initiative, enhancement of technology transfer towards commercialization can be incentivized. In order to encourage growth of enterprise/start-ups, creation of research/technology park may be a good option. Setting up of dedicated venture funds for supporting innovative entrepreneurship may boost technology transfer and augmentation. Through reforms and intervention of S&T, societal and rural issues may be handled effectively.

(vi) Fostering PPP: PPP in some select areas is a kind of I-A interaction, that must be fostered to achieve the target. Growth of technology clusters and common technology platforms through PPP may provide technological competency and growth in economy and employment. Proper policies and regulations may foster PPP.

8.2.2 Ice-Breaking Initiatives

- Academia to employ industry's experts as part-time guest faculty. A research chair may be constituted.
- Academia to offer at least 6 months (short-term) courses on high-end research for experts/professionals in industry.
- Academia to carry out R&D on specific industry problems/path-breaking discoveries/technologies as market demands.
- Industry need to support basic research for knowledge creation and enhancement.
- Industry to participate in technology development involving translational work.
- To get the students exposed to industry atmosphere, industry needs to provide summer trainings/problem specific projects for students and research scholars from academic institute.
- In development of new products/processes, industry needs to offer R&D projects to academia. Industry may also offer them research fellowships or post-doctoral fellowships on topics of their interests.
- Industry to encourage their professionals to take up collaborative projects of their interests in academic institutes.

Many successful I-A collaborations with the support of government funding (from several scientific departments) have led to the path-breaking products, processes, technologies which are of most importance and benefit to the society. Some of such successful projects are listed in table 8.3.

Table 8.3: Some of the Successful Industry-Academia Collaborative Projects

S. No.	Name	Title of the Project
1.	Advenio TecnoSys Pvt. Ltd.	Computer Assisted Reading Tool for Automatic Detection and Grading of Diabetic Retinopathy.
2.	Amar Immunodiagnostics Pvt. Ltd.	Development of Diagnostic Tools for GMO Testing and Agriculture Disease Diagnostics.
3.	Bejo Sheetal Seeds Pvt. Ltd.	Genetically Modified Vegetable Crops for Insect Pest and Disease Resistance.
4.	Bharat Biotech International Ltd.	Development and Standardization of Manufacturing and Testing Methodologies for Human Neonatal Rotavirus Vaccine Candidate.
5.	GVS Biotech Pvt. Ltd.	Commercial Scale Extraction Unit to Produce Zero Calorie Natural Sweeteners from Stevia Leaves.
6.	Healthline Pvt. Ltd.	Silk Protein Blend Film Development and Commercialization for Burn Wound Management.
7.	Life care Innovations Pvt. Ltd.	Development of Affordable, Toxicity Free Amphotericin B Loaded Liposomal Preparation for Treatment of Kalaazar: A Pre Proof of Concept.
8.	PRIVI Organics Ltd.	Enzyme Catalyzed Manufacture of Esters.
9.	Rasi Seeds Pvt. Ltd.	Transgenic Cassava Production with Genes Conferring Resistance to Indian Cassava Mosaic Virus Disease.
10.	USV Ltd.	Development of a Vaccine Capable of Eliciting Immunological Memory for the Prevention of Typhoid.

8.2.3 Suggested Measures for Successful Collaborations

- To encourage the forging of knowledge-based alliances with private industry either in bilateral or in a consortium mode in the new and emerging areas of S&T.
- Set up incubation centers, in few select laboratories/institutes in specialized areas for nurturing start-up companies and encouraging early stage innovation through appropriate hand-holding mechanisms.
- To formulate a comprehensive set of enabling guidelines to promote knowledge-based

innovator-entrepreneurs in laboratories. Scientists need to be allowed to establish ventures based on knowledge generated while retaining their services in the organizations.

- To evolve a policy for acquisition of IP/knowledge-base and nurture them into commercially viable processes, products, and services, through appropriate PPP.
- Stimulate new opportunities for PPP. India's top academic institutes and national laboratories need to be encouraged for asset creation in their campuses through co-locating industrial R&D centers in their campuses by co-sharing facilities and resources.
- To encourage mobility of scientists in R&D, and associated functions such as business development, IPR management, technology transfer and information technology, etc. from academia to industry and vice versa by creating enabling provisions. The scientists working in academics may also be allowed to avail a sabbatical leave within the confines of industry or work in the industrial R&D laboratories.
- To set-up offshore business entities, selectively, based on a sound feasibility and financial analysis as well as quantification of benefits to national research laboratories and academic intuitions. Also while creating such off shore entities, time barred exit/closure routes on account of non-performance must be spelt out clearly.
- Among the three major systems in academia-national laboratories, top level technological institutes and universities, in areas of resources, reputation, management and expertise the first two are distinctly stronger and therefore should co-opt reputed university departments as collaborators in major research/consultancy projects.
- Consultancy and research activities needs to focus on value addition industries as well as academics should highlight the problem solving potential of the academic sector.
- The identification of thrust areas where academia contribute towards path-breaking R&D leading to products/processes/technologies of industrial importance.
- The government funding agencies should augment the R&D infrastructure in universities to catch up with high-end research.

8.3 Conclusion

In general, I-A collaborations lead to development of path-breaking discoveries/products/ processes for technology development for societal benefit. To meet the future challenges of developing a new range of technologies, both industry and academia must come forward for innovative and fruitful collaborations. India should promote development of indigenous technologies. Industry must take a lead to avail benefits of government's scheme/program with such collaborations with academia. The UGC should also ensure that its new university-industry scheme to get more popularised and get implemented. The academic syllabus needs to be industry oriented with a motive of getting/bringing technology/products to the market. The academia should also change their mind set and start interaction with industry by coming out from their comfort zone. They must involve industry for exchange of knowledge to carry out translational researches, forward innovation, R&D in newer areas to bring newer technologies. In a win-win situation, professionals from both sides should be exposed to industry and academia environment as well. Industry should be open in discussing the problems being faced in their routine research work and involve experts from the academic institutions.

The government can intervene and play a facilitating role enabling greater interaction between industry and academia/national R&D centres that can help the flow of funds from industry to academia for R&D activity which might lead to better and newer products and services. For this, developing a workable protocol for facilitating interaction amongst these players is most important. Government should promote setting up new TBIs/common research/technology parks for encouraging start-ups. The various shortcomings and inhibitions as regards to I-A collaborations need to be circumvented by putting into place an integrated I-A collaborative policy by incorporating detailed strategies to realise India's quest for technological leadership. This will help to develop a conducive environment for fruitful I-A connect to achieve beneficial results for the development of society.

References

1. Y. S. Lee, The Sustainability of University-Industry Research Collaboration: An Empirical Assessment, Journal of Technology Transfer, 25 (2000) p. 111–133.
2. P. Jalote, Challenges in Industry-Academia Collaboration (2006), https://www.iiitd.edu.in/~jalote/GenArticles/IndAcadCollab.pdf.
3. M.M. Gandhi, Industry-Academia Collaboration in India: Recent Initiatives, Issues, Challenges, Opportunities and Strategies, The Business & Management Review, 5 (2014) p. 45-67.
4. M. Dakshayini and P. Jayarekha, Academia-Industry Collaboration to Improve the Quality of Teaching-Learning Process, Journal of Engineering Education Transformations, Special Issue (2015).
5. T. U. Devi, A Sustainable Integrated Model for Industry-Academia Interface, SMS Journal of Entrepreneurship & Innovation, 2 (2016) p. 69-75.
6. M. Khokhar, N. Batta, R. Trikha and R. Tewari, Foundation for Innovation and Technology Transfer: A Case Study on Industry–Academia Interface in India, International Journal of Development Research, 06 (2016) p. 7708-7718.

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Recommendations for Enhancing the Industry-Academia Linkages

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In the twenty first century, Science, Technology and Innovation (STI) are considered to be the key drivers of the economic growth and development of a nation. To achieve success in these parameters, it is imperative for any nation to have a robust Research & Development (R&D) policy as well as its implementation plan. For converting innovative research into commercial products/processes, the hand-holding of industry and academia [Higher Education Institutes (HEIs) and R&D institutes] is of paramount importance. In India, Industry-Academia (I-A) handshake is in its infancy and primarily limited to IITs, IISc-Bangalore, ICT-Mumbai, TERI-New Delhi and National Chemical Laboratory (NCL)-Pune.

As per the Science, Technology and Innovation (STI) Policy-2013 of India, I-A interactions, especially in the domain of R&D, need to be strengthened for developing novel, innovative and futuristic technologies which have either commercial value or address societal problems of the country. Keeping these objectives in mind, in 2014, DST (GoI, New Delhi) established a 'Centre for Policy Research' (CPR) at Panjab University, Chandigarh to understand the I-A R&D ecosystem prevailing in the public and private sectors of India and generate evidence based recommendations for making a vibrant and robust I-A R&D ecosystem.

Since its inception, the Centre is engaged in studying I-A programmes/schemes/activities of various organizations/agencies (public and private) including IITs, universities, R&D institutions, funding agencies (*DST, CSIR, BIRAC, MeitY, MHRD, UGC, AICTE and many others), banking sector (SBI, ICICI, SIDBI, etc.) and Industry-associations (CII, FICCI, NASCOM, ASSOCHAM, etc.). This Centre has also organized many meets, conferences and seminars in which major stakeholders including scientists from IITs, IISc-Bangalore, central and state universities, experts from industries (Reliance Industries Ltd., Infosys Ltd., HCL Technologies Ltd., Tata Consultancy Services Ltd., Monsanto, GE Healthcare, Fresenius Kabi, Abbott Laboratories, Cipla Ltd., Mother Dairy Fruit & Vegetable Pvt. Ltd., H.J. Heinz Company, Nestlé, etc.), industry associations (FICCI and CII) and government officials from DST, DBT, ICMR, CSIR, DSIR, TIFAC and NRDC deliberated upon strengthening the I-A ecosystem in India. The outcome of these studies and personal interactions with reputed scientists [Dr Girish Sahni, DG, CSIR; Prof. Ashok Jhunjhunwala, IIT-Madras; Dr M K Bhan, fmr. Secretary, DBT (GoI); Dr V M Katoch, fmr. DG, ICMR (GoI); Dr Baldev Raj, Director, National Institute for Advanced Studies (NIAS), Bengaluru and Prof. H P Khincha, IISc-Bangalore] are being presented in the form of recommendations as depicted in figure 9.1.

**All abbreviations mentioned in this chapter are explained in 'Symbols and Abbreviations'*

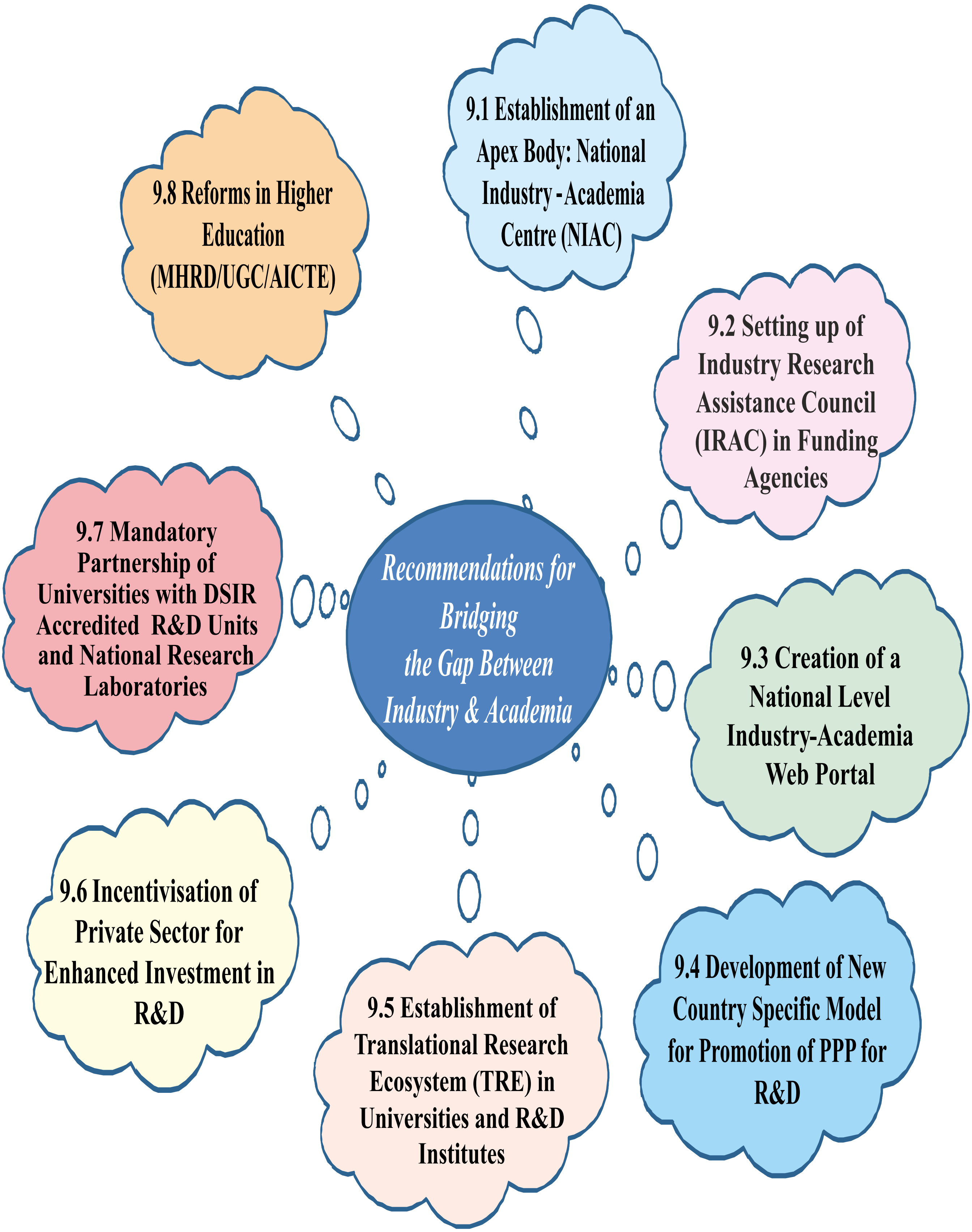

Figure 9.1: Recommendations for Enhancing the Industry-Academia Linkages in India

9.1 Establishment of an Apex Body: *National Industry-Academia Centre* (NIAC): In India, large number of I-A programmes/schemes/activities are being carried out by the public and private organizations which can be placed in three categories, a) Government Funding Agencies, b) Industries/Industry Associations, and c) Finance Sector (Figure 9.2).

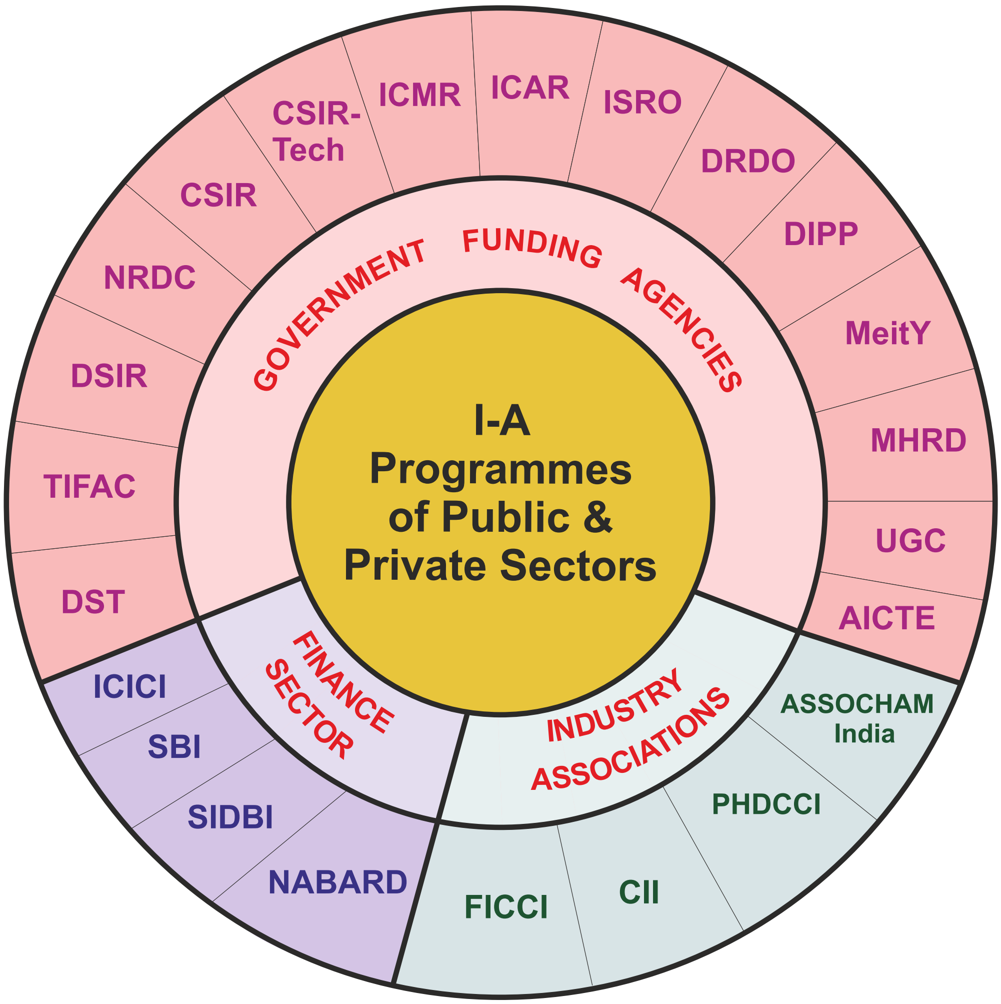

Figure 9.2: Industry-Academia Programmes of Public and Private Sectors

Government Funding Agencies: In the public sector, government agencies, such as DST, BIRAC, DSIR, DIPP, CSIR, MHRD, TIFAC, MeitY and DAE are in the forefront of floating programmes/schemes for enhancing I-A R&D ecosystem in India. DST sponsored 'PM's Fellowship Scheme for Doctoral Research', wherein the industry and the academia join hands for applied research is one such popular scheme. On similar lines, CSIR has decided to launch a new scheme viz. 'CSIR-Indusrty Sponsored Research Fellowship Scheme' which would provide platform for CSIR and industry to co-create scientific manpower (Ph.D level). The 'NMITLI Programme' of CSIR is one of the country's largest PPP initiatives for promoting collaborative R&D by synergizing public funded R&D institutions and the private sector i.e., industries. DSIR through its programmes like BIRD-Crf, PACE, PRISM and TePP is contributing worthily in enhancing I-A linkages in the R&D domain. DIPP's initiatives under the programmes MIUS, AIM and 'Invest India' have led to the creation of a sustainable I-A interface. DIPP also created 'Cell for IPR Promotion and Management ' (CIPAM) for bringing public awareness in field of IPR in the country. BIRAC, a DBT created *not for profit* Section 8 Public Sector Enterprise, has floated many schemes, such as SBIRI, BIPP and CRS for interlinking biotech industries and academic sector for pursuing research in the field of biotechnology.

The setting up of R&D institutes by various ministries to cater to the needs of industrial sector has started paying good dividends. A Pune based 'Automotive Research Association of India' (ARAI), set up by Ministry of Heavy Industries & Public Enterprises, GoI and automotive industry, is an outstanding example of I-A collaboration. ARAI has become a 100% self reliant institute, generates patents and technologies on regular basis and has opened branches in S. Korea and China. It has also started a few academic courses in collaboration with India and USA based universities.

Another positive move for bringing industry and academia under one roof for promoting innovation is the establishment of 'Centres of Excellence' (CoEs) as a shared/collaborative R&D facility of industry and academia. Many CoEs, such as TCOEs, CEWiT and CoEIoT in the areas of Telecom and IT industries have come up in the public as well as in the private sectors. Creation of CoEs in other industrial fields, such as agriculture, healthcare, civil, chemical, mechanical, electrical, aeronautics and many more can play a catalytic role for engaging industries in collaborative R&D which would certainly enhance the tangible scientific outcomes in the form of novel commercial products, technologies and processes leading to generation of innovative products. In addition to the establishment of CoEs, government agencies have set up 'Incubators', 'Accelerators' and 'Science Parks' in various parts of India to stimulate innovative research, entrepreneurship and I-A interactions.

DST has embarked upon an ambitious project of setting up dedicated 'Industrial Hubs' wherein academia and industry work together for generating innovative instruments/components. NIDHI, a new initiative of DST is becoming highly popular for the promotion of entrepreneurship via establishment of technology incubators and science parks. DST has also established dedicated agencies like TDB and TIFAC. TDB is working with a mandate of accelerating uptake of indigenous technologies and fostering collaborative and contract research between industries, academic and research institutions. TIFAC is working extensively for technology development in the country by leveraging close collaboration between industry and academia for technology transfer and commercialization. Likewise, DSIR has established NRDC, an autonomous body with a prime objective of promoting innovations, patents and technologies emerging out of the public sector (universities and R&D institutes). For providing translational research assistance to the scientists in commercializing their laboratory research, CSIR has partnered with a business incubator (Venture Centre) and a financial bank (SBI) to set up CSIR-Tech in NCL-Pune. DIPP has released 'National Intellectual Property Rights Policy-2016' approved by Union

Cabinet with a focus to spur innovation and has designed future roadmaps for IPRs in India. In addition, DIPP has recently created a separate body named 'Cell for IPR Promotion and Management' (CIPAM) for promotion and facilitation of patenting in India amongst the students, research scholars and scientists.

In the education sector, MHRD is at the forefront of laying emphasis on collaborative I-A research. It has established 'Council for Industry & Higher Education Collaboration' (CIHEC) for bridging the gap between the academia and the industry. MHRD has embarked upon an ambitious scheme, 'Impacting Research Innovation and Technology' (IMPRINT), a pan IIT and IISc joint initiative for promoting inclusive growth and self reliance in partnership with industrial sector to address the societal needs of the nation in high-priority domains identified by the government. In the year (2016), MHRD announced the creation of 'Higher Education Financing Agency' (HEFA) to promote innovation in HEIs like, IITs, IIMs and Central Universities with a corpus fund of ~₹ 2,000 crores of which government will provide ₹ 1,000 crores as equity and rest will be arranged from the private sector. Two important bodies of MHRD namely, AICTE and UGC have also taken a few initiatives for the promotion of I-A research collaborations. AICTE is supporting the creation of 'Research Parks', 'Industry Institute Partnership Cell' (IIPC) and implementing 'Innovation Promotion Scheme' (IPS) in the education sector. UGC has recently initiated 'University-Industry Linkage' (UIL) programme for bridging the gap between the university teachers/researchers and the industries.

Industries/Industry Associations: The industry associations have also started pursuing the national agenda of stimulating I-A interactions. FICCI and ASSOCHAM have floated schemes like 'Invest India' (joint venture of public and private sectors), creation of 'National Knowledge Hubs' for increasing I-A interactions, developing commercial pathway for technologies developed in the universities and the research laboratories. These industry associations are also partnering with the government agencies in developing 'Knowledge Parks' and 'Technology Parks'. Another top notch industry association, CII, in partnership with AICTE, a regulatory body of MHRD, regularly conducts CII-AICTE survey of 'Industry-Linked Technical Institutes' of India. Each year, this survey lists the top academic institutes of India having strong linkages with industries. CII has also partnered with TDB (DST) to create an autonomous organization 'GITA' to facilitate industry oriented research by establishing research collaborations between industry, academia and research institutes globally.

Industry has also come forward for the setting up of laboratories and CoEs in various academic institutes for pursuing collaborative research as per their needs. Creation of such laboratories and CoEs by industries in IITs have extensively contributed to the robust technology generation and commercialization profile of IITs. Industries have also created number of 'Industrial Chairs' and 'Scholarships/Fellowships' in the academic institutes for strengthening I-A ecosystem.

Finance Sector: The financial sector (SIDBI, SBI, ICICI, NABARD, etc.) has introduced schemes for the promotion of 'Entrepreneurship' and 'Start-Up' culture in HEIs. Certain banks (World Bank, SIDBI, Kerala Gramin Bank) are collaborating with public funding agencies for establishing 'Innovation Parks', and encouraging entrepreneurship amongst women and economically weaker strata of society. SIDBI has played an important role in strengthening SMEs by financially supporting the establishment of 'SIDBI Innovation and Incubation Centre' (SIIC) at IIT-Kanpur. SIDBI, in association with TIFAC has initiated 'TIFAC-SIDBI Revolving Fund for Technology Innovation-(SRIJAN Scheme)' to support I-A research projects. Other banks like ICICI, NABARD and IDBI have also introduced several financing schemes for supporting R&D activities of SMEs, such as 'ICICI Foundation for Inclusive Growth', 'Agricultural Commercialization and Enterprise (ACE) Title III Programme', 'Technology Institution (TI) Programme' and 'Technology Financing Scheme'. ICICI bank under its CSR, programme has created 'Social Initiatives Group' and 'Technology Financing Group' to help industry and institutions to undertake technology oriented projects.

Recommendations

- **Although, many I-A related R&D programmes/schemes/activities are being carried out in India, there is no common platform where all the information pertaining to I-A ecosystem in India is available. It will be prudent to have a centralized place e.g. NIAC (National Industry-Academia Centre), wherein all the information pertaining to I-A ecosystem in India is available and accessible to all. The collated I-A information will help in avoiding overlaps as well as identifying gaps in the I-A programmes. NIAC may liaison with international I-A bodies and learn from their experiences to strengthen I-A ecosystem of India.**

- **It is suggested that NIAC should be governed by a 'Council' comprising of experts from academia, industries and government sector. The governing council should be responsible for designing as well as implementation of the I-A Policies. In India, designing of policies and their implementation is governed by separate bodies, which results in dilution in the execution of the plans. The policies made by the central government are passed on to the States for their execution. Unfortunately, at times, desired results (from States) are not achieved because of dilution in the commitment level of State functionaries. Each State has its own priorities and certainly I-A linkage is not high on their priority list. In China and S. Korea, only one body is responsible for both activities (planning & implementation) and is yielding very encouraging results. It is recommended that India should also have a single body which is responsible for drafting I-A policy as well as its implementation.**

9.2 Setting up of *Industry Research Assistance Councils* (IRAC) in the Funding Agencies: Across the globe, the industrial sector has understood the importance of scientific innovations for their sustenance. The industrially developed countries are fully aware of the fact that to remain competitive in the global market, it is essential to come up with better innovative products for commercial gains and societal uplift. For this to happen, it is imperative that each nation introduces schemes for stimulating and enhancing R&D ecosystem of the public and private sectors. Large industry corporates have their own R&D set ups, but MSMEs find it difficult to invest in R&D as research is a capital intensive activity. As their profit margins are limited or nil, they are unable to give wings to their wonderful innovative ideas. In developed economies (USA, U.K., Germany and Finland) the governments have put in place dedicated policies to promote R&D of private sector, especially MSMEs. Taking cue from these countries, India should also come out with robust policies to address the R&D ventures of private sector.

A few ministries in India have taken initiatives to stimulate R&D of private sector, especially SMEs. To promote R&D programmes of Biotech-industries and entrepreneurial spirits of young researchers, in 2012 DBT (GoI), New Delhi created an autonomous *not for profit* Section 8 Enterprise, called Biotechnology Industry Research Assistance Council (BIRAC; www.birac.nic.in, for details please see chapter 2, annexure I). During its five years of existence, BIRAC has initiated many Biotech-centric schemes with funds contributed by the public sector (₹ 677 crores) and the private sector (₹ 765 crores). A substantial number of products/technologies have been generated through BIRAC schemes which are the outcome of R&D carried out under PPP mode (please see pages 80-81). Up till now, BIRAC has supported 346 companies, 104 start-ups and strengthened 150 SMEs (BIRAC Brochure, 2016). BIRAC has also been instrumental in catalyzing 115 I-A collaborations. Two programmes of BIRAC namely, Small Business Innovation Research Initiative (SBIRI) and Biotechnology Industry Partnership Programme (BIPP) are very popular with the Biotech industry (Table 9.1). In addition, there are many young bright minds who wish to become entrepreneurs, but need mentors, space and finances to give practical shape to their creative ideas. BIRAC has floated a wonderful scheme in which 'University Innovation Clusters' have been set up in five universities, wherein selected 'Innovation Fellows' are provided with financial assistance as well as mentoring for converting their industry-related research idea to a stage of *proof of concept*. After successful completion of this stage, the 'Innovation Fellows' will be further supported till the product/technology is ready to be sold to a company or the fellow may set up his/her own industrial venture. The following table lists various programmes introduced by BIRAC to promote I-A collaborations and entrepreneurship in the field of Biotechnology.

Table 9.1: Industry-Academia Programmes of BIRAC

S. No.	Programme	Brief Details
1.	**Small Business Innovation Research Initiative (SBIRI)**	SBIRI facilitates innovations in the field of biotechnology via PPP mode.
2.	**Biotechnology Industry Partnership Programme (BIPP)**	BIPP promotes government partnership with industrial sector for supporting path-breaking research in futuristic technological areas.
3.	**Contract Research and Service Scheme (CRS)**	CRS aims to enable promotion of academic-research having commercial potential by providing financial assistance to engage either CROs or industries.
4.	**Biotechnology Ignition Grant Scheme (BIG)**	BIG is made available to scientist entrepreneurs working in research institutes, academia to initiate their own start-ups.
5.	**University Innovation Cluster (UIC)**	These centres are working to promote entrepreneurial culture and pursue industry oriented research having commercial importance.
6.	**BIRAC Regional Innovation Centre (BRIC) at IKP Knowledge Park**	Mapping of regional innovation ecosystem for Southern India to bring out technologies of commercial importance.
7.	**Bio-Incubator Support (BIS)**	BIS is harnessing entrepreneurial potential of start-ups and provides access to well-developed infrastructure networking platforms. BIS has been instrumental in the establishment of 15 'Bioincubators' in India.
8.	**Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI)**	Promotes indigenous and grass root innovations in the area of life sciences.
9.	**BIRAC AcE Fund - Accelerating Entrepreneurs**	Provides access to equity based fund for budding entrepreneurs.
10.	**Social Innovation Programme for Products: Affordable & Relevant to Societal Health (SPARSH)**	Aims to provide solutions to the most pressing problems of the country in field of biotechnology.

Another ministry which is gaining momentum for the promotion of R&D between industry and academia is the Ministry of Electronics & Information Technology (MeitY). It has established 'Entrepreneur's Parks', 'Software Technology Parks' and 'Incubation Centres' in various parts of India to boost Intellectual Property (IP) creation and technology development in Electronics and IT sectors (Table 9.2).

Table 9.2: Industry-Academia Linked Programmes of MeitY

S. No.	Programme	Brief Details
1.	**Visvesvaraya Ph.D Scheme for Electronics and IT**	The funding provided by industry and MeitY is in the ratio of 3:7, for the researcher pursuing Ph.D based on an industrial project.
2.	**Funding and Support to Industry and Academic Institutions through GITA**	It is a combined initiative of DST, MeitY, GITA and foreign agencies, such as Global Affairs Canada (GAC), Canada and Centre for the Development of Industrial Technology (CDTI), Spain for generation of innovative products, processes or services.
3.	**Scheme of Financial Assistance for Setting Up of Electronics and ICT Academies**	Under this scheme financial assistance (₹ 148.47 crores) will be provided by MeitY for establishing Electronics and ICT academies in HEIs.
4.	**Scheme for Financial Assistance to Select States/UTs for Skill Development in Electronics System Design and Manufacturing (ESDM) Sector**	Main objective of this scheme is to enhance skill capacity in domain of ESDM through public and private partnerships. It will also facilitate resource sharing between the academia and industry partners.
5.	**Incubators for Electronics**	MeitY has approved setting up of an 'Electropreneur Park' for development of ESDM industry.
6.	**National Portal of India**	This portal acts as a single window access point for seeking information related to services offered by the government for all the stakeholders under various domains, such as agriculture, rural and urban development.
7.	**Technology Incubation and Development of Entrepreneurs (TIDE)**	Aims to assist HEIs to intensify technology development in their technology incubation centres and providing financial and mentoring support to young enterprises.

Recommendations

BIRAC has been acknowledged by the scientific and the industrial bodies of India as a highly successful model for the promotion of entrepreneurship, R&D of MSMEs, collaborative research between academia & industry, and investments in R&D under public private partnership mode. On similar lines, another organization i.e., MeitY, has initiated many schemes for enhancing R&D ecosystem in the fields of electronics and IT. In order to enhance the R&D activities of other sectors, it is strongly recommended that learning from the success of these organizations, similar models may be adopted by other funding agencies catering to agro sector (ICAR), medical sector (ICMR), engineering sector (IT, Electronics, Aviation, Chemical, Mechanical and Civil), higher education sector (MHRD, UGC and AICTE) and so on.

9.3 Creation of a *National Level Industry-Academia Web Portal*: Thousands of Indian scientists working in the universities and R&D institutes are doing excellent research and regularly publishing in national/international journals. However, the private sector finds it difficult to access it for the lack of a web portal displaying scientific information sought by the industrial sector i.e. availability of scientific expertise, instrumentation facilities, patents and technologies, etc. available in the institutes. Because of advancements in IT sector, industry has no problem in interacting with a scientist or an institute located at a distant place in India or worldwide. If web portals can be designed and made accessible to industry, this will be a benchmark in enhancing I-A interactions. In many forums industry has shown a keen desire for the creation of a national level I-A web portal. At national level, there are a few web portals that provide access to the technologies available for commercialization in different domains, such as:

a) **Technology Portal:** The government of India has established National Research and Development Corporation (NRDC) with an aim of promoting, developing and commercialising the technologies/know-how produced as a result of R&D activities of universities/institutes of the country. The website of NRDC hosts a 'Technology Portal' (http://fccollc.com/nrdclive/index.php) and an 'Innovation Portal' (https://www.nrdcindia.com/english/index.php/programmes/innovation-portal) which provides information about technologies (via technology databank), inventions, patents, inventors, manufactures, etc., thereby acting as a single window access point. The 'Technology Portal' also has a link to the funding agencies and other R&D institutions of the country. This gives an opportunity to all the stakeholders to work together towards the process of technology building.

b) **Techpedia** (www.techpedia.sristi.org)**:** A voluntary organization named as Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI) has developed a web portal, Techpedia, which hosts the technology projects from various academic sectors such as universities, colleges and schools. SRISTI aims to connect technical students and young researchers of the country with the real life problems by putting forth the technical problems of industries (mainly SMEs). This enables generation of affordable real time solutions. The web portal also hosts a list of assistive technologies and industry defined projects from industries and academics.

Though, these web portals are informative, but industry desires to seek more information from R&D institutes/universities which can be categorized as i) Essential Information and ii) Desired Information.

i) Essential Information:

- Patents (filed/granted)
- Technologies (transferred/developed/under development)
- Consultancy Projects Undertaken
- IPR Policy
- Consultancy Policy
- I-A Research Projects Undertaken
- Availability of Scientific Expertise
- Centres of Excellence (R&D)
- Abstracts of Ph.D./M.Phil/M.Sc Theses
- Infrastructure Facilities like, High-end Instruments, Test Beds, Animal Facility, Library, Workshops, Fermentation Facility, Technology Business Incubator, Entrepreneurship Cell, IPR Cell, I-A Cell, Technology Transfer Cell, etc.
- Interactive I-A Portal

ii) Desirable Information:

- Guest Faculty/Adjunct Faculty (from industry)
- Industry Sponsored Research Projects/Scholarships/Fellowships/Chairs
- Schedule of I-A/Entrepreneurship/IPR Meets
- Courses on Business Management
- Academic Programmes and Syllabi of the Institute

Keeping the requirements of the industrial sector in mind, DST-Centre for Policy Research at Panjab University, Chandigarh, has created a single window web portal which can be accessed at www.industryacademiaportal.com. This web portal has the R&D related information of 25 HEIs/R&D institutes located in and around Chandigarh. These institutions have formed a cluster named as CRIKC (Chandigarh Region Innovation and Knowledge Cluster; http://crikc.puchd.ac.in/). CRIKC has recently been registered as a society and comprises of following institutes:

Higher Education Institutes	• Panjab University (PU), Chandigarh • Indian Institute of Science Education and Research (IISER), Mohali • National Institute of Pharmaceutical Education and Research (NIPER), Mohali • Chitkara University, Punjab • Rayat-Bahra University, Mohali
Research Organization	• Institute for Development and Communication (IDC), Chandigarh • Centre for Research in Rural and Industrial Development, Chandigarh
Medical Institutes	• Post Graduate Institute of Medical Education and Research (PGIMER), Chandigarh • Government Medical College & Hospital (GMCH), Chandigarh
Engineering Institutes	• Indian Institute of Technology (IIT), Ropar • PEC University of Technology, Chandigarh • National Institute of Technical Teachers Training & Research (NITTR), Chandigarh • Chandigarh College of Engineering and Technology (CCET), Chandigarh • Centre for Development of Advanced Computing (C-DAC), Mohali
CSIR Laboratories	• Institute of Microbial Technology (IMTECH), Chandigarh • Central Scientific Instruments Organisation (CSIO), Chandigarh
DBT Laboratories	• Center of Innovative and Applied Bioprocessing (CIAB), Mohali • National Agri-Food Biotechnology Institute (NABI), Mohali
DRDO Laboratories	• Snow & Avalanche Study Estt. (SASE), Chandigarh • Defence Institute of High Altitude Research (DIHAR), Chandigarh • Terminal Ballistics Research Laboratory (TBRL), Chandigarh
DST Laboratory/Unit	• Institute of Nano Science & Technology (INST), Mohali • Punjab State Council for Science and Technology (PSCST),
	Chandigarh
Department of Space	• Semi-Conductor Laboratory (SCL), Mohali
Management Institute	• Indian School of Business (ISB), Mohali

The mandate of CRIKC is to foster and sustain close academic alliances between institutions of higher education and research in the Chandigarh region. CRIKC is in the process of extending its arm to the industrial belt of Chandigarh region (Chandigarh, Panchkula, Mohali and Baddi) to address its R&D challenges. The strengthening of I-A research is one of the important features of STI Policy-2013 of GoI. CRIKC-Industry handshake is one way of fulfilling the goals of STI Policy-2013 . The glimpse of the CRIKC web portal is as under:

HOME | SCIENTIFIC EXPERTISE | FACILITIES AVAILABLE | PATENTS | TECHNOLOGY | I-A EVENTS | CENTRE FOR EXCELLENCE | INDUSTRY QUERY | R & D INCENTIVES TO INDUSTRY | CONTACT SOURCES

Home

Industry-Academia (I-A) Interaction is one of the key drivers for economical development of a nation. Strong I-A linkages can lead to development of innovative technologies. For instance, according to Global Competitiveness Index-2016-17, most advanced countries like Finland, United States, Switzerland, United Kingdom and Singapore are the leading countries of the world in the field of I-A linkages. Strong I-A linkages in these countries has led to impact ful technology innovations, thus making them globally competitive. On the other hand, India is globally ranked at 24^{th} position in university-industry collaboration. India has all the wherewithal to emulate these countries. What is needed is the change in the mindset of industry and academia so that both sectors start working together for the betterment of science and society.

Chandigarh Region Innovation and Knowledge Cluster (CRIKC) is one of the unique knowledge cluster/hub comprising of 25 academic and research institutes, working with a mandate of providing platform to academia and industry to pursue collaborative research.

The CRIKC web portal has all the necessary information sought by the industrial sector. The portal also has an industry-query link, where industry can upload its research problem.

Recommendations

All research oriented institutes (universities, national research laboratories and industries) should be mandated to upload information related to scientific research on the institute's web site. The website should clearly display the following information- Availability of scientific expertise, Patents (filed/granted), Technologies (transferred/available, under development), Scientific-infrastructure, Industry-Academia research collaborations, Consultancy projects undertaken, Start-ups, etc. 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.

9.4 Development of a Country Specific Model for R&D under PPP Mode: The emergence of India as a global economic power calls for high levels of technological advancements for economic benefits and addressing societal problems. Though, India has progressed immensely in the domain of scientific publications, however, technology based innovations are limited. This is due to the fact that R&D activities of both the public and the private sectors have generally remained disconnected from each other, thereby, creating a large gap in technology development and technology deployment. The STI Policy-2013 of India calls for a strong partnership between academia and industry for fostering R&D ecosystem. This statement, along with the limited financial investment by the public and the private sectors in the domain of R&D calls for pooling of resources under PPP mode. Many countries have embraced the concept of PPP for R&D as it provides not only the essential capital, but also professional competence in the form of focused approach, better management of finances and time bound projects. In India, PPP model has been quite successful in the transport sector i.e. infrastructure for airports, seaports and roads. However, PPP model for R&D has yet to gain a firm footing, though the benefits accruing from this strategic partnership are huge for the nation's economy and addressing societal needs. Worldwide, the most successful and prevalent PPP model for R&D is the Triple-Helix model in which major stakeholders are academia, industry and government. In this model, the academia provides the necessary intelligentsia to address the research problems of the industry. The funds for developing the infrastructure and conducting R&D are contributed by the public (government) and private (industry) sectors in varying proportions. In addition to Triple-Helix model, bipartite models (government-industry or academia-industry) also exist for R&D under PPP mode. In India, both types of models exist. A glimpse of these models is provided in figure 9.3. For more information, please see chapter 5 entitled, 'Public Private Partnership Models for R&D in India'. Based on the mode of public and private sectors engagements in the domain of R&D in India, the PPP model may be divided into two categories: PPP (Technically Correct) and PPP (In Practice). The former category refers to the establishment of a partnership in which the roles of public and private sectors are legally defined. In the latter category, the public sector partners with the private sector, but the roles/responsibilities are not tightly bound by legalities. The examples of these two categories are mentioned in figure 9.3.

Fig. 9.3: Existing Models of R&D Under PPP Mode in India

1. Government-Industry Model (GIM)

- **A. Global Innovation and Technology Alliance (GITA), New Delhi**
- **B. Autonomous Institutes**
  - *ARAI, Pune*
  - *IPIRTI, Bengaluru*
- **C. Centres of Excellence**
  - *CoEIoT, New Delhi*
  - *PEC University of Technology, Chandigarh*
- **D. Technology Business Incubators**
  - *LSI at IKP, Hyderabad*
  - *TBI at SRI, Delhi*

2. Academia-Industry Model (AIM)

- **A. Industrial Set Ups in Academic Sector**
  - *Laboratory set up*
  - *Industrial Chairs*
  - *Fellowships*
  - *Scholarships*
- **B. Centres of Excellence**
  - *IBM Software Centres of Excellence*
- **C. Entrepreneurship Development Programmes**
  - *Pfizer-Foundation for Innovation and Technology Transfer (FITT), IIT-Delhi, New Delhi*

3. Government-Academia-Industry Model (GAIM)

- **A. Autonomous Academic Institutes**
  - *BCP, Mumbai*
  - *ICT, Mumbai*
- **B. Govt. Sponsored Funding Agencies**
  - *BIRAC, New Delhi*
  - *BCIL, New Delhi*
  - *CSIR-Tech, Pune*
- **C. Centres of Excellence**
  - *Telecom Centre of Excellence (TCOE)*
  - *MHRD Supported CoE under FAST*
  - *CEWiT, Chennai*
- **D. Technology Business Incubators**
  - *MITCON TBI, Pune; BITS Pilani TBI, Pilani; MUTBI, Manipal*
- **E. Science Parks**
  - *STEP, IIT Kharagpur; BIT-STEP, Ranchi; Thapar University-STEP, Patiala*

Note: Examples of each model are bulleted. For detail information, please see chapter 5 entitled 'Public Private Partnership Models for R&D in India'.

The successful examples of the PPP models (R&D) mentioned above are discussed below:

- **Global Innovation and Technology Alliance (GITA)**

  Public sector: DST (GoI), New Delhi

  Private sector: CII, New Delhi

GITA (www.gita.org.in) is a *not for profit* Section 8 Company created under public private partnership mode. It is jointly promoted by a public sector, Technology Development Board (TDB) of DST, GoI and a private sector, Confederation of Indian Industry (CII). It is an collaborative platform of government and industry through which industrial investments are encouraged for innovative technology development and commercialization. GITA supports technology partnerships between HEIs/R&D institutions and industry not only in India but also across the globe (U.K., Taiwan, Canada, Spain, S. Korea, Finland, Israel, etc.). GITA has introduced various bilateral and multilateral programmes to aid in technology development and commercialization between academic institutes and industry at a global level. It has instituted 'Technology Acquisition Fund Programme' (TAFP) and 'Technology Acquisition and Development Fund' (TADF) for assisting Indian MSMEs to get hold of advanced technologies in the form of specialized service, patent, technology and product from various organization located worldwide. Creation of such collaborative body for various industrial sectors can revolutionize technological growth of Indian industry.

Under PPP mode, GITA has been instrumental in developing nineteen innovations of national importance including remote healthcare solutions, organic energy mill, bus scheduling systems and next-generation low cost optical coherence tomography. GITA has also undertaken various industrial visits and awareness programmes to strengthen I-A ecosystem in India.

Recommendations

GITA is a public-private organization set up jointly by CII and TDB for the promotion of R&D at national and international levels. It has many success stories to its credit for enhancing the R&D ecosystem in India. It is recommended that more R&D organizations be set up, on the lines of GITA, by promoting alliances between industry associations (FICCI, ASSOCHAM, NASCOM, PHD Chambers of Commerce and Industry, etc.) and government funding agencies (DST, CSIR, DRDO, MoEF&CC, MeitY, ICMR, ICAR, BIRAC, MHRD and many more). These types of alliances will immensely help India in developing innovative technologies/products of international standards.

- **Biotechnology Industry Research Assistance Council (BIRAC)**

  Public sector: DBT (GoI), New Delhi

  Private sector: Biotech Industry

To provide a boost to entrepreneurship and I-A collaborative research under PPP mode, DBT (GoI), created an autonomous *not for profit* Section 8 Enterprise, called BIRAC (www.birac.nic.in) which caters to the needs of the biotech industry. BIRAC is working to fulfil three main objectives which are as a) supporting early and late stage innovation research, b) enabling services for promoting the innovation ecosystem and c) product innovation and commercialization for addressing grand challenges of national relevance. Creation of BIRAC has greatly enhanced the technology development and generation of useful products in biotech sector. BIRAC is providing funding support through its different schemes as mentioned in previous section to overcome intrinsic risk involved in innovation pathways right from the ideation to product development, scale up and market commercialization. Programmes, such as SBIRI, BIPP and CRS are successfully bridging I-A collaboration of biotech companies and academic institutes pursuing biotechnology and promoting PPP in biotech sector. 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. BIRAC has brought nearly 30 products/technologies to the market, promoted over 115 I-A research collaborations, supported more than 340 companies and 104 biotech start-ups and generated close to 230 employment opportunities in the field of biotechnology. *For details of BIRAC please see pages 64- 81.*

Recommendations

BIRAC has been acknowledged by the scientific and the industrial bodies of India as a highly successful model for the promotion of entrepreneurship, R&D in SMEs, collaborative research between academia & industry, and investments in R&D under public private partnership mode. It is strongly recommended that BIRAC type models may be adopted by other funding agencies catering to agro sector (ICAR), medical sector (ICMR), engineering sector (IT, Electronics, Aviation, Chemical, Mechanical and Civil), MHRD (UGC and AICTE) and so on. Such a move will certainly help India in improving its global ranking in the domain of Science and Technology, and also migrating from 'Factor Driven' economy to 'Efficiency Driven' economy.

- **Automotive Research Association of India (ARAI)**

  Public sector: Ministry of Heavy Industries and Public Enterprises (MoHI&PE)

  Private sector: Automobile Industry

To cater to the R&D problems of industrial sector, GoI has set up a few research institutes in association with industries and/or industry associations. One shining example of this kind of PPP is a Pune based ARAI (www.araiindia.com), established under the aegis of Ministry of Heavy Industries and Public Enterprises, GoI. ARAI is a leading autonomous research institute of the automotive industry and plays an essential role in designing less polluting, safe and more efficient vehicles. It provides technical assistance in the domains of R&D along with testing, homologation, framing and certification of vehicle regulations. The governing body of ARAI comprises of 21 members, out which 18 are from the private sector i.e. industries. More than 70 automobile industries are affiliated with ARAI for their R&D projects. ARAI is credited with 15 granted patents and 18 filed patents till date. Many technologies have been transferred to various automobile industries. ARAI has become a self sustainable research institute. It has been generating enough financial resources (~₹ 200 crores/year for year 2014-15) which takes care of institutes' financial liabilities including the salary and pension of the employees. Nearly 50% of the income is generated through R&D activities. ARAI has achieved international recognition and opened branches in a couple of Asian countries like China and S. Korea. The institute has also started post-graduate courses in collaboration with top notch institutions like VIT, Vellore and University of Alabama, Birmingham and Braunschweig University, Germany.

Recommendations

ARAI is a successful example of public-private institute catering to the needs of the automobile industry including R&D. Because of the dedication of the scientists, workers and the administrative staff, ARAI has transformed into a completely self-sustainable institute. More than fifty percent of its revenues are generated through its R&D activities. ARAI can act as a model for a) setting up new institutes addressing the R&D and other needs of the industries, and b) improving the functioning of under-performing institutes, established by government of India to address R&D challenges of the industries.

- **Institute of Chemical Technology, Mumbai**

Public sector: State Government, Maharashtra
Private sector: Industry and Industry Associations

Institute of Chemical Technology (ICT), Mumbai (www.ictmumbai.edu.in), earlier known as UDCT, has been recognized as one of the champions of university-industry linkages by the scientific and industrial bodies worldwide. For the last three years in a row, ICT has been ranked as number one, in the category of 'Best Institute-Industry Linkage' by CII-AICTE survey report (2014-16). This institute was established by the Maharashtra State Government at the request/involvement of chemical industries/industry associations. Since its inception, ICT has a vibrant presence of industries in their governance, teaching and R&D programmes. ICT Mumbai has been elevated to the status of *deemed to be university* because of its excellent education system, R&D and I-A collaborations. This institute has successfully completed over 300 industry sponsored research projects, carried out more than 260 consultancies, generated nearly 500 entrepreneurs and signed ~56 MoUs with industries. In addition, ICT Mumbai has filed close to 310 patents in the last ten years and published nearly 3000 research articles since 2015. Recently, ICT Mumbai has signed a MoU with Israel government for undertaking collaborative research in the field of Chemical Engineering. The institute has faculty strength of 80 and more than 70 faculty members have industrial tie ups in the areas of research and consultancy. The chemical, food and pharma industries have set up dedicated laboratories and industry-chairs and floated many scholarships/fellowships for students and young researchers. The financial support from the government is limited to salary component only. The other financial needs of the institute are met through students fee and earnings from the private sector.

Recommendations

- **One of the major reasons for transformation of ICT Mumbai, from a college to a *deemed to be university*, is the strong bondage of this institute with the industrial sector in the areas of administration, teaching and research. The contribution of the faculty and researchers of the ICT Mumbai in addressing the R&D challenges of Chemical, Food and Pharma industries are exemplary.**
- **It is suggested that MHRD in association with DIPP, Ministry of Commerce & Industry and industries/industry associations may establish colleges/institutes in various branches of Engineering, Biotechnology, Microbiology, Bio-engineering, Environment, Computer Science, etc. under PPP mode by adopting the model of ICT Mumbai.**
- **MHRD has floated schemes for the setting up of new Indian Institutes of Information Technology (IIITs) and Polytechnics under *not for profit* PPP (N-PPP) mode. A few of them e.g. IIIT-Hyderabad (www.iiit.ac.in) and IIIT-Pune (temporary campus at the Siddhant College of Engineering, Pune) have been started under N-PPP mode. It is recommended that the administration and functioning of these institutes may be carried out on the pattern of ICT Mumbai. The idea of establishing HEIs in collaboration with industries/industry associations will automatically result in boosting R&D ecosystem in India.**

➢ **Centres of Excellence (CoEs)**

Public sector: ***MeitY and MHRD (GoI), New Delhi***

Private sector: ***Telecom and Electronics Industry***

The CoEs existing in many institutes (IITs, universities, colleges and R&D institutions) are successful examples of pursuing R&D under PPP mode. These CoEs have been established under bipartite (government-industry/academia-industry) and tripartite (government-industry-academia) models of PPP. Most notable examples of such CoEs are Telecom Centres of Excellence (TCOEs) in IITs, IIM-Ahmedabad and IISc-Bangalore. Creation of TCOEs under PPP mode has led to generation of mobile solutions for their respective industrial partners. TCOEs have successfully generated 20 patents and 14 other IPRs. TCOEs have launched 5 technologies for operating networks in India which are- Digital Kisan Mandi by IIT-Kanpur and BSNL, Auto Customer Acquisition Form by IIT-Madras and Reliance Communications, Mobile Social Networking Platform, Unlicensed Band Radio and Network Opex Optimization by IIT-Bombay and Tata Teleservices. IIT-Kanpur has manufactured 'Variable Phase Power Plant for Rural Areas' with an aim to bring down 25% reduction in the running of the gensets.

The Centre of Excellence in Wireless Technology (CEWiT) in IIT-Madras is another example of successful CoE. It has created broadband wireless simulator for testing LTE and 4G technologies in association with IIT-Madras, IIT-Kharagpur, IIT-Bombay and IIT-Kanpur. CEWiT is working in partnership with 15 telecom industries. Major achievements of CEWiT till date have been the creation of LTE test beds, simulators, Indian languages for mobiles and strengthening 4G ecosystem.

A few other CoEs of eminence are National Centre for Flexible Electronics (FlexE) in IIT-Kanpur; Centre of Excellence for Internet of Things (CoEIoT), New Delhi and IBM Software Centre of Excellence at various places in India.

Centre of Excellence in Industrial and Product Design has been set up at PEC University of Technology in 2013 by NPIU, under Technical Education Quality Improvement Programme (TEQIP Phase–II), a World Bank Assisted Project in Technical Education with initial funding of 5 Crores. The Centre has the mission to encourage, facilitate interdisciplinary and collaborative research to address the needs of industry and healthcare providers. The Centre is partnering with leading organizations, such as PGIMER Chandigarh, INTEL Technologies Bangalore, Minda Corporation Ltd., Noida, Central Tool Room, Ludhiana for its research activities. The Centre is developing as a resource centre so as to become a preferred destination for industry, healthcare providers to carry out sponsored research, train and develop professional talent, proficient in the areas of ergonomics and design. The Centre has actively collaborated with Department of Oral Health Sciences, PGIMER Chandigarh for the Design of Patient Specific Maxillofacial Implants, Templates and Cutting Guides. These devices are being used for maxillofacial surgery procedures in patients with complex injuries, infection and tumor.

Recommendations

The existing CoEs under PPP mode are playing a catalytic role in the industrial growth (R&D) and strengthening of I-A linkages. It is suggested that different ministries set aside special funds for the creation of 'R&D Centres of Excellence' under PPP mode in HEIs and R&D institutions. Such centres should come up only if an institute is in long term agreement with industry (Pharma, IT, Electronics, Nanotechnology, Environment, Automobile, Chemical, Food, Aviation, etc.).

- **Technology Business Incubators (TBIs) and Science Parks**

Public sector: Government Funding Agencies

Private sector: Private Organizations

Various government organizations like, DST, DBT and MHRD have taken an impactful Initiative by building TBIs all over India to incubate indigenous technologies for creating technology based new enterprises, facilitating transfer of technologies and entrepreneurship development. DST through 'Institution Mechanisms Building Initiative' has established nearly 66 TBIs in various public and private organizations (http://www.nstedb.com/institutional/tbi.htm). These initiatives are bringing public and private sectors under one umbrella where government's funding support for the 'Incubators' is being utilized by the private sector to generate start-ups, and strengthening MSMEs in their R&D efforts for generating novel products/technologies/processes. Government has set up 'Incubators' not only in public sector but private sector as well e.g. Life Science Incubator at IKP, Hyderabad; TBI at Shriram Institute for Industrial Research (SRI), Delhi; TBI at BITS, Pilani and TBI at Manipal University, Manipal. Looking at the success of TBIs set up by DST, other agencies/ministries like BIRAC, MeitY and MSME have also come forward in providing financial help for establishing TBIs.

In order to strengthen R&D, innovation and entrepreneurship ecosystem in India, the funding agencies have created Science Parks/Technology Parks/Entrepreneurship Parks. For example, DST has established number of Science Technology Entrepreneurship Parks (STEPs) in various public and private organizations with a mandate of creating an environment for entrepreneurship and innovation. The major objectives of STEPs are to a) forge linkages between academic/R&D institutions and the industries, and b) promote innovative entrepreneurship. The department has so far catalyzed the establishment of 15 STEPs in different parts of the country which have promoted R&D of nearly 788 industrial units, generated annual turnover of around ₹130 crores and employment for 5000 persons. The efforts of STEPs have been responsible for the development of more than 100 new products. The government has also established STEPs in private organizations, such as Birla Institute of Technology, Ranchi and Thapar Institute of Engineering and Technology University, Patiala.

Recommendations

TBIs and Science Parks are ideal platforms for generating entrepreneurship/start-ups carrying out translational research, industry-academia collaborative research, R&D by entrepreneurs/companies having limited financial resources, and scale up studies. These places are excellent examples of private sector utilizing the infrastructure developed by the public sector. It is recommended that TBIs be set up in all universities and public funded R&D institutes, which are excelling in scientific publications. All ministries and funding agencies should have a dedicated cell responsible for establishing as well as monitoring the progress of TBIs. Moreover, to make these TBIs and Science Parks accessible to young entrepreneurs and MSMEs, it is suggested that government, through its agencies like DST, MHRD, DBT and others should introduce 'Outreach Awareness Programmes'.

9.5 Establishment of Translational Research Ecosystem (TRE) in Universities and R&D Institutes:

As per SJR-International Science Ranking-2015 (published by Elsevier B.V.), India is amongst the top five nations in number of research publications. However, its global ranking takes a nosedive (47) in the IPR indicator (IPRI Report-2016, published by Americans for Tax Reforms Foundation). These reports suggest that Indian scientists are good at publishing their research but unable to translate their findings into patent(s)/technology(ies). One of the major reasons for this drawback is the absence of Translational Research Ecosystem (TRE) in majority of the universities and R&D institutes. The essential components of TRE comprise of I-A cell, IPR cell and Technology-Transfer cell. The I-A cell assists the scientists in identifying suitable industries, the IPR cell provides assistance in prior-art search of patents, patent filing and protection from patent infringements, whereas, the Technology-Transfer cell assesses the legitimate value of the patent-licensing or technology to be transferred.

A scientist's forte is to pursue research and is not well conversant with IPR and Technology-Transfer protocols. In the absence of TRE, the scientific community finds it difficult to translate its research into a patent or a technology. Therefore, scientists end up in publishing their research work, even though it has commercial implications. In India, only a handful of institutes, such as IITs, IISc-Bangalore, ICT-Mumbai and NCL-Pune have effective TRE and thus their scientists are able to convert their research into patents and technologies. Table 9.3 presents the status of patents and technologies developed at first generation IITs, which is very impressive.

Table 9.3: IP Profile of 1st Generation IITs

IP Attributes	IIT Kharagpur	IIT Bombay	IIT Madras	IIT Kanpur	IIT Delhi	IIT Guwahati
Publications (2014-15)	2162	~1500	1194	1298 (2014)	1300	1250
Patents (2010-15)						
Filed	231	569	239	204	146	37
Granted	13	>61	25	9	25	6
Technology Available	214	409	358	6	50	05
Technology Licensed (till date)	24	>140	60	60	15	06

Source: *IIT Bombay, R&D highlights 2016, Annual Reports (IIT-K) 2010-2015; Annual Reports (IIT-M) 2010-2015, Annual Reports (IIT Bombay) 2010-2015, Questionnaire filled by IITs for DST-CPR at PU, Chd., http://www.iitk.ac.in/, http://www.iitr.ac.in/, http://www.iitb.ac.in/, https://www.IIT-M.ac.in/, http://www.iitd.ac.in/, http://www.iitkgp.ac.in/, http://www.iitg.ac.in/, External Peer Review committee Report (IIT Delhi -2015), External Peer Review Committee Report (IIT Kharagpur -2015)*

Although, all three components of TRE are equally important, but, I-A cell is the most prominent, as it provides a platform for academia and industry to interact with each other. Amongst all the I-A cells of IITs, Foundation for Innovation in Technology Transfer (FITT) based in IIT-Delhi Campus, is the first I-A interface established by the Government of India in 1990s. FITT is an autonomous body which assists the scientists of IIT-Delhi and other institutes in converting their academic knowledge into commercial products. It not only scouts for potential buyers for the scientific intellect of the institutes, but also, brings R&D related challenges of the industries' to the intelligentsia. It is a win-win situation for both the parties. FITT is a financially self sufficient body with a bank balance of > ₹36 crores. It has a dedicated staff including a professionally qualified Managing Director. FITT is well connected with the private sector. With the involvement of FITT, IIT-Delhi has witnessed significant increase in its number of patents, technology transfers, consultancies, entrepreneurship and start-ups. Till date, it has licensed ~77 technologies and incubated > 58 Start-ups. (*For details please see pages 122-137*). Notable technologies developed through FITT are listed in table below.

Table 9.4: 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 fibre 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*

<u>Recommendations</u>

- **It is recommended that Translational Research Ecosystem (TRE) existing in IITs be extended to universities. In the initial phase top 50 universities, doing quality research as evidenced by research publications, be empowered with TRE. If possible, these universities may be guided (mentored) by an IIT or IISc faculty in the initial phase. Based on the experiences and success of these universities, TRE may be extended to the universities. Similarly, research organizations, such as CSIR, DRDO, ICAR, ICMR, DAE, etc. may adopt TRE system of IITs for converting their innovations into commercial products.**
- **Each science oriented university and national research laboratories should set-up an I-A interface based on FITT model for a) attracting industry for collaborative R&D, and b) for showcasing their innovative research to the industrial sectors. This interface (or cell) should be autonomous and registered as a *not for profit* body under Section 8 of The Companies Act 2013, in order to avoid the administrative red tapism existing in public funded institutes. The funding agencies like DST, CSIR, DBT, MHRD, AICTE, UGC and many more should introduce dedicated schemes for providing financial assistance for setting up of I-A Cells.**

- **The I-A Cell may undertake the following responsibilities:**
    - **Act as a fulcrum between academia and industry.**
    - **Attracting industries for addressing their R&D problems .**
    - **Marketing of the institutes' innovative research.**
    - **Dissemination of I-A related schemes of the government.**
    - **Creation of I-A linkage portal.**
    - **Providing assistance in establishing incubators/pilot scale facilities.**
    - **Running industry related skill development certificate/diploma courses.**
    - **Creation of 'Industry Chairs' in the universities by the private sector.**
    - **Organizing I-A meets.**

9.6 Incentivization of Private Sector for Enhancing Investment in R&D: Worldwide, it has been acknowledged that the scientific innovations are critical for the economic development, wealth creation and enhancing the visibility of the nations. However, creation of scientific innovations is a capital intensive programme. Each nation, developed or developing, is laying emphasis on conducting R&D programme via PPP mode. In India, the private sector, primarily industries, have shown a lukewarm response to government's initiative for PPP in R&D. In 2013, a 'Joint Committee of Industry and Government' '(JCIG) was formed by DST in partnership with CII to incentivize the private sector for enhancement in its R&D investments. JCIG released a whitepaper entitled **'Stimulation of Private Sector's Investment into R&D'.** The main emphasis of this whitepaper was to achieve 50:50 R&D investment partnership between the private and public sector by 2017, which is currently around 25 (private):75 (public). To stimulate private sector for increasing their financial budget for R&D activities, the government has introduced many new incentives, which are as follows.

Incentives provided to the private sector by Government of India, as on Nov. 2015 (http://dsir.csir.res.in/ webdsir /#files/12plan/bird-crf/fisr.html)

***(i) 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].

(ii) Incentives based on indirect taxes

- Customs duty exemption to in-house R&D units established by private companies, other than a hospital for capital equipment and consumables needed for R&D. (*Notification No.24/2007-customs, dated 1st March, 2007 as amended from time to time*).
- Central excise duty exemption to in-house R&D units established by private companies, other than a hospital for capital equipment and consumables needed for R&D. (*Notification No.16/2007-central excise, dated 1st 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 23rd, 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 23rd 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 1st March 2003 (entry substituted at S. No. 248) of the table in the said notification*] subject to conditions mentioned in the notifications.

DST-Centre for Policy Research at Panjab University, Chandigarh has held meetings with the industry representatives for stimulation of private sector's investment in R&D. Their suggestions are listed in the 'Recommendations' section.

Recommendations

- In India, R&D expenditure by private sector includes Plant & Machinery, Materials & Consumables, Utilities & Services. However, following items are not covered under R&D expenditure: Expenditure incurred on land and building (for R&D), Cost of using R&D infrastructure of public institutions, Funds provided by industry to research scholars in institutions for industrial research, Cost of development for R&D, Cost of IP purchased as sub components of final R&D output, Cost of patent filing/maintenance and Investments by venture capitalists in technology ventures. In many countries such as France, Germany, Japan, Netherlands, U.K., and USA, most of the expenditure under these items fall under R&D category.
- In case of genuineness of the failure of the R&D project, the loan taken by the industry for a concerned project may be written off.
- To encourage R&D by small businesses, government should provide financial guarantee, as is the case in Germany.
- A fixed percentage of commercial products, developed through R&D under PPP mode, should be purchased by the government. Though this rule already exists under 'Minimum Exchange Scheme', but is rarely practiced.
- Securing of loans against IP of the companies
- Following companies have been restricted for seeking R&D incentives: beer, wine and other alcoholic drinks; confectionary, tooth pastes and steel furniture. Government may relook for extending R&D incentives to these companies.
- Creation of 'Special Fund' for global partnership in R&D by public and private sectors.
- The 'Exit Strategy' needs to be specified at the onset of each programme/project.
- A right mix of loan, equity and grant-in-aid according to the stage of technology development, should be provided.
- Partial financial support by the government for the setting up of 'Demonstration of Scale-up Level' plants by the industries. This stage is last part of the series of steps involved prior to the commercialization of technology and involves high expenditures to the tune of thousands of crores of rupees. Industries have many technologies ready for execution at Demonstration of Scale-up Level, but are reluctant to take all the risks by themselves, and are looking towards government for financial support.
- It requires considerable efforts to avail the R&D incentives from the public fund. The whole process needs to be streamlined and made less complicated.
- A certain percentage of Corporate Social Responsibility (CSR) fund should be allowed for R&D activities of public sector, HEIs and R&D labs.

9.7 Mandatory R&D Partnership amongst Universities, National Research Laboratories and DSIR Accredited R&D Units: The major components of R&D ecosystem of India are Universities (~750), National Research Laboratories (~300) and DSIR accredited R&D Units (~1800). All the three components have their own strengths and limitations related to scientific research as mentioned below:

Sector	Strengths	Limitations
Universities	· Rich in intelligentsia · Rich in man power · Good in research publications	· High end instruments, especially in state universities. · Lack of knowledge of translational research · Lack of industry exposure · Low on patents, innovations and technology development
National Research Laboratories	· Skilled scientists · Sophisticated instruments · Good in research publications	· Low on manpower · Lack of knowledge of translational research · Lack of industry exposure · Low on patents, innovations and technology development
DSIR accredited R&D units in the private sector	· Good in translational research · Fully aware of current and futuristic areas of R&D · Professional out look	· Limited funds for R&D · R&D outputs do not match the financial benefits and other incentives secured from the government. · Limited awareness about the availability of scientific expertise available in universities and national research laboratories.

The above mentioned table suggests that the strengths of each sector can overcome the limitations of other sector(s), provided strong linkages are established amongst all the three sectors, which is by no means an easy task. However, the benefits accruing from this alliance will be immense, if such an alliance is achieved. The government will be the biggest beneficiary of this kind of linkage. Without providing additional funds, there will be a big jump in the number of I-A collaborative research projects which in turn will lead to increased number of patents, novel innovations and technologies. The improvement in these domains will certainly catapult the economy of the nation.

Each state can be the beneficiary of this kind of I-A alliance as all the three components are present in nearly all the states. Figure 9.4 depicts the number of universities (NAAC 'A' Grade), DSIR accredited R&D units of industries and national research laboratories in each state.

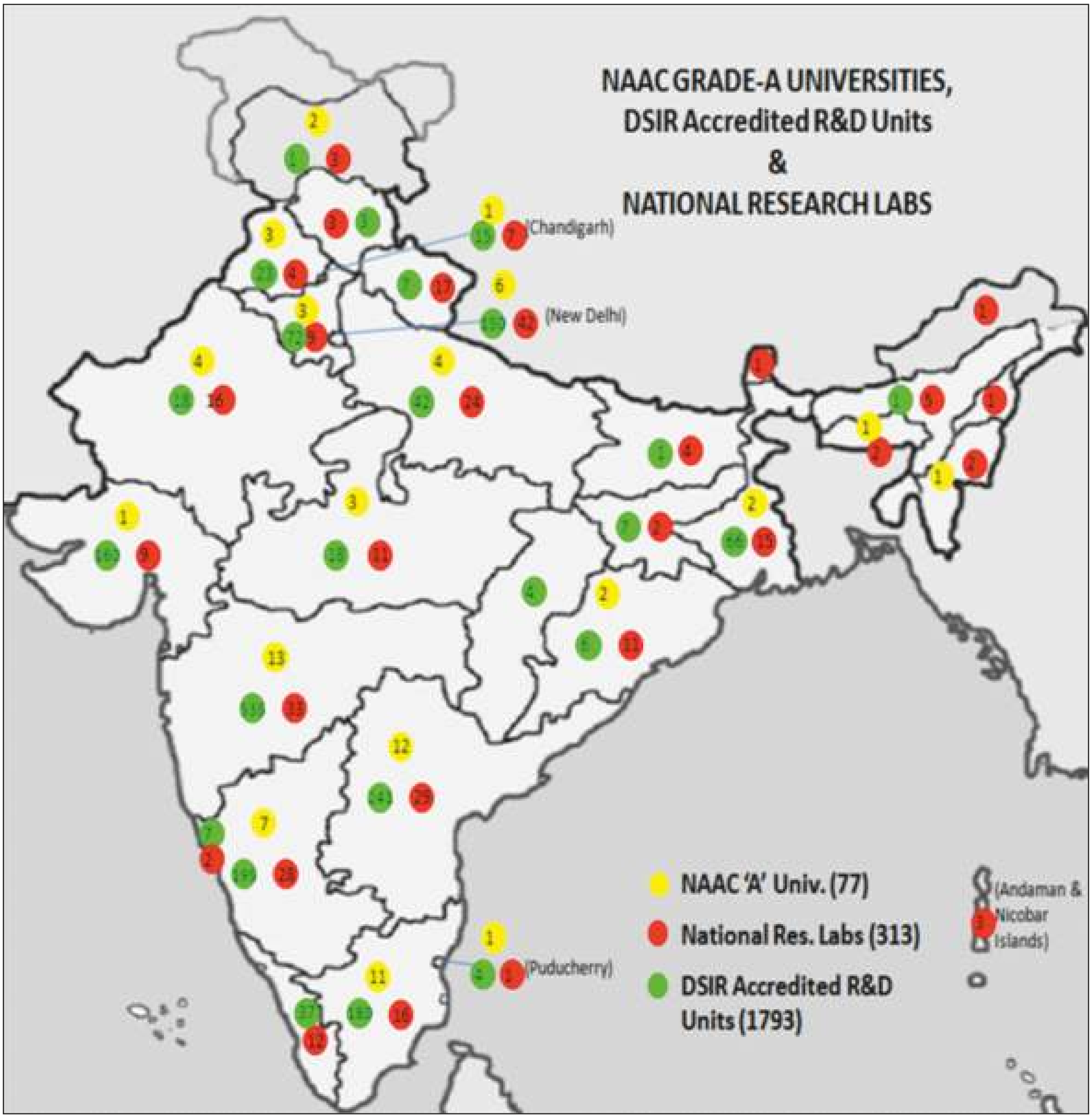

Figure 9.4: Number of NAAC 'A' Grade Universities, DSIR Accredited R&D Units and National Research Laboratories in India

<u>Recommendations</u>

- **To enhance the R&D output of the three sectors i.e. universities, R&D institutes and industries, it is recommended that, each institute of a particular sector (e.g. university) should be mandated by the government/funding agencies to partner with other two sectors (e.g. R&D institute and R&D unit of the industry). Such partnerships will help the scientists of the public sector (universities and R&D institutes) to work on real life scientific challenges being faced by the private sector i.e. industries. In return, industry would be benefitted by the intelligentsia of the public sector for the development of futuristic innovations for commercial and societal gains. Such tripartite partnership will**

definitely boost the levels of applied research/patents/technologies in India, without pumping in additional funds by the funding agencies.

- **The assessment of the effectiveness of the tripartite connectivity should be evaluated annually by a body comprising of all the stakeholders.**
- **The successful tripartite partnerships should be incentivized by the government in cash or kind.**

9.8 Reforms in Higher Education (MHRD/UGC/AICTE)

To give an impetus to industry oriented R&D in HEIs, primarily universities, one has to first understand the R&D ecosystem prevailing in the universities i.e. quality of research, presence of I-A interface, IPR Cell, Technology-Transfer Cell and Entrepreneurship Cell, efforts of the institute to attract industry for R&D, and weightage to R&D activities for the promotion of teaching faculty. As universities are the backbone for innovations, it is prudent to have a serious look into parameters as discussed below:

Creation of Autonomous I-A Cell Under Section 8 of The Companies Act 2013 in the Universities: Each R&D oriented university should have a vibrant I-A Cell as this is the most vital component for bringing academic and industry sectors under one roof. The I-A Cell will act as a catalyst in organizing I-A meets of the experts from both the sides which will help in confidence building measures and identifying the strengths of each other on which R&D projects can be defined. The I-A Cell may also take up added responsibility of IP and technology transfer engagements of the institute. All the responsibilities owned by I-A Cell should be carried out by experts. University should desist from delegating these responsibilities to university professors, who are already burdened with too much teaching, and guiding Masters' students and Ph.D scholars and their own research. The I-A Cell should be headed by a full-time professional having marketing sense and knowledge of IPR. In order to overcome the hassles of institute's rules and regulations, it is suggested that each university should have an autonomous, *not for profit* I-A Cell under Section 8 of The Companies Act 2013, to convert academic knowledge into commercial entities.

Creation of University-Industry Web Portal:

Universities should have an *Industry Web Portals* catering to the following points:

- Availability of scientific expertise in the universities
- Sophisticated instruments
- Infrastructure facilities like animal housing facility, library, workshops and fermentation facility
- Latest technologies which can be adopted by industry
- Patents held by the universities
- Start-up companies by university alumni
- Innovative products generated

- Entrepreneurship programmes
- Availability of jobs in the public and private sectors
- I-A meets/IPR/Entrepreneurship meets
- Business management programmes
- Each academic institute should have *Web Portals of Databanks* for easy access by the industrial sector.

Creation of MHRD-Tech: CSIR in partnership with State Bank of India and Pune based 'Venture Centre' has set up CSIR-Tech, which assists scientists of public and private sectors in translational research. CSIR-Tech functions like a match maker between the scientists and the industries. In fact, it is industry-academia interface in true sence. CSIR-Tech is a good concept, but has not taken-off as expected. It is suggested that learning from the experiences of CSIR-Tech, it will be prudent, if MHRD-Tech can be created which would specifically cater to the needs of the universities.

CSIR is the leading patent filing organization in India. It assists its scientists in patenting and commercialization of the technologies developed at their institutes. CSIR also provides funding for the patent filing at national as well as international level. Unfortunately, UGC does not provide such financial help to its scientists/researchers, even though it is a public funded body like CSIR. There are only a handful of universities which provide partial financial assistance to their professors. A university professor has to either shell out money from his/her own pocket or look towards industrial sector. Hence, UGC should earmark special budget for university teachers for filing and maintenance of the patents. The protection of university teachers' inventions i.e. intellectual property, will not only raise the branding of the universities, but also help in (a) revenue generation by way of industry buying the patent(s) and (b) promoting new Start-ups.

Reforms in Promotion Criteria for Teaching Faculty: Up till now**,** India has a total of 759 universities (central universities-47, state universities-350, *deemed to be* universities-123 and private universities-239). In addition, there are autonomous organizations/institutes (IITs, NITs, IISERs, IIMs, R&D institutes, etc.) which have been granted permission to award degrees by MHRD. Earlier, the mandate of HEIs was only to impart education. However, under changed circumstances, these institutes are being asked to become less reliant on the government for their financial liabilities and generate their own resources. The common approach adopted by the universities is to increase the students' fee. Not much emphasis is given to tap endowments and commercialization of IP accomplished by academia. In order to lay more emphasis on IP generation, a relook into 'Promotion Policy of UGC' is needed. The promotion criterion for faculty of the universities is heavily tilted towards research publications. The promotion of university/college professors can easily be met by publishing a few research papers and totally ignoring IP component and I-A tie-ups (R&D, consultancy, industry visits, etc.). Following table lists the industry-related clauses mentioned in the UGC-accredited Academic Performance Indicators (APIs) and the recommendations suggested by DST-Centre for Policy Research at Panjab University, Chandigarh.

Table 9.5: API Requirement for Faculty Promotion

S. No.	Industry Related clauses in API	Existing		Recommendations
		Particulars	Maximum Points	
1.	Consultancy Projects (Clause IIICi)	Amount mobilized with minimum of ₹10.00 lakhs	10/₹10 lakhs	· Minimum limit of ₹10 lakhs (for consultancy) should be brought down to one lakh. · Graded system should be introduced in which minimum of 2 points be awarded for a consultancy worth ₹ one lakh, and 10 points for consultancy worth ₹10 lakhs or more.
2.	Projects Outcome/ Outputs (Clause IIICiv)	Patent/ Technology Transfer/ Product/Process	30/National level and 50/ International level	· Distinction should be made between patent filed/examined/granted by awarding different scores depending on the status of patent application. · Technology Transfer (TT) needs to be given a separate category and awarded more points than the patents category as developing a technology requires highly focused and more intense research.

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.

Dedicated R&D Funds for State Universities by the Funding Agencies: In general, HEIs (central universities, IITs, IIMs, IISERs, etc.) which are directly under the control of MHRD performing quite well in imparting quality education and research. These institutes are major contributors towards the scientific kitty (R&D, high impact research publications, patents, technology transfers, etc.) of the nation. However, these institutes constitute a small percentage of total number of HEIs in India (Table 9.6).

Table 9.6: Distribution of Universities (as on July 5th, 2016)

Type	Number	Percentage
Universities		
State Universities	350	46.11
Deemed to be Universities	123	16.21
Central Universities	47	6.19
Private Universities	239	31.49
Total	**759**	**100.0**
Autonomous Institutes	**Number**	
Indian Institutes of Technology (IITs)	23	
Indian Institutes of Information Technology and Management (IIITs)	24	
Indian Institutes of Science Education and Research (IISERs)	6	
Indian Institute of Science (IISc)	1	
National Institutes of Technology (NITs)	30	
National Institute of Technical Teacher's Training & Research (NITTTRs)	4	
Indian Institutes of Management (IIMs)	19	

If India has to raise its level of scientific innovations, for economic prosperity and societal welfare, it needs to rope in many universities especially State universities as they constitute ~46% of the total universities. Unfortunately, majority of State universities are starved of funds. Sometimes, it is difficult for the State governments to release even salaries on time. Under such scenario, it is difficult to comprehend that State universities' faculty could do quality research, as it is a capital intensive endeavour. Barring a few, most of the State universities do not have adequate infrastructure for innovative research, and also lack basic components of translational research e.g. I-A Cell.

Inspite of limited availability of R&D ecosystem in State universities, a small section of the scientific faculty carries out quality research, as evident from publications in high impact journals, and patents/technologies. In addition, most of the young faculty hired in State-universities is highly qualified (thanks to stiff competition) as evidenced by their research publications and patents/technologies. These young turks are eager to do quality research but lose interest with the passage of time for lack of facilities for R&D. Because of the less priority given to higher education by the State governments, it is well-nigh impossible to expect innovative research from such young faculty. With the passage of time, these young, bright minds (of State universities) lose interest in research and migrate to the comfort zone, just like their senior colleagues. 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 TRE. It is high time MHRD should take serious note of this grim situation and introduce special schemes for enhancing the R&D infrastructure of State universities.

It is strongly recommended that central government, through its funding agencies, creates a special R&D fund for State governed universities to be utilized for development of R&D infrastructure. 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 funded.

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. The statutory bodies of MHRD like UGC and AICTE do provide a budget to the universities for the construction of buildings. Unfortunately, the amount sanctioned is quite limited, which is used by the universities for constructing hostels and academic –buildings. The priorities of the university for usage of funds for the buildings (hostels, academic, etc.) is understandable. Because of limited or no building-funds available for other purposes including R&D ecosystem, the above mentioned facilities are not encouraged in the universities or are allocated bare minimum space in already congested buildings. 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.

Industry-Academia Scholarship/Fellowship Schemes: DST (GoI) has introduced 'PM's Fellowship Scheme for Doctoral Research' in which both the industry and the academia jointly guide a Ph.D student for his/her research project. This scheme has been welcomed by the public and private sectors and is gaining momentum amongst the young researchers as the project has more chances of success because the industry is associated with the beginning of the project and all concerns (industry related) for the development of a technology are taken into account. In addition, the Ph.D scholar, after the completion of Ph.D has better chance of being absorbed by the industry. In this 'PM's Fellowship Scheme for Doctoral Research', a Ph.D scholar's salary is enhanced as industry also contributes towards his/her salary. 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.

Setting up of IPR Academies: For commercialization of innovative research, it is essential that research findings are not made public till a patent has been filed. Unfortunately, this simple fact is not known to a large section of intelligentsia (academicians, scientists, doctors, engineers, etc.). Majority of them present their research findings either in a conference/seminar or submit to a research journal and then think of patenting their innovative idea, which cannot be done as the novel information has been brought already in the public domain. Similarly, large section of intelligentsia is oblivious of the difference between IPR and IP. In addition, many scientists are still oblivious of the methods for patent search, patent filing, prior-art patent search etc. In the current century, it is advisable that intelligentsia and young researchers are made aware of the basic understanding of IPR. A few government agencies like DST, TIFAC, NRDC and CIPAM are running IPR awareness programmes. However, these programmes are able to cater to a small section of society. In order to reach out to lakhs of young researchers, university professors and scientists, 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. These resource persons should be permanent employees of the universities and should train university staff and students in their respective universities. 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.

National Fair for Promoting I-A Programmes/Activities: UGC should organize national fair on industry and industrial expectations/requirements in universities. At the national level, various events are being conducted for the promotion of innovation, entrepreneurship and I-A interaction. For example, 'India International Science Festival' jointly organized by CSIR, Ministry of Science and Technology, ICAR and Vijnana Bharati; 'Innovation and Entrepreneurship Meet' organized by the joint efforts of CII, DST and AICTE; 'India International Innovation Fair' organized by India Innovators Association and V Group and 'Bangalore India Bio' organized by the Government of Karnataka, ABLE, Vision group on Biotechnology and MM Activ Sci-Tech Communications. Such initiatives should be organized in universities as well.

Setting up of Autonomous Innovation Universities: Universities (Central or State) publishing research papers in high impact journals, should be identified and declared as 'Innovation Universities'. These universities should be empowered with high end instruments and other R&D related facilities/infrastructure and granted autonomous status, as enjoyed by autonomous HEIs, such as IITs and IIMs. In addition, the teaching load of scientists engaged in research should be lessened, so that they can devote more time for innovative research.

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/fervor 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.

Miscellaneous

➢ **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.
- Industry should be involved from the very beginning in the research projects having industrial implications. Using this approach, the project will be more focused and shorten the time for commercialization of the technology developed.
- 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.
- By and large, the Project Appraisal Committee (PAC) of funding agencies comprise of only scientists, who are responsible for granting as well as evaluation of the research projects. There is no accountability if principal-investigator fails to deliver, whatever was committed in the research proposal, and sometimes granted yet another project! At times it has been felt that research projects are sanctioned even though they are not up to the mark. To overcome these concerns, it is high time for intervention by a third party (industry personnel, business management experts etc.) for assessing as well as granting of research projects by funding agencies. For example, the research projects of applied nature may be evaluated/assessed by an industry expert. His/her comments on sanctioning as well as the outcome of the projects should be taken seriously.

List of Symbols and Abbreviations	
Symbols & Abbreviations	**Description**
₹	Rupee
£	Pound
$	Dollar
~	Approximately
&	And
A2K+	Access to Knowledge for Technology Development and Dissemination
ABLE	Association of Biotechnology Led Enterprises
AcE	Accelerating Entrepreneurs
ACE	Agricultural Commercialization & Enterprise
ACMA	Automotive Components Manufacturers Association
AICET	Airtel IIT Delhi Centre of Excellence in Telecommunications
AICTE	All India Council for Technical Education
AIFI	Association of Indian Forging Industry
AIIMS	All India Institute of Medical Sciences
AIM	Academia-Industry Model, Atal Innovation Mission
AISC	Automotive Industry Standards Committee
AISRF	Australia-India Strategic Research Fund
AMPRI	Advance Material and Process Research Institute
AMR	Anti-Microbial Resistance
AMRF	Amrut Mody Research Fund
APCTT	Asian and Pacific Centre for Transfer of Technology
APEDA	Agriculture and Processed Food Products Exports Development
API	Academic Performance Indicators
ARAI	Automotive Research Association of India
ASQ	American Society for Quality
ASSOCHAM	Associated Chambers of Commerce and Industry of India
ATAC	Accelerated Technology Assessment and Commercialization

B.Tech	Bachelor of Technology
B2B	Bench to Bassinet
BARC	Bhabha Atomic Research Centre
BBIF	Biotechnology Business Incubation Facility
BBSRC	Biotechnology and Biological Sciences Research Council
BCIL	Biotechnology Consortium India Ltd.
BCP	Bombay College of Pharmacy
BHEL	Bharat Heavy Electricals Ltd.
BIG	Biotechnology Ignition Grant
BIPP	Biotechnology Industry Partnership Programme
BIRAC	Biotechnology Industry Research Assistance Council
BIRD-crf	Building Industrial R&D and Common Research Facilities
BIRPI	Bureaux for the Protection of Intellectual Property
BIS	Bio-Incubator Support
BITS	Birla Institute of Technology & Science
BMB	Bamboo Mat Board
BMCS	Bamboo Mat Corrugated Sheet
BMT	Bamboo Technology
BMVC	Bamboo Mat Veneer Composite
BPCL	Bharat Petroleum Corporation Limited
BRIC	BIRAC Regional Innovation Centre
BRIT	Board of Radiation and Isotope Technology
BRNS	Board of Research in Nuclear Sciences
BSNL	Bharat Sanchar Nigam Limited
BTRA	Bombay Textile Research Association
CAN	Controller Area Network
CARIAD	Centre for Advanced Research in International Agricultural Development
CAS	Career Advancement Scheme
CBRI	Central Building Research Institute
C-CAMP	Centre for Cellular and Molecular Platforms
CCET	Chandigarh College of Engineering and Technology

Cd4	Cluster of Differentiation 4
C-DAC	Centre for Development of Advanced Computing
CDEEP	Centre for Distance Engineering Education Programme
CDFD	Centre for DNA Fingerprinting and Diagnostics
CDRI	Central Drug Research Institute
CDSCO	Central Drugs Standard Control Organization
CECRI	Central Electro Chemical Research Institute
CEERI	Central Electronics Engineering Research Institute
CEFIPRA	Centre Franco-Indien pour la Promotion de Recherche Avancée [Indo-French Centre for the Promotion of Advanced Research (IFCPAR)]
CEL	Center for Entrepreneurial Leadership
CEO	Chief Executive Officer
CEP	Continuing Education Programme
CEWiT	Centre of Excellence in Wireless Technology
CfEL	Centre of Entrepreneurial Learning
CFI	Centre for Innovation
CFTRI	Central Food Technological Research Institute
CGCRI	Central Glass and Ceramic Research Institute
CGPDTM	Controller General of Patents, Designs & Trade Marks
CIAB	Center of Innovative and Applied Bioprocessing
CIBI	Centre for Innovation and Business Incubation
CIHEC	Council for Industry Higher Education Cooperation
CII	Confederation of Indian Industry
CIIPP	Centre for Institute Industry Partnership Programme
CIMAP	Central Institute of Medicinal and Aromatic Plants
CIPAM	Cell for IPR Promotion and Management
CLRI	Central Leather Research Institute
CMC	Christian Medical College
CMD	Chairman and Managing Director
CMERI	Central Mechanical Engineering Research Institute
CMTI	Central Manufacturing Technology Institute

CNG	Compressed Natural Gas
CoE	Centre of Excellence
CPP	Consultancy Promotion Programme
CPPRI	Central Pulp & Paper Research Institute
CPR	Cardio Pulmonary Resuscitation
CRAMS	Contract Research and Manufacturing Systems
CRDI	Common Rail Direct Injection
CRIKC	Chandigarh Region Innovation and Knowledge Cluster
CRO	Contract Research Organization
CRRI	Central Road Research Institute
CRS	Contract Research and Service Scheme
CRTDH	Common Research and Technology Development Hubs
CSIE	Centre for Social Innovation and Entrepreneurship
CSIO	Central Scientific Instruments Organisation
CSIR	Council of Scientific and Industrial Research
CSMCRI	Central Salt and Marine Chemicals Research Institute
CSR	Corporate Social Responsibility
C-TIDES	Cell for Technology Innovation, Development and Entrepreneurship Support
CTPL	CSIR-Tech Private Limited
CURIE	Centre for Undergraduate Research In Engineering
D	Dimensional
DAE	Department of Atomic Energy
DARE	Department of Agricultural Research and Education
DBT	Department of Biotechnology
DCGI	Drug Controller General of India
DeitY	Department of Electronics and Information Technology
DFID	Department for International Development
DHA	Docosa Hexanoic Acid
DIHAR	Defence Institute of High Altitude Research
DIPP	Department of Industrial Policy and Promotion
DIT	Department of Information Technology

DNA	Deoxyribose Nucleic Acid
DoRT&H	Department of Road Transport & Highways
DoT	Department of Telecommunications
DRDO	Defence Research & Development Organisation
DSCE	Desai Sethi Centre for Entrepreneurship
DSIR	Department of Scientific and Industrial Research
DSP	Digital Signal Processing
DST	Department of Science and Technology
CPR	Centre for Policy Research
DTDDF	DAE Technologies Display and Dissemination Facility
du	Dextranase Unit
DVP	Distinguished Visiting Professorship
E&C	Electronics and Communication
EAC	Entrepreneurship Awareness Camp
E-Cell	Entrepreneurship Cell
ECP	Entrepreneurship Curriculum Programme
ECRA	Early Career Research Award
EDC	Entrepreneurship Development Cell
EDI	Entrepreneurship Development Institute
EDP	Entrepreneurship Development Programmes
EEG	Electroencephalography
EEN	Enterprise Europe Network
EIR	Entrepreneur in Residence
ENB	Entrepreneurship and Business
ER	Extramural Research
ERNET	Education and Research Network
ESDM	Electronics System Design and Manufacturing
ETA	Early Translational Accelerator
EXIM	Export Import
FAST	Frontier Areas of Science and Technology
FCoF	Freelancers and Co-Founder Platform

FDI	Foreign Direct Investment
FDP	Faculty Development Programme
FICCI	Federation of Indian Chambers of Commerce and Industry
FITT	Foundation for Innovation and Technology Transfer
FLexE	Flexible Electronics
FLO	FICCI Ladies Organization
FPGA	Field Programmable Gate Array
FTO	Freedom to Operate
GAIM	Government-Academia-Industry Model
GCI	Global Competitiveness Index
GDP	Gross Domestic Product
GERD	Gross Expenditure on R&D
GI	Geographical Indicators
GIAN	Global Initiative for Academic Network
GII	Global Innovation Index
GIM	Government-Industry Model
GITA	Global Innovation and Technology Alliance
gm	gram
GMCH	Government Medical College & Hospital
GMOs	Genetically Modified Organisms
GMP	Good Manufacturing Practices
GoI	Government of India
Govt.	Government
GSBTM	Gujarat State Biotechnology Mission
GYTI	Gandhian Young Technological Innovation
HAL	Hindustan Aeronautics Limited
HBN	Honey Bee Network
HCV	Higher Calorific Values
HEFA	Higher Education Financing Agency
HEI	Higher Education Institute
HGT	Home Grown Technology

HPCL	Hindustan Petroleum Corporation Limited
HPV	Human Papillomavirus
HR	Human Resource
HRD	Human Resource Development
HTIC	Healthcare Technology Innovation Centre
HWB	Heavy Water Board
I-A	Industry-Academia
IABMS	Indian Association of Biomedical Scientists
IAEA	International Atomic Energy Agency
IARGI	I-A Research/Government Interface
IARI	Indian Agricultural Research Institute
IBM	International Business Machines
IC	Incubation Centre
IC&SR	Industrial Consultancy and Sponsored Research
ICAR	Indian Council of Agricultural Research
ICGEB	International Centre for Genetic Engineering and Biotechnology
ICICI	Industrial Credit and Investment Corporation of India
ICMR	Indian Council of Medical Research
ICT	Institute of Chemical Technology, Information and Communication Technology
IDB	Industrial Development Board
IDBI	Industrial Development Bank of India
IDC	Institute for Development and Communication
IDLSS	Integrated Development of Leather Sector Scheme
IDP	Instrumentation Development Programme
IEDC	Innovation and Entrepreneurship Development Centre
IESA	India Electronics & Semiconductor Association
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
IFCI	Industrial Finance Corporation of India
IGCAR	Indira Gandhi Centre for Atomic Research

IHBT	Institute of Himalayan Bioresource Technology
IIC	IIT-G Incubation Centre
IICB	Indian Institute of Chemical Biology
IICT	Indian Institute of Chemical Technology
IIEC	Innovation and Entrepreneurship Centre
IIF	India Innovation Fund
IIIC	Industry Institute Interaction Cell
IIIM	Indian Institute Interactive Medicine
IIIT	Indian Institute of Information and Technology
IIM	Indian Institute of Management
IIMA	Indian Institute of Management, Ahmedabad
IIP	Indian Institute of Petroleum
IIP	Industry Immersion Program
IIPC	Industry Institute Partnership Cell
IIPME	Industry Innovation Programme on Medical Electronics
IISc	Indian Institute of Science
IISER	Indian Institute of Science Education and Research
IIT	Indian Institute of Technology
IIT(BHU)	Indian Institute of Technology, Banaras Hindu University
IIT-B	Indian Institute of Technology, Bombay
IIT-BBS	Indian Institute of Technology, Bhubaneswar
IIT-D	Indian Institute of Technology, Delhi
IITDM	Indian Institute of Information Technology Design and Manufacturing
IIT-G	Indian Institute of Technology, Guwahati
IIT-GN	Indian Institute of Technology, Gandhinagar
IIT-H	Indian Institute of Technology, Hyderabad
IIT-I	Indian Institute of Technology, Indore
IIT-J	Indian Institute of Technology, Jodhpur
IIT-K	Indian Institute of Technology, Kanpur
IIT-KGP	Indian Institute of Technology, Kharagpur
IIT-M	Indian Institute of Technology, Madras

IIT-MN	Indian Institute of Technology, Mandi
IIT-P	Indian Institute of Technology, Patna
IITR	Indian Institute of Toxicology Research
IIT-R	Indian Institute of Technology, Roorkee
IIT-RPR	Indian Institute of Technology, Ropar
IKP	ICICI Knowledge Park
IMF	International Monetary Fund
IMMT	Institute of Minerals and Materials Technology
IMPRINT	Impacting Research Innovation and Technology
IMTECH	Institute of Microbial Technology
INAE	Indian National Academy of Engineering
INNO INDIGO	Innovation Driven Initiative for the Development and Integration of Indian and European Research
INSPIRE	Innovation in Science Pursuit for Inspired Research
INST	Institute of Nano Science & Technology
IoT	Internet of Things
IP	Intellectual Property
IPA-MSB	Indian Pharmaceutical Association-Maharashtra State Branch
IPFC	Intellectual Property Facilitation Centre
IPIRTI	Indian Plywood Industries Research and Training Institute
IPO	Indian Patent Office
IP-PPP	In Practice-Public Private Partnerships
IPR	Intellectual Property Right
IPRI	International Property Rights Index
IPS	Innovation Promotion Scheme
IRAC	Industry Research Assistance Council
IRCC	Industrial Research and Consultancy Centre
IRD	Industrial Research & Development
IRDP	Industry R&D Promotion Programme
ISB	Indian School of Business
ISBN	International Standard Book Number

ISRO	Indian Space and Research Organisation
i-STED	Innovation-S&T based Entrepreneurship Development
ISTP	Industry Study Tour Programme
ISVF	India Science Venture Fund
IT	Information Technology
ITTP	International Technology Transfer Programme
IVIG	Intravenous Immunoglobulin
JCIG	Joint Committee of Industry and Government
JICA	Japan International Cooperation Agency
JRF	Junior Research Fellowship
KAUSHAL	Knowledge Acquisition and Up-gradation of Skilled Human Abilities and Livelihood
KEM	King Edward Memorial
KIIT	Kalinga Institute of Industrial Technology
KIRAN	Knowledge Involvement in Research Advancement through Nurturing
KSIDC	Kerala State Industrial Development Corporation
KW	Kilo Watt
L	Litre
LDCs	Least Developed Countries
LLP	Limited Liability Partnership
LPG	Liquefied Petroleum Gas
LSI	Life Science Incubator
Ltd.	Limited
LTE	Long-Term Evolution
M.Sc.	Masters of Science
M.Tech	Master of Technology
MCIIE	Malaviya Centre for Innovation, Incubation and Entrepreneurship
MeitY	Ministry of Electronics and Information Technology
MFPI	Ministry of Food Processing Industry
MGIRI	Mahatma Gandhi Institute for Rural Industrialization
MHRD	Ministry of Human Resource Development

MIIUS	Modified Industrial Infrastructure Upgradation Scheme
MNC	Multinational Corporation
MNRE	Ministry of New and Renewable Energy
MoA	Ministry of Agriculture
MoC	Ministry of Communication
MoEF&CC	Ministry of Environment, Forest and Climate Control
MOF	Mixed Oxide Fuel
MoHI&PE	Ministry of Heavy Industries and Public Enterprises
MoRT&H	Ministry of Road Transport & Highways
MoU	Memorandum of Understanding
MSME	Ministry of Micro, Small and Medium Enterprises
MSMEs	Micro, Small and Medium Enterprises
MTA	Material Transfer Agreement
MUTBI	Manipal University Technology Business Incubator
NA	Not Applicable
NAAC	National Assessment and Accreditation Council
NABARD	National Bank for Agriculture and Rural Development
NABI	National Agri-Food Biotechnology Institute
NABL	National Accreditation Board for Testing and Calibration Laboratories
NAL	National Aerospace Laboratories
NASSCOM	National Association of Software and Services Companies
NATAG	Nano Applications and Technology Advisory Group
NATP	National Agricultural Technology Project
NBRC	National Brain Research Centre
NBRI	National Botanical Research Institute
NBSAP	National Biodiversity Strategy and Action Plan
NCB	National Council for Cement and Building Materials
NCCBM	National Council for Cement and Building Materials
NCCS	National Centre for Cell Science
NCL	National Chemical Laboratory
NCPRE	National Centre for Photovoltaic Research and Education

NDDS	Novel Drug Delivery Systems
NEC	National Entrepreneurship Challenge
NEERI	National Environmental Engineering Research Institute
NEEV	Nurture and Empower Entrepreneurial Ventures
NEGP	National E-Governance Plan
NEIST	North East Institute of Science and Technology
NEN	National Entrepreneur Network
NFC	Nuclear Fuel Complex
NGO	Non-Governmental Organization
NGRI	National Geophysical Research Institute
NIAC	National Industry-Academia Centre
NIAS	National Institute for Advanced Studies
NIC	National Innovation Council
NID	National Institute of Design
NIDHI	National Initiative for Developing and Harnessing Innovations
NII	National Institute of Immunology
NIIST	National Institute for Interdisciplinary Science and Technology
NIMSME	National Institute for Micro, Small and Medium Enterprises
NIO	National Institute of Oceanography
NIPER	National Institute of Pharmaceutical Education and Research
NIPGR	National Institute for Plant Genome Research
NIRF	National Institutional Ranking Framework
NISSAT	National Information System for Science & Technology
NIT	National Institute of Technology
NITTTR	National Institute of Technical Teachers Training & Research
NMITLI	New Millennium Indian Technology Leadership Initiative
NML	National Metallurgical Laboratory
NNRMS	National Natural Resources Management System
NOIDA	New Okhla Industrial Development Authority
NPC	National Productivity Council
NPDF	National Post-Doctoral Fellowship

NPIU	National Project Implementation Unit
NPL	National Physical Laboratory
N-PPP	Not for Profit Public Private Partnership
NRDC	National Research Development Corporation
NSIC	National Small Industries Corporation
NSTEDB	National Science & Technology Entrepreneurship Development Board
OEM	Original Engine Manufacturer
OHSAS	Occupational Health and Safety Management
OIL	Oil India Limited
ONGC	Oil and Natural Gas Corporation
OPPI	Organization of Pharmaceutical Producers of India
PAC	Policy and Analysis Cell, Project Appraisal Committee
PACE	Patent Acquisition and Collaborative Research and Technology Development
PATSER	Programme Aimed at Technological Self Reliance
PBC	Programme and Budget Committee
PCR	Professional Candidate Registration, Polymerase Chain Reaction
PCT	Patent Cooperation Treaty
PERD	Pharmaceutical Education and Research Development
PFC	Patent Facilitation Center
PFRI	Public Funded Research Institutions
PG	Post Graduate
PGIMER	Postgraduate Institute of Medical Education and Research
Ph.D	Doctor of Philosophy
PHDCCI	Progress Harmony Development Chambers of Commerce and Industry
PI	Principal Investigator
PIC	Patent Information Centre
PIDIIP	Pfizer IIT Delhi Innovation and IP Program
PM	Prime Minister
PMKVY	Pradhan Mantri Kaushal Vikas Yojana

PNB	Punjab National Bank
PoCC	Proof of Concept Centre
POSOCO	Power System Operation Corporation Limited
PPP	Public Private Partnerships
PPSA	POSCO Power System Award
PRAYAS	Promotion and Acceleration of Young and Aspiring Technology Entrepreneurs
PRC	Policy Research Centre
PRISM	Promoting Innovations in Individuals, Start-ups and MSMEs
PSCST	Punjab State Council for Science and Technology
PU	Panjab University
Chd.	Chandigarh
PURSE	Promotion of University Research and Scientific Excellence
Pvt.	Private
QEEE	Quality Enhancement in Engineering Education
QIP	Quality Improvement Programme
QUT	Queensland University of Technology
R&D	Research and Development
RIT	Rajarambapu Institute of Technology
RAPID	Research Alliance for Product Innovation and Development
RCB	Regional Centre for Biotechnology
RCSRC	Regional Cyber Security Research Centre
RDI	In-house R&D Units
RGNIIPM	Rajiv Gandhi National Institute of Intellectual Property Management
RICET	RailTel IITR Centre of Excellence in Telecom
RIL	Reliance Industries Limited
RITCOE	Reliance IITM Telecom Centre of Excellence
RNA	Ribose Nucleic Acid
RTBI	Rural Technology and Business Incubator
RUSA	Rashtriya Ucchtar Aavishkar Abhiyaan
RuTAG	Rural Technology Action Group

S&T	Science and Technology
SAARC	South Asian Association for Regional Cooperation
SAB	Secondary Agriculture Bio-Cluster
SAC	Space Application Centre
SAIC	Secondary Agriculture Innovation Cell
SAMEER	Society for Applied Microwave Electronic Engineering and Research
SAP	Special Assistance Programme
SASE	Snow & Avalanche Study Establishment
SBERTC–IITK	Syndicate Bank Entrepreneurship Research and Training Centre at the Indian Institute of Technology, Kanpur
SBI	State Bank of India
SBIRI	Small Business Innovation Research Initiative
SBTIC	Society for Biotechnology Incubation Centre
SCDT	Samtel Centre for Display Technologies
SCL	Semi-Conductor Laboratory
SCTI	Steinbeis Centre for Technology Transfer India
SDGs	Sustainable Development Goals
SEBI	Securities and Exchange Board of India
SERB	Science and Engineering Research Board
SERC	Structural Engineering Research Centre
SESC	Student Entrepreneurship Support Cell
SETU	Self-Employment and Talent Utilization
SGPGIMS	Sanjay Gandhi Post Graduate Institute of Medical Sciences
SIDBI	Small Industries Development Bank of India
SIF	Social Innovation Fund
SIG	Social Initiatives Group
SIIC	SIDBI Innovation and Incubation Centre
SIIP	Social Innovation Immersion Programe
SINE	Society for Innovation and Entrepreneurship
SIRO	Scientific and Industrial Research Organization
SJR	Scimago Journal Rank

SMEs	Small and Medium Sized Enterprises
SMU	Singapore Management University
SOP	Standard Operating Procedures
sp	Species
SPARSH	Social Innovation Programme for Products: Affordable and Relevant to Social Health
SPMCIL	Security Printing and Mining Corporation of India Limited
SPREAD	Sponsored Research and Development Board
SRF	Senior Research Fellowship
SRI	Shriram Institute of Industrial Research
SRIC	Sponsored Research & Industrial Consultancy
SRIRU	Sponsored Research and Industrial Relations Unit
SRISTI	Society for Research and Initiatives for Sustainable Technologies and Institutions
SSI&A&RI	Small Scale Industries and Agro and Rural Industries
SSP	Start-up Services Platform
SSS	Seed Support System
STED	S&T Entrepreneurship Development Project
STEP	Science and Technology Entrepreneur Park
STI	Science, Technology and Innovation
STPI	Software Technology Parks of India
SWT	Scientists Welfare Trust
TBI	Technology Business Incubator
TBIU	Technology Business Incubation Unit
TCFs	Technology Commercialization Facilitators
TCL	Tata Chemicals Limited
TCOE	Telecom Centre of Excellence
TC-PPP	Technically Correct-Public Private Partnerships
TCS	Tata Consultancy Services
TDB	Technology Development Board
TDDP	Technology Development and Demonstration Program
TDUPW	Technology Development and Utilization Programme for Women
TEAM	TERI's Enhanced Acidification and Methanation

TEDP	Technology based EDP
TePP	Technopreneur Promotion Programme
TEQIP	Technical Education Quality Improvement Programme
TEQUP	Technology and Quality Up gradation
TERI	The Energy and Resources Institute
TFG	Technology Finance Group
THSTI	Translational Health Science and Technology Institute
TIC	Technology Incubation Centre
TICET	Tata Teleservices IITB Centre of Excellence in Telecommunications
TIDE	Technology Incubation and Development of Entrepreneurs
TI-DSP	Texas Instruments Digital Signal Processing
TIETS	Technology Incubation and Entrepreneurship Training Society
TIFAC	Technology Information, Forecasting and Assessment Council
TMP	Technology Management Programme
TOCIC	TePP Outreach cum Cluster Innovation Centre
TRE	Translational Research Ecosystem
TREMAP	Technology Refinement and Marketing Programme
TSDP	Technology Systems Development Programmes
TU	Thapar University
TUC	TePP Outreach Centre
TUFS	Technology Upgradation Fund Scheme for The Textile Industries
UCSSIC	UNIDO Centre for South-South Industrial Cooperation
UDCT	University Department of Chemical Technology
UG	Under Graduate
UGC	University Grants Commission
UIC	University Innovation Cluster
UIL	University-Industry Inter-Linkage
UILCs	University-Industry Inter-Linkage Centres
U.K.	United Kingdom
UL	Underwriters Laboratories
UN	United Nations

UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UN-ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
US	United States
USA	United States of America
USD	United States Dollar
UT	Union Territory
VASVIK	Vividhlaxi Audyogik Samshodhan Vikas Kendra
VICET	Vodafone Essar-IIT Centre of Excellence in Telecommunications
VIT	Vellore Institute of Technology
VLSI	Very-Large-Scale Integration
WEF	World Economic Forum
WHO	World Health Organization
WINS	Women in Start-ups
WIPO	World Intellectual Property Organization
WMG	Warwick Manufacturing Group
ZTM-BPD	Zonal Technology Management and Business Planning and Development

About the Co-Authors

Dr Ajit Singh Naosekpam is working as a Sr. Scientist D in DST- Centre for Policy Research at Panjab University, Chandigarh since 2014. Earned his Ph.D. (Biotechnology) in 2012 from Institute of Himalayan Bioresource Technology (IHBT), Palampur under CSIR-Senior Research Fellowship after completing Masters in Science (Botany) from Manipur University, Imphal. He has published seven research papers, one book chapter and submitted 23 Gene sequences to GenBank, National Center for Biotechnology Information (NCBI), USA. His major research areas are *Incentivisation of Private Sector for Enhancement in R&D Investments*.

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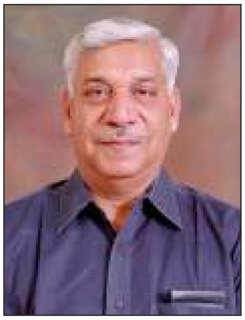
About the Author



Dr Rupinder Tewari is a professor in the Department of Microbial Biotechnology, and Chief-Coordinator, DST-Centre for Policy Research at Panjab University, Chandigarh, with 38 years of teaching and research in his pocket. After a B.Sc (Hons. School), M.Sc (Hons. School) and Ph.D in the field of Microbiology from Panjab University, Chandigarh, he secured a second Ph.D (Microbiology) from the University of London, London, (U.K.) and Post-Doctorate from Washington University, Saint Louis, USA. The recipient of the *Rockefeller Biotechnology Fellowship* (USA) and *Commonwealth Academic Staff Scholarship* (U.K.), he has published over 100 research papers in international journals and four books in the field of Microbiology and Biotechnology.

Prof. Tewari has vast administrative experience. In the Panjab University, he has been a *Fellow* of the highest governing body of the university i.e. Senate; *Dean* (Faculty of Sciences); *Founder & Chairperson*, Department of Microbial Biotechnology; *Chairperson*, Department of Biotechnology; *Founder & Chief Coordinator*, Centre for Innovation Cluster (Biotechnology), funded by Biotechnology Industry Research Assistance Council (BIRAC; GoI); *Founder,* Bio-Incubator Facility; *Director (Hony.)*, Centre for Industry-Institute Partnership Programme; Director (*Hony.),* Central Instrumentation Laboratory and *Coordinator,* UGC-SAP (Biotechnology). In addition, Prof. Tewari has been *Founder*, Association of Microbiologists of India (Chandigarh Unit); *Co-Founder*, Chandigarh Region Innovation & Knowledge Cluster (CRIKC); *Expert-member*, DST-Project Appraisal Committee (Animal Sciences); *Member*, Board of Directors, Venus Remedies Pvt. Ltd., Panchkula (Haryana) and *Member*, 'Chandigarh Incubator' being set up by the U.T. Administration.

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