DST- Centre for Policy Research, Panjab University, Chandigarh

Sanctioned by the Department of Science and Technology (DST),

(DST/PRC/CPR-03/2013, Est. in Jan. 2014)

ANNUAL REPORT
(April 2019- March 2020)

Coordinator: Prof Rupinder Tewari

https://cpr.puchd.ac.in/

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Vision of the Centre

To Strengthen Industry-Academia R&D Ecosystem in India

Objectives

Objective 1: Development of a New Country Specific Model for Promotion of Public Private Partnership (PPP) for R&D.

Objective 2: Identify Areas of Policy Gaps for Stimulation of Private Sector Investment in R&D and Suggest Changes in Policy Environment.

Objective 3: Adopt Evidence Based Approaches for Identifying and Promoting Areas for Generation of Intellectual Properties.

The Centre has carried out evidence based studies in the above mentioned objectives and published in the form of Books, Reports and Research Papers. More than 20 conferences/workshops/seminars/symposiums have been organized in which officials/scientists of NITI Aayog, Funding Agencies, O/PSA, UGC, AICTE, Universities, National Res. Labs and representatives from Industries (small, medium and large scale) and Industry Associations share their experiences.

In addition, the Centre has created an a) Industry-Academia web portal of Chandigarh region, b) Medical Device Innovation Cluster, c) Contributed significantly in drafting 'University Business Linkage Programme' for UGC and organized hands-on-training in the fields of 'Patent Search and Filing'. A few of the recommendations have been carried forward at the national level. Detailed information can be accessed from the Centre's website (https://cpr.puchd.ac.in/).

Activities of the Centre (2019-20)

Activity 1: Case Study on 'BIRAC, GoI as a Successful Model of PPP for R&D in India'

BIRAC, a Section 8 Company was set up by GoI for the promotion of PPP in the domain of Biotechnology. BIRAC offers funding & support programmes/schemes catering to all stages of innovation i.e. Idea generation ⟶ PoC Prototype development (industry ready) (Figure 1). BIRAC has created 'Technology Portal' displaying various technologies and products developed by BIRAC beneficiaries and are readily available to be taken up. BIRAC has dedicated divisions for a) submitting recommendations to government for strengthening biotech sector; b) national and international strategic alliances; and c) Make in India Initiative.

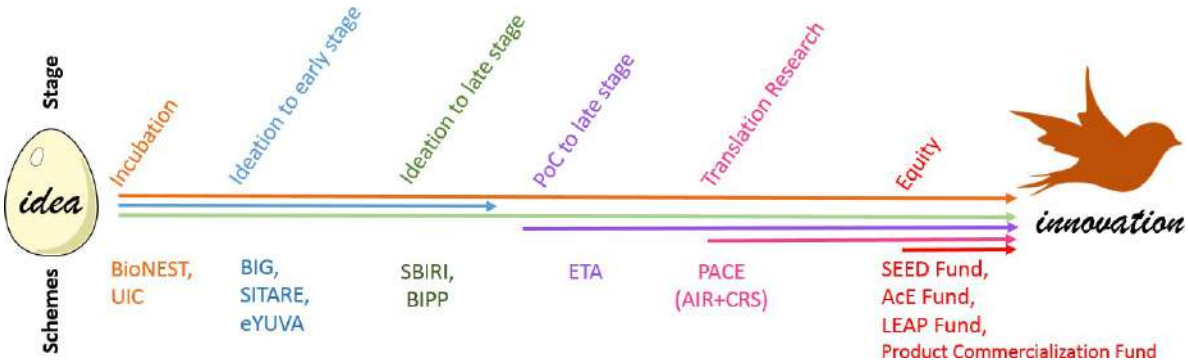


Figure 1: Overview of R&D Schemes Floated by BIRAC under PPP mode.

During its 7 years of existence, BIRAC has initiated many Biotech-centric schemes with funds contributed by the public sector and the private sector with funding commitment of ₹ 978 Cr and ₹ 937 Cr, respectively. A substantial number of products/technologies have been generated through BIRAC schemes are the outcome of R&D carried out under PPP mode. The impact of BIRAC in past 7 years is presented in Figure 2. A detailed study of nearly 70 pages has been prepared on the programmes/schemes of BIRAC and submitted to BIRAC for review (Annexure I).

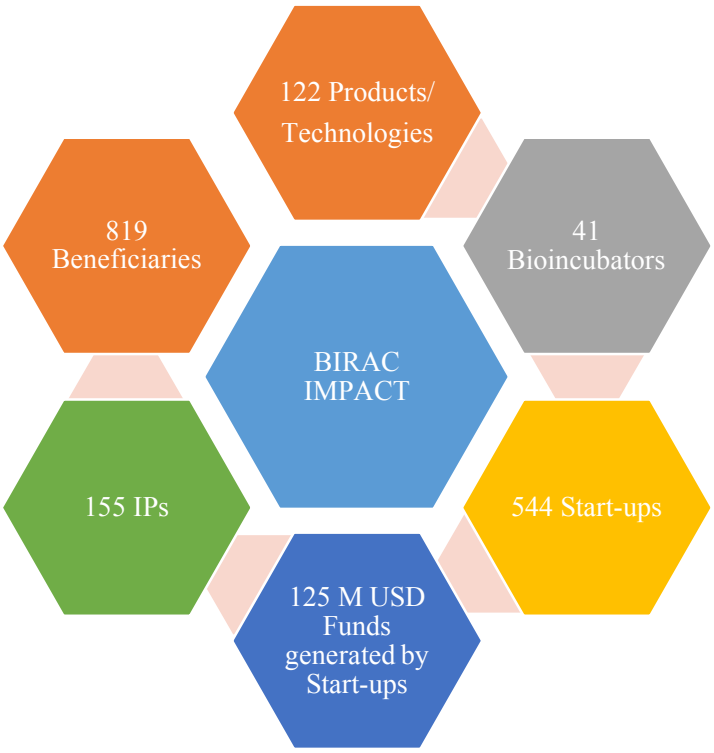


Figure 2: Impact of BIRAC Programmes and Schemes

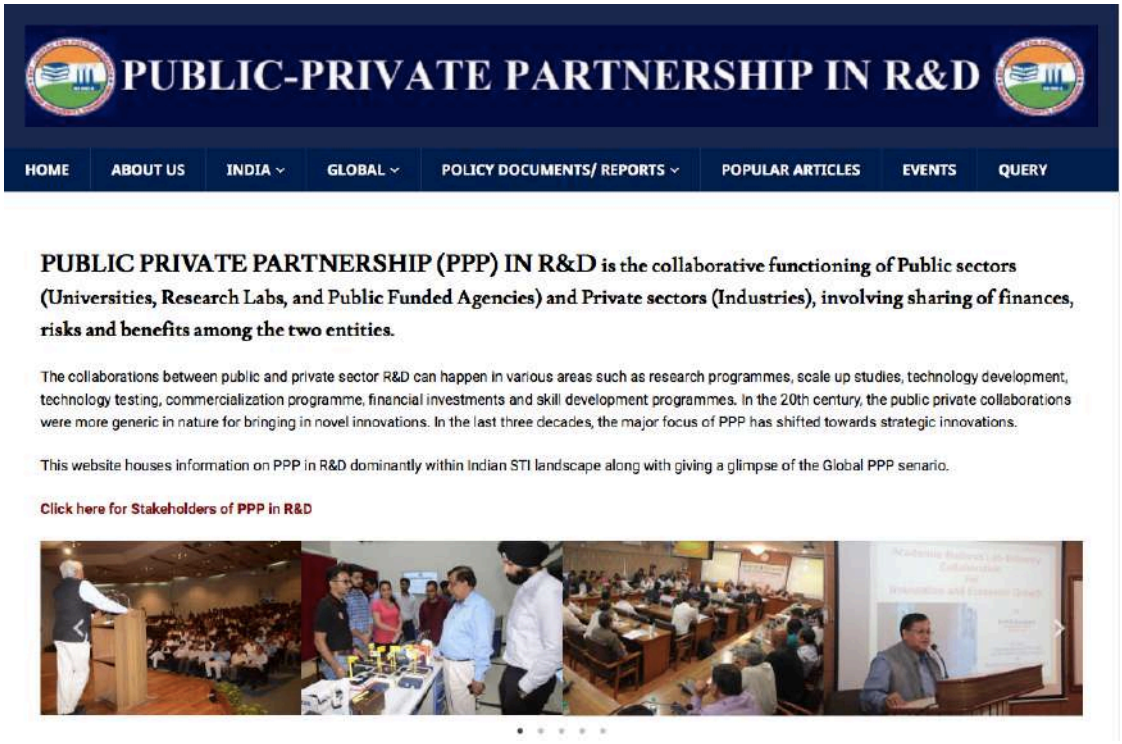
Activity 2: Creation of 'Comprehensive PPP for R&D Web-portal'

World over, Public-Private Partnership (PPP) in R&D is being perceived as an important and effective tool to enhance the innovation index of the nation. The handshake between the public sector (Academia and the government) and the private sector (primarily industries) is a win-win situation for both the entities. In India, there are magnitude of PPP in R&D programmes implemented by the public sector (DST, CSIR, BIRAC etc.) as well as the private sector (financial institutions and industry associations) as mentioned below (Figure 3).

Figure 3: Agencies/ Departments Floating PPP Programmes

Therefore, a platform has been created where the information pertaining to PPP in R&D is available. It is created with a view point that it will benefit those engaged in R&D and policy makers. Till now a Web-portal has been developed where all the information pertaining to PPP in R&D for Indian Ministries is available under one roof to one and all. This work will be taken forward and more information will be added, the focus will be dominantly on Indian landscape, but will also cover some of the Global scenarios.

A glimpse of the web-portal (https://ppprnd.puchd.ac.in) is as follows:



Activity 3: A Study on 'Stimulation of Private Sector Investments in R&D: A Global Comparison'

All innovative nations provide a pool of incentives to the private sector, especially MSMEs, for enhancing their R&D activities. A study was conducted to understand various incentives (tax incentives & financial support) prevalent in USA, UK, Japan, S. Korea, Israel, Taiwan, Germany, France, Finland, Ireland, Netherlands, Sweden, Switzerland, Canada, China, Singapore and Australia, in order to draw lessons for India. The R&D incentives implemented in these countries are summarized below.

R&D Incentivization followed by Select Innovation Based Countries

S. No.	Country	Funding Support	R&D Tax Credit	R&D Tax Deduction	Vol. based	Increm-ental based	Refun-dable	Carry Forwa-rded	Preferential Tax Incentives		Patent Box
									SMEs	Collab. Res.	
1.	Australia	√	√	n.s.	√	×	√ (SMEs)	√	√	×	×
2.	Canada	√	√	n.s.	√	×	√ (SMEs)	√	√	×	×
3.	China	√	n.s.	√	×	×	×	×	×	×	√
4.	Finland	n.s.	×	×	×	×	×	×	×	×	×
5.	France	√	√	n.s.	√	×	√	√	√	√	√
6.	Germany	√	×	×	×	×	×	×	×	×	×
7.	India	× (limited)	n.s.	√	√	×	×	√ (loss)	×	×	√
8.	Ireland	√	√	n.s.	√	×	√	√	×	×	√
9.	Israel	√	n.s.	√	×	×	×	×	×	×	×
10.	Japan	√	n.s.	n.s.	√	√ (R&D intensity)	×	×	√	√	×
11.	Netherlands	√	n.s.	n.s.	×	×	×	×	×	×	√
12.	S. Korea	√	√	n.s.	×	√	×	√	√	×	√
13.	Singapore	√	n.s.	√	×	×	×	×	×	×	×
14.	Sweden	×	×	×	√	×	√	×	×	×	×
15.	Switzerland	√	×	×	×	×	×	×	×	×	×
16.	Taiwan	√	√	√	√	×	n.s.	n.s.	√	n.s.	√
17.	UK	√	√	√	√	×	√ (SMEs)	√	×	×	√
18.	USA	√	√	n.s.	×	√	√ (start-ups)	√	√	×	√

Source: OECD Compendium of R&D Incentives (2016, 2017); PWC (2017), Deloitte Touche Tohmatsu Limited (2017, 2018); n.s: not specified; SMEs: Small and Medium Enterprise

The data is compiled and presented as a chapter in DST-CPR's book entitled 'Public Private Partnership for R&D…. a global perspective' ISBN: 978-93-85046-68-1, published by Studium Press Ltd., New Delhi.

Recommendations:

1. **Introducing Tax Reforms**

   Enhancement of private sector 'R&D Tax Incentives' on the following lines – a) Graded Tax incentives as per scale of the industry, as is being practised by S. Korea, US, UK and Japan; b) Special Tax Incentives for I-A Collaborative Research (Japan and Singapore); c) Target Based Tax Incentives (US and China); d) Tax Incentives for Venture Capitalists (China); e) Tax

Incentives on Incremental R&D (US and Japan); f) Development and Expansion Incentives (Singapore); and g) Commercialization Incentives (Singapore)

2. **Introduce 'Innovation Vouchers/Cheques'**

   On the lines of 'Innovation Voucher' schemes of countries like Ireland, Finland and UK, scheme of Innovation Vouchers may be introduced in India. Such Vouchers are availed by the private sector, especially SMEs, to engage with public research institutes for initiating research collaborations.

3. **Creation of Innovation/Technology Hubs for SMEs**

   In order to boost the innovation ecosystem of financially starved industries, funding agencies, in association with M/o MSME, may set up sector agnostic 'Innovation/Technology Hubs for SMEs' at select PRIs, preferably in close proximity to the MSME clusters, under PPP mode.

4. **Institution of a 'Fast Track R&D Fund'**

   Many R&D problems of micro and small industries can be solved by incurring relatively small amount of money, i.e. less than one or two lakh Rupees. However, starvation of finances as well as reluctance of applying for government funds (lengthy paper work and too much time taken for disbursement of funds) preclude the industries for seeking such funds. To overcome this predicament, it is proposed that funding agencies like DST may institute 'Fast Track R&D Fund' for addressing industrial R&D issues requiring small amount of funds. These funds could be transferred to the industries (or partnering university) within a month's time after the receipt of research proposal.

5. **Incentivizing Schemes for Industries**

   Government may introduce incentivization schemes (cash or kind) encouraging industries to set up research laboratories/R&D skill Centres in PRIs. The extent of incentivization may vary depending on the financial commitment of the industries for establishing Industrial Labs@PRIs.

6. **Creation of Industry Research and Development Group (IRDG)**

   Ireland has IRDG comprising of industries engaged in R&D. Such a group advises the government on the needs and reforms needed to promote innovation in Ireland industries. Such domain specific groups may be created in India.

Activity 4: Commercialization of Patents Granted to HEIs and NRLs of India

Period of the Study: January 2010 - December 2017

In the previous exercise, DST-CPR had conducted a study on research articles publications and patents (granted & filed) status of 904 institutions. The study can be accessed from the official website of the Centre. (http://cpr.puchd.ac.in/wp-content/uploads/2016/09/Book-2-PDF-min.pdf). Further it was advised by the 'Advisory Committee (IP)' to conduct a study on commercialization status of patents granted to the Indian HEIs and NRLs. To achieve this the Centre collected information regarding working and non-working status, licensees, reasons mentioned for not working of patent, etc. from the official website of Indian Patent Office and analyzed the collected patent information.

The study is mainly based on the patents commercialization ecosystem of Indian HEIs and NRLs for a period of 8 years, from January 2010 to December 2017. Institutions (904) considered for the study include HEIs (351) and all national R&D institutions (553). The HEIs comprise of Institutions of National Importance (INIs), universities, engineering institutes, pharma institutes and private universities, based on the NIRF rankings released in 2016. The national R&D labs, included in this study, have been established under 27 ministries of Govt. of India and 2 independent departments under the Prime Minister's office**.**

This study has been compiled based on the 'Working Statements' filed by the patentee/assignee at Indian Patent Office, in the prescribed Form-27 of the Indian Patents Act, 1970. Information was collected regarding working and non-working status, revenue generated after commercialization, licensees, and reasons mentioned for non-working of patent, etc. from the official website of Indian Patent Office (https://ipindiaservices.gov.in/publicsearch) and the data points were analysed. The main purpose of the study was to identify the institutes having remarkable patent commercialization ecosystem and the reasons behind the non-working of the patents. A total of 1961 patents were granted to 186 institutes (from 904 institutions), for the duration of the study.

The institutions are categorized into HEIs, NRLs and Others (Industry/PSU/Board/Council/Hospital) and the breakup is shown in Figure 1 below.

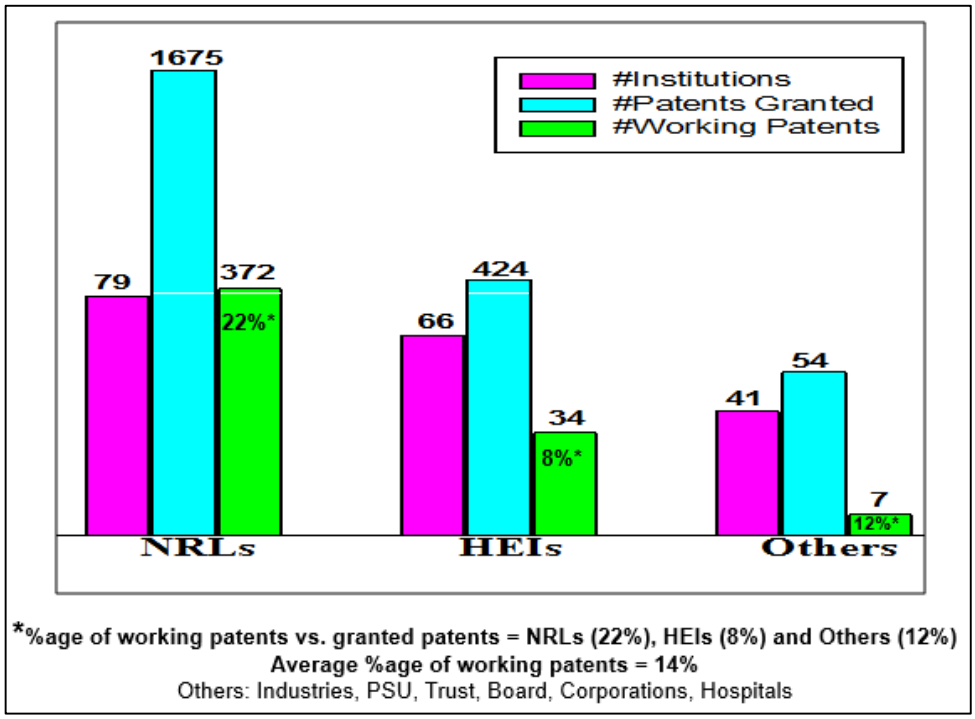


Figure 1: Categorization of the Institutions having granted & working patents

The top 10 institutes with the maximum count of patents for the duration studied, is shown in the Figure 2 below.

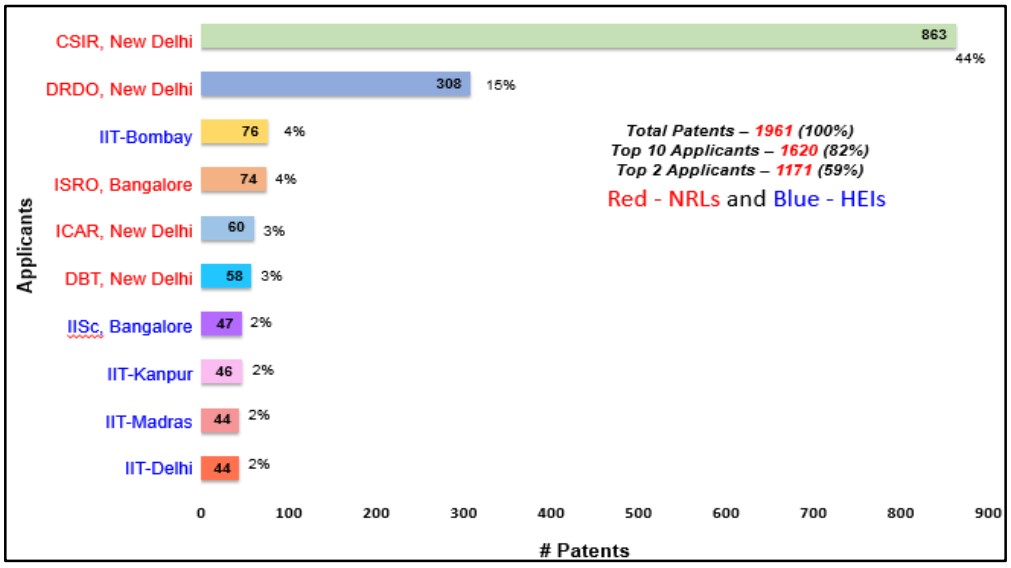


Figure 2: Top 10 institutes with maximum granted patents (Jan. 2010 – Dec. 2017)

Field Wise Analysis: The patents were further categorized based on the field they belong to, such as Chemical Sciences, Engineering, Pharma/Drugs, Food/Agriculture, Biotechnology, Physics, Medical Science, etc. as shown in Fig. 3 below:

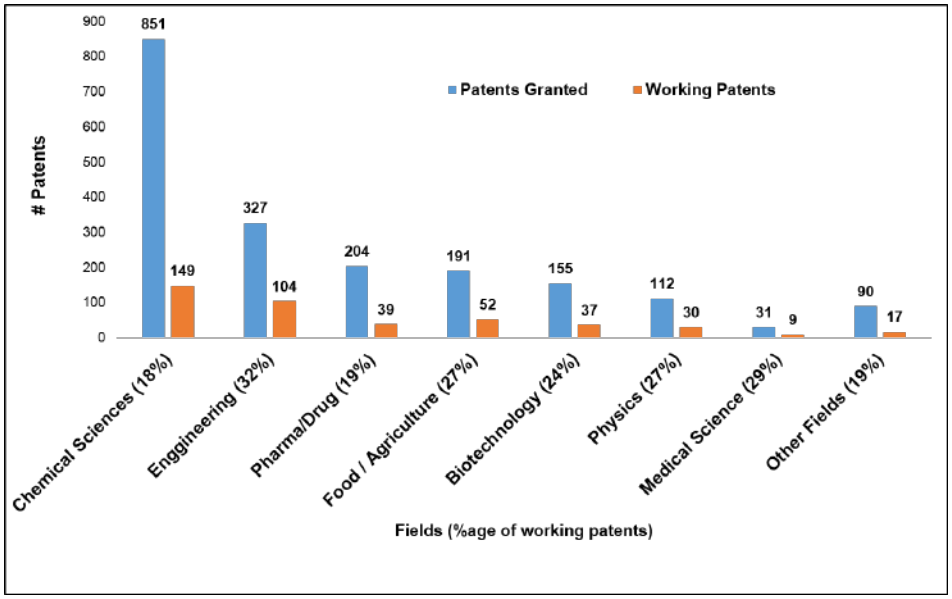


Figure 3: Field-wise Breakup of Total Patents (Jan. 2010 – Dec. 2017)

The year-wise trend of patents based on the working statements filed in the Patent Office is depicted in the Figure 4 below.

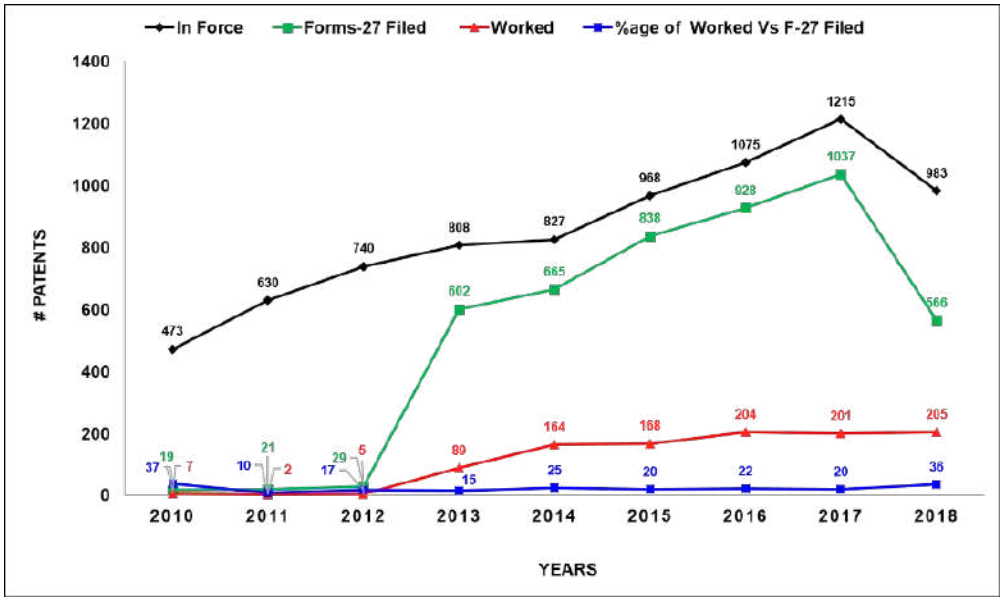


Figure 4: Year-wise Trend of Patents Granted (In Force/Worked/ filing of Form-27), (2010 – 2018*)

**Period: Information from Form-27 for the patents has been extracted for the period 2010-18*

The most common reasons provided by the patentees for the non-working patents are illustrated in Figure 5 below.

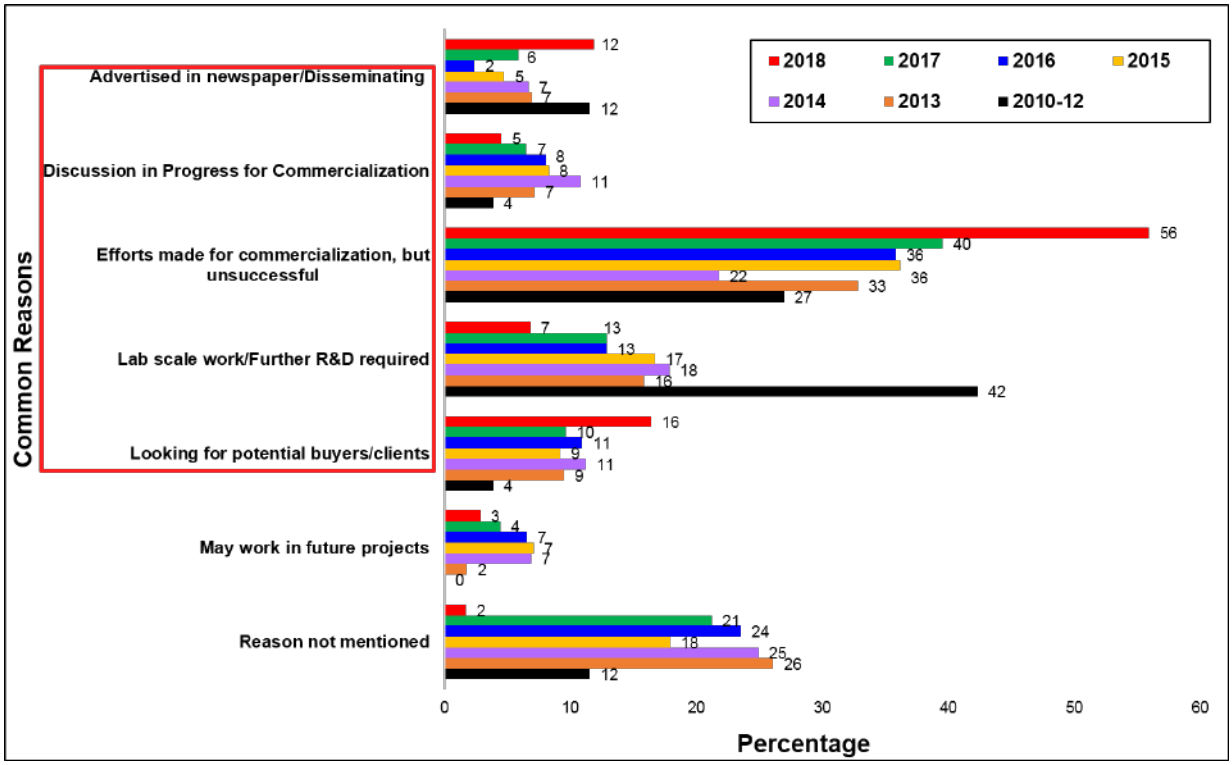


Figure 5: Common Reasons for Non-Working Patents

Recommendations: The outcome of the study also resulted in some recommendation for enhancing patent commercialization in India. A few of the recommendations are mentioned herein below:

- Indian researchers and scientists should be made patent savvy. Creation of 'Patent Cells' in research oriented institutes. These PCs should work with state PICs via hub and spoke model.
- MHRD (AICTE and UGC) should have dedicated patent/technology commercialisation cells.
- Emphasis on TRL of Technologies prior to engaging with industry.
- Incentivisation of individuals who successfully execute technology commercialisation. *(BIRAC Model, Gandhian Young Technological Innovation - SRISTI Awards).*
- Awareness should be made about 'Compulsory License' and should be practiced on a serious mode. Mandatory but not being followed.
- Technologies not up to mark. Not industry ready. TRL should be accessed.
- Creation of an 'Indian Patent Trust System' to deal with ceased or lapsed patents and Non-working patents as in S. Korea.
- Creation of a 'National Patent Web Portal' to disseminate existing technologies
- Patents and Technology fair should be organised to increase patents commercialization ecosystem, national and state wise.
- A clause may be added in the Form-27 to ask patentee about specific requirements and potential industry which can take up that patent. CGPDTM should establish a dedicated cell to look after Form-27 filing issues or CIPAM can take up this responsibility.

- Form-27 needs modifications and should be strictly adhered to.
- Reasons for not commercialisation of patents as mentioned in the Form-27 should be looked into.-seriousness

Activity 5: Comprehensive Roadmap for Strengthening R&D Ecosystem of India via PPP Model

PPPs in research and innovation are conceived as legal relationships or agreements over fixed-term/indefinite period of time, linking public and private actors e.g. industry, universities, public research/technology institutions, entrepreneurs, etc., where both sides interact in the decision-making process, and co-invest scarce resources such as money, personnel, facility, and information in order to achieve specific joint objectives in research and innovation. In other words, PPPs provide a legal structure to pool resources and gather critical mass, which enables a scale of effort that individual firms would not be able to achieve in spite of strong funding for firm innovation. The partners share risk, reward, and responsibility for shared investments. The fundamental rationale of most PPPs in research and innovation is to leverage broader economic and social benefits from joint investments to accelerate innovation and technological solutions to address key challenges of the economy and societal wellbeing.

For governments, PPPs are an attractive tool to address both market and coordination failures in research and innovation activities and leveraging private investment in STI activities. For business, partnering with public research can help solve problems, develop new markets or generate value through co-operation and co-production.

PPPs effectuate enhanced innovation capabilities, availability of multi-disciplinary expertise, better accordance within the national innovation system, and provision of fitting incentives to the stakeholders, amongst other accouterments. Across the world, varied modalities of PPPs in R&D are being practiced, such as collaborative research programmes, technology/research centres, industrial set-ups in universities, assistance to SMEs, innovation procurement, technology extension and commercialization programmes, amongst others.

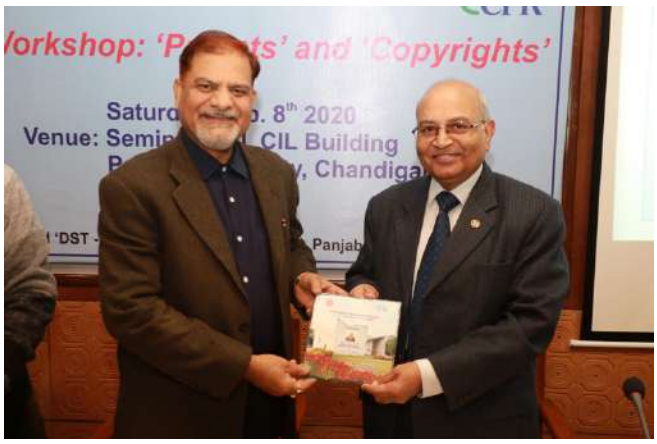
Through a study on “Public Private Partnerships in STI”, being practiced worldwide attempts have been made to understand the mechanisms involved that have impacted several nations. Through the study of initiatives taken in foreign countries, models and lessons that can be adapted to the Indian scenario have been identified. The recommendations consist of elements captured from varied

programmes, which will be of great interest to collaborators, government agencies/organizations, policy makers and other stakeholders of the STI ecosystem of developing nations.

The ‘Suggestive Roadmap for Strengthening R&D Ecosystem through PPP’ especially for developing countries based on best practices from all over the world has been incorporated as a chapter in the book entitled “Public Private Partnerships (PPP) in R&D….a global perspective” ISBN: 978-93-85046-68-1, published by Studium Press (India) Pvt. Ltd.

Meetings Organized by the Centre (2019-20)

- **One-day Workshop on 'Patents' and 'Copyrights'**, held on February 8th, 2020 at Seminar Hall of Department of SAIF/CIL, Panjab University, Chandigarh



Prof. Raj Kumar (VC, PU, Chd.) facilitating Prof. SK Jain (Atal Bihari Vajpayee School of Management & Entrepreneurship, Jawaharlal Nehru University, New Delhi) as key note speaker of the workshop.

L to R: Prof. Rupinder Tewari (Coordinator, DST-CPR, PU, Chd.), Prof. Raj Kumar (VC, PU, Chd.) and Prof. SK Jain (Atal Bihari Vajpayee School of Management & Entrepreneurship, Jawaharlal Nehru University, New Delhi) on the dais.

- **'Roundtable Meet' entitled Challenges in Technology Commercialization**, held on February 1st, 2020 at Seminar Hall of Department of SAIF/CIL, Panjab University, Chandigarh

To strengthen the innovation ecosystem of India, DST-Centre for Policy Research (CPR) at Panjab University (PU), Chandigarh in collaboration with Chandigarh Region Innovation and Knowledge Cluster (CRIKC) organized a 'Roundtable-Meet' entitled CHALLENGES IN TECHNOLOGY COMMERCIALIZATION' on Saturday, February 1, 2020 in Panjab University, Chandigarh. The technology experts from 15 CRIKC member institutes deliberated on the gaps existing in technology commercialization and also suggested solutions to most of these challenges (Annexure II).

L to R: Prof. Rupinder Tewari (Coordinator, DST-CPR, PU, Chd.), Prof. Raj kumar (VC, PU, Chd.), Prof. R K Sinha (Director, CSIR-CSIO, Chd.) and Prof. Shyam Sundar Pattnaik (Director, NIIITR, Chd.) on the dais.

Prof. Raj kumar (VC, PU, Chd.) facilitating Prof. R K Sinha (Director, CSIR-CSIO, Chd.) key note speaker of the event.

- **Hands-on Training in Patent Search and Filing**, held on September 29, 2019 at Seminar Hall of Department of SAIF/CIL, Panjab University, Chandigarh

L to R: Ms. Amandeep Sandhu (Scientific Officer, DST-CPR, PU, Chd.), Ms. Mamta Bhardwaj (Sr. Scientist C, DST-CPR, PU, Chd.), Prof. Rupinder Tewari (coordinator, DST-CPR, PU, Chd.), Ms Divya Kaushik (Scientist C, PSCST, Chd.) and Ms Sangeeta Manohar (Patent Agent) interacting with the audience.

Ms Divya Kaushik (Scientist C, PSCST, Chd.) delivering lecture on IPR.

- **4th Advisory Committee Meeting,** held on July 13, 2019 at TIFAC, A' Wing, Vishwakarma Bhavan, Shaheed Jeet Singh Marg, New Delhi


Meeting deliberations between experts during 4th IPR Advisory Committee Meeting

- **Pre-Screening Meeting of Agro-Tech Proposals** under Technology Development Transfer Programme, DST, GoI, held on July 11-12, 2019 at IIT Delhi


DST-TDP Agro expert working groups pre screening Research proposals

- **5th Workshop on Management of Biomass (Agri-waste and Municipal-waste) into Bio-resources**, held on April 23rd, 2019 at Seminar Hall of Department of SAIF/CIL, Panjab University, Chandigarh

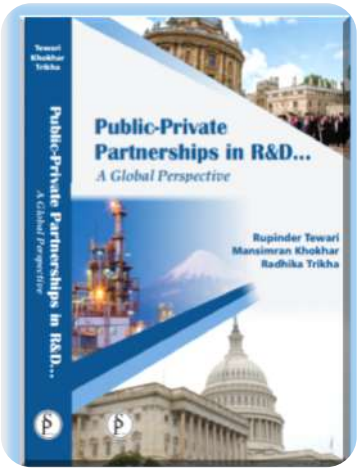
L to R: Prof. Shankarji Jha (Dean of University Instructions, PU, Chd.), Mr Suresh Kumar (IAS, Chief Principal Secretary to Chief Minister (Punjab)), Prof. T R Sharma (Fmr. Exe. Director NABI), Prof. Rupinder Tewari (Coordinator, DST-CPR, PU, Chd.) and Prof. S S Marwaha (Chairman, PPCB, Patiala)

L to R: Dr. Anita Agarwal (Scientist E, DST, GoI), Dr. M H Mehta (Chairman, Gujarat Life Sciences, Ahmedabad.), Prof. Shankarji Jha (Dean of University Instructions, PU, Chd.), Mr Suresh Kumar (IAS, Chief Principal Secretary to Chief Minister (Punjab)) and Prof. S S Marwaha (Chairman, PPCB, Patiala) interacting with the audience.

Publications of the Centre (2019-20)

A: Book Publication

1. "Public Private Partnerships (PPP) in R&D….a global perspective" ISBN: 978-93-85046-68-1, published by Studium Press (India) Pvt. Ltd.



B: Research Publications

1. Radhika Trikha and Rupinder Tewari. (2019). **Invigorating Government Mediated R&D Incentivization of Private Sector in India**. Proceedings of the 'International Conference on Innovation Driven Economic Growth in Asia Focusing on India.
2. Mamta Bhardwaj, Amandeep Sandhu and Rupinder Tewari. (2019). **Research Publications and Commercialization of Patents Generated by the Academic and Research Sectors in India** Proceedings of the 'International Conference on Innovation Driven Economic Growth in Asia Focusing on India.
3. Mamta Bhardwaj and Rupinder Tewari. (2020) **"Research Profile of Indian Higher Education Institutions"** submitted for publication in International Journal for Multi Disciplinary Engineering and Business Management (Communicated).
4. Mamta Bhardwaj and Amandeep Sandhu. (2020). "**A Study on Working/Non-working Status of Patents Granted to HEIs and NRLs of India"** submitted for publication in "Current Science" (Communicated).
5. Mamta Bhardwaj and Amandeep Sandhu. (2020). **"Significance of Patents Licensing for Enhancing Translational Research Ecosystem in India" submitted** for publication in "Current Science" (Communicated).
6. Mamta Bhardwaj, Amandeep Sandhu and Navkiran Ghumman. (2020). **"Patent Commercialization Profile of Top Performing Indian HEIs"** submitted for publication in "Current Science" (Communicated).

Outreach Activities

- International Interdisciplinary Conference, ICONICA-2020, on 'Next-Gen Paradigms in Health Care' held from 13-14th February 2020, at Panjab University.
- International Conference on 'Innovation Driven Economic Growth in Asia Focusing on India' held from 27 -29th November 2019, at Goa University.
- One-week workshop 'Science, Technology, Innovation (STI) Policy for Turbulent Times' held on June 17-21, 2019, at University of Sussex, UK.
- Workshop on 'Bio-entrepreneurship avenues for innovation' held on 12th April 2019, at Institute of Microbial Technology (CSIR-IMTECH), Chandigarh.

Other Activities carried out by the Centre (2019-20)

a) Upon request from UGC, GoI a draft of '**University-Industry Linkage Programme**' was prepared by Prof. R Tewari and submitted to UGC in April 2019 (Annexure III). Subsequently, the UGC constituted a Working Committee, for vetting of the draft. Prof. Tewari was member expert of the Working Committee.

b) **Course drafted**

- Foundation Course on Intellectual Property Rights (IPR) for UG and PG students, and Ph.D. research scholars in PU, Chd.

c) **Panel expert**

- Expert Member of the committee set up for establishing 'DST-Technology Enabling Centres (TECs)' in the Indian Universities.
- Programme Advisory Committee (PAC) meeting for Agro-Technology Development Projects under Technology Development Programme of DST.
- Industry Academia Expert Group Meet of Department of Science and Technology (DST), Government of Rajasthan held on 17th Feb. 2020 at BISR, Jaipur.

d) **Proposals drafted and submitted**

- Funding Proposal for establishment of 'University Institute of Intellectual Property Rights' at Panjab University, Chandigarh to DPIIT, Ministry of Commerce and Industries, GoI, New Delhi.

e) **Awards/Recognition**

- Prof. Rupinder Tewari was awarded 'IPR Chair Professor' by DPIIT, Ministry of Commerce and Industries, GoI, New Delhi.
- Outstanding Reviewer Award-2019 by Emerald Publishing Limited to Ms Mamta Bhardwaj, Sr. Scientist C, DST-CPR at PU, Chd.

f) Coordinated the visit of a **7-member delegation to University of Sussex, UK** for one-week workshop 'Science, Technology, Innovation (STI) Policy for Turbulent Times' held at University of Sussex, UK from June 17-21, 2019. (Annexure IV).

g) **Chairing a Session (International Conference)**

- Moderator and delivered a talk in the Session 'Future of SME & Startup Ecosystem' in the ASIP 9th Conference – Technology and Innovation for SMEs held in University of Philippines, Quezon City, Diliman, Philippines from Oct. 3-5, 2019.

- Moderator and delivered a talk in 'Second Sino-India Dialogue on Science, Technology and Innovation (STI) Policies' held in Chinese Academy of Science and Technology for

Development (CASTED), Beijing, from December 16th – 18th, 2019.

h) **Talks/Lectures Delivered**

- National Workshop on Leadership for promoting ethics and morality in research held on March 5th, 2020 at Panjab University, Chandigarh. Topic: Role of Intellectual Property Rights in Research.
- International Conference on 'Innovation driven economic growth in Asia focusing on India' held on 27th-29th November, 2019, at Goa University. Topic: Commercialization of Patents Granted to HEIs and NRLs of India (Jan. 2010 – Dec. 2017); Mapping of Patents & Research Publications of HEIs and NRLs; Invigorating Government Mediated R&D Incentivization of Private Sector in India.
- Indian School of Business (ISB)-Mohali (August 2019); Topic: Role of Industry-Academia Interactions in National S&T Ecosystem.
- Indian Technical and Economic Cooperation (ITEC) training program on Biopharmaceuticals in NIPER, Mohali (28 Aug. 2019); Topic: Strengthening Industry-Academia R&D Regime in Developing Countries.
- Society for Promotion of Science, Technology and Innovation (18 May 2019); Topic: Industry-Academia R&D Ecosystem in India.
- IPR workshop organized by Department of Pharmaceutical Science, PU, Chd. (9 April 2019); Topic: Industry- Academia R&D schemes for HEIs.

i) **Professional Development Programmes undertaken by the Scientific Staff**

S. No.	Course	Employees
1.	World Intellectual Property Organization (WIPO) Advanced Courses (DL 301 Patents; DL 450 Intellectual Property Management)	Dr Mansimran (DST-STI-PDF), Dr Radhika (Sr Scientist D), Ms Mamta (Sr Scientist C)
2.	Post Graduate Diploma in Intellectual Property Rights (IPR) under Indira Gandhi National Open University (IGNOU), New Delhi.	Dr Mansimran (DST-STI-PDF) and Ms. Amandeep Sandhu (Scientific Officer)
3.	ST201x: Managing Innovation from Indian Institute of Management Bangalore	Dr Radhika (Sr. Scientist D)

DST-CPR Staff

S.No.	Name	Designation
Coordinator: Prof. Rupinder Tewari		
1.	Dr. Radhika Trikha	Sr. Scientist D (At Present: DST-STI-Senior Policy Fellow)
2.	Dr. Mansimran Khokhar	DST-STI-Post Doctoral Fellow
3.	Ms. Mamta Bhardwaj	Sr. Scientist C
4.	Ms. Sukriti Paliwal	Scientific Officer
5.	Ms. Amandeep Sandhu	Scientific Officer
6.	Mr Rohan	Data Entry Operator
7.	Mr Ravi	Cleaner cum Helper

Future Activities (Work Plan 2020-21)

We can add the detailed research proposals even

Objective 1: Mapping Innovation (R&D) Effectiveness of DST funded State S&T Councils (Northern Region)

Objective 2: Linking Industry Associations, DICs, PCBs and S&T Councils with the Academic Sector

Objective 3: Assessing R&D Ecosystem of Select Higher Education Institutions (HEIs) of India.

Objective 4: Developing a Comprehensive 'Public Private Partnership in R&D' Web-portal.

Objective 5: Drafting 'IPR Toolkit' for Universities and Higher Education Institutes of India.

Annexure I

सत्यमेव जयते
Department of Science & Technology
Govt. of India

DST CPR

A Case Study on

Biotechnology Industry Research Assistance Council (BIRAC)….. India's Prototype for PPP in R&D

Study Carried Out by

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EXECUTIVE SUMMARY

Biotechnology, a relatively recently acknowledged field, has disruptively revolutionized the international industrial landscape. Biotechnological innovations have dramatically transformed the socio-economic framework worldwide, with Biotech-hubs mushrooming in concentrated areas of the American, European and Asia-Pacific region. Indian Biotechnology industry, comprising majorly of SMEs and start-ups, ranks 12th globally, and contributes 3% of the global share, making it one of the most promising Bio-economies in the world. Having acknowledged this potential, it was vital to institute a mechanism that would constantly support these young enterprises and in turn, consistently deliver new Bio-innovations. Hence, DBT, GoI, in 2012, taking inspiration from the American and Canadian programmes, took a landmark decision of instituting BIRAC, a Section 8, not for profit Public Sector Enterprise, to further boost the Indian Biotech sector.

BIRAC functions through a dynamic set of schemes and programmes that not only associate young entrepreneurs and researchers with scientific experts, but also offers stage-specific support throughout the innovation cycle. It promotes academic entrepreneurship through incubation schemes such as BioNEST and UICs, with the establishment of Bio-incubators and pre-incubators in the academic set-up.

Further, its schemes, BIG, SITARE and eYUVA are dedicated to supporting 'Ideation to Early Stage' of the innovation cycle, where the innovation is still in its preliminary stages of development. BIRAC, through its two industry-specific PPP schemes, SBIRI and BIPP supports all innovations of the private sector that fall in the 'Ideation to Late stage' of the innovation cycle, thus effectively stimulating the private sector R&D. It facilitates early translation of innovations at the 'PoC to late stage' through its ETA scheme and supports translation of academic research through the PACE scheme. Apprehending the uncertain nature of the phase right after a start-up commences commercialization of its technology/product (also known as 'Valley of Death'), BIRAC has instituted a set of equity funds such as, SEED Fund, AcE Fund, LEAP Fund and Product Commercialization Fund to bring the start-ups to a point where they can sustain themselves.

Ever since its inception, BIRAC, has placed networking as one of its principal agendas and connected extensively with the various stakeholders of the innovation ecosystem. It not only

enjoys a pan-India presence but has left its mark globally, through a number of strategic national and international partnerships. It has nationally associated with organizations like TISS, IAN, TiE-Delhi, ICMR, LEHS-WISH and MeitY and initiated a number of sector-specific programmes. In order to promote region-specific growth, BIRAC has established four regional centres (BRIC/BREC/BRBC/BRTC), each catering to a different domain of innovation. BIRAC has also associated internationally with organizations like Wellcome Trust, CEFIPRA and BPI France, USAID, Nesta, BMGF, UKTI, TEKES (now Business Finland), QUT and World Bank, to resolve a number of national and international socio-economic issues through biotechnological interventions. It promotes social entrepreneurship through its schemes, SIIP and SPARSH.

BIRAC has a number of auxiliary bodies such as, Policy and Analysis Cell, Intellectual Property Management and Technology Commercialization Unit, FIRST-Hub and Make in India Facilitation Cell that are detailed to assist it in a specific manner. It further has a Technology Portal that showcases all the technologies/products developed with the assistance of BIRAC, for connecting them to potential consumer industry.

BIRAC is built upon a number of strikingly essential characteristics that have contributed immensely to its success. The most extraordinary characteristic of BIRAC, is its dynamic framework of schemes and programmes that comprehensively support each stage of the innovation cycle, right from ideation to commercialization. Also, most BIRAC schemes work on the PPP model, ensuring active participation by the private sector, which has been one of the greatest challenges for the country. Thus, BIRAC is the quintessential PPP Prototype for the country, for it has not only done the impossible, but has achieved it in the most impressive manner.

1. INTRODUCTION

Technological innovations are a vital determinant that drive and sustain long term economic growth of a country. Countries that have been able to keep up with socio-economic demands through innovation fostering policy responses have matured into developed economies. Biotechnological innovations, have been a key player in this process. Due to their disruptive potential, they have revolutionized the global economic landscape.

The latter part of the 20th Century saw an exponential rise in the Biotech sector. Biotech hubs have mushroomed in concentrated areas of the American continent (USA, Mexico), European continent (UK, Germany, Spain, France and Belgium) and Asia-Pacific region (Korea, Japan, China). The last 10 years have seen persistent acceleration in the Global Biotech Industry, which achieved a revenue of US$399bn and growth of 2% in 2017. It is further projected that the industry is all set to overshoot an estimated value of $775bn by mid-2020s.

Indian Biotech industry is the rising star of Bio-economies, presently ranked at 12th position, globally with a strong hold in pharmaceuticals and vaccines. In 2018, it was valued at US$45bn, with a share of 3% in the Global Biotech industry, comprising of close to 800 companies with an average growth rate of 20% over a period of 2005-2017. A large proportion of these Biotech companies are Small and Medium sized enterprises. The SMEs usually, have high innovative potential but low financial bearing. This results in most of them falling prey to the 'valley of death'. On the contrary, academia has no dearth of funds but is apprehensive to commercialize its research. These issues were realized and addressed by the government, which instituted a dedicated body in 1986 catering to the Biotechnology sector, known as Department of Biotechnology. It was also appreciated that innovation and its commercialization, specifically in the field of Biotechnology, could only be promoted through effective stimulation of Industry-Academia (I-A) collaborations in the country. Thus, DBT formulated National Biotechnology Development Strategy in 2007 and declared allocation of 30% of its budget for Public Private Partnership (PPP) via creation of a dedicated entity that would execute and implement PPP. Taking inspiration from the American and Canadian PPP R&D programs, a dedicated PPP R&D program, Biotechnology Industry Research Assistance Program (BIRAP) was launched in India in 2009 to support the Indian Biotech Sector. In 2012, BIRAP graduated to a Section 8, 'Not for Profit' Public Sector Enterprise called Biotechnology Industry Research Assistance Council (BIRAC).

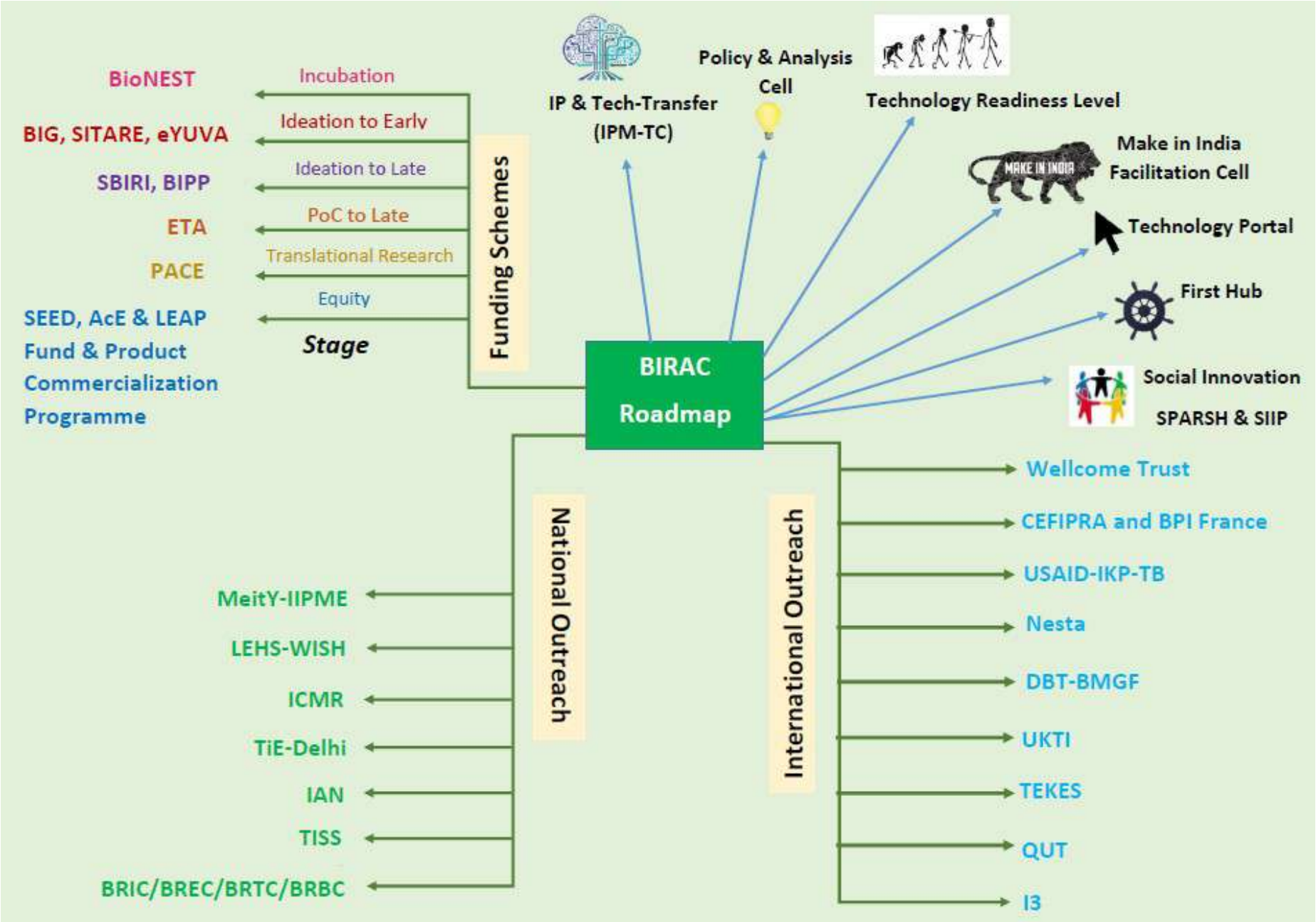


Fig 1. Functional Blueprint of BIRAC

(For Abbreviations Refer to Appendix 1)

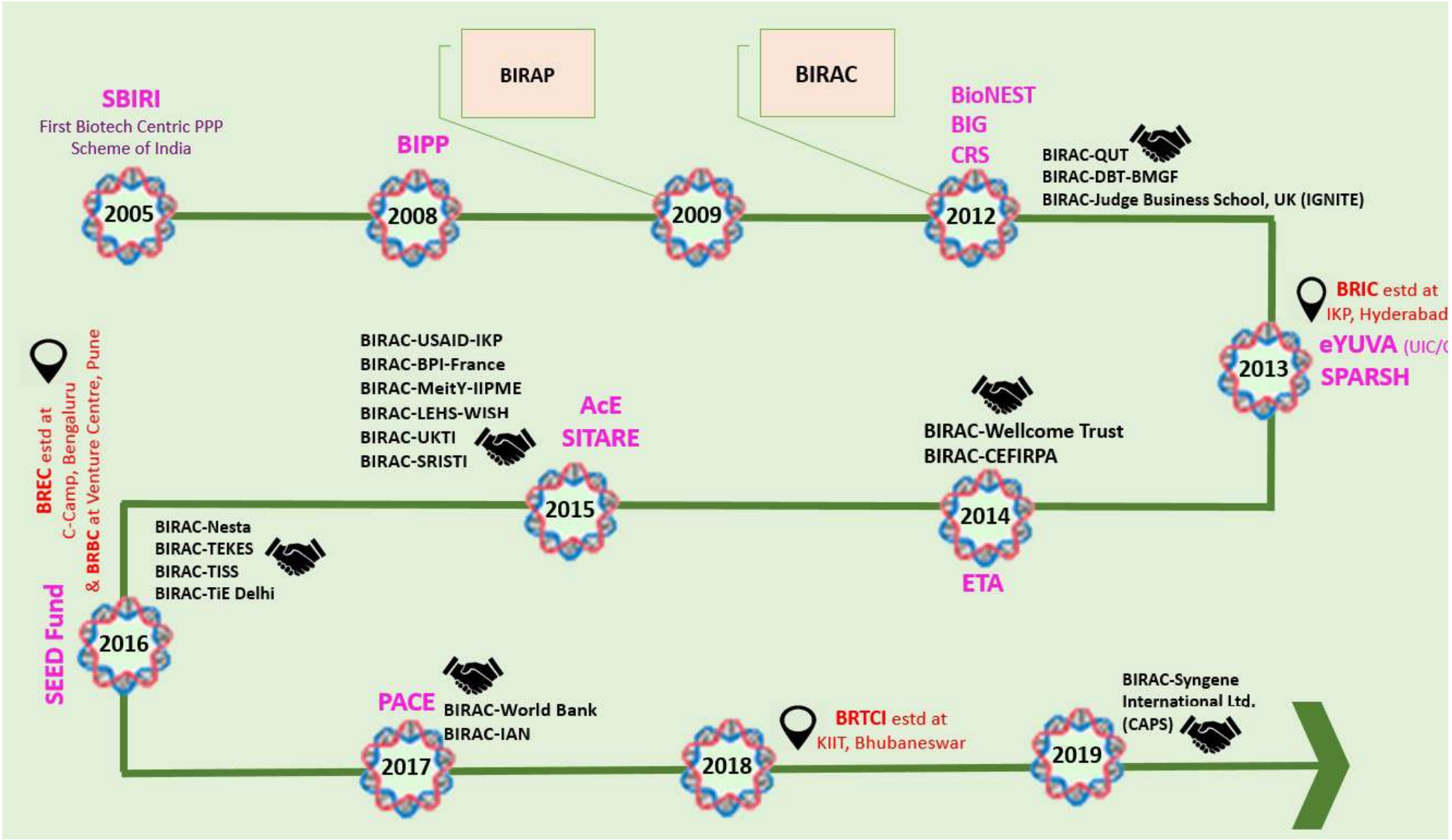


Fig 2: BIRAC's Timeline

Figure Legends: **- BIRAC's Regional Centre;** **- BIRAC Schemes;** **- BIRAC Collaborations**

(For Abbreviations Refer to Appendix 1)

2. BIOTECHNOLOGY INDUSTRY RESEARCH ASSISTANCE COUNCIL (BIRAC)

BIRAC is an autonomous, not-for-profit organization that is a Section 8, schedule B, public sector enterprise registered under the Companies Act, 2013. It is an exclusive I-A interface agency, that caters to national societal needs and works strategically to promote R&D activities related to biotechnology, thus making the enterprises in this sector globally competitive.

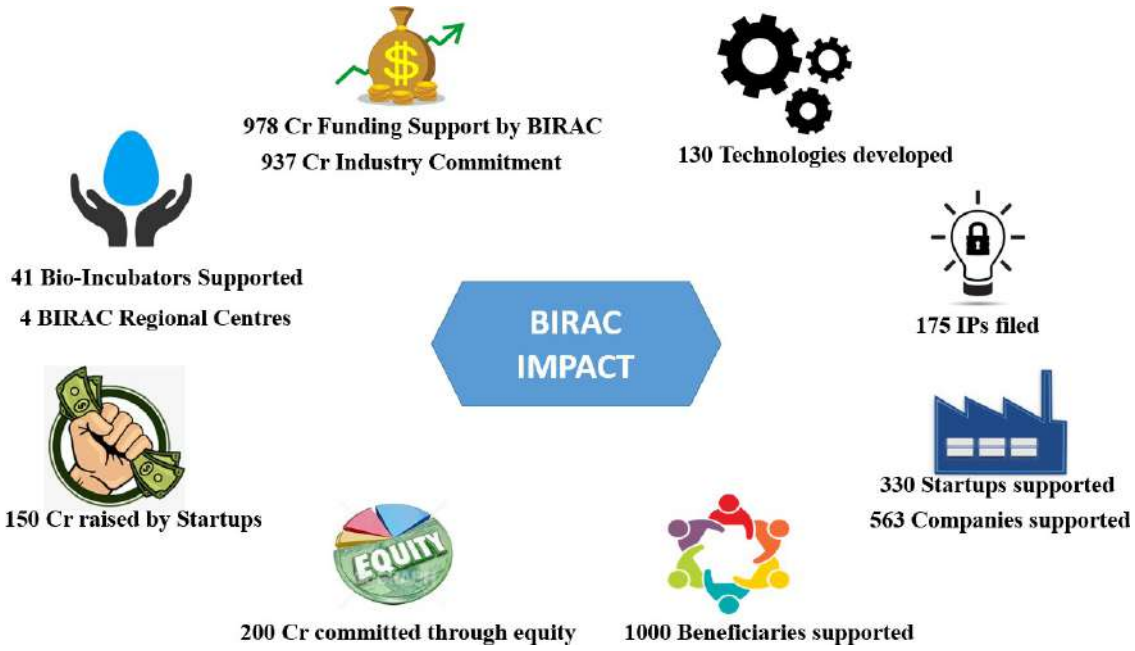


Fig 3: BIRAC Impact

The primary agenda of BIRAC is to *"stimulate, foster and enhance the strategic research and innovation capabilities of the Indian biotech industry, particularly start-ups and SMEs"* and has successfully lived up to it. BIRAC has been an active player in the innovation ecosystem of the country, and anchors itself on the PPP model. By 2019, BIRAC has successfully assisted 336 Start-ups in kick-starting their entrepreneurial journey that has resulted in an economic gain of over ₹ 859 Cr (Fig 3). BIRAC has been able to achieve this through a robust administrative and organizational structure and a spectrum of schemes customized according to the innovation cycle. These schemes have been elaborated in Section 2 and 3.

2.1 Organization and Governance of BIRAC

The governing body of BIRAC is headed by the Chairman (Secretary of DBT) and Managing Director along with Director (Finance) and Director (Operations) and four non-executive independent directors. (Fig 4).

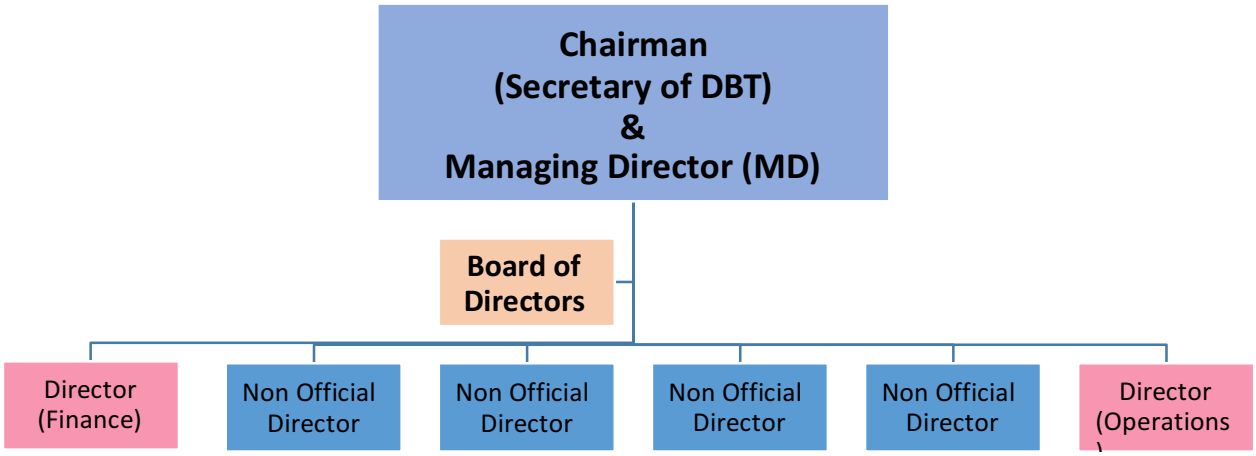


Fig 4: Administrative Framework of BIRAC

(Source: http://www.birac.nic.in/webcontent/RTI_10_05_2018.pdf)

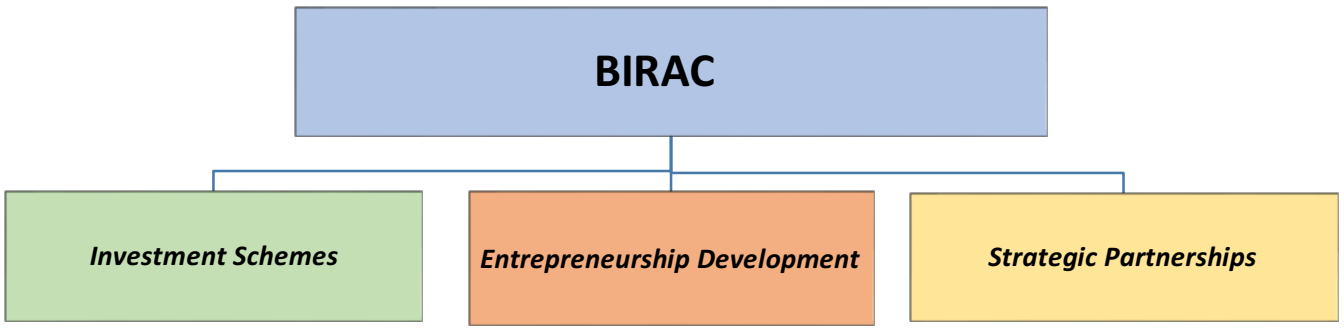


Fig 5: Functional Framework of BIRAC

(Source: http://www.birac.nic.in/webcontent/RTI_10_05_2018.pdf)

BIRAC is functionally organized to work under three verticals i.e., Investment Schemes, Entrepreneurship Development and Strategic Partnerships, each having a designated function. *Investment Schemes* that provide assistance to academia, entrepreneurs, Startups, SMEs and Biotech Companies at all stages. *Entrepreneurship Development* is not only engaged in

providing financial assistance to budding entrepreneurs but is providing the right infrastructure, mentoring, licensing, IP, regulatory guidance and networking for technology transfer. *Strategic Partnership group* involves national and international collaborations inclusive of the Government departments and Ministries (both Central and State), industry organizations, international bilateral agencies, philanthropic organizations and corporate sector. Its main aim is to channelize and make provisions for the resources and leave global footprints through its activities.

3. BIRAC PANORAMA

BIRAC has a dynamic framework of schemes and programs that comprehensively cover every stage of innovation process, right from ideation to commercialization (Fig 6). This has widened the scope of services offered by BIRAC, thereby serving a much larger pool of stakeholders. In figure 5, the schemes have been elaborated, in the order of the stage where the support is provided.

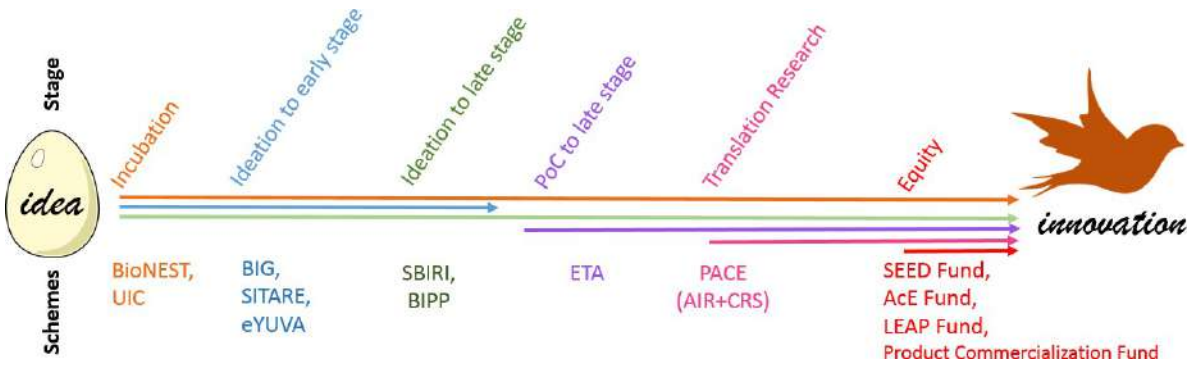


Fig 6: BIRAC Schemes According to the Stage at which Support is provided

3.1 Incubation Schemes

3.1.1. Bioincubators Nurturing Entrepreneurship for Scaling Technologies (BioNEST)

(http://www.birac.nic.in/bionest.php)

Business incubation is the phenomenon of providing assistance to innovative ideas, right from the stage of conception, till they are ready for commercialization. Bio-incubation is a specialized form of Business Incubation customized for Biotech and Life Science startups that provides them not only with business and infrastructural support but also assistance in carrying out the research through specialized technical facilities.

BIRAC introduced BioNEST in 2012, as an incubation programme that hand-holds innovative ideas by providing them with the specialized infrastructure and business mentoring required to up-scale and validate these ideas to convert them into market ready products.

BIRAC requires the host institute to comply with a certain set of eligibility criteria to set up a BioNEST. They are:

- The BioNEST incubator may be administered either by an individual host institute (existing academic/research organization/research hospital) or collaboratively under the PPP mode.
- The host institute is required to have competent infrastructural and mentoring provisions, and the potential to sustain entrepreneurial activities
- BIRAC is also partnering with various Biotech/Science and Technology Councils at the State level for creating BioNEST facilities in these states.

Fig 7: Location of Bio-NEST Incubators Setup by BIRAC

- Apart from creating new BioNEST facilities, it is also upgrading the existing incubators that may or may not have been supported by BIRAC under the Bio- incubator Support Scheme (BISS).

Fig 8: Impact of BioNEST

Table 1: Bio-Incubators Setup under the BioNEST Scheme

(In order of decreasing number of Incubatees)

S. No	Name of Bio-Incubator	Incubation Space (in sq.ft.)	Total Number of Incubatees Supported	Number of Incubatees funded under BIRAC Scheme	Number of Incubatees not funded under BIRAC Scheme
1	Bio-Incubator, Venture Center, NCL , Pune, Maharashtra	10900	52	42	10
2	IKP-EDEN, Bengaluru, Karnataka	6572	28	17	11
3	SIDBI Innovation & Incubation Centre (SIIC) at IIT-Kanpur, Kanpur, Uttar Pradesh	10500	21	2	19
4	Society for Innovation and Entrepreneurship (SINE), IIT-Mumbai, Mumbai, Maharashtra	4500	20	10	10
5	C-CAMP, Bengaluru, Karnataka	16500	20	18	2
6	RiiDL (Research Innovation Incubation Design laboratory	8550	18	0	18

	Foundation), Somaiya Vidyavihar, Mumbai, Maharashtra				
7	Hyderabad University, Hyderabad, Telangana	10000	17	3	14
8	MedTech Incubation (MTI) - HTIC, Chennai, Tamil Nadu	20250	17	4	13
9	IITM Bioincubator, Chennai, Tamil Nadu	10000	16	5	11
10	Panjab University (PU), Chandigarh	10000	15	8	7
11	IKP Knowledge Park, Hyderabad, Telangana	10013	14	4	10
12	Society for Bio-Technology Incubation Center (SBTIC), Hyderabad, Telangana	34667	11	0	11
13	Savli Technology and Business Incubator(STBI), Savli, Vadodara, Gujarat	15000	11	1	10
14	SRISTI Innovation, Ahmedabad, Gujarat	13550	10	0	10
15	Clean Energy International Incubation Center, Delhi	20000	8	0	8
16	IIIT, Hyderabad, Telangana	8000	8	0	8
17	Ahmedabad University, Ahmedabad, Gujarat	9000	7	1	6
18	IIHR, Bengaluru, Karnataka	6000	7	0	7
19	Golden Jubilee Women Biotech Park, Chennai, Tamil Nadu	5000	6	1	5
20	B. V. PATEL PERD Centre, Ahmedabad, Gujarat	3627	6	1	5
21	Hyderabad Eye Institute, Hyderabad, Telangana	10000	5	4	1
22	Biotechnology Business Incubation (BBIF),FITT, IIT-Delhi, Delhi	3550	5	4	1
23	PSG-STEP, Coimbatore, Tamil Nadu	6170	4	1	3
24	BITS BIRAC BioNEST, BITS Pilani, Goa	3000	4	1	3
25	a-IDEA, NAARM-TBI, Rajendar Nragar, Hyderabad, Telangana	10500	3	0	3
26	VIT-TBI, Vellore, Tamil Nadu	6000	3	0	3
27	BioNcube ICRISAT, Hyderabad, Telangana	24000	1	1	0
28	RCB, Faridabad, Uttar Pradesh	20000	1	1	0
29	SPMVV Society For Innovation Incubation Entrprenuership, Tirupati, Andhra Pradesh	5000	0	0	0

30	Technology Incubation and Entrepreneurship Development Society (TIEDS), Kharagpur, West Bengal	5000	0	0	0
31	Andhra Pradesh Med Tech Zone, Visakhapatnam, Andhra Pradesh	25000	0	0	0
32	B.S. Abdur Rahman Crescent Institute of Science & Technology, Chennai, Tamil Nadu	5000	0	0	0
33	ZTM-BPD, IARI, Delhi	5000	0	0	0
34	KIIT Technology Business Incubator (KIIT-TBI), Bhubaneswar, Odisha	26000	39	34	5
35	Bangalore Bioinnovation Centre (BBC), Bengaluru, Karnataka	5000	0	0	0

(Source: http://www.birac.nic.in/bionest.php)

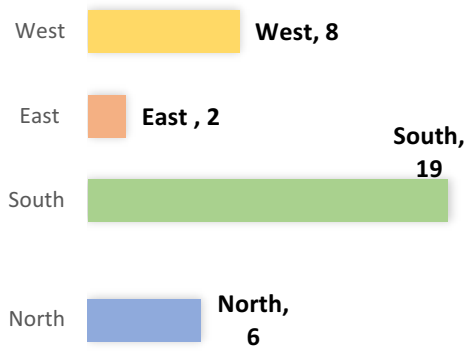


Fig 9: Break up of Bio-incubators based on their location

It is evident from Table 1 and Fig 9 that majority of Bioincubators (18) are located in southern region of India, followed by western (8), northern (6) and eastern (2) part of India.

Bio-Incubator at Venture Centre, Pune- Venture Centre, Pune, hosts one of the most successful Bio-incubators in the country which is funded and supported by BIRAC. It has assisted maximum number of Biotech Startups (Table 1) in the country, working in the domain of biopharma, agrobiotech, industrial biotech, clean technology, biomedical engineering, diagnostics, biomass value addition renewable fuels/chemicals/materials, bioinformatics, bio/medical services and related disciplines.

Startups like Abhiruchi Probiotics, are a spin-off of this incubator and are engaged in developing probiotic food additives using a strain of *Brevibacterium casei* AP9 that reduces the absorption of cholesterol in Gastro Intestinal tract. Similarly, another spin-off from the same incubator, Barefeet Analytics carries out trace analysis of food, biofluids and pharmaceuticals through mass spectrometry. Other successful Startups from Venture Centre Pune are, Shantani Proteome

Analytics, Seagull Biosolutions, Sofomo, Jbn Enterprises, Actorious Innovations and Research Pvt. Ltd., Embryyo, Jeevtronics Pvt. Ltd., Nayam Innovations Pvt Ltd, NobleExhange Solutions Pvt Ltd, inDNA Research Labs Pvt Ltd, Module Innovations Pvt. Ltd., SynThera Biomedical Pvt. Ltd., Genrich Membranes Pvt Ltd, Orthocrafts Innovation Pvt Ltd, Barefeet Analytics Pvt Ltd, BiolMed Innovations Pvt Ltd, and VIVIRA Process Technology. More information on these Startups is available at *http://startups.venturecenter.co.in/*

3.2 Ideation to Early Stage

3.2.1. Biotechnology Ignition Grant (BIG)

(http://www.birac.nic.in/big.php)

In order to channelize the 'Bio-Innovation' ecosystem in the country, BIRAC introduced a funding scheme called 'Biotechnology Ignition Grant' that is meant to hand-hold and encourage scientists with an entrepreneurial bent of mind, who are either a part of academia, or research institute or own a Startup. Such individuals can receive BIG funding either by being based in a BIRAC sponsored incubator, or through having the ownership of a Startup with a dedicated R&D facility. This assists the innovation process by alleviating all hindrances that occur due to financial crunch. BIRAC functions through its six partners (Fig 10), which act as the nodal centres for easy disbursal of funds.

Fig 10. BIG Partners

(1. FITT, Delhi; 2. Centre for Cellular and Molecular Platforms (C-CAMP), Bengaluru; 3. Venture Centre, Pune; 4. IKP Knowledge Park, Hyderabad; 5. KIIT-TBI, Bhubaneswar; 6. FITT, Delhi)

The main objectives of BIG are:

- To support projects that aim to establish or validate proof of concept for a promising and innovative technology idea.
- To promote the creation of new Startups based on innovative technology ideas and/or to support early Startups to establish and validate their technology ideas up to the POC stage.

BIG is open to both Individuals and Companies with specific eligibility criteria for each, which have been listed below:

Individual	Company/ LLP
➢ *Must be a citizen of India* ➢ *The primary applicant must be the team leader and must be intending to be associated with an incubator, when applying for the grant, with a proof of having initiated discussions about the same.* ➢ *In case the applicant is associated with an academic or a research organization, they must produce an NOC from the head or a document proving the termination of association with the previous employer.* ➢ *In case the applicant is associated with a for-profit company, the applicant must produce a letter of termination or apply as a company.* ➢ *Individual who holds a share in a company cannot apply as an individual.*	➢ *Must be registered under Indian Companies Act, 1956/ 2013.* ➢ *The company must have been incorporated not earlier than 2009.* ➢ *Indian citizens are shareholders of more than 51% of the capital of the company.* ➢ *The project leader must be a citizen of India and must have the desired qualification (PhD/MTech/BTech/ BPharm/MD/MBBS/BDS/MSc/M.Phil/M.Des/MPH/MBA/MSW and equivalents with under- graduate training in Science, Medicine, Engineering. Project Leaders with a BSc degree with at least 1 year of full-time work or research experience shall also be eligible.)* ➢ *Must have a functional in-house R&D Facility.*

BIG calls for proposals biannually, on 1st January and 1st July. The proposals are scrutinized by the BIG partners through their experts. The proposals are then shortlisted through a detailed presentation that is evaluated by a Technical Expert Panel. The shortlisted proposals are forwarded to the Expert Selection Committee at BIRAC, New Delhi, who take the final call.

They are evaluated on their technical feasibility, novelty, importance and potential, commercialization strategy, team, barriers and strategies to address challenges and the action plan.

The project is also evaluated for due diligence and monitored to check the progress, based on which the funds are released. BIG funds each project for a period of maximum 18 months, with a cap of ₹ 50 lakh. The funding is provided as a Grant-in-aid with no expectations of royalty.

In 2012, BIRAC joined hands with the Centre for Entrepreneurial Learning at the Cambridge Judge Business School, University of Cambridge UoC, UK, to provide optimal exposure to BIG grantees to the innovation and entrepreneurial ecosystem at UoC. BIRAC has been sending five of its BIG grantees to participate in a two week boot camp programme called *'IGNITE'* (http://www.birac.nic.in/desc_new.php?id=276), held at Judge Business School, which provides them with opportunities to explore their innovative ideas and convert them into a business venture. The first phase of the workshop deals with mentoring by experts on crucial areas of entrepreneurship, while the second week dwells more on networking

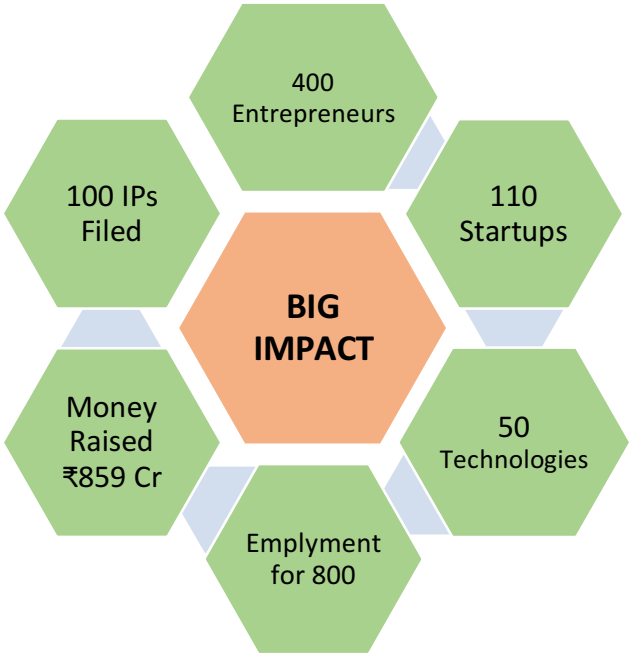


Fig 11. Impact of BIG

with Startups and established pharmaceutical companies from UK. More than 29 entrepreneurs have benefitted by attending this workshop till date.

Fig 12: Some of the Products Developed and Commercialized through BIG Scheme

(Source:http://www.birac.nic.in/webcontent/1554103938_birac_brochure_01_04_2019.pdf)

a) Device enabling early diagnosis of pregnancy disorder b) Device to convert conventional stethoscope into digital stethoscope c) Production of microcrystalline cellulose and silica from raw rice husk d) A Thermo-tolerant and acid stable phylase in a Novel SSF Bioreactor

3.2.2. Students Innovations for Advancement of Research Explorations (SITARE)

(http://www.birac.nic.in/desc_new.php?id=261)

In order to promote a sense of entrepreneurship amongst students from colleges and universities, BIRAC has joined hands with SRISTI (Society for Research and Initiatives for Sustainable Technologies and Institutions) a non-profit organization based in Ahmedabad, Gujarat, through a MoU signed in 2015. Together, they have introduced awards under two heads:

i. BIRAC-SRISTI GYTI Awards: Awards a grant of 15 lakhs to 15 innovative ideas with a commercialization potential, at the pan-India level. The selected ideas are incubated for a duration of 2 years.

ii. BIRAC-SRISTI Appreciation Awards: Awards a grant of 1 Lakh to 100 innovators to graduate their innovations to the next level.

BIRAC along with SRISTI also organizes BIIS (Biotech Innovation Ignition School) workshops, which is a month long participatory and interactive training session for students.

Fig 13: Impact of SITARE

(Source: BIRAC Brochure 2019)

3.2.3. Encouraging Youth for Undertaking Innovative Research Through Vibrant Acceleration (eYUVA)

(http://www.birac.nic.in/desc_new.php?id=262)

BIRAC desires to build an entrepreneurial culture amongst the youth and has taken steps in this direction through its scheme eYUVA to channelize the local ecosystem. It intends to develop a sense of social responsibility as well, so that the innovations have a social impact. The eYUVA programme is executed through the establishment of University Innovation Clusters (UIC) and Cluster Innovation Centres (CIC) in the academic institutes.

The basic idea behind establishing these Centres is 'pre-incubation' of ideas and beefing up the translational process. These Centres also lead to effective networking amongst the various stakeholders of the innovation ecosystem. The five CICs established in the country are Anna University, Chennai; Panjab University, Chandigarh; Tamil Nadu Agricultural University, Coimbatore; University of Rajasthan, Jaipur; and University of Agricultural Sciences, Dharwad. The basic features of the UIC/CIC are:

- An incubation area of 2500 to 3000 Sq. ft
- A cluster of 5-6 students/ young entrepreneurs are supported in each UIC?CIC to take their ideas to *proof of concept* (PoC) stage
- A provision for Innovation fellowships (valid for 3 years) at the Post Masters and Post Doctoral Level.
- Mentoring, Networking opportunity, IP and Technology Management, interaction with the Industry
- Dedicated mentoring group from both Academia and Industry

3.3 Ideation to Late Stage

3.3.1. Small Business Innovation Research Initiative (SBIRI)

(http://www.birac.nic.in/desc_new.php?id=217)

SBIRI was the inaugural Biotechnology-specific PPP scheme of DBT. It was floated in 2005 with the intention of fostering high risk-early stage innovations, all the way to the point of successful commercialization through partnerships between public and private sectors. SBIRI works with the following objectives:

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

The proposals are only accepted from the Private partner, which may be with or without an industrial/academic partner. SBIRI has a specific set of eligibility criteria for both the partners in the PPP setup*:*

Industrial Partner	Academic Partner
➢ *Can be a Company (under the Companies Act, 2013) or Limited Liability Partnership (LLP) (under the Limited Liability Partnership Act, 2008) or Joint Ventures either in the form of Company/ LLP* ➢ *Either of the above entities can apply jointly with other private or public partners (Universities or Institutes).* ➢ *More than half the shares of the participating Industry must be held by Indian Citizens (Holding valid Indian passport. Not applicable for Person of Indian Origin/ Overseas Citizens of India)*	➢ *Can be Public/Private Universities or colleges in India/National Research Laboratories/Not- for- profit Private Research Labs/ Societies/ Foundations*

- *Minimum half the number of partners of the participating Industry must be Indian Citizens*
- *Must have the infrastructural requirements to carry out the project / have provision to be incubated*

SBIRI calls for proposals tri-annually *(*15th February – 31st March*;* 15th June – 31st July*;* 15th October – 30th November). The proposal can only be submitted online during the specific period mentioned above. The proposals are first screened by the Technical Expert Committee (TEC) and further evaluated on the basis of Technical strength of PoC, Clarity of strategy, Potential for creating a technology or product, National / Social relevance, Commercial potential or Translational capacity, Investigators credentials and/or Collaborative team's expertise.

The PIs of the short-listed projects are called for presentations which are evaluated on the basis of Presence of preliminary data or PoC, Clarity of milestones, Competency of applicant and partnering entity to carrying out the proposed research, Relevance of project deliverable as commercially viable product/process and any other aspect that the committee may consider relevant. SBIRI funds the selected project based on the total cost of the Project, which may fall under any one of the three categories:

Total Project Cost	**Support by BIRAC**
Up to ₹ 25 Lakh	80% of the total cost
Between ₹ 25 Lakh and ₹ 100 Lakh	50% of the total cost (with a minimum of ₹ 20 Lakh)
Above ₹ 100 Lakh (for a project with an Academic Partner)	Funding to the Company does not exceed ₹ 50 Lakh as Grant-in aid

The salient features of IP governance are as follows:

- IP generated through the course of the project is jointly owned by the 'recipient of funds' unless there is another arrangement. Management of IP rights will be considered as a special case in case the project holds national importance. Such cases will be subjected to compulsory licensing and can be intervened if the government deems so.
- All expenditure carried out to protect the IP will be borne by the IP holder(s).

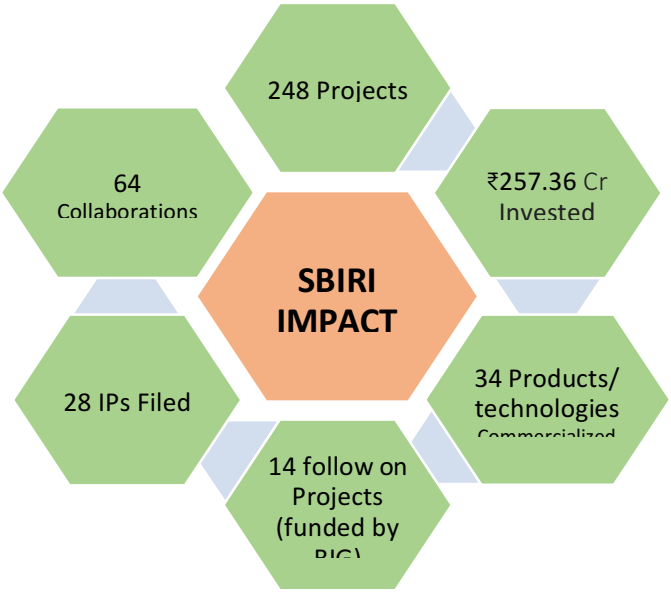


Fig 14: Impact of SBIRI

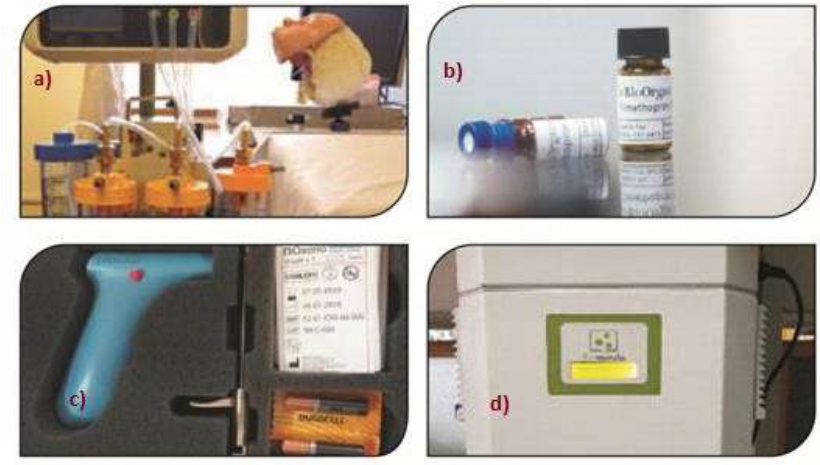


Fig 15: Some of the Products Successfully Commercialized through SBIRI Scheme of BIRAC

(Source: BIRAC Annual Report 2017-18)

a) Device for reduction of Ventilator associated pneumonia (Coco Labs Pvt Ltd, Bengaluru) b) Glucuronides and their deuterium labelled analogs (Bio-organics and Applied Materials Pvt Ltd, Bengaluru) c)Device to remove foreign bodies in nasal passage (Innaccel Technologies Pvt Ltd, Bengaluru) d) Device for electrodynamic ablation of pathogens (Biomoneta Research Pvt Ltd, Bengaluru)

3.3.2. Biotechnology Industry Partnership Programme (BIPP)

(http://www.birac.nic.in/desc_new.php?id=216)

BIPP is another PPP programme of BIRAC wherein the government partners with the private sector (industries) to promote innovation in areas with major societal impact and 'economic potential'. BIPP supports early stage high risk innovation, with a special emphasis on IP ownership. BIPP works around specific themes:

i. Drugs
ii. Vaccines and clinical trials
iii. Biosimilars and Stem Cells
iv. Devices and Diagnostics
v. Agriculture
vi. Industrial Biotechnology
vii. Bioinformatics

BIPP has found success ever since its inception, in 2009, and adhered to its agenda of bringing together two or more industries or industry and academia, for the development of a product that has high commercialization potential. It is preferred that preliminary development of the product/process takes place in the academia, and the industry adopts it for further validation. BIPP funds projects which falls in any of these following categories:

Category I: Areas with major social relevance but uncertain market driven demand

Category II: High risk, discovery and innovation research with relevance for making India globally competitive

Category III A: Evaluation & validation of already existing products of high national importance promoting local innovations (Clinical trials)

Category III B: Evaluation & validation of already existing products of high national importance promoting local innovation (agriculture field trials)

Category IV: Shared cost of major facilities which are critical for enabling innovation

The USP of BIPP is hastening the progress of *'high-risk'* technology development, starting from ideation stage till the product/process reaches the market. It also supports nationally and socially relevant innovations where the market returns are still not guaranteed. For projects running in collaborative mode, BIPP needs the preliminary research to be carried out by the academic partner and the industry takes on further.

BIPP calls for proposals tri-annually (15th February – 31st March; 15th June – 31st July; 15th October – 30th November). The proposal can be submitted by a) solely by an Indian Company, *b)* jointly by an Indian Company and National R&D Organizations and Institutions, and c) by a group of Indian Companies along with National Research Organizations etc. The eligibility criteria for the partners submitting the proposal are:

Industrial Partner	Academic Partner
➢ *Can be a single or consortia of Indian Company i.e. - Small, Medium or Large.* ➢ *More than half the shares of the participating Industry must be held by Indian Citizens (holding valid Indian passport. Not applicable for Person of Indian Origin/ Overseas Citizens of India)* ➢ *Must have the infrastructural requirements to carry out the project / have provision to be incubated*	➢ *Can be Public/Private Universities or colleges in India/National Research Laboratories/Not-for-profit Private Research Labs/Societies/ Foundations*

BIPP funds 50% of the total project cost and the remaining cost is to be paid by the applicant of the proposal i.e. company. BIRAC funds the project in the form of Grant-in-aid, and have a commitment of royalty payment (except Category IV: Shared cost major facilities, critical for enabling innovation). The salient features of IP governance are as follows:

- The IP is by default, owned by the Industry.
- All expenditure carried out to protect the IP will be borne by the IP holder(s).
- The IP owners are also required to disburse any information regarding the project at the global level
- The product/process may be accessible at a nominal price wherever necessary (especially in developing countries)
- The product/process may be accessible globally for further research and development, subject to pre-defined conditions.

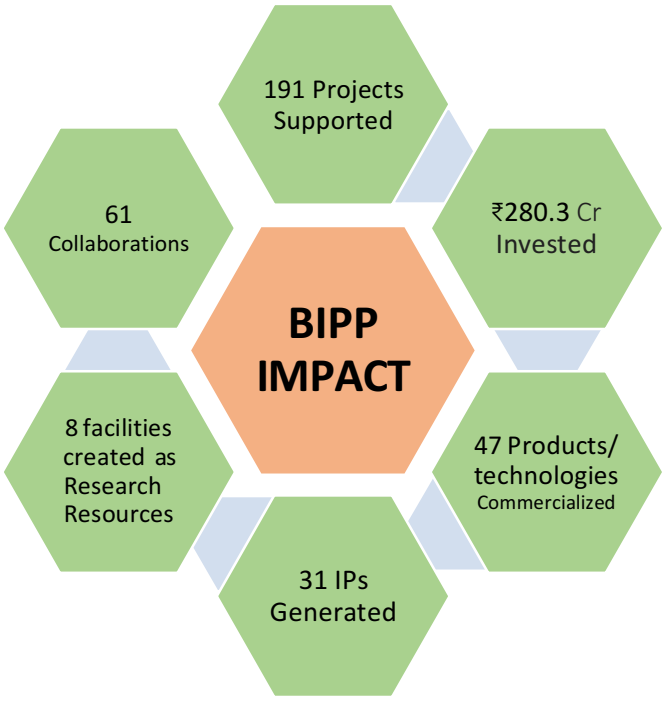


Fig 16: Impact of BIPP

Fig 17: Some of the Products Successfully Commercialized through BIPP Scheme of BIRAC

(Source: BIRAC Annual Report 2017-18)

a) Sperm sorting system (Jiva Sciences Pvt Ltd), b) Whole Slide Scanner, OncoScan (Optra Systems Pvt Ltd) c) ACIX100, Microfluidics platform with a plastic disposable cartridge (Achira Labs Pvt Ltd)

Although, SBIRI and BIPP both aim at elevating the status of industrial R&D, yet they address slightly different agendas. While SBIRI focusses on assisting early-stage R&D of the industry (particularly start-ups and SMEs), through its PPP format, BIPP (also a PPP scheme) focusses

on partially assisting high-risk/ transformative technologies, limited to specified domains, but extending to large industries as well.

3.4 Proof of Concept to Late Stage

3.4.1. Early Translational Accelerator (ETA)

(http://www.birac.nic.in/desc_new.php?id=280)

The ETAs have been established with the intent of identifying innovations in academic institutions that are at the PoC stage and in need of assistance in their validation and technology transfer i.e. to accelerate the translation process. It brings out this translation through engagements with the industry, academia and sometimes even with international partners. Being the connecting link between the industry and academia, ETA recognizes academic ideas that are still at the PoC, up-scales these ideas and presents them to the industries for potential commercial utilization. Of the 10 ETAs proposed, two have been established at C-CAMP and IIT-Madras. *ETA at C-CAMP* specifically works in the field of Healthcare whereas *ETA-IB at IIT-Madras* focuses on Industrial Biotechnology.

3.5 Translation Stage

3.5.1. Promoting Academic Research Conversion to Enterprise (PACE)

(http://www.birac.nic.in/desc_new.php?id=286)

High risk research is a forte of the academia which does not always have to measure in wins and losses. But most of this research is not able to reach the proof-of concept stage. In order to speed up the translational process, and ensure that an innovation successfully reaches its PoC stage and gets validated, BIRAC introduced a scheme known as PACE. This scheme has two basic constituents, i.e. AIR and CRS.

i) Academic Innovation Research (AIR)

- This scheme focuses on the development of PoC for a product/process in academia that may or may not have an industry partner.
- The projects supported by this scheme must have reached a stage of proof of concept and must be of a high commercial value.

- The project is supported for a maximum of 18 months (which may be increased on recommendation by the TEC-Technical Expert Committee)
- The project is funded with a cap of ₹50 Lakh.
- The IPRs may be solely owned by the academia or shared with the industry, based on an agreement between the two.

Eligibility criteria:

Academia	Industry
➢ *May be a Public or Private Institute/University/NGO or Research Foundation* ➢ *Applicant may apply either individually or along with an academic/Industrial partner*	➢ *Must be a company registered under the Indian Companies Act, 2013 with at least 51% shares with Indian Citizens (Indian citizens are those who have a valid Indian Passport. Not applicable to Person of Indian Origin-PIO or Overseas Citizenship of India-OCI)* ➢ *The applicant company must have a functional R&D facility with itself or maybe associated with an Incubator.*

ii) Contract Research Scheme (CRS)

- This caters to the next stage of the innovation process and takes the PoC developed by the academia to be validated by the industrial partner.
- There is no fixed time limit for this project.
- CRS provides funding to both the academic as well as industrial partner, with noceiling on the amount.
- The academia holds the IPRs, but the industry partner has 'first right of refusal' in case the IP is proposed to be commercially exploited.
- The primary applicant of the project is academia and can have one or more partners, one of which must be a company.

Eligibility criteria:

Academia	Industry
➢ *May be a Public or Private Institute/University/NGO or Research Foundation* ➢ *Applicant may apply either individually or along with an academic/ Industrial partner*	➢ *The applicant company must have a functional R&D facility with itself or maybe associated with an Incubator.*

*PACE calls for proposals tri-annually (*15th February – 31st March*;* 15th June – 31st July*;* 15th October – 30th November). The proposals are screened and evaluated by the TEC.

Fig 18: Impact of PACE

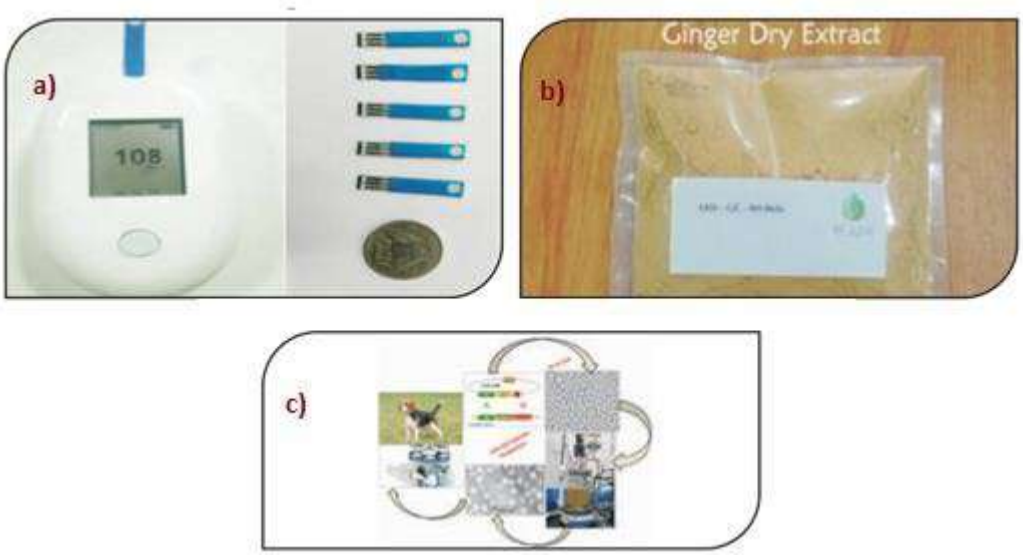


Fig 19: Some of the Products Successfully Commercialized through PACE Scheme of BIRAC *(Source: BIRAC Annual Report 2017-18)*

a) Non-enzymatic glucose sensor based glucometer (Amrita School of Biotechnology, Kerela and Wipro Technologies Pvt Ltd, Bengaluru) b) Ginger Dry Extract (Kerela Agriculture University and Arjuna Naturals, Aluva) c) Virus like particle vaccine against a Canine disease (TRPVB and Palamur Bioscience Pvt Ltd, Telangana)

3.6 Equity Funding

3.6.1. Accelerating Entrepreneurs Fund (AcE Fund)

(http://www.birac.nic.in/aceFund.php)

The AcE fund is a master-fund (Fund of Funds) that has been slotted exclusively for Biotech Startups. This fund supports Startups in their most crucial phase and prevent them from falling into the 'Valley of Death'. It joins hands with Securities and Exchange Board of India (SEBI) registered Alternative Investment Funds (AIFs) to provide 'Risk capital' to the Biotech Startups.

3.6.2. Sustainable Entrepreneurship and Enterprise Development Fund (SEED Fund)

(http://www.birac.nic.in/seedFund.php)

BIRAC endeavours to handhold a biotech specific business venture specifically at its most crucial stage, i.e. the Startup phase, through its SEED Fund. The basic idea of providing this assistance is to bring the Startups to a point where they are capable enough to raise money through angel investors or venture capitalists or seek a loan. This is not an independent scheme

but rather a support programme to incubation to ensure that the Startups survive the 'Valley of Death'.

The funding is provided in the form of Grant-in-aid assistance of ₹ 200 Lakhs to select BIRAC funded incubators. The funds are disbursed (₹ 30 Lakh per Startup) through these incubators, which are required to develop an independent process to screen out applicants to receive the fund. BIRAC has laid out certain criteria for the incubators to be eligible disburse SEED Fund:

- Incubator must be supported by BIRAC's BioNEST Scheme
- Must be operational for the last three years and house at least 5 Startups
- Must have functional IP&TT facilities
- Must be well versed with the functioning and management of early stage funding schemes.

Fig 20: Impact of SEED Fund

3.6.3. Launching Entrepreneurial Driven Affordable Products (LEAP) Fund

This fund assists Biotech Startups in commercialization of their products or technologies. This fund is provided against equity and equity linked instruments with the maximum amount of ₹ 1Cr per Startup.

3.6.4. Product Commercialization Program

Beyond the technical and funding formalities, a Start-up also requires support in order to commercialize its product. For this purpose, BIRAC introduced the Product Commercialization Program in 2017-18, in order to boost the commercialization process of the technology/ product. This includes assistance in IP and business management, market research, networking as well as legal and regulatory issues. BIRAC becomes the product commercial partner of the Start-up so that it may assist it in any process that will hasten the commercialization of the product.

4. STRATEGIC ALLIANCES AND PARTNERSHIPS OF BIRAC

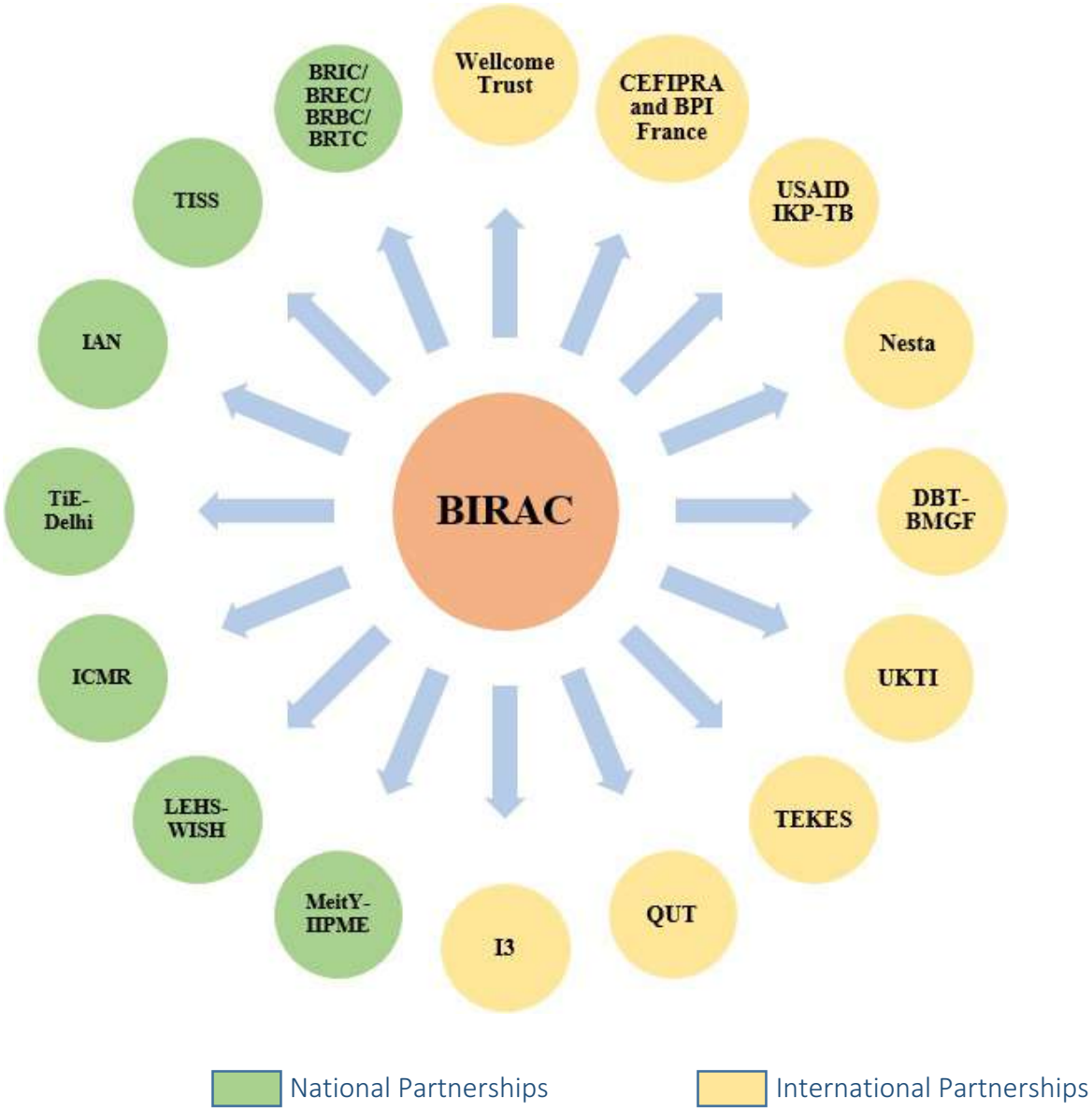


Fig 21: National and International Partnerships of BIRAC

***Abbreviations**: MeitY-IIPME: Ministry of Electronics and Information Technology, Government of India-Industry Innovation Programme on Medical Electronics; LEHS-WISH: Lords Education and Health Society-Wadhwani Initiative for Sustainable Healthcare; ICMR: Indian Council of Medical Research; TiE: The Indus Entrepreneurs; IAN: Indian Angel Network; TISS: Tata Institute of Social Sciences; BRIC: BIRAC Innovation Centre; BREC: BIRAC Entrepreneurship Centre; BRTC: BIRAC Regional Techno Entrepreneurship Centre; DBT-BMGF: Department of Biotechnology-Bill and Melinda Gates Foundation; UKTI: UK Trade and Investment; QUT: Queensland University of Technology; Nesta- National Endowment for Science, Technology and the Arts.*

BIRAC has struck alliances and partnered with various national and international authorities to boost innovations in biotech sector (Fig 21). These partnerships have led to the promotion of Indian innovation ecosystem at the global level.

4. 1 National Partnerships:

4.1.1. Ministry of Electronics and Information Technology, Government of India (MeitY)-Industry Innovation Programme on Medical Electronics (IIPME)

BIRAC partnered with MeitY in 2015, through the program called IIPME, which intends to encourage innovations related to Medical Electronics. It focusses on the following four areas i.e. Imaging and navigation, Technologies for chronic diseases, Convergence of medical device and bioinformatics, and Increasing the outreach through Medical electronics.A total of 34 projects have been supported so far and some of them have successfully led to the development of prototypes, e.g., X-ray to 3D model conversion software for Surgery Planning, Hand cranked defibrillator for low resource settings, Artificial Larynx for voice

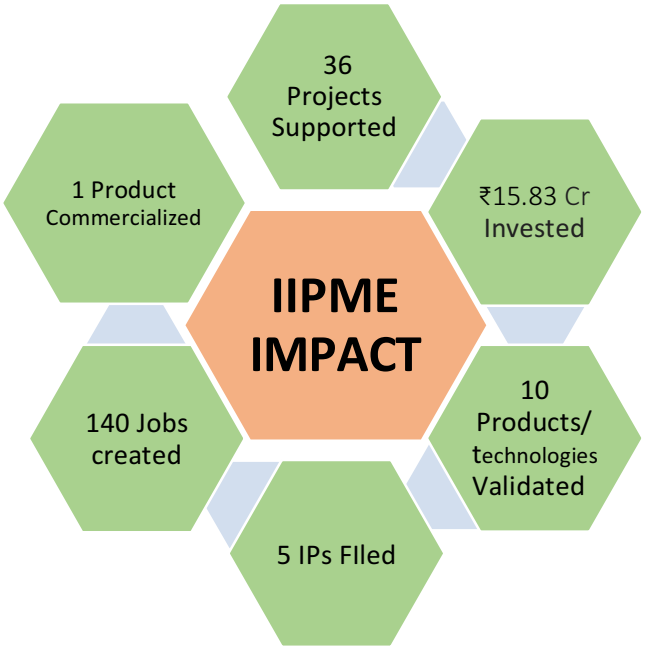


Fig 22: Impact of IIPME

restoration, Surgical navigation system for orthopedic surgeries, Non-invasive opto-glucometer and Laproscopic surgical training simulator.

Fig 23: Technologies successfully commercialized through IIPME

(Source: BIRAC Annual Report 2017-18)

a)Hexapod Patient Couch-Panacea Medtech Pvt. Ltd; b) Hand cranked defibrillator for low resource settings-Jeevtronics Pvt. Ltd; c) Surgical navigation system for orthopedic surgeries-Arthritis Research Pvt.; d)Laproscopic surgical training simulator-Merkel Haptics Systems Pvt. Ltd)

4.1.2. Lords Education and Health Society-Wadhwani Initiative for Sustainable Healthcare (LEHS-WISH)

In 2015, BIRAC partnered with LEHS-WISH to implement their SCALE programme which intends to hasten the process of delivering 'primary and preventive healthcare' to the country. It achieves it by synergizing the competencies of innovators and social enterprises through public-private partnerships, working synchronously with the state governments. The innovations are delivered to the primary health care centres which serve as the first consumers of the high impact innovations that are worthy of being scaled up. Till date, four technologies have been validated through this partnership.

4.1.3. Indian Council of Medical Research (ICMR)

BIRAC has joined hands with ICMR through a MoU for making the best use of resources in terms of infrastructure and knowledge sharing. This allows Startups and SMEs affiliated with BIRAC to make use of the ICMR facilities such as validation of technologies and clinical

trials. Of various proposals shared by BIRAC with ICMR, two have been screened for clinical validation and will be supported through infrastructure, protocol development and validation strategy development.

4.1.4. The Indus Entrepreneurs (TiE)-Delhi

BIRAC joined hands with TiE-Delhi in 2016 to bring the best of both organizations on the table and provide an interface for BIRAC funded Startups to interact with funders and investors. BIRAC and TiE utilized this partnership to organize an event in 2017-18, to acknowledge and appreciate women entrepreneurs in the field of Biotechnology. The award known as WInER Award (Women In Entrepreneurial Research), was bestowed upon 15 select winners. Each winner was presented a sum of ₹ 5 Lakh on International Women's day. These awardees undergo a week long training at the Golden Jubilee Women Biotech Park, Chennai where they receive training of IP and business management. The top 3 awardees arescreened out, and receive a sum of ₹ 25 Lakhs each. BIRAC also organizes awareness workshops in collaboration with TiE, to develop a sense of entrepreneurship at IIT Roorkee, Chitkara University and Lucknow Biotech Park.

4.1.5. Indian Angel Network (IAN)

BIRAC got together with IAN through a MoU in 2017 which gives an opportunity to BIRAC funded Startups to network with the largest angel network in the world through various pitching sessions.

4.1.6. Tata Institute of Social Sciences (TISS)

BIRAC partnered with TISS in 2016 in order to encourage social entrepreneurship through mentoring and knowledge support. TISS also intends to help BIRAC in understanding the footprint of social impact and workout ways to strengthen it.

4.1.7. BIRAC Regional Centres

To promote entrepreneurship in southern and eastern parts of India, BIRAC has set up dedicated centres namely, BIRAC Innovation Centre (*BRIC)* at IKP Knowledge Park, Hyderabad in *2013*; BIRAC Entrepreneurship Centre (*BREC)* at C-Camp, Bangalore in 2016); BIRAC Bio-Innovation Centre (*BRBC)* at NCL, Pune in 2016); and BIRAC-Techno Entrepreneurship Centre (*BRTIC)* at KIIT Bhubaneswar in 2018.

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 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. Till date, it has covered 22 clusters, engaged more than 750 innovators, organized more than 55 workshop relating to its theme and connected almost 200 Key Opinion Leaders.

BREC works through entrepreneurship development programmes, workshops and boot camps. Since 2017, it has mentored more than 90 Startups, brought together more than 200 investors and Startups, mentored over 200 entrepreneurs in specified domain, organized workshops for nearly 700 participants and organized the National Bio Entrepreneurship programme supported by 11 industry partners.

BRBC has been actively providing venture mentoring services and connected more than 120 entrepreneurs with mentors, trained 15 incubation managers, enlightened more than 100 students to scientific entrepreneurship, educated more than 50 participants through venture base camps and assisted 50 Startups in resolving regulatory problems.

BRTCI, has been recently set up at KIIT, Bhubaneswar to caterto the Technical and Entrepreneurial aspects of Biotech Industry of the Eastern and the North Eastern Region.

4. 2 International Partnerships:

4.2.1. *Wellcome Trust*

BIRAC has allied with UK-based Wellcome Trust, to support innovations especially in the field of diagnostics of Infectious Diseases. This partnership works with the objective to fund translational research projects to deliver safe and effective healthcare products for India at affordable costs through collaborative research. Two projects have been funded till date through the first call of this alliance:

- 'High Sensitivity Multiplex point-of-care assay systems for the detection of blood borne infections in emergency setting' being collaboratively executed by Translational Health Science And Technology Institute (THSTI, India) - Designinnova (India) and University of Turku (Finland).
- 'A Bench side molecular assay for detection of drug resistant bacteria was pursued by VITAS Pharma, Hyderabad. It has been recently completed, leading to the development of a Loop-mediated isothermal amplification (LAMP), designed specifically to detect carbapenem resistant Gram negative bacteria (CRGNB).

4.2.2. *Centre Franco-Indien pour la Promotion de la Recherche Avancée (CEFIPRA) – Banque Publique d'Investissement (BPI) FRANCE*

In an endeavour to enable and support 'high quality bilateral research' and promote Indo-French alliance, amongst various stakeholders of the innovation ecosystem, BIRAC has collaborated with CEFIPRA-BPI France, (an Indo-French Centre for promotion of advanced research in India). Through this initiative two partnership programs, with the French Embassy (2014) and BPI France (2015) have been initiated.

Programs with French Embassy: The first call for the program, in 2015 with the French Embassy led to selection of two projects related to development of molecular diagnostics for Cardiovascular Diseases. The second call, came for a different theme and selected projects to work on development of i) molecular diagnostics for the Alzheimer's and related disorders, ii) technologies that can assist in mobility of physically impaired individuals, iii) biomaterials and cell engineering for health applications.

Program with BPI France: This program called for proposals, in 2016, in the field of Digital Health and Customized Medicine and is now developing a tool related to Telemedicine.

4.2.3. USAID IKP-TB

BIRAC has allied with United States Agency for International Development (USAID) through an agreement with IKP, Hyderabad to work on 'Innovations in tuberculosis control in India'. The first call for proposals was dedicated to resolving the issue of 'Treatment Adherence of TB' in collaboration BMGF. The second call has been floated to develop new diagnostics for TB. The projects finally selected through the second phase for final development of diagnostics are:

a) A filter paper based method of MTB sample collection, transportation and storage at room temperature, b) NextGen Real time MTB LAMP detection by Smart Genie, and c) Biomarker-based triage test for TB.

4.2.4. National Endowment for Science, Technology and the Arts (NESTA)

BIRAC is collaborating with Nesta (UK based innovation charity organization) to address the problem of anti-microbial resistance (AMR), through the Longitude Prize. Nesta has supported 9 innovators from India who can be the potential recipients of the Longitude Prize.

4.2.5. Department of Biotechnology-Bill and Melinda Gates Foundation (DBT-BMGF)

Department of Biotechnology, GoI got into an alliance with BMGF through a MoU in 2012, which is being executed through BIRAC. This alliance functions through a dedicated Program Management Unit (PMU) that manages the Indian offshoot of the Global Grand Challenges, initiated by BMGF program known as *Grand Challenges India* (GCI) to resolve the most pressing health related issues of the country. This has been recently, in 2016, joined by Wellcome Trust and USAID, to collaboratively to address the critical health challenges in the country and devise sustainably innovative solutions to address them. GCI has a wide scope of project support, funding programs right from the preliminary lab research to innovations at the scale-up stage. The focal areas of GCI includes:

i. Maternal and Child Health
ii. Infectious Diseases
iii. Vaccines
iv. Point-of-care Diagnostics
v. Agricultural Development
vi. Food and Nutrition
vii. Sanitation and Hygiene

One of the most successful outcomes of GCI have been, 'Re-invent the Toilet' Challenge, launched in 2013. It targets the issues of sanitation, particularly in the rural areas. The program was successfully completed in 2017, and led to the recommendation of two projects to be up-scaled.

Fig 24: Successful Projects from the 'Re-Invent the Toilet' Challenge of GCI

a) Solar Powered Self-sustainable, electronic Toilet designed for slums b) Toilet with an in built waste-water treatment system (Source: BIRAC Annual Report 2017-2018)

*4.2.6. **TEKES** (renamed as: Business Finland)*

BIRAC has partnered with the Finnish public funding agency, TEKES (which has now joined hands with FinPro and is called Business Finland) to widen the horizons of Indian Startups through exposure to Finnish expertise and innovation ecosystem. This program focuses primarily in the field of Medical Technology. Indian Startups supported by BIRAC also get an opportunity to network at the global level through an international event known as SLUSH where they can interact with the various stakeholders of the international players of the innovation ecosystem.

4.2.7. Queensland University of Technology (QUT), Australia

In 2012, Queensland University of Technology, Australia, joined hands with the Government of India through an agreement to transfer technologies related to:

- Bio-fortification of Banana with extra Vitamin A and Iron
- Tackling infection of Banana Bunchy Top Virus (BBTV)
- Development of Fusarium Wilt resistance in Banana

This agreement was signed under the project, "Development and Transfer of Technology from Queensland University of Technology, Australia to India for Bio-fortification and Disease

Resistance in Banana", with a duration of 6 years. QUT transferred these technologies to five Indian Partners:

i. National Agri-Food Biotechnology Institute, Mohali, Punjab
ii. National Research Centre for Banana, Trichy, Tamil Nadu
iii. Bhabha Atomic Research Centre, Trombay, Mumbai
iv. Tamil Nadu Agricultural University, Centre for Plant Molecular Biology & Biotechnology, Coimbatore
v. Indian Institute of Horticultural Research, Bangalore, Karnataka

These institutes will be working with two India specific cultivars of banana i.e. Grand Nain and Rasthali, leading to the development of their Bio-fortified and disease resistant versions. The deliverables from both the Australian and Indian side were clearly defined in the agreement and are listed as follows:

4.2.8. National Biopharma Mission - Innovate in India (I3)

Department of Biotechnology, GoI, in association with World Bank, instituted a collaborative I-A programme, called the National Biopharma Mission in 2017, under the 'Innovate in India (I3) - Empowering biotech entrepreneurs & accelerating inclusive innovation' initiative. The programme has been executed by BIRAC, in order to provide an impetus to the biopharmaceutical industry in the country. A total sum of 1500cr INR has been allocated for the mission with half the share by the World Bank. The primary vision of the mission is *to make the country a hub for design and development of novel, affordable and effective biopharmaceutical products and solutions.* The mission intends to assist i) Academia in translating their research; ii) Start-ups and SMEs through assistance in the high-risk phase; iii) industry by improving the quality of its innovative R&D. This initiative intends to have a major socio-economic impact on the country through provision of affordable healthcare.

The work-plan of I3 includes:

- The programme intends to create a system of 'shared infrastructure' for generation of know-how and product validation.

- The translational research will be facilitated through the provision of assistance for product validation, clinical trials, de-risking of new bio-pharmaceutical products and promote relatively new avenues such as 'translational bioinformatics' and 'bioethics'.
- The program intends to focus on issues like on Immunization against HPV or Dengue, Bio-pharmaceuticals for treatment of Cancer, Diabetes and Rheumatoid Arthritis and Devices and Diagnostics related to the field.

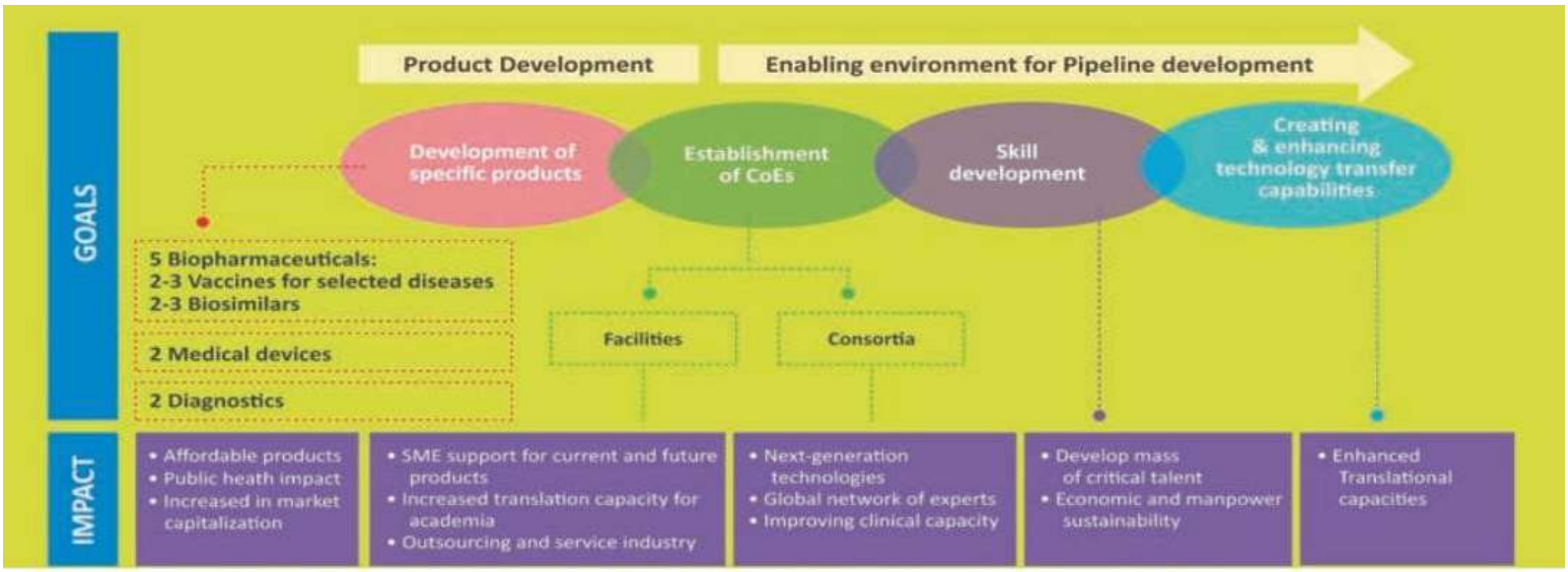


Fig 25: Goals and Impact of National Biopharma Mission

(Source: http://www.birac.nic.in/webcontent/1554103938_birac_brochure_01_04_2019.pdf)

Centre for Advanced Protein Studies (CAPS) - In order to address the challenges faced in protein studies, particularly by the bio-pharmaceutical industry, BIRAC in association with Syngene International Ltd, set up CAPS at Bengaluru in 2019, under the National Biopharma Mission. The Centre is said to 'host a state-of-the-art GLP accredited analytical laboratory', available to academia, start-ups and SMEs (and MMEs).

4.2.9. UK Trade and Investment (UKTI)

BIRAC joined hands with UKTI in 2015 through a MoU for stimulating collaborations amongst the two countries in the Biotech/ life science sector.

5. BIRAC AND SOCIAL ENTREPRENEURSHIP

5.1. Social Innovation Immersion Program (SIIP)

BIRAC also believes that entrepreneurs must be encouraged to take up society's mostpressing problems and find solutions to them. For the same, it has floated a program called SIIP that aims at creating a pool of biotech "Social Innovators" who not only identify needs & gaps within communities, but also bridge the gaps either through innovative product development or services.

SIIP provides monthly fellowship to the innovators and connects them with the rural clinical settings. They also get an opportunity to develop a prototype through this grant. Specific themes of this programme are Maternal and Child Health, Ageing and Health and Waste to Value. The young entrepreneurs are mentored by BIRAC SIIP knowledge partner (Venture Centre, Pune; C-CAMP, Bengaluru; KIIT, Bhubaneswar; TISS, Mumbai). These social innovators hold the rights of the IP created during the process of innovation. Up until now**,** 35 innovators have been mentored through this program with 10 fellows receiving a follow on funding, leading to identification of 70 solutions and development of almost 12 prototypes.

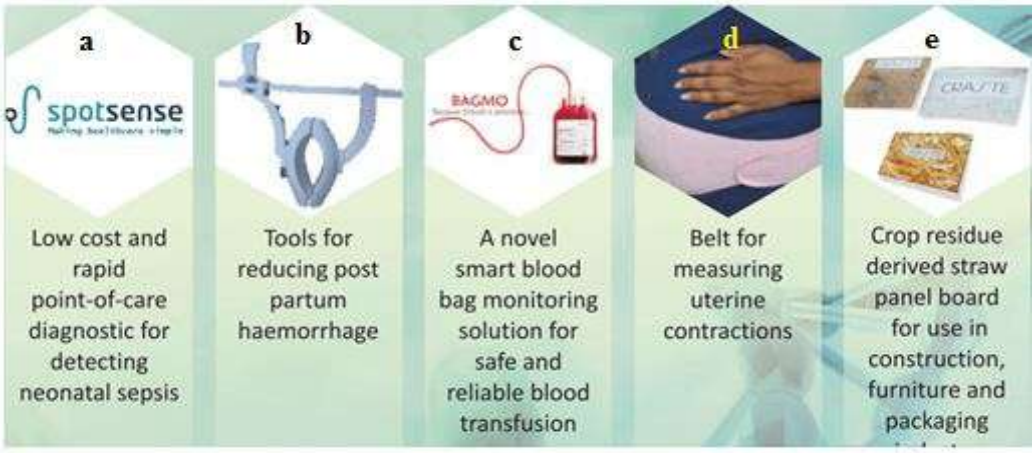


Fig 26: Prototypes Developed with the Assistance of SIIP Scheme of BIRAC

(Source: BIRAC Brochure 2019)

a)Neonatal sepsis detection kit- Spotsense Bangalore; b) Tools for reducing post-partum haemorrhage c) Smart Blood bag monitoring solution- Bagmo Pvt Ltd; d) Belt for measuring uterine contractions -Pradin technologies; e) Crop residue derived straw panel board-Kuantum Papers Ltd

5.2. Social Innovation Programme for Products: Affordable & Relevant to Societal Health (SPARSH)

SPARSH, another scheme of BIRAC, encourages social entrepreneurs to develop products and processes that will benefit all sections of the society. SPARSH provides financial and technical assistance for the development of 'need based solutions' that may lower the cost of healthcare facilities in the country. SPARSH works to achieve the following objectives:

- Identify and provide support to cutting edge innovations towards affordable product development that can bring significant social impact and address challenges of inclusive growth.
- Provide support in form of impact funding of biotech product innovations (with social goals) that can be scaled-up.
- Create and foster a pool of social innovators in the field of biotech and provide a platform to share the best practices, understand intricacies of business models in social innovation and network.

Till date, 47 projects have been supported of which 18 have accomplished their objectives. More than 13 products/ technologies have been delivered with the assistance of SPARSH. Some of them have been illustrated in Fig 15.

Fig 27: Products Successfully Commercialized through SPARSH Scheme of BIRAC

(Source: BIRAC Brochure 2019)

a) SAANS developed by Coeo Labs Pvt Ltd b)Rhino Digester developed by Flycatcher Technologies LLP c)RightBiotic developed by Xcellence in Bio Innovations and Technologies Pvt Ltd d)ReMeDi-Nova developed by Neurosynaptic Communications Pvt Ltd.

6. POLICY AND ANALYSIS CELL (PAC)

BIRAC has a dedicated team for analyzing proposals received under various schemes for specific fields such as Agriculture, Healthcare, Industrial Biotechnology, Green Technology and Secondary Agriculture. This analysis is carried out under the expertise of 'Key Opinion Leaders'. PAC also plays a vital role in chalking out future activities and identify issues that need to be addressed and worked upon.

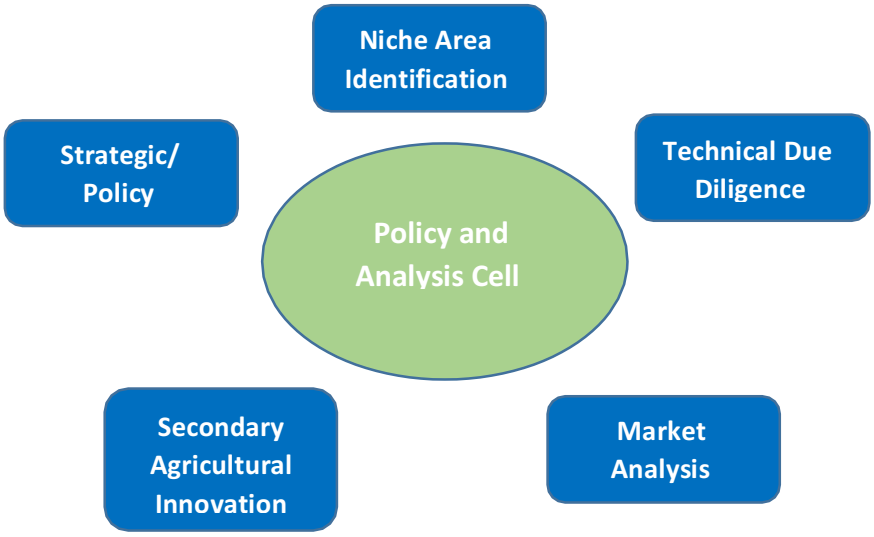


Fig 28: Focus areas of PAC

i. **Strategic/ Policy Discussion**

PAC, under this head, brings together various stakeholders of the innovation ecosystem to discuss matters related to policy. Some of the key areas of discussion have been Bio-incubators, Bio-manufacturing, Infrastructural Needs of Agri-Biotech Sector, Foreign Direct Investment in Pharmaceutical Industry, Translational Facilities, Industry-Academia Collaborations through CRS. PAC, has successfully worked out a mechanism to assist collaboration of Industry and Academia. It has also initiated 'Grand Challenges' in the field of RNA interference and successfully addressed various challenges faced by industry through various schemes.

ii. Niche Area Identification

This initiative is of vital importance as it helps decides the future course of action for the organization. Some of the niche areas identified by PAC are Industrial Enzymes, Maternal Care and Molecular Diagnostics.

iii. Technical Due Diligence Support

PAC plays a crucial role in assessing the worth of the various proposals that reach BIRAC under various schemes. The proposals are vetted for their feasibility, IP potential and Market Potential before they are recommended for support.

iv. Market Analysis

BIRAC keeps a check on the market by procuring and analyzing various databases. PAC uses this data and compiles a detailed report on the designated domain. It is presently working on compiling reports on Influenza Vaccines, Mobile healthcare and the Industrial Enzyme sector of the country.

v. Secondary Agricultural Innovation Cell

BIRAC, under the umbrella of PAC, has established a Secondary Agricultural Innovation Cell, in order to assist SMEs (specifically from the agro-based sector) in reaching the international market. It also helps individuals in creating successful enterprises in this sector.

7. INTELLECTUAL PROPERTY MANAGEMENT AND TECHNOLOGY COMMERCIALIZATION UNIT (IPM-TC)

BIRAC understands the importance of IP in innovation and hence has commissioned a dedicated IPM-TC at DBT-ICT Centre for Energy Biosciences, Mumbai which scrutinizes the received proposals (under PPP schemes) for their IP value. It has also empaneled firms that are well-versed with IP and Technology Transfer know-how. The main scheme through which BIRAC funds the IP, is the Patent Assistance Funding Scheme. Technology mapping is yet another initiative of BIRAC that not only helps in stocktaking the number of technologies ready for commercialization, but also identify technologies that have the potential to be developed further for commercialization. In line with its agenda, BIRAC offers a number of services (Fig 16) to both the public (Academia) and private sector (SMEs, Startups and other elements of the Biotech Industry).

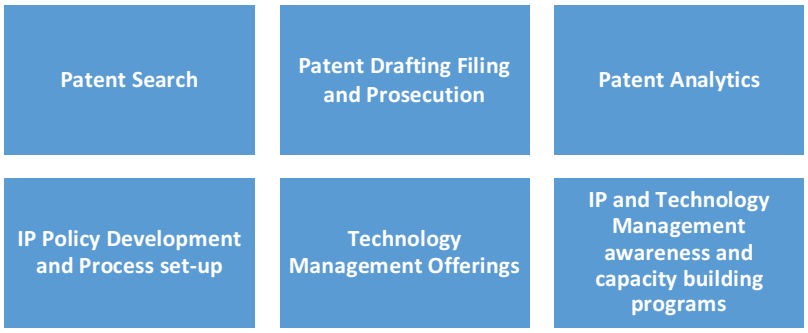


Fig 29: IP and TT Services Offered by BIRAC

8. FACILITATION OF INNOVATION AND REGULATION FOR STARTUPS AND INNOVATORS (FIRST) HUB

(http://www.birac.nic.in/desc_new.php?id=427)

BIRAC has been fueling in all efforts to promote national initiatives like 'Startup India' and 'Make in India' through the setting up of a Facilitation Unit, which act as a nodal point to resolve issues related to Startups, Entrepreneurs, Researchers, Academia, Incubators and Small and Medium enterprises. Along with updating its programs to the dynamically evolving innovation ecosystem, BIRAC also facilitate their queries related to administration, financial support, mentoring, investment, IP, I-A collaborations and market analysis, through its designated unit called 'First Hub'.

First Hub is open to queries every first Friday of the Month at BIRAC office from 3:00 pm to 5:00 pm. Queries are directed to officers from DBT, BIRAC, ICMR, Central Drugs Standard Control Organisation (CDSCO) and other relevant government organizations.

9. TECHNOLOGY PORTAL

(http://www.birac.nic.in/technologyportal.php)

BIRAC has developed an active platform, in the form of a Technology Portal (Fig. 30), for connecting entrepreneurs, domain experts, manufacturers and investors with the technologies and innovations that have been created through BIRAC schemes. The portal catalogues the innovation with details about its working, the inventors and the technology readiness level. This not only provides an opportunity to the nascent technologies emerging to find a partner for maturation and value addition, but also to an Industry looking for a solution to its problems.

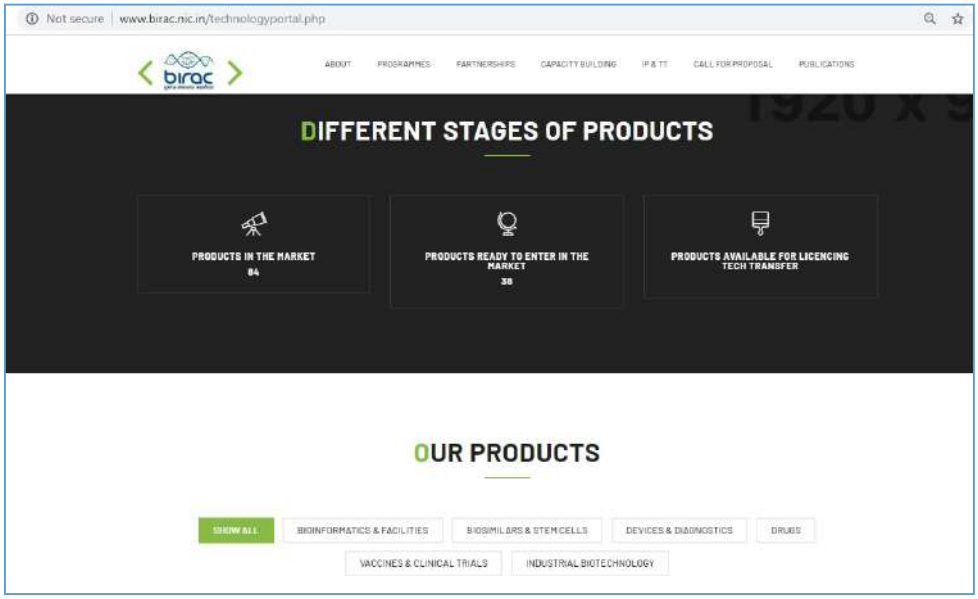


Fig 30: Home-page of the Technology Portal of BIRAC
(http://www.birac.nic.in/technologyportal.php)

The portal has been designed to be user friendly, with the products categorized according to their technology readiness levels and domain to which they belong. This gives the interested party an easy access to the desired technology, which can further lead to alliances or technology transfer, thus promoting translation of research work.

In addition, BIRAC also has the ***3i (Innovate in India) Portal*** which provides user friendly and convenient platform for effective management of various funding schemes of BIRAC. This portal is constantly updated to add new features, making it convenient to operate. Reports by BIRAC are also constantly added, which makes data mining and analysis relatively much more convenient. It does not only assist in conducting surveys and generating reports but also been extended to manage loan recoveries under BIPP and SBIRI.

10. TECHNOLOGY READINESS LEVEL (TRLs)

The process of innovation graduates through various phases, right from ideation to product/technology commercialization. Each stage requires a different kind of intervention and monitoring. Understanding the vitality of this concept, BIRAC took inspiration from the TRL model of National Aeronautics and Space Administration (NASA), USA to introduce a theme-specific 9 level TRL model of its own. These models assist BIRAC in assessing the funding schemes that an innovation is eligible to, based on the maturity of the technology. The TRLs for Drugs and Drug delivery have been illustrated in Fig 31.

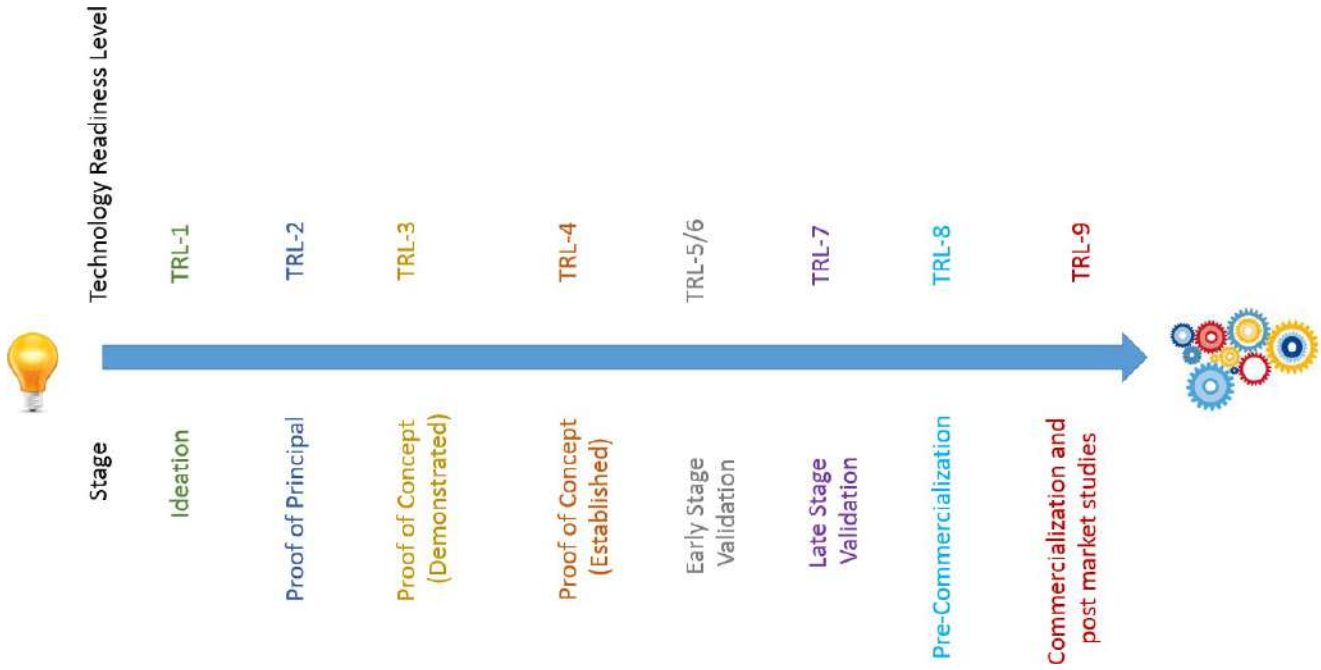


Fig 31: Technology Readiness Levels as Classified by BIRAC (Drugs and Drug Delivery)

BIRAC has designed similar models for 9 other thematic areas. These are Vaccines Biosimilars, Regenerative Medicine, Medical Devices and Diagnostics, Artificial Intelligence, Big Data Analysis, IoTs, Software Development, Industrial Biotechnology (Including Secondary Agriculture) Agriculture, Aqua Culture and Fisheries and Veterinary Sciences.

11. MAKE IN INDIA FACILITATION CELL

Supporting Government of India's initiative to promote home grown technologies, BIRAC constituted the 'Make in India Facilitation Cell' in 2014, to foster and promote the Indian Biotech Industry. This dedicated unit of BIRAC works to achieve four major objectives (Fig. 32)

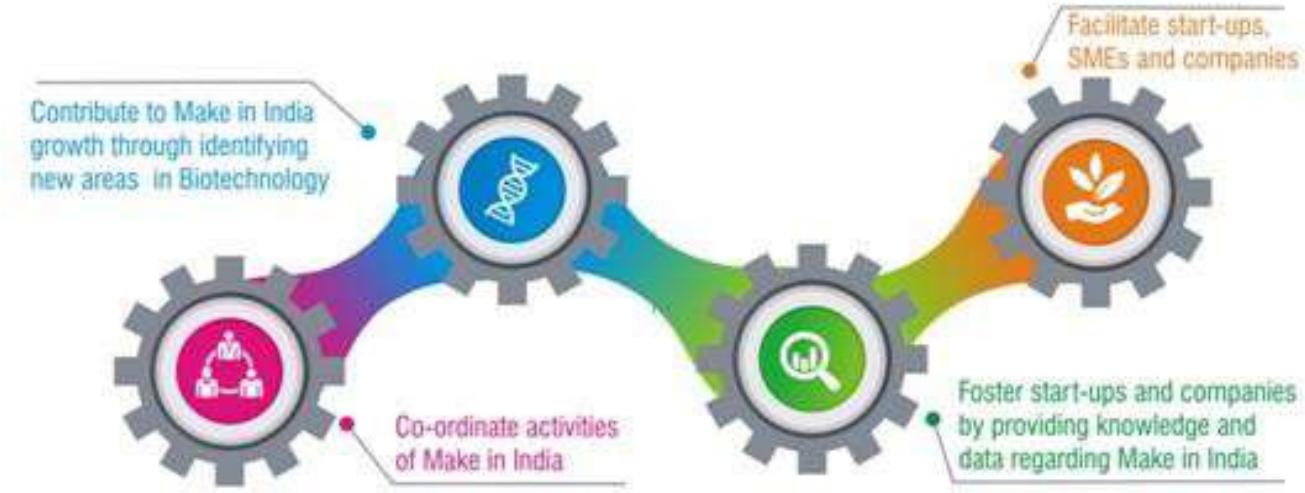


Fig 32: Objectives of Make in India Facilitation Cell of BIRAC
(Source: http://www.birac.nic.in/mii/Introduction-to-Make-in-India.php)

Fig 33: 'Make in India' Biotechnology Page *(Source: http://www.birac.nic.in/mii/)*

The 'Make in India' Biotechnology page (Fig 33) has 8 tabs, each of which leads to a designate path-

MII REPORT- Re-directs the user to a comprehensive report prepared by BIRAC in September 2016, entailing the challenges and opportunities for the Indian Biotech sector along with case studies of select countries.

MII ACHIEVEMENTS REPORT - Guides towards a report comprising the accomplishments of the Indian Biotech industry through the last decade, especially the acceleration it has seen after the institution of BIRAC.

TECHNOLOGY PORTAL - Directs towards the Technology Portal of BIRAC (See Section 9) ***MAKE IN INDIA PORTAL*** **-** Directs towards the 'Make In India' Portal *(http://www.makeinindia.com/home)* that has details of government policies, developments and action plan to make India self-reliant.

WHAT'S NEW **-** Leads to the latest developments in the Biotechnology sector.

VIDEOS *and* ***DOWNLOADS*** **-** Comprises the Videos and relevant documents, related to BIRAC or BIOTECHNOLOGY.

BIRAC FOOTPRINTS **-** This is a page illustrating the outreach and presence of BIRAC pan India.

12. BIRAC-IMPACT ANALYSIS

The success of BIRAC can be measured by the number of technologies that have successfully been manifested out of its various schemes. At present, BIRAC enjoys a pan-India presence and has assisted the successful commercialization of 84 products with 38 products on their way to the market and a fair number of them, ready to be licensed. BIRAC has till date, successfully supported 236 Companies, 161 Institutes, 99 Entrepreneurs, 364 Startups and 152 (Bio-NEST) Startups.

i. Companies Supported

BIRAC has been bolstering the private sector with its consistent support, as evident from the 230 registered companies it has assisted. An analysis of the region-wise distribution of these

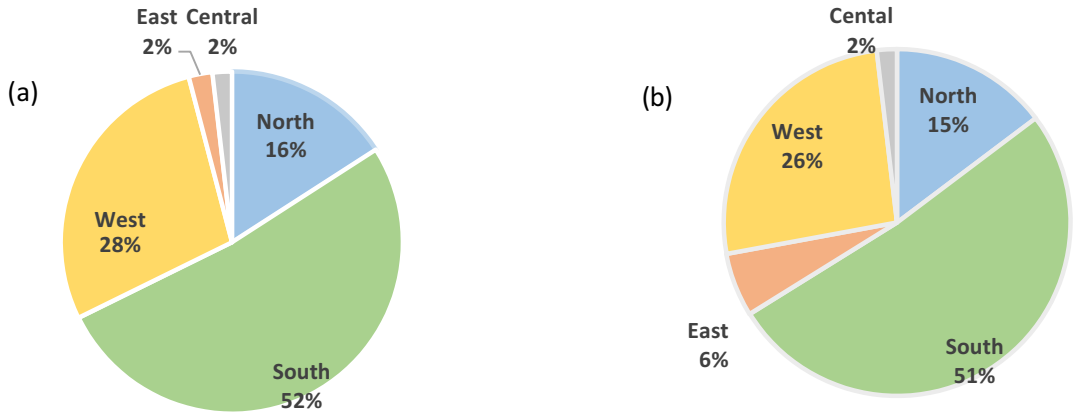


Fig 34: Region-Wise Distribution of Companies (a) and Startups (b) Supported by BIRAC

companies showed that 52% of these are based in the South, 28% in the West, 16% in the North and 2 % each in Central and East India (Fig 34 a). Most of these companies are located in Hyderabad, Bengaluru, Chennai, Mumbai, Pune, Ahmedabad, Delhi and NCR area.

ii. Startups Supported

BIRAC has supported 330 Startups (Fig 34 b), 51% of which are from South India, 26% from the West, 15% from the North, 6% from East and 2% from Central India. Most of these Startups are based in Bengaluru, Chennai, Hyderabad, Mumbai, Pune, Ahmedabad and Delhi. The well-established industrial base at these locations with extensive Entrepreneurial culture makes for a perfect recipe to the mushrooming of Startups.

iii. Institutes Supported

BIRAC has supported 161 institutes (Fig 35), 48% of which are located in the South, 28% from the North, 16% from West, 7% from East and only 1% from Central India. As with the other analysis, it can be safely concluded that the southern part of the country leads in innovative research assisted by BIRAC. However, instead of the West following it, North India does. This observation demands a probe to ascertain the factors leading to a gap between the Industry and Academia in the northern part of the country.

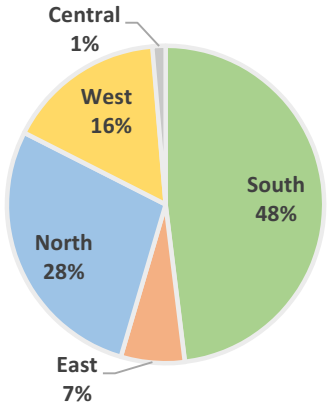


Fig 35: Region-wise support offered by BIRAC to Institutes

Products in the market

84 products have been delivered to the market through the support of BIRAC. These products hail from diverse sectors which have been classified into 7 broad sectors, namely Agri-Biotechnology, Animal Biotechnology, Environment Biotechnology, Healthcare & Pharma, Industrial Biotechnology, Multi-sector and Value Added Products (Fig 36). Maximum products from the Healthcare & Pharma sector were developed and commercialized with the assistance of BIRAC.

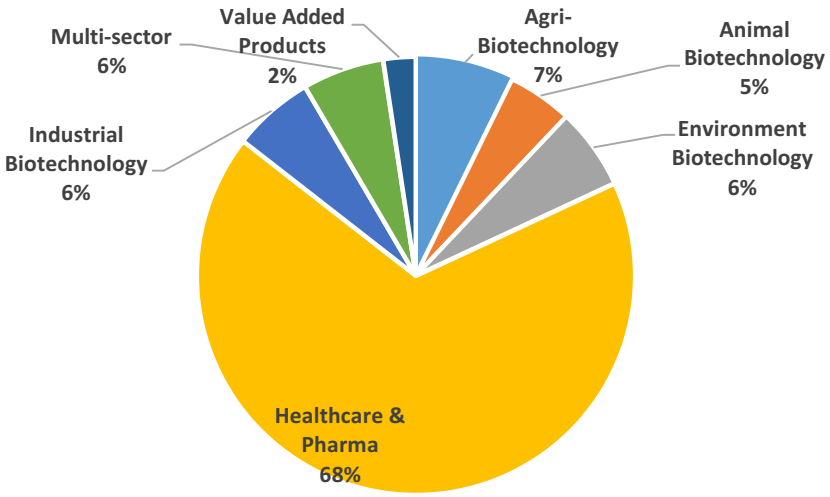


Fig 36: Sector-Wise Distribution of Products Commercialized with the Assistance of BIRAC

The trend for region-wise distribution of the product commercialization matched with the entrepreneurial culture in these regions, with South India delivering maximum number of BIRAC assisted products, followed by West, North and East (Fig 37).

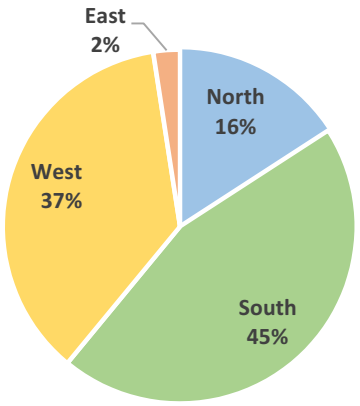


Fig 37: Region-wise distribution of Products commercialized with the assistance of BIRAC

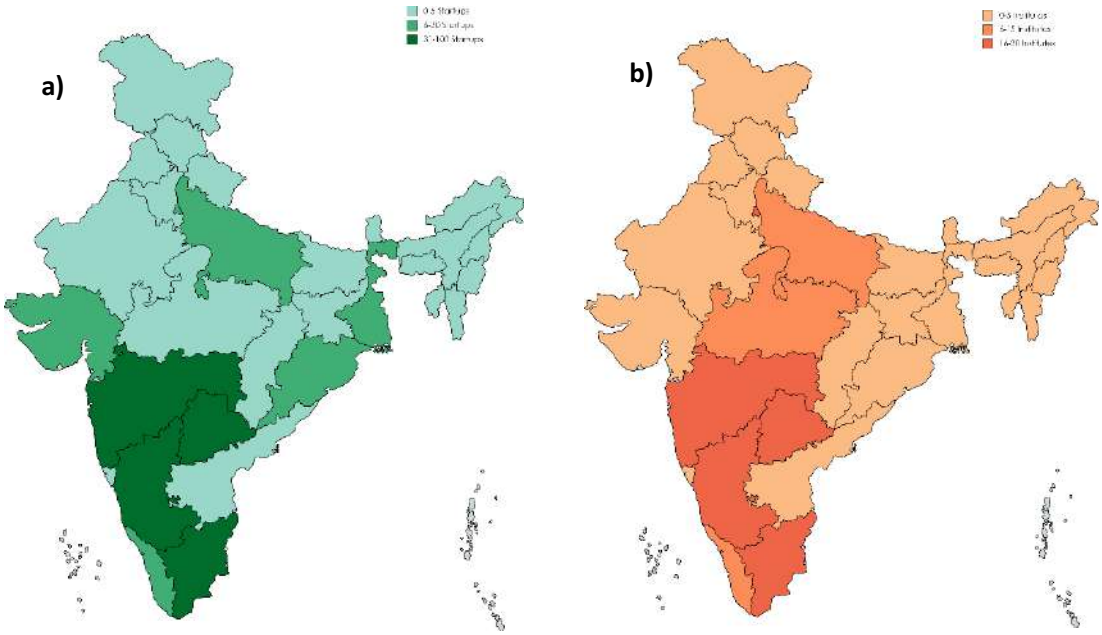


Fig 38: State-wise distribution of BIRAC beneficiaries a) Startup b) Institutes

It is interesting to note that the general pattern of state-wise distribution of Startups and Institutes that sought BIRAC's assistance, is roughly the same (Fig 38). However, the peculiarity arises for

states like Gujarat, Odisha and West Bengal, where the rising Startup culture is not dependent on the assistance taken by Institutes i.e. Academia. On the contrary, states like Madhya Pradesh have been consistently receiving assistance from BIRAC, but are still to catchup on the Startup culture.

BIRAC and PPP trends

BIRAC's commitment towards Public Private Partnership (PPP) is evident from the incremental rise in the PPP investment every single year. (Fig 39 a). Its efforts have been received well and reciprocated by both Industry and Academia, with scientists, students, startups and MSMEs reaching out to it for assistance.

This is evident from the consistent growth in the number of projects that have been supported by BIRAC (Fig 39 b). This model has bridged the gap between the public and private sector, to bring them on the same page, through its innovative set of schemes, as observable through the rise in the number of collaborative projects carried out (Fig 39 c).

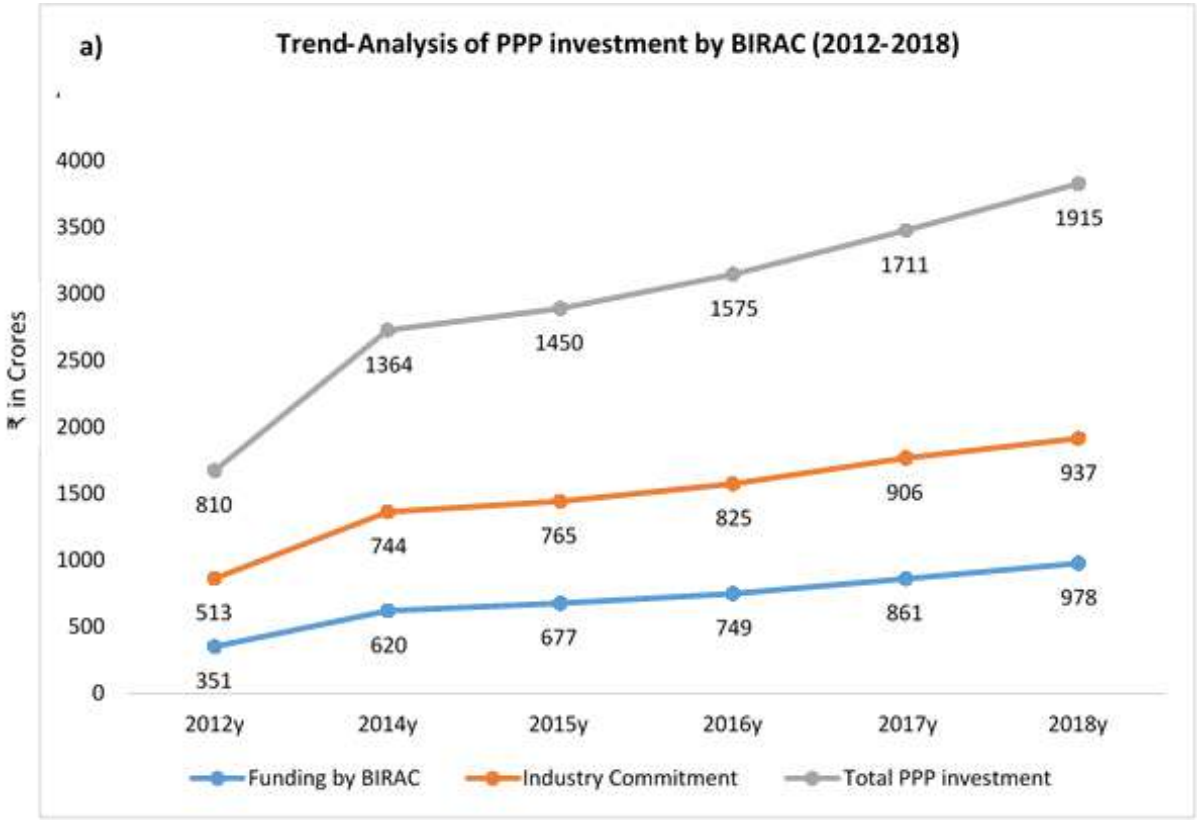
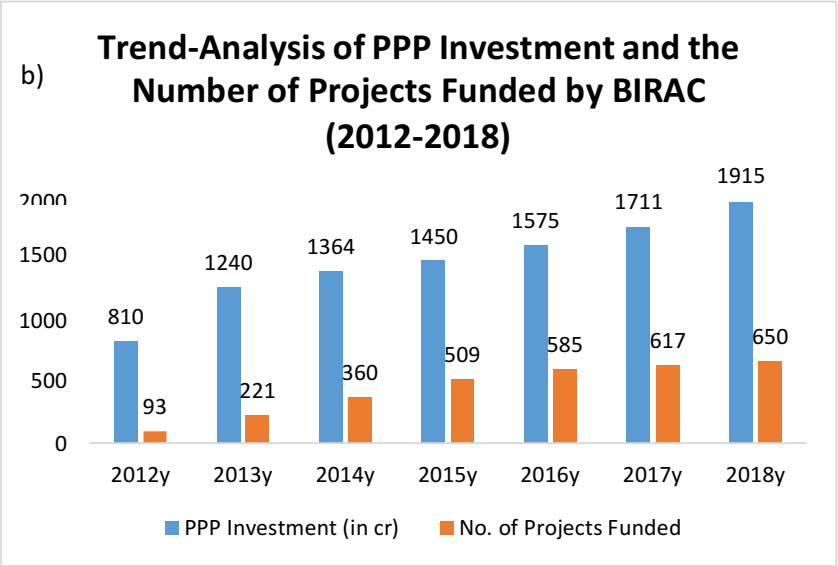


Fig 39: Analyzing trends in BIRAC based on a) PPP Investment (₹ in Crores) by BIRAC (2012-2018)



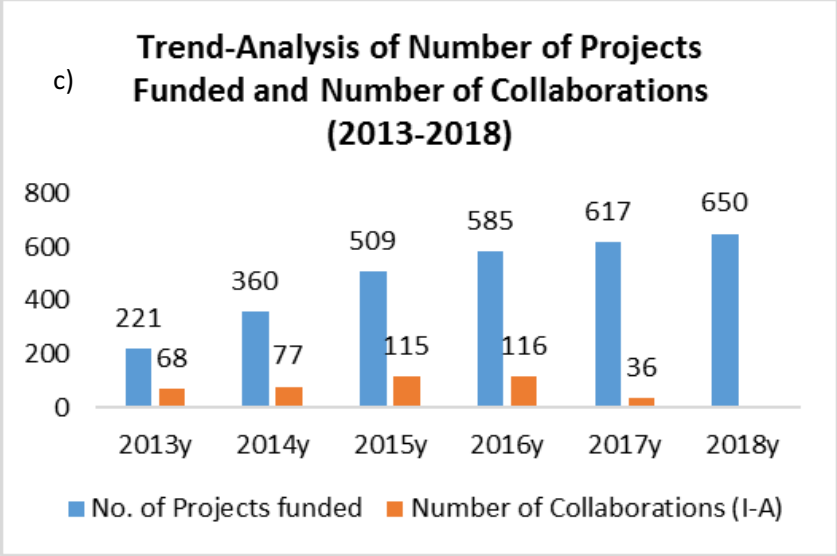
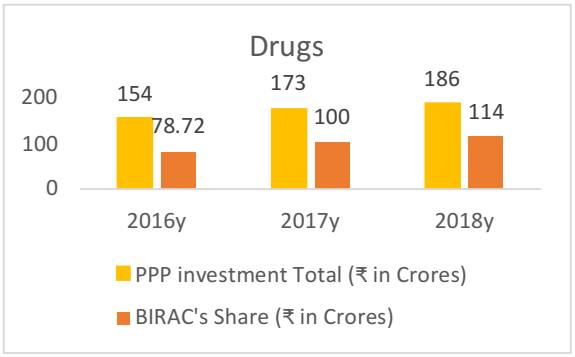
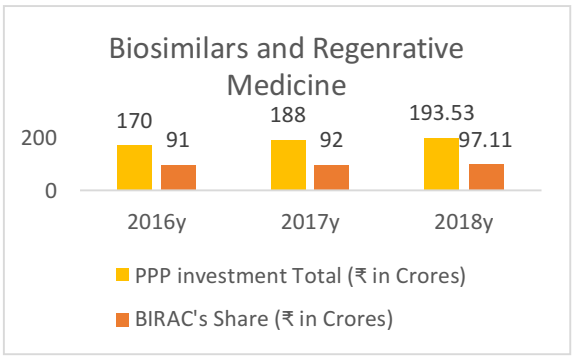
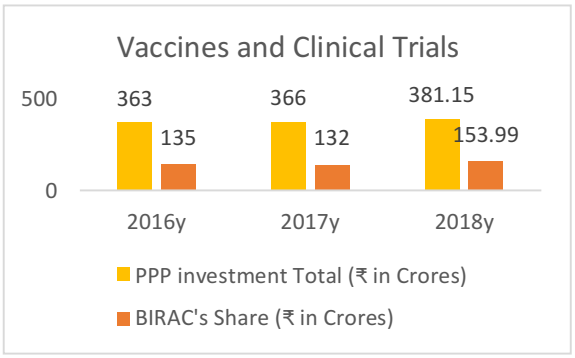


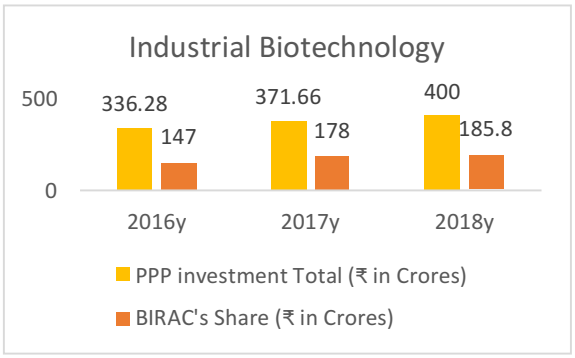
Fig 39: Analyzing trends in BIRAC based on
***b)* Number of Projects Funded (2012-2018) c) Number of Collaborations (2013-2018)**

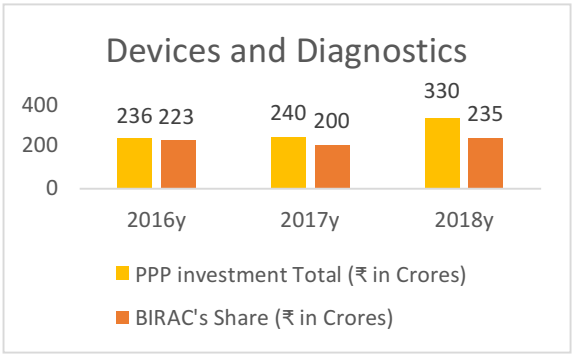
BIRAC supports Biotech-centric projects, in any one of the seven focus areas, i.e. Drugs, Biosimilars and Regenerative Medicine, Vaccines and Clinical Trials, Industrial Biotechnology, Agriculture and Bioinformatics and Facility. A quick analysis of Fig 40, shows that Industrial Biotechnology has received a major share of the PPP investment. While most other sectors have been seeing a growth in PPP investment, Bioinformatics is the only field that has seen a drop in it. This could be further looked into, for identifying the reasons for this fall. Devices and Diagnostics was another field which saw a fall in investment by BIRAC in 2017, but bounced back in 2018.

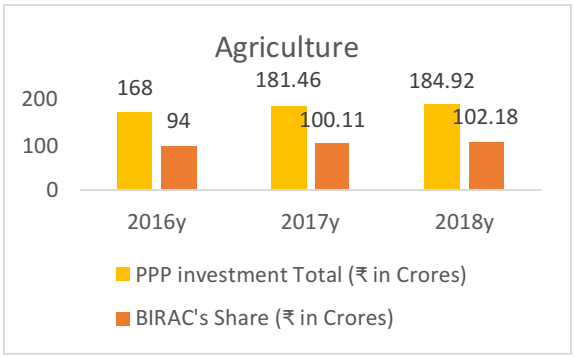












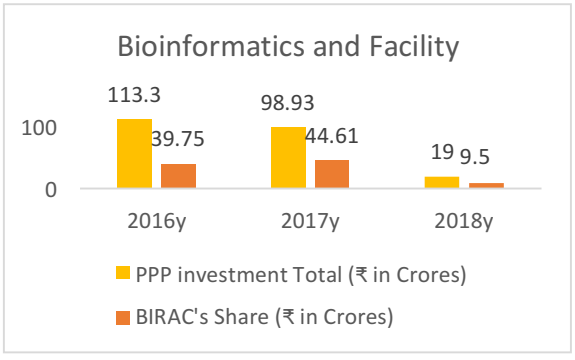


Figure 40: Theme-wise Analysis of PPP Investment (Total) and BIRAC's Share for the period 2016 to 2018 *(All the values mentioned in the graphs are ₹ in Crores)*

The rising PPP investment has further influenced an increment in the IP generated. The ascending bars in Fig 41 for IP generated, has further consolidates BIRAC's claims, for having successfully assisted Innovative ideas with commercialization potential.

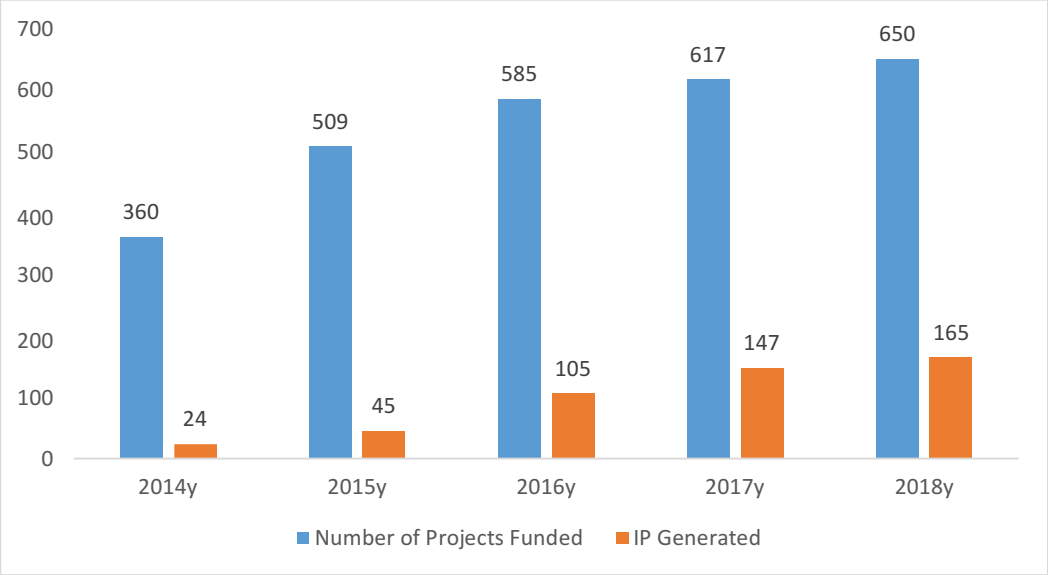


Fig 41: Trend-Analysis of IP Generated in comparison to the Projects Funded (2014-2018)

CONCLUDING REMARKS

The success of BIRAC is anchored upon a dynamic set of elements that deliver high-powered support and solutions to the Indian Biotech Industry. These may be emulated by other ministries/departments to achieve multi-sectorial advancement at the national level.

1. Section 8 Company

The money intensive, yet risky nature of the bio-pharmaceutical research leaves the Indian public sector, to carry the entire financial load of performing R&D, all by itself, with only a minor contribution by the private sector. Moreover, bureaucratic inclination of the public sector, further slows down the delivery of bio-innovations. The institution of BIRAC as a Section 8 company, has not only checked the red-tapism prevalent in the public sector but facilitated the easy disbursal of its schemes/programmes. Being a section 8 company, BIRAC enjoys the legal and functional independence that may be missing in other entities of similar nature and has a lot more credibility than the regular 'not for profit' organizations, trusts and societies. Thus, it can serve as a role-

model for the institution of sector-specific Section 8 companies within other ministries and departments.

2. **Stage Specific Support through Dynamically Oriented Programmes and Schemes** BIRAC works through a dynamic set of schemes/programmes that are tailor-made for each stage of the innovation cycle. It supports innovative ideas at the *Ideation stage* (BioNEST, UICs); *Ideation to Early Stage* (BIG, SITARE, eYUVA); *Ideation to Late stage* (SBIRI, BIPP); *PoC to late stage* (ETA, PACE) and *Equity Funds* (SEED Fund, AcE Fund, LEAP Fund, Product Commercialization Fund). Such a mechanism ensures that no stage of the innovation cycle is left unassisted. BIRAC may therefore be treated as a template to formulate similar programmes for other sectors as well.

3. Dedicated Schemes for Industry and Academia

BIRAC has a varied set of schemes/programmes that are customized to suit the requirements of its beneficiaries (Scientists/SMEs/start-ups). Programmes like, BioNEST, BIG, eYUVA and UICs have given a fresh impetus to bio-entrepreneurship in academia, and PACE and ETA have brought academic innovations much closer to the market. Funding schemes such as SBIRI, BIPP, BIG and PACE have further promoted PPP in R&D, serving to mutually benefit both the public and the private sector. Since, bio-innovations can turn out to be money-intensive and have a fair share of involved risk, BIRAC has handheld high-risk innovations of the private sector through BIPP, and that of the public sector through PACE. The loan/equity based funding support offered by BIRAC has ensured that start-ups and SMEs are handheld in their most vulnerable phase, 'the valley of death'. These programmes can be treated as a standard, for development of similar schemes, dedicated to various sectors.

4. PPP Mode of Functioning

BIRAC has a number of programmes that function only in PPP mode (SBIRI, BIPP, PACE, I3, etc.), thereby ensuring that the resources and expertise of both Industry and Academia are synergized to deliver the desired outcome. This not only ensures better and faster delivery of solutions, reduction/sharing of risk between public and private sector, but also results in much better management of the project. BIRAC's PPP framework may be taken as a template to institute similar PPP promoting organizations in other sectors.

5. Robust Administrative and Functional Framework

BIRAC enjoys a robust administrative and financial framework which is built upon three verticals, *Investment Schemes, Entrepreneurship Development and Strategic Partnerships*, each detailed

with a dedicated objective. Clearly defined roles and responsibilities at each stage of management, not only ensures efficient managerial output, but also delivers seamless governance

6. National and International Outreach

Placing 'networking' as one of the principal agendas, BIRAC has connected extensively with the various stakeholders of the innovation ecosystem. It not only enjoys a pan-India presence but has left its mark globally, through a number of strategic national and international alliances. It has nationally associated with organizations like TISS, IAN, TiE-Delhi, ICMR, LEHS-WISH and MeitY and initiated a number of sector-specific programmes. BIRAC has also joined hands with international organizations like Wellcome Trust, CEFIPRA and BPI France, USAID, Nesta, BMGF, UKTI, TEKES (now Business Finland), QUT and World Bank, to resolve a number of national and international socio-economic issues through biotechnological interventions. This reaffirms the fact that joining forces with the right allies, not only halves the troubles and doubles the assets, but also brings you much closer to the destination.

7. Region-specific development through Knowledge-clusters

In pursuit of understanding regional innovation requirements and capacities, BIRAC, in association with IKP-Hyderabad established BRIC, which intends to stimulate the national bio-innovation ecosystem, through the creation of bio-clusters. These knowledge clusters not only help identify gaps but also intend to devise interventions that promote biotech industry through tailor-made initiatives, specific to the requirements of the region. Other ministries may take lessons from this initiative to promote a region specific development in their sector.

8. Technology Portal

BIRAC hosts an interactive web-portal that houses all the technologies and products that have been developed with the assistance of BIRAC and are available to be commercialized/licensed. This portal acts as a show-window for the industries to browse through and connect directly with the innovator, thereby facilitating easy translation/commercialization. Similar web-portals may be designed by other ministries/departments in order to bridge the gap of ignorance between the innovator of the technology and its consumer industry.

9. 'Make in India' Facilitation Cell

Pursuing the vision of 'Make in India' initiative, introduced by GoI in 2014, BIRAC instituted a dedicated 'Make in India' Facilitation Cell, to 'promote the manufacturing capabilities of the Indian Biotechnology sector'. Such an initiative is a clear display of BIRAC's commitment of complying with a national agenda.

10. Promotion of Entrepreneurship

BIRAC, ever since its inception, has been emphasizing on promotion of entrepreneurship amongst the students/young innovators. All its schemes, in some way or the other have been directly or indirectly aimed at promoting a sense of entrepreneurship. While eYUVA (CICs/UICs), BioNEST, SITARE, BIG, PACE and ETA, have been oriented around promoting entrepreneurship in academia, SBIRI, BIPP and Equity funds (SEED/AcE/LEAP Funds) have handheld the private sector and thus encouraged entrepreneurs. This must be appreciated by other departments to vitalize a culture of entrepreneurship within all the industrial sectors of the country.

11. Auxiliary Assistance

BIRAC also provides additional assistance through assessment of the Technology Readiness Level to provide Level specific support, vetting of technologies for potential intellectual property protection and technology transfer, connects beneficiaries to potential end users / licensees through its Technology Portal and invites Startup and innovation related queries of varied nature through First HUB. A dedicated Policy Analysis Cell lays out a blueprint for the effective functioning of the organization.

12. Auditing and Self-Appraisal

BIRAC floats periodic reports with multi-dimensional analysis of all its schemes based on a comprehensive set of parameters. Such introspection has been the key factor behind BIRACs leap to success in a short span of time. Its BRIC has also been engaged in understanding the efficiency of disbursal of its present schemes/programmes, in order to develop highly focused programmes to address the requirements.

13. Multiple Facilitation Nodes

Rather than functioning on a singular platform, BIRAC has branched out with a strong national presence, through its regional centres (BRIC, BREC and BRBC), BioNEST Incubators, BIG partners and UICs/CICs, each of which have been entrusted with a specific set of responsibilities. They have not only been facilitating a sense of academic entrepreneurship, but certain BioNEST incubators/BIG partners are also entrusted with disbursal of specific grants/loans/equity funds as well as technical and mentoring services.

Biotech sector of the country has seen an exponential rise in PPP investment, since 2012, with **₹978 Cr being invested by the public sector (BIRAC), ₹937 Cr by the private sector (Industry) and ₹200 Cr through equity in the last 7 years. It has established close to 41 Bio-**

incubators and 4 BIRAC Regional Centres, and has delivered 130 technologies, 175 IPs and 330 start-ups. It regularly undertakes self-appraisal on various parameters, and publishes elaborate reports showcasing its performance in the previous financial year.

Due to its given attributes, BIRAC has successfully served as an instrument to accelerate the Indian Biotech sector. It has also validated the fact that participation of the private sector alleviates the problem of funding deficit and hence delivers the expected innovative outcomes. Although BIRAC is tailor made for the money intensive Biotech Industry, similar councils with lesser money involvement may be instituted by otherR&D active ministries to stimulate and promote the varied Industrial sectors in the count

APPENDIX 1

Abbreviations:

***AcE**- Accelerating Entrepreneurs Fund*

***BIG**-Biotechnology Ignition Grant*

***BioNEST**- Bioincubators Nurturing Entrepreneurship for Scaling Technologies*

***BIPP**- Biotechnology Industry Partnership Programme*

***BIRAP-** Biotechnology Industry Research Assistance Programme*

***BMGF**-Bill and Melinda Gates Foundation **BRBC**-*

*BIRAC Regional Bio-Innovation Centre **BREC**-*

*BIRAC Regional Entrepreneurship Centre **BRIC**-*

BIRAC Regional Innovation Centre

***BRTCI-** BIRAC Regional Techno-Entrepreneurship Centre*

***CAPS-**Centre for Advanced Protein Studies*

***CIC**- Cluster Innovation Centre*

***CEFIPRA**- Indo-French Centre for the Promotion of Advance Research (IFCPAR)*

***CRS**- Contact Research Scheme*

***ETA-**Early Translation Accelerator*

***eYUVA**- Encouraging Youth for Fellowship*

***I3**- Innovate in India- National Biopharma Mission*

***IAN**-Indian Angels Network*

***ICMR**- Indian Council of Medical Research*

***IIPME**-Industry Innovation Programme on Medical Electronics*

***IKP**- ICICI Knowledge Park*

***KIIT**- Kalinga Institute of Industrial Technology*

LEHS-WISH*- Lords Education and Health Society-Wadhwani Initiative for Sustainable Healthcare)*

MeitY*- Ministry of Electronics and Information Technology* ***Nesta-*** *National Endowment for Science, Technology and the Arts* ***PACE****- Promoting Academic Research Conversion to Enterprise* ***QUT****- Queens University of Technology*

SBIRI*-Small Business Innovation Research Initiative*

SEED FUND*-Sustainable Entrepreneurship and Enterprise Development Fund*

SIIP*-Social Innovation Immersion Program*

SITARE*- Students Innovations for Advancement of Research Explorations*

SPARSH*- Social Innovation Programme for Products: Affordable & Relevant to Societal Health*

SRISHTI*- Society for Research and Innovation for Sustainable Technologies and Institutions*

TEKES*-Merged with FinPro in Jan., 2018 now known as Business Finland*

TiE*-BIRAC-The Indus Entrepreneurs Delhi* ***TISS****- Tata Institute of Social Sciences* ***UIC****- University Innovation Cluster*

UKTI-*UK Trade and Investment*

USAID IKP-TB*-U.S. Agency for International Development-ICICI Knowledge Park-Tuberculosis*

Information Regarding	Accessible at:
1. Sector-wise contribution of Public (BIRAC) and Private (Industries) Sector 2. Theme-wise projects sanctioned 3. Theme-wise IP generated 4. Region-wise distribution of Products 5. BIRAC beneficiaries & Collaborations 6. Theme-wise Assessment 7. Innovation Profiles of BIRAC beneficiaries	***For 2012:*** http://www.birac.nic.in/webcontent/BIRAC_Compendium_2012.pdf
	For 2013: http://www.birac.nic.in/webcontent/BIRAC_Compendium_2013.pdf
	For 2014: http://birac.nic.in/webcontent/BIRAC_Compendium_2014.pdf
	For 2015: http://www.birac.nic.in/webcontent/birac_compendium_2015.pdf
	For 2016: http://www.birac.nic.in/webcontent/birac_compendium_2016.pdf
	For 2017: http://www.birac.nic.in/webcontent/birac_compendium_biological_book_file.pdf
	For 2018: http://www.birac.nic.in/webcontent/1538651473_birac_compendium_04_10_2018.pdf

About DST-CPR at Panjab University, Chandigarh

DST-Centre for Policy Research (DST-CPR) at Panjab University, Chandigarh is one of the five centres set up by Department of Science and Technolo Government of India, in 2014, as a part of SHRISTI (Science, Research and Innovation System for High Technology-led path for India), for the effectiv implementation of the Science, Technology and Innovation Policy (STI), 2013. The Centre makes evidence-based recommendations to DST, based on i three main objectives,

(i) promoting Public Private Partnership (PPP) in Research and Development (R&D)

(ii) stimulating private sector investment in R&D

(iii) identifying and promoting areas for generation of Intellectual Properties.

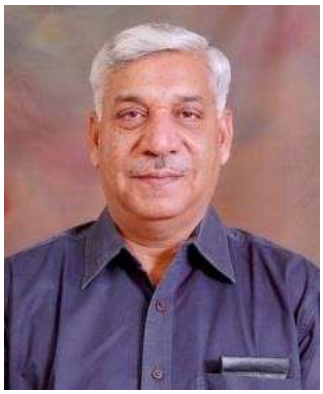
Until now, the Centre has submitted 10 reports and 2 books to Government of India. One of the books, "Industry-Academia R&D Ecosystem in India ar evidence based study", published by the Centre in 2016, has mentioned BIRAC as a shining example of PPP catering to the Biotech Indu (http://cpr.puchd.ac.in/wp-content/uploads/2017/05/Industry-Academia-RD-Ecosystem-in-India.pdf). Tremendous progress made by the organization s 2016, makes it imperative to carry out a comprehensive study on its programmes. Hence, in line with the first objective of the Centre, the present case s has been carried out to appreciate the viable functioning methods employed by BIRAC. BIRAC has successfully demonstrated that synergizing the resou and expertise of the PUBLIC and PRIVATE sector channelizes productive energies leading to Innovation, and can be presented as a Model for other fun agencies to follow. Most of the data for the study has been retrieved from the official website of BIRAC (www.birac.nic).

Acknowledgments

DST, GoI for financial assistance and timely guidance.

Our colleagues at DST-Centre for Policy Research, Panjab University for their suggestions and constant support.

About the Authors



Prof. Rupinder Tewari is the founder & professor in the Department of Microbial Biotechnology, and Chief-Coordinator, DST-Centre for Policy Research at Panjab University, Chandigarh, with a rich experience of 40 years in the domains of academics and research. After graduation, post-graduation and PhD from the Dept. of Microbiology (Hons. School), Panjab University, he went on to receive a second PhD (Microbiology) from University of London, London (UK) and a Post- Doctorate from Washington University, Saint Louis, USA. He is a recipient of the prestigious *Rockefeller Biotechnology Fellowship (USA)* and *Commonwealth Academic Staff Scholarship (UK)*. He has to his credit over 100 research publications in international journals and four books in the field of Microbiology and Biotechnology. His recent books, *'Mapping Patents and Research Publications of Higher Education Institutes and National R&D Laboratories of India'* and '*Industry-Academia R&D Ecosystem in India. an evidence based study*', have been highly appreciated by the policy makers, ministries and funding agencies of Government of India. Prof. Tewari has vast administrative experience and held eminent positions at Panjab University, such as Dean (Faculty of Sciences); Chairperson, Department of Biotechnology; Founder & Chief- Coordinator, Centre for Innovation Cluster (Biotechnology); Director (Hony.), Centre for Industry-Institute Partnership Programme. In addition, Prof. Tewari has been the Founder of *Association of Microbiologists of India (Chandigarh Unit);* Co-Founder, *Chandigarh Region Innovation & Knowledge Cluster (CRIKC);* and Member, Board of Directors, Nectar Life Sciences Ltd., Chandigarh.

Dr. Navkiran Kaur is working as Sr. Scientist-C with DST-Centre for Policy Research at Panjab University, Chandigarh since April 2018. She is pursuing her research work in the domain of PPP Models in India. She is a graduate and post graduate from the Dept. of Biotechnology (Hons. School), Panjab University, Chandigarh. She is the recipient of the University Gold Medal (Biotechnology), UGC-Junior Research Fellowship and received her doctoral degree from the Dept. of Microbial Biotechnology, Panjab University, Chandigarh with specialization in Molecular Biology and Structure Based Drug Design. She has research publications in journals of international repute and has presented her research work in a number of conferences. She has been actively involved in organizing various industry-academia meet/symposia at the Centre ever since she joined. She has previously worked as a Career Counsellor/ Life skills coach and was actively involved in conducting workshops on Soft Skills through various schools and colleges in the country.

Annexure II

One Day Round-Table Meet on Technology Commercialization

Saturday 1st Feb. 2020
Panjab University, Chandigarh

To strengthen the innovation ecosystem of India, DST-Centre for Policy Research (CPR) at Panjab University (PU), Chandigarh in collaboration with Chandigarh Region Innovation and Knowledge Cluster (CRIKC) organized a 'Roundtable-Meet' entitled CHALLENGES IN TECHNOLOGY COMMERCIALIZATION' on Saturday, February 1, 2020 in Panjab University, Chandigarh.

The technology experts from 15 CRIKC member institutes [Indian institute of Technology (IIT)-Ropar, Panjab University-Chandigarh, Indian Institute of Science Education and Research (IISER)-Mohali, Punjab Engineering College (PEC)-Chandigarh, National Institute of Technical Teachers Training & Research (NITTTR)-Chandigarh, Chitkara University-Chandigarh, Council of Scientific and Industrial Research (CSIR) -Institute of Microbial Technology (IMTECH)-Chandigarh, CSIR- Central Scientific Instruments Organisation (CSIO)-Chandigarh, National Institute of Pharmaceutical Education and Research (NIPER)-Mohali, National Agri-Food Biotechnology Institute (NABI)-Mohali, Center of Innovative and Applied Bioprocessing (CIAB)-Mohali, Centre for Development of Advanced Computing (C-DAC)-Mohali, Semi-Conductor Laboratory (SCL)-Mohali, Punjab State Council for Science & Technology (PSCST)-Chandigarh and Maharaja Aggrasen University-Baddi; Annexure 1] deliberated on the gaps existing in technology commercialization and also suggested solutions to most of these challenges.

Recommendations

1. The academic institutes (Higher Education Institutes and National Research Labs.) engaged in active research should have a vibrant Business Management Cell (BMC), which acts as a moderator/catalyst between the industry and the academia. BMCs (or its equivalent) are considered a vital component for promoting innovations and as exist in IISc-Bangalore, many IITs and foreign universities known for generating R&D led innovations. Each BMC

2. Although, there are many funding schemes for generating technology/innovative products, but there are limited schemes for the updation of technologies that have been created in the universities or national research labs. In the present era, technologies become obsolete within couple of years after hitting the market. These days Internet of Things (IoT) enabled technologies are needed/preferred over analog based technologies/products. Hence, it is recommended that more schemes for updating existing technologies may be introduced. Such schemes will also aid in modernizing the existing technologies and make them future ready.
3. A properly certified technology/product [i.e. high Technology Readiness Levels (TRL)] stands high chance of success to be taken up by the industry. A company has faith in certified product/technology. Unfortunately, majority of scientists are not aware of TRLs, nor there are enough testing centres/certification centres to evaluate technologies/products created in the R&D labs. Automobile and Aviation sectors have good testing centres/certifications, but in other domains, the situation is not encouraging. Government should seriously look into this issue, and set up sector-specific testing centres/certification in R&D labs.
4. There are many technologies lying unsold in the R&D labs. It is due to the fact that not much emphasis is laid on marketing the technologies/products by national research labs and universities. Also, the stakeholders (industries and entrepreneurs) are un-aware about these technologies. To fill these gaps, CSIR has come up with Fast Track Commercialization (FTC) funding scheme and has started paying dividends. Such an initiative will contribute in self sustenance of at least 25% of the R&D budget of each lab. It is suggested that other funding agencies may set up a similar scheme for speedy commercialization of technologies lying unsold in the laboratories.
5. For stimulating technology commercialization, CSIR-CSIO at Chandigarh engaged many MBA interns (from PU, Chd.) for market survey/study. It was a win-win situation for CSIO and PU as the results of such experiment were quite positive. It is suggested that R&D labs and research oriented universities may engage MBA students for technology marketing through internship or short term trainings.
6. It has been observed that the presence of an experienced industry R&D personnel in the academic environment has a positive influence on the scientific community. It is suggested

mind set. This model is working very well in the state of Orissa.

7. A scientist can prepare/create/design a lab-scale prototype. But the industry is interested in an improved version i.e. commercial prototype, which requires further research and inputs from the industry. Unfortunately, there are not many schemes which cater to this aspect of Translational Research. Department of Biotechnology (DBT) has constituted a Section 8 Company 'Biotechnology Industry Research Assistance Council (BIRAC)' that supports technology development through idea generation to prototype development and commercialization of the technology, hence catering to each stage of technology development. It is suggested that dedicated funding schemes for taking lab-scale prototype to commercial prototype should be introduced by govt. funding agencies.
8. Generally, funding agencies introduce schemes in a mission mode approach; in other words funds are allocated for a limited/fixed time period. This approach has not delivered desired results as commercializable technologies have a long gestation period, and also need to be updated from time to time, if it has to survive/succeed the market completion. Hence, Long Term Funding Schemes are required spanning 10-15 years, catering to different sectors.
9. Dr. Abdul Kalam (Fmr. President of India) recommended setting up of 100 Centres of Excellence (CoEs) in various fields of research, on long term basis. But only 25-30 were established and even some of them are closed as of now. These CoEs have to be sustained as continued R&D efforts are needed to remain competitive in the market.
10. Industries should also change their mind set of funding short term (1-3 yrs) research projects. Rather they should go for long term investment by establishing CoEs, cooperative labs, etc. wherein, the scientists of industries and academia work hand in hand. Such CoEs should also have highly skilled technical staff.
11. Many technologies rely on the availability of components from the market. Hence, an institute/R&D lab. must have a strong network with the vendors. This aspect is very important for technology commercialization. It is also recommended that each institute must have a list of its alumni who have setup industrial units. Such units have a natural bonding with their alma mater and would be happy to render their services, even at a cheaper price.
12. Scientific leadership is also one of the important parameters for success in Translational

and research labs should be led by experienced scientific leaders accompanied by team of members from science and management background.

13. Although Corporate Social Responsibility (CSR) funds of industries can be used for carrying out R&D work in the universities/research labs. But industries are not free to utilize these funds; government influences where to spend CSR money e.g. Ganga purification plan. This point needs serious consideration by the government.
14. Government's Research Support System is not conducive for the majority of institutions. It prefers IITs and Institutes of Eminence. No long term plans for supporting R&D in universities and colleges, which are over 1,000 in number.
15. More emphasis should be given to Inter-Disciplinary and Trans-Disciplinary research. It should be reflected not only in R&D, but in hiring of faculty in the universities. Chances of Translational Research will be much higher if the diversified group of professional's work on a project, rather than a homogenous group.
16. Sometimes, an industry buys the technology but does not use it as imported item fetches more value. Government intervention is needed in this matter. Moreover, the academic/research institute that sells the technology to the industry should be closely associated with industry for technology use and technology maintenance and government should provide a support system to nurture this.
17. Too much time is taken up for the grant of a patent in India. This process needs to be speeded up. Patented technology fetches more value. In addition to this, the protection of utility patents for small inventions can be introduced in India.
18. Many innovative technologies are lying on the shelves of R&D labs. A mechanism needs to be developed through which young aspiring minds (budding entrepreneurs) should come to know about these technologies and may decide to set up their own industrial unit. Each lab should develop interactive web platform where the technologies developed and available for licensing should be marketed.
19. Market-to-Mind approach is far better than Mind-to-Market approach. Hence, scientists should engage with industries and work on an industry generated R&D problem right from the initiation of idea/research project. This approach has more chance of success and also reduces the time taken to generate industry ready prototype.
20. In developed nations, the industry provides necessary funds for R&D to be carried out in

developing countries, it is the government which contributes towards R&D funds. Central Government may look into this aspect seriously. It can reduce its share of R&D expenditure, by granting more incentives (tangible and intangible) to the industries.

21. In India, BIRAC is a highly successful model of promoting public-private R&D partnership. It has various funding schemes, starting from the ideation stage to technology commercialization for public and private sectors. BIRAC also assists in TRL evaluation of medical/pharma technologies. The R&D investment share of public and private sectors in the BIRAC sponsored projects is nearly 50-50. Many patents/technologies/start-ups have been generated in short span of its existence. It is suggested that each funding agency should look into BIRAC model and strengthen/re-orient their funding schemes accordingly.
22. Some Indian funding agencies like DST, DBT, MeitY etc. have set up number of Technology Business Incubators (TBIs) across India for converting an innovative idea into prototypes. But, the next phase (i.e. Accelerator phase) of taking the prototype to market is very critical. Most of the entrepreneurs fail here. This phase also called as 'Valley of Death' phase, needs a strong hand holding by the government. Government has responded by setting a few domain specific Accelerators. But, the need of the hour is to establish many more Accelerators, especially in the domain of 'Clinical Testings' for Phase 2 and Phase 3 studies.
23. In the present innovation era, only those industries will survive which have their own R&D set-up and/or tied up with academia (universities and R&D labs). In India, many industries situated in the State of Orissa are collaborating with academic institutes and the results are very encouraging. It is suggested that all industries may tie up with universities and R&D labs, preferably the ones closely located. In fact, the latest Industrial Policy-2019 also emphasizes this very point.
24. In the majority of the universities, there is no provision of relaxation in the teaching load of a professor/scientist excelling in R&D. It takes a heavy toll on the scientist. MHRD may look into this aspect. Also it is suggested that MHRD may introduce positions of Research-Professor, Research- Assoc. Professor and Research- Asstt. Professor in the universities to promote good quality research in the academic environment.
25. Avenues should be created for incentivization of scientists engaged in Translational

state level and institute level.

27. After the retirement of scientists, the process of technology commercialization of his/her developed-technologies gets halted. Special assistance scheme should be introduced for taking up such halted technologies along with the introduction of R&D grants for retired scientists. Hand-over of technologies is required and technology development/commercialization should not stop if a scientist leaves.
28. National Research Organizations e.g. CSIR are meant for assisting industries and not for financial benefits. Hence, the technologies should not be priced exorbitantly. It should be priced moderately so as to encourage industry to buy it.
29. A national policy needs to be in place for the purchase of homegrown technologies/products. CSIO made 6 Linear Accelerators in 1990s. All were working efficiently in hospitals. Prices of foreign Accelerators came down heavily in India. But. Govt. stop funding for making more Accelerators.
30. It has been observed that institutes which hire experienced and super-annuated scientists, display better R&D outcomes and tend to secure more funds from the agencies. It is suggested that universities should be encouraged to hire such scientists as Adjunct Faculty.
31. The auditing of the universities, R&D labs and funding agencies should be a serious business and should be done annually by competent team who are fully aware of the ins and outs of the organizations.
32. Developing a technology is far more challenging than publishing a research paper. In India, fear of failure is considered as a stigma. Also, promotion-evaluators give more emphasis to published papers than to patents granted and commercialized. The hard work and time invested in technology development in case of failure are not considered and does not find favours with evaluators. Abroad, it is considered as a part of success and not as a failure. This mind set needs to be changed in India.
33. The current mind-set of Indian scientists is more towards research project (for publications) rather than technology oriented project. This needs to be changed. For this, interphase needs to be created wherein academia and industry people meet and join hands to address societal issues requiring R&D interventions, and work on industry problems needing intellect of academia.

industry as per the agreement signed. The scientist has to change his mind set, if he/she desires to work on an industry-academia research project. He/she should tune the mind to complete the project well before the set dead-line.

35. Many scientists in universities and research labs. have wonderful ideas, which can be converted into innovative products/technologies. Government has put in place Faculty-Entrepreneurship Policy, but scientists are not aware of it. In other cases, universities are reluctant to grant leave to scientists to become entrepreneurs, because of limited teaching staff. This situation requires the immediate attention of MHRD.

ANNEXURE 1 (a part of Annexure II)

Participants of Roundtable Meet on 'Challenges in Technology Commercialization'
Feb. 1 2020

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42.	**Ms. Amandeep Sandhu**	
43.	**Ms. Sukriti Paliwal**	

Annexure III

Draft for

UNIVERSITY–INDUSTRY (or UNIVERSITY-BUSINESS) LINKAGE PROGRAM

for

UGC, NEW DELHI

Drafted by:

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University-Business Linkage for Enhancing R&D in India

Introduction: It is a well-acknowledged fact that in the 21st century development of nations is closely linked to their depth of Science, Technology and Innovation (STI). Developed nations score heavily in the science related indicators as measured by the latest Global Innovation Index (GII) Report published in 2018 (https://www.globalinnovationindex.org/gii-2018-report). By and large, the performance of developing economies in these indicators is much below expectations. Of late, serious efforts are being made by developing countries to improve their index of STI and the results have started pouring in.

Till mid-20th century, nations like India, S. Korea, Singapore, Taiwan and China were considered poor and struggling economies. However, except India all the above mentioned nations have catapulted into the category of strong economies mainly due to the dynamic and pragmatic approaches of the respective governments for strengthening their innovation ecosystem including the healthy and symbiotic relationship between public (academia) and private (industries) sectors for generating economic and societal innovations.

It is well established that developed countries have reaped immense benefits from university-industry collaborations in the field of R&D even though the goal and mission of academia and industry are wide apart. Academia pursues excellence in the domain of knowledge, whereas industries aim towards commercial gains. However, the success of both entities is dependent on each other. Industry looks up to academia for R&D solutions and universities seek industry-involvement for commercialization of research carried out in their laboratories (Fig.1).

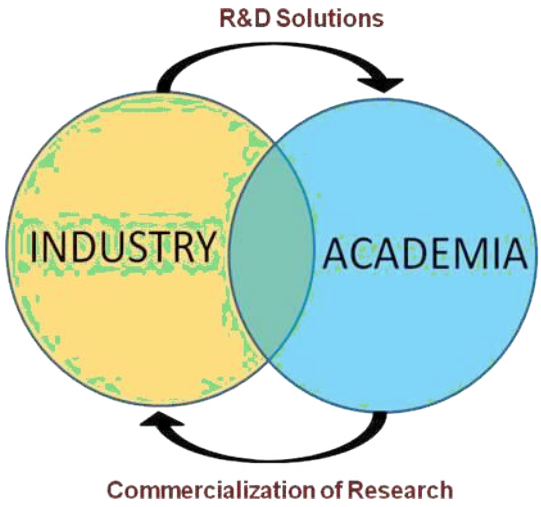

Figure 1: Aspirations of Academia and Industry from each other

As per GII-2018 Report (https://www.globalinnovationindex.org/gii-2018-report), developed countries such as Switzerland, USA, and Israel are the top three leaders in the parameter 'University-Industry Collaboration'. Unfortunately, India is ranked 26 despite having a vast network of HEIs (>850 universities; central universities: 48; state universities: 392; state private universities: 317; deemed to be universities: 125)(https://www.ugc.ac.in/oldpdf/Consolidated%20list%20of%20All%20Universities.pdf). In recent years, one of the major concerns for policy-makers in India has been to ensure the seamless transfer of wealth of scientific knowledge generated by academia to industry for commercial success.

Hence, it is imperative to strengthen University-Industry Collaborative Framework for R&D which can only be achieved through beefing up the synergistic activities between the two. The Government earnestly desires that industry and universities should work hand in hand for nation building, as is the practice in developed nations. To stimulate Industry-Academia R&D collaborations and make evidence-based recommendations to the government, DST, GoI has set up a 'Centre for Policy Research' at Panjab University, Chandigarh (http://cpr.puchd.ac.in/).The Centre has staff of 5 scientists working on various aspects of PPP in R&D.

In accordance with the tasks delegated to the Centre, DST-CPR at PU, Chd. has served as a forum to bring the Industry and Academia together by means of Conferences/ Seminars/ Symposiums, which have been patronized by **Dr. V.K. Saraswat** (Member NITI Aayog); **Dr.**

VijayRaghavan (Principal Scientific Advisor to GoI); **Dr. Arabinda Mitra** (Scientific Secretary, Office of the Principal Scientific Advisor to GoI); **Dr. Girish Sahni** (Ex-DG, CSIR); **Dr. Anil D. Sahasrabudhe** (Chairman, AICTE); **Dr. G.D. Yadav** (Vice Chancellor, ICT, Mumbai); **Dr. V.M. Katoch** (Fmr. DG, ICMR); **Dr. Anil Wali** (MD, FITT-IIT-Delhi); **Mr. Rajendra Mootha** (COO, IIT Madras Research Park); **Ms. Deepanwita Chattopadhyay** (Chairman & CEO, IKP Knowledge Park) and various Directors of National Research Laboratories, representatives from various Industry associations and the Industry (Reliance, Monsanto, Infosys, HCL, Mother Dairy, Panacea Biotech etc.). The outcomes of the meetings have been submitted in the form of Reports (9) to DST, GoI, New Delhi (http://cpr.puchd.ac.in/archives/). In addition, DST-CPR has published 2 books and two are in the pipeline (to be released in the year 2019).

Published books:

- Industry-Academia R&D Ecosystem in India (http://cpr.puchd.ac.in/wp-content/uploads/2017/05/Industry-Academia-RD-Ecosystem-in- India.pdf)
- Mapping Patents and Research Publications of Higher Education Institutes and National R&D Laboratories of India (http://cpr.puchd.ac.in/wp-content/uploads/2016/09/Book-2-PDF-min.pdf)

Figure 2: Books Published by DST-CPR at PU, Chandigarh.

Forthcoming Books:

- Public - Private Partnerships in R&D .....*a global perspective*
- Incentivization of Private Sector for Enhancing Investment in R&D ..... *a global outlook*

In India, many government agencies, industries/industry associations and financial institutions have floated programmes/schemes for strengthening Industry-Academia co-operation for the generation and conversion of knowledge based- innovations into products/ technologies for commercial or societal gains. A snapshot of the public-private partnership in R&D programmes/schemes, compiled by DST-CPR, is presented in Annexure-1. The data presented in the table indicates that it is not only the public sector, which is funding various schemes for enhancing PPP in R&D but private sector as well as financial institutions are also contributing (financially) towards industry-academia partnerships. From the table, it is also observed that UGC has only one programme, 'University-Industry Inter-Linkage Centres (UIL Centres)', whereas other agencies/organizations have floated many schemes. It is high time UGC becomes pro-active in promoting University-Industry (Business) activities by launching new programmes/schemes.

Recommendations for UGC for Promoting 'University-Business Interactions'

Setting Up of 'University-Business Council'

UGC is the most important higher education body for guiding and regulating the activities of universities and colleges in India. It started the journey of promoting industry-academia (I-A) interactions by setting up University-Industry Linkage programme. Unfortunately, it did not make any significant impact. To provide a new vigour to the endeavours of UGC to boost public-private co-operative research and innovation, it is suggested UGC sponsored University Business Council (UBC) be established which acts as an over-arching body for advising, formulating as well as implementing various I-A schemes/promotions in the universities and colleges. The Head Quarter of UBC may be located in UGC HQ in Delhi or in a university. UBC will have 3 important components: Academic Body, Executive body and Office of UBC (Figure 3).

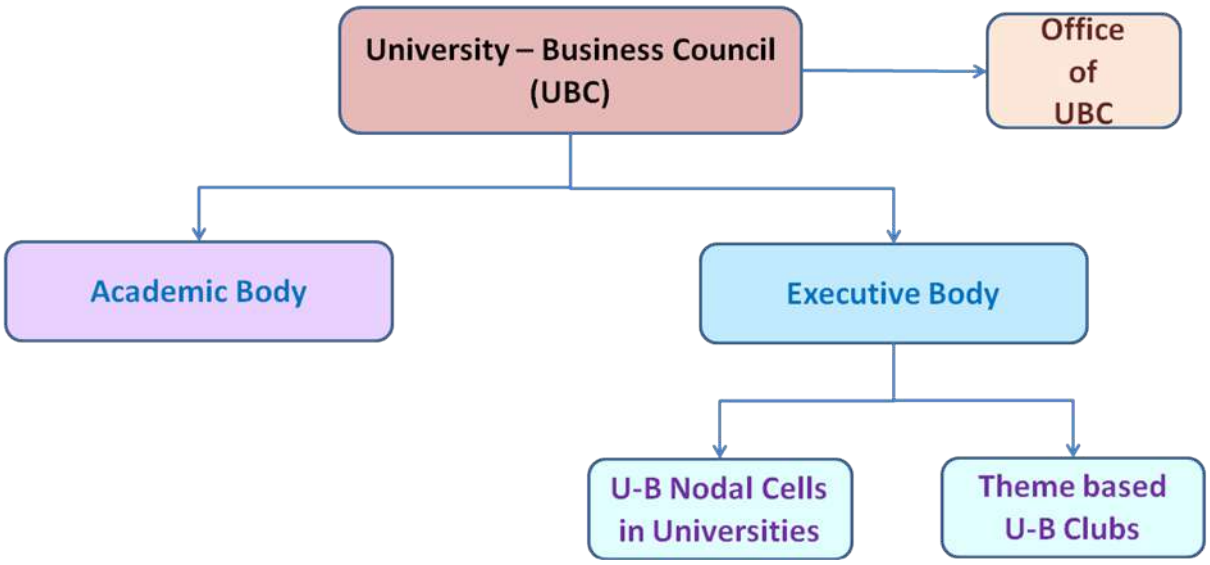

Figure 3: University-Business Council Framework

Academic Body – the most supreme body of UBC. It should comprise of 7-8 members representing three important pillars i.e. academia, industry and financial institutions such as SIDBI, NABARD, ICICI, SBI, etc. These financial institutions have floated schemes for promotion of innovation via public-private collaboration. They can also guide UGC pertaining to financial issues of I-A R&D collaborations. The Advisory Body may co-opt members from other relevant organizations such as DST, NITI Aayog, MHRD, AICTE etc. as per the need.

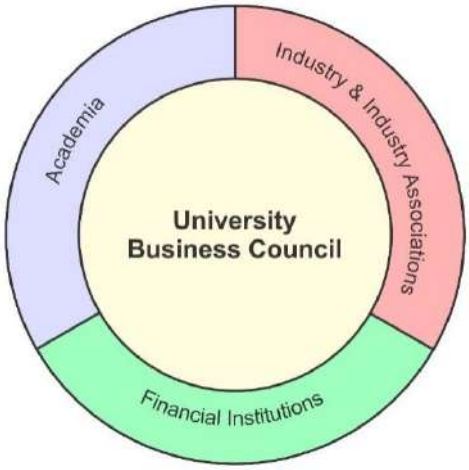

Figure 4: Three pillars of Academic Body of University-Business Council

Executive Body – For execution of the decisions undertaken by the Advisory Body, a 10-12 member Executive Body (EB) may be constituted. EB should be connected with all the universities of India. Though, it seems an improbable proposition, but it can be done by identifying one university in each State as a Nodal University, which will in turn connect with other universities of the State. Nodal Universities will act as a bridge between EB and universities/colleges located in a particular State.

Office of UBC- will act as a 'nerve centre'. Its responsibilities shall include:

- Maintenance of records/data (past, present & future) pertaining to I-A activities of UBC and other agencies and government bodies (Central and State level). This input will be crucial for formulating guidelines/activities for UGC and its affiliated universities/colleges.
- Liasioning with Central and State agencies/organization, universities, industries, industry-associations, national research laboratories, S&T divisions of foreign embassies situated in India, Research/Technology Parks and Incubators (Figure 5).
- Hosting a web portal pertaining to I-A activities, patents and technologies of universities affiliated to UGC. Such activities can be out sourced to a university/agency or carried out by UGC staff.

It will be prudent if a senior faculty member from a university, well conversant with industry-academia ecosystem, is appointed as Coordinator in the Office of UBC for a

fixed time period. This faculty member may be hired on deputation basis, as is the practice in the Office of PSA, GoI, New Delhi.

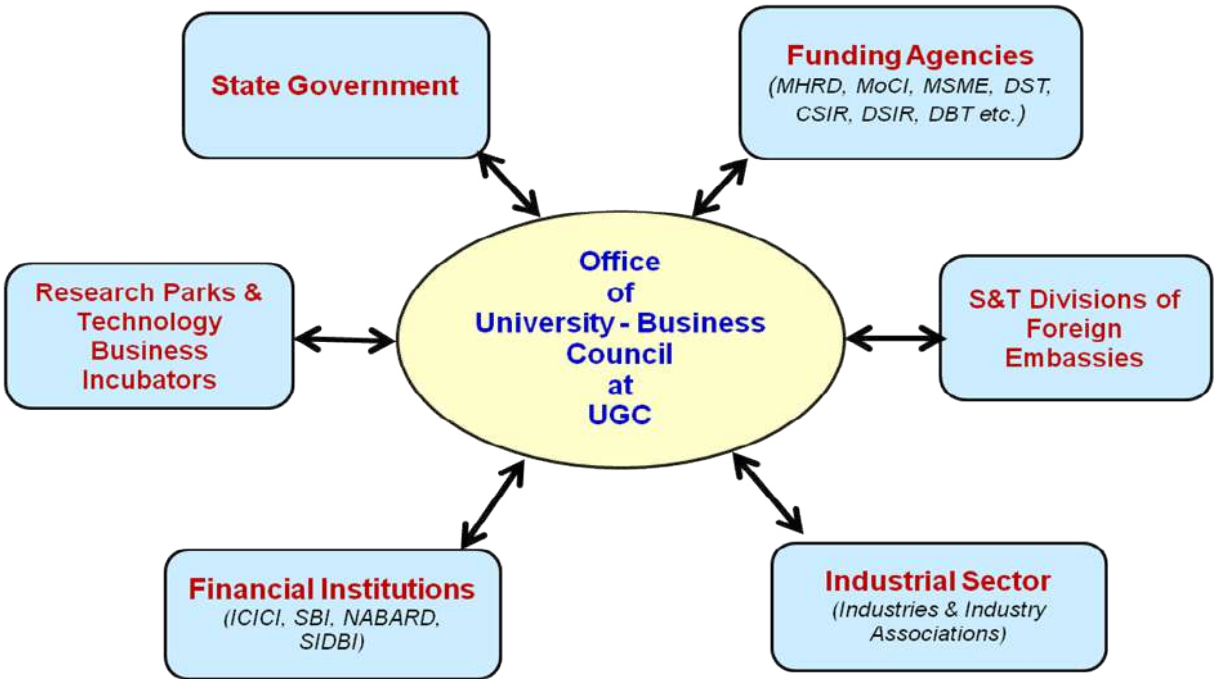

Figure 5: Networking of University-Business Council with different bodies/ agencies/ organizations

2. Creation of UGC-Tech Fund

For filing and maintenance of patents, the scientists of National Research Laboratories (CSIR DRDO, DBT, DoS, ICAR, DAE etc.) are financially supported by their respective funding agencies. Unfortunately, UGC does not provide such financial help to its scientists/researchers. There are only a handful of universities which provide partial financial assistance to their researchers/scientists. A university professor has to either shell out money from his/her own pocket or look towards TIFAC and NRDC, which have a limited amount of funds. As UGC is emphasising on stimulating 'Translational Research' in the universities, it is suggested that UGC may set up a dedicated budget called UGC-Tech Fund, which can be used by university/college teachers/researchers for filing and maintenance of the patents.

UGC-Tech Fund may seek inputs from the United Kingdom's 'Higher Education Innovation Fund' (http://www.hefce.ac.uk/), designed to support knowledge transfers;

engage in networking with business; establish liaison and technology transfer offices to provide advice and to negotiate consultancy assignments, contract, collaborative research projects, and license agreements; establish spinouts; provide entrepreneurship training for science and engineering graduates; and provide work placement for students in the industry.

3. Setting up Value Creation Centres (VCCs) in the Universities

A scientist's forte is to pursue research. He/she is not fully conversant with the nuances of commercialization of technologies/products such as drafting a business proposal, prior-art search of patents, patent drafting and filing, protection from patent infringements, identifying suitable industry, assessing the legitimate value of the patent-licensing or technology to be transferred, technology-transfer protocols and much more. For taking laboratory research to market, it is imperative that universities, especially research oriented universities, should have a dedicated VCC which caters to the following tasks:

- Industry-Academia Cell
- Intellectual Property Cell,
- Technology Transfer Office
- Entrepreneurship Cell
- Business to Market Cell
- Legal Cell

VCC should be actively involved in

- developing a strong network with financial institutions, angel investors and venture capitalists for raising funds needed for successful R&D findings (of the institute)
- assisting budding entrepreneurs and Start-Ups.
- act as an interface between industry and academia
- present itself as a vibrant place by conducting seminars/conclaves/special talks by industry personnel, successful entrepreneurs, financial wizards etc.

In many IITs (primarily first generation IITs) and IISc-Bangalore, such facilities as mentioned above already exist. It is suggested that UGC may set aside funds for the

establishment of VCCs in research oriented universities, which could be identified based on the R&D related parameters of NIRF. It is advised that such centres 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 tape existing in the public funded institutes.

Recently, DST, GoI has identified a few universities for setting up of Technology Enabling Centres (TECs). These Centres will have whole-time experts for providing assistance to scientists/researchers in matters related to translational research (patenting, preparing a business proposal, acting as a bridge between academia and industry, financial guidance and so on). DST, GoI will provide all the financial assistance to TECs for first five years. Subsequently, these will have to self-support themselves. A programme on the similar lines, under the ambit of VCCs may be initiated by UGC.

4. Setting up Industry specific Web Portals

Even though a sizable number of Indian scientists (universities and R&D institutes) are conducting applied research and generating patents, the private sector finds it difficult to access this information, due to the absence of a platform where such information is displayed. Also, there is no platform which connects Indian industries to the academia for seeking solutions for their R&D related problems. Similarly, academia finds it hard to identify an industry which might be interested in the applied research being carried out in the universities or research labs. In other countries, I-A web portals have become an important tool for bringing Industry and Academia closer to each other. For example, in Japan there are many web portals (mentioned below) which act as bridge between industry and academia for working towards innovative R&D.

- **J-STORE** (JST Science Technology Research Result Database for Enterprise Development) is a free database, which provides the results of research undertaken by the public research institutions and universities, as collected by the Japan Science and Technology Agency (JST). It aims at technologically transferring research results to enterprises and encourages the commercialization of research results.

- **Portal site for I-A-G Collaboration (Japan)**: The "Industry–Academia– Government Guidepost" website provides a wide range of information related to I-A-G collaborations.
- **Industry-Academia-Government Collaboration Support Database** (http://sangakukan.jp/shiendb/): Provides following information- R&D Support programmes of funding agencies, financial assistance programmes by Foundations and other bodies, Venture Capital and Events related to I-A-G collaboration.
- In India, similar web portal (iacrikc@puchd.ac.in) has been created in which industry relevant information (Patents, Technologies, Instruments, Scientific expertise, Centres of Excellence etc.) of nearly 30 institutes (Universities, National Research Laboratories, Medical institutes, Engineering institutes, and Management institutes) located in and around Chandigarh has been uploaded. The portal is known as Chandigarh Region Innovation and Knowledge Cluster (CRIKC) I-A web portal (https://iacrikc.puchd.ac.in). I-A CRIKC web portal has been appreciated by the office of Principal Scientific Advisor to GoI, NITI Aayog members and many more.

It is suggested that UGC may fund for the establishment of 'State level I-A Web Portal' on the lines of Chandigarh Region Innovation and Knowledge Cluster

(CRIKC) I-A web portal (https://iacrikc.puchd.ac.in). This responsibility may be allocated to one of the universities in the State. Creation of such I-A web portals will be a benchmark in enhancing I-A interactions. It is suggested that each university be mandated by UGC to upload information related to *Availability of scientific expertise, Patents (filed/granted), Technologies (transferred/available, under development), Scientific-infrastructure, Industry- Academia research collaborations, Consultancy projects undertaken, Technology Business Incubators and Start-ups* in a prescribed format, so that it is easier to collate the relevant information on a single UGC sponsored web portal.

5. Creation of Innovation Clusters

By and large, addressing the industries' research-problems or development of an industry-ready prototype by university researchers require multi-disciplinary approach. Usually, such multiple disciplines (of profession) are not present in a single institute. For example, developing a medical diagnostic kit requires the active participation of biologist and engineers (mechanical, electronic etc.). Therefore, creation of an academic cluster (virtual) is highly desirable. It is recommended that HEIs and national research laboratories located in close proximity should form an Innovation Cluster, which acts as a single window to solve the R&D related problems of the industries. Such academia clusters should develop contacts with local industries and also other industries located elsewhere in India and abroad. Such Clusters are quite common in other countries. UK has a N8 Cluster, also known as N8 Research Partnership. It is a collaboration of the eight research intensive Universities in the North of England: Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield and York. Working with universities, industry and society, N8 aims at maximizing the impact of research base by:

- promoting deeper collaboration between universities, business & society
- establishing innovative research capabilities & programmes of national and international prominence
- driving economic growth by generating income, supporting jobs and new businesses

It is further added that the idea of having knowledge cluster/hub has its genesis in the 'Narayan Murthy Report' April 2012, commissioned by Planning Commission on

'Corporate Participation in Higher Education'. This also finds echoed in the 'Knowledge Commission Report' of GOI. Further, the idea of having a knowledge cluster/hub is also inclusive of the 'Meta-University' concept, being advocated by MHRD, GOI in its RUSA document. Furthermore, 'Science, Technology and Innovation Policy (STI), 2013 ' of GOI also refers to clusters/hubs as tools for innovations. Of late such a few academia clusters have come up in India e.g. Chandigarh Region Innovation and Knowledge Cluster (CRIKC), Research and Innovation Circle of Hyderabad (RICH). The aim of these clusters/hubs is to promote excellent research (fundamental and applied). UGC may set aside funds for Cluster formation, especially in cities where large number of HEIs, National research labs and industrial hubs are located e.g. Bangalore, Chennai, Mumbai, Delhi, Pune, Dehradun, Nagpur, Mysore, Lucknow, Kanpur, Bhuvneshwar, Guwahati etc.

6. Setting up Industry – Academia Chairs

Setting up of 'Industry-Academia Chairs' in the universities aims at appointing representatives (from academia and industry) that push development of business oriented applied research at universities. Creation of I-A Chairs and appointment of such personnel as Chair Holders can enable the realization of the following objectives -

- Increased delivery of innovative applied research solutions to local companies at the community and/or regional level
- Increased participation of faculty and researchers in applied research activities
- Increased opportunities for students to gain industrial problem-solving experience
- Increased knowledge and technology transfer between universities and companies, with the objective of increasing the productivity and competitiveness of local companies, particularly Small and Medium-sized Enterprises (SMEs)

It is suggested that UGC alone or in association with other funding agencies/industries may set up at least 20 such Chairs in the universities.

7. Mandatory Linking of HEIs with Industries

Industries and academia have their own strengths and limitation in pursuing scientific research. Universities are rich in intelligentsia and manpower but lack in power of carrying out translational research. On the other hand, industries have sound knowledge of translational research work, aware of demands of futuristic innovations, but face glitch of R&D funding and availability of requisite scientific expertise. Handholding of industries and academia can overcome the limitations of each other, in the pursuits of innovations for societal as well as economical needs. Therefore, it is suggested that-

a) Research-oriented universities be mandated to tie up with at least 5 industries, preferably medium and small scale industries for pursuing innovative research.

b) There are nearly 2000 DSIR certified R&D units of the industries, which avail lots of benefits, in the form of direct and indirect benefits, from GoI for pursuing industry oriented research. It may be good idea if industries having DSIR certified R&D units are mandated to tie up with at least 2 universities.

c) In India, each district of a State has District Industry Centres (DICs) which are the focal points for promoting Small and Medium Sized Enterprises (SMEs) located in a particular area and facilitating them with all the necessary services/facilities required for their development. For solving their R&D problems it is advisable that such industrial units are linked with the universities located in that State, which can offer technical and mentoring services. If the need be, both the stakeholders can jointly apply for research grant to various funding agencies for product development and improvement.

8. Linking Universities with Local PICs

It is now an accepted fact that, an overwhelming percentage of teaching faculty in the universities has little knowledge of IPR. Unless the teaching community is IPR savvy, it cannot emphasize the importance/necessity of IPR to the young students/researchers.

To promote the spirit of IPR, Technology Information Forecasting and Assessment Council (TIFAC), GoI has established 20 ‘Patent Information Centres’ (PICs) in

various States of India for providing assistance towards patent filing by public and private sectors. Panjab University, Chandigarh is the IPR Nodal Centre of PIC for State of Punjab. PU has immensely benefitted from PIC-Punjab by collectively organizing IP seminars and workshops, assistance/guidance in Patent search/filing and many more.

In addition, Department of Industrial Policy and Promotion (DIPP), GoI has created a Cell for IPR Promotion & Management (CIPAM) for creating awareness about IPR. CIPAM has been mandated to deliver IPR-related talks/workshops all over India. In order to strengthen the IPR regime of universities, UGC may pass a directive to research oriented universities to partner with at least one PIC and CIPAM. Efforts should also be made by the universities to establish a 'Patent Nodal Centre' in the campus under the aegis of PIC.

9. Mentoring of Universities by IIT and IIM

It is a well acknowledged fact that the IITs of India rub shoulders with globally top ranked universities in the domains of generation of skilled manpower, R&D, I-A research collaborations, consultancy, start-ups and generation of crores of rupees for the institute by licencing out patents/technologies, contract research and consultancies. A study carried out by DST-Centre for Policy Research at Panjab University, Chandigarh on S&T parameters of IITs indicated that IITs are generating a significant amount of revenues running to hundreds of crores of rupees by converting their academic knowledge into commercial entities (patents/technologies/consultancies/start-ups) is mentioned in Table 1.

Table 1: Science and Technology Indicators of First 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*** ***Granted***	 231 13	 569 >61	 239 25	 204 9	 146 25	 37 6
Technology available	214	409	358	6	50	05
Technology Licensed (till date)	24	>140	60	60	15	06

Source:http://cpr.puchd.ac.in/wp-content/uploads/2017/05/Industry-Academia-RD-Ecosystem-in-India.pdf

Looking at the stupendous success of IITs, GoI has established many new such institutes all over India. Each new IIT is being mentored by an old IIT e.g. IIT-Ropar is being mentored by IIT-Roorkee.

In India, there are a handful of universities (around 50), which are regularly publishing large number of research papers in reputed journals but are poor in the domain of patents/technologies. These universities are devoid of value chain needed for converting scientific knowledge into innovative product/technology. To boost the generation of skilled manpower and translational research in such universities, it is suggested that universities having strong potential in the area of applied research be guided/mentored by the faculty of IITs. Such a venture will certainly assist the faculty and researchers of the institutes to convert their academic wealth into commercial success by means of patents, technology transfers etc.

As majority of the public funded universities are financially starved it is suggested that select universities having the potential of applied research be guided/mentored by the faculty of Management Institutions such as IIMs and ISBs.

10. Sabbatical Leave (Industry-Academia) for Faculty Members

Teaching faculties of the universities in India are not well acquainted with the industrial environment, latest technological advancements and the allied needs of the industries. They are therefore unable to imbibe the same in their academic curricula and undertake and publish research with little relevance to industries.

To overcome these concerns, it is suggested that universities should create avenues for the teachers especially working in the fields of Life Sciences, Biotechnology, Microbiology, Pharma, Nanotechnology, Agriculture, Engineering and even basic sciences (Chemistry, Physics, Botany etc.) to spend some time in the R&D units of the industries. Mobility of such teachers/scientists from universities/colleges to industries, with full pay protection along with an honorarium should be encouraged. It is suggested that UGC create a provision of 'Sabbatical Leave (I-A)' for the faculty

members with full pay protection along with an honorarium, should be encouraged. This provision will act as a strong instrument for developing and strengthening linkages between university and industry. A university professor spending one or two semesters with an industry will not only enhances personal relations between him/her and industry/industrial personnel but also makes way for the involvement of graduate students leading towards masters or doctoral degree research. The faculty visitor is immensely benefitted by means of follow on contacts, learning of novel methods and technological developments, and so on, and the industrial host benefits through being introduced to academia ecosystem. Another very important advantage of Sabbatical leave is that it brings real-life relevance to the research at the universities and is a way to periodically revise the curriculum according to the demands of the industry. Sabbatical leaves also help in exploring unmapped avenues of research, specifically those that may be indispensable for the industry.

11. Introducing I-S schemes for Students, Post-docs and Researchers

In order to prepare industry ready manpower and stimulate the concept of translational research in young minds, many governments have put in place dedicated programmes at UG, PG and PDF levels. To promote I-A R&D, Canada has introduced many schemes which are as follows:

- ***Mitacs-Accelerate*:** Industry oriented R&D internships for **graduate students** that foster the transfer of technology and its commercialization. 'Mitacs- Accelerate' enables Canadian companies and not-for-profit organizations to address their business needs through research partnerships with the country's top universities, professors, and graduate students. For over a decade now, the Accelerate program has offered work-integrated learning opportunities that support demand driven research projects that stimulate innovation. This program promotes cutting edge R&D, and cultivates a skilled-workforce that is innovation-literate
- ***Mitacs-Elevate*:** Industrial R&D management training and industrial research experience for postdoctoral fellows through classroom and on-site learning. 'Mitacs-Elevate', a **fellowship program for postdoctoral candidates**, which includes tailor-made research administration training. This training program's duration is of 2 years during which the postdocs assume and pilot a research

project. Throughout the 2 year period, the fellows are provided with empirical as well as experimental guidance and training in R&D through the means of their research collaborations (industry-academia) and the curriculum of the programme. The fellows gather skills related to articulation, delivery, management, supervision and other significant business abilities pertinent to research management careers in both industry and academia. These opportunities and prospects provide skills complementary to their specialization ensuring that the trained fellows are capable of leading large-scale projects in their future careers.

- ***Mitacs-Step:*** Develop business-ready skills through workshops for **graduate students and postdocs** led by industry leaders. The 'Mitacs- Step' programme provides workshops for development of professional skills. These workshops are aimed at training graduates and postdoctoral students, and endowing them with skills that prepare them for workplace. The training program is designed in accordance with the requirement of the employers. The training supplements their research experience and specialization with the tools necessary for commercial success. The workshops are conducted by experienced and leading personnel from the private sector and industry who themselves have to undergo a highly spirited selection process for being chosen to become a workshop facilitator. The facilitators are experts and are proficient in their relevant fields and also possess immense knowledge for succeeding professionally. Workshops offer prospects for hands-on, winning, and empirical education.

To give a boost to I-A interactions/collaborations similar programmes may be introduced by UGC in universities/colleges for imparting industry oriented courses and carrying out applied research.

12. Creation of Industry Supported Centres of Excellence in Universities

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. The Centre of Excellence in Wireless Technology (CEWiT) in IIT-Madras and National Centre for Flexible Electronics (FlexE) in IIT-Kanpur are yet another examples of successful CoEs. The existing CoEs under PPP mode are playing a catalytic role in the industrial growth (R&D) and strengthening of industry-academia linkages.

It is suggested that UGC may set aside special funds for the creation of 'R&D Centres of Excellence' under PPP mode in HEIs. Such centres should come up only if a university/institute is in long term agreement with industry (Pharma, IT, Electronics, Nanotechnology, Environment, Automobile, Chemical, Food, Aviation, etc.) and has ample of space and infrastructure for supporting the CoE.

13. Industry-Academia Schemes

Research is the backbone of innovation in both academic as well as the industrial sector of a modern economy, making the foundation for development of new products/processes/services, which can be advanced through the means of entrepreneurial activities, transfer of knowledge and technology etc. The academia accomplishes new ideas and knowledge and the industry patronizes the translation and conversion of the wisdom and ideas into technologies for practical application. Thus, research in both these sector enhances and complements each other in a huge manner and consequently it is imperative for the two, to join forces for providing the society with the best available technology and services. While witnessing the global scenario it is evident that the collaborations and linkages between the two have not only empowered the two sectors, but has also led to advancement of technology significantly.

India is home to top quality academic institutes and pioneering industries. Therefore, supporting the engagement of the two sectors will enhance and invigorate the ecosystem tremendously.

These initiatives may be modelled on successful global programmes e.g. –

- *Industry/University Cooperative Research Centres (I/UCRC)* of USA ensure that the research undertaken in these centres at academic setting is in

alignment with the requirements of the industry. The Centre confers with the members, from industry and academia, to decide upon an agenda for research, which focuses on research opportunities and interests that are mutual. NSF provides financial support only 100,000 USD annually for 5 years. To be eligible for NSF support, the Centre has to pledge 300,000 USD from industrial partners and involvement of at least six firms. The Centre is also advocated to engage other universities, in the R&D projects, to ensure activities with a wide research base.

- *Grant Opportunities for Academic Liaison with Industry (GOALI*) of USA is another initiative that aims at promoting I-A partnerships by providing funding/fellowships and opportunities that support a blend of I-A linkages. The programmes allow for mobilization of faculty/ postdoctoral fellows/students to conduct research and gain experience in an industrial setting; industrial scientists and engineers to bring industrys' perspective and integrative skills to academia; and interdisciplinary university-industry teams to undertake collaborative research projects. A few examples are mentioned below.
    - An extended (of several months duration) faculty experience in industry to foster industry-university collaboration; or at the beginning of a multiple-year university-based research project to enable hassle-free transfer of research results to industry.
    - Visit of a leading engineer, scientist, or manager from industry to a university, to catalyze collaborative research or teach and develop curricula.
    - Support for one or two semesters of work in industry by a graduate or an undergraduate student under the guidance of an academic advisor;
    - Post-doctoral support for one or two years of work in an industrial setting, under the guidance of an academic mentor in collaboration with an industrial partner
- The *Idea to Innovation (I2I)* programme (Canada) aims at accelerating the development of promising technology and promotes its transfer to companies. It finances the faculty members of the academia to help in R&D projects, which seem to have a profound potential of technology transfer. This is done through a set of phases by giving significant help in the starting stages of validating

technology and accessing market. Four types of funding are available depending on the maturity level of the technology or the level of engrossment of an investment/industrial partner.

- 'Germination Program' of Taiwan, provides a common platform for universities and industries with an aim at providing assistance for building a 'pre- development mechanism' for the advancement of results of research undertaken in institutions and universities into a high-value business model. Govt of Taiwan has set up 8 Germination Centres in the universities.

- Even though UGC can initiate programmes solely it will be prudent if program supporting partnership and association of industries with academia be started in association with MSME and DST, GoI.

14. Incentivization Schemes

Labels: France awards the label "Carnot", which is a certification given to research institutions and institutes of higher education that foster and undertakes collaborative research with industries (SMEs & large corporations). This label was introduced in 2006 and the institutes are rewarded based on their turnover from their activities for the industry.

The Government provides funding to Carnot institutes to expand their scientific and technical skills, to sharpen specialized skills needed to strengthen partnerships with private enterprises, and to provide research based services to private enterprises. Selection Criteria for institutes to be labelled as Carnot Institutes:

i) Name recognition of candidate institution in the research field, consistency with research policy in the region, etc.
ii) Contribution to social issues, strategy for promoting joint research, etc.
iii) Governance, solid organization structure
iv) Mechanisms for improving activity quality: acquirement of ISO and other certifications, human resources development strategies, etc.
v) Intellectual property policy: intellectual property management, utilization strategy, etc.
vi) Social and economic partnerships, including experience partnering with SMEs

viii) Actual experience in international collaboration, quality of international partnerships, etc.

ix) Consistency with activity objectives, the Carnot Charter, etc.

The programme is highly successful as the contractual relationships between the Carnot institutes and the industry have grown from €120 million to €470 million in the ten years of programme existence. Hence, UGC may adopt this scheme and award label to universities proactive in interactions with industries i.e. involvement of industry personnel in teaching and governance, private sector investments in the institutes (i.e. scholarships, fellowships, establishing laboratories (teaching/research), Centres of Excellence), collective organization of seminars/summits/conferences/workshops, consultancy, contractual research and collaborative R&D, and so on. MHRD/UGC may set aside a fund, which can only be used by labelled-universities. The suggestive name for this label could be '***Bhatnagar-Institutes***', after the legendary Indian scientist and the founding UGC Chairman.

Incentives: cash or kind (funds to attend international conferences, less teaching load, Reforms in Promotion Criteria for Teaching Faculty

15. Theme based Research Institutes on the basis of PPP Model

At the request of chemical industry Maharashtra State government set up Institute of Chemical Technology (ICT), Mumbai (http://ictmumbai.edu.in/), earlier called University Department of Chemical Technology under the University of Mumbai. The pundits of science and technology consider ICT-Mumbai as an exemplary model of one industry-academia partnership. It has more than 230 industry sponsored projects worth ₹84.7 crores, generated more than 500 first generation entrepreneurs, scores of patents have been granted and over 300 are in the pipeline. The remarkable progress of ICT-Mumbai in the domains of higher education and research has catapulted ICT-Mumbai as an autonomous deemed to be university.

In 2017, GoI passed an act 'Indian Institutes of Information Technology (Public- Private Partnership) Act-2017' which allows creating of Polytechnics and Indian Institutes of Information Technology (IIITs) under MHRD, via PPP mode. For example, IIITs have been established with a capital cost of around ₹ 128 crores per

institute, with central government, state government and industrial sector contributing in the ratio 50:35:15 respectively.

For taking this initiative forward GoI or State governments may start a dialogue with Industries leading in R&D investment (over ₹ 1000 crores) such as TATA, RIL, Mahindra and Mahindra etc. A society, charitable trust or Section 25 company operating under PPP mode can undertake the responsibility of establishing HEIs. Some of the large corporates have set up private institutes of higher learning and research e.g. Dhirubhai Ambani-Institute for Information and Communication Technology at Gandhinagar, Birla Institute of Technology and Science (BITS) at Pilani, Goa, Dubai and Hyderabad, Apeejay Satya University at Gurgaon, Azim Premji University at Bengaluru, Shiv Nadar University in Noida etc. All these private institutions are doing very well in the domain of R&D. To attract more private investment in such ventures, it is suggested that the government lay down attractive norms e.g. providing land at a nominal cost, for increased participation of industries/industry associations/philanthropists.

16. Creation of TBIs, Accelerators and Science Parks in Universities

TBIs, Accelerators and Science/Technology/Research 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 and possess support mechanism for creation of TBIs and science parks in terms of land, building, instrumentation and other required infrastructural support.

17. Re-look at the Promotion Criterion of University Faculty

The promotion criterion for university-faculty is heavily tilted towards research publications. The promotion of university/college professors can easily be met by publishing a few research papers and completely ignoring Intellectual-Property (IP) component and Industry-Academia (I-A) tie-ups (R&D, consultancy, industry visits, etc.). Secondly, allocated scores for 'Research Publications' and 'Patents' is 8 and
10 respectively, even though publishing a research paper is much easier than

patenting. Also, rules are silent whether a patent score of 10 is meant for patent filed or patent granted. It is suggested that, 'patent filed' and 'research publication' may be scored at par i.e. 10, but 'patent granted' should be allocated a score of 15. In addition, if a patent is licensed out to a firm/company the score should be increased to 20.

18. Revisiting National Institutional Ranking Framework (NIRF)

In 2015, MHRD introduced NIRF for holistic evaluation and ranking of Higher Educational Institutions of India. The NIRF-2018 framework includes five basic parameters on which an institution is evaluated. Each parameter has been allocated 100 marks. One of the five parameters i.e. Research and Professional Practice" has four sub-parameters:

- Number of Publications (35 Marks)
- Quality of Publications (35 marks)
- IPR and Patent Profile (15 Marks) *(It includes earnings from Patents)*
- Footprints of Projects, Professional Practice and Executive Development Programmes (15 marks) *(It includes earnings from Consultancy)*

The marks allocated to Publication Profile (Number and Quality) are distinctly much more than the combined marks (<35) allotted to IPR, Patent, Patent- earnings and Consultancy. The Central Government is pushing for enhanced innovations from HEIs and have introduced various schemes for stimulating innovation culture/ecosystem. It is suggested that marks allocated to the sub- parameters ('IPR and Patent Profile', and 'Footprints of Projects, Professional Practice and Executive Development Programmes') be enhanced significantly so that HEIs take this aspect seriously.

Annexure-I: Major Public Private Partnership Programmes in R&D Initiated by Various Agencies/Organizations

S. No.	Department/Agencies	Programmes/Schemes/Initiatives
		Government
1.	Department of Science and Technology (DST; www.dst.gov.in)	➢ India Innovation Growth Programme 2.0 ➢ Technology Development Program (TDP)
	Science and Engineering Research Board (http://www.serb.gov.in)	➢ Prime Minister's Fellowship for Doctoral Research
	National Science & Technology Entrepreneurship Development Board (NSTEDB; http://www.nstedb.com/)	➢ National Initiative For Developing And Harnessing Innovations (NIDHI)
2.	Technology Development Board (http://tdb.gov.in/)	➢ Financial Assistance Programme (TDB) ➢ Seed Support Scheme & Venture Capital Fund
3.	Global Innovation and Technology Alliance (GITA; www. gita.org.in)	➢ Bilateral programmes ➢ Multilateral programmes ➢ Technology Acquisition Fund Programme
4.	Technology Information, Forecasting and Assessment Council (TIFAC; www.tifac.org.in)	➢ Advanced Composites Programme ➢ Revolving Technology Innovation Fund
5.	Department of Scientific and Industrial Research (DSIR; www.dsir.gov.in)	➢ Patent Acquisition and Collaborative Research and Technology Development (PACE) ➢ Promoting Innovations in Individuals, Start-ups and MSMEs (PRISM) ➢ Consultancy Promotion Programme (CPP)
	Council of Scientific and Industrial Research (CSIR; www.csirhrdg.res.in)	➢ New Millennium Indian Technology Leadership Initiative' (NMITLI)
	National Research Development Cooperation (NRDC; www.nrdcindia.com)	➢ Knowledge Management system for Technology Promotion
6.	Biotechnology Industry Research Assistance Council (BIRAC; http://www.birac.nic.in)	➢ Small Business Innovation Research Initiative (SBIRI) ➢ Biotechnology Industry Partnership Programme (BIPP) ➢ Promoting Academic Research Conversion to Enterprise (PACE)
7.	Ministry of Electronics and Information Technology (MeitY; www.deity.gov.in)	➢ Multiplier Grant Scheme (MGS) ➢ Modified Special Incentive Package Scheme(M-SIPS)
8.	Ministry of Micro, Small & Medium Enterprises (M/o MSME; http://msme.gov.in)	➢ A Scheme for promoting Innovation, Rural Industry & Entrepreneurship (ASPIRE)
9.	Indian Council of Agricultural Research (ICAR; www.icar.org.in)	➢ *National Agriculture Innovation Fund*
10.	Department of Pharmaceuticals (http://pharmaceuticals.gov.in/)	➢ **Cluster Development Programme for Pharma Sector (CDP-PS)**
11.	Department of Industrial Policy and Promotion (DIPP; http://dipp.nic.in/)	➢ Invest India
12.	Defence Research and Development Organization(DRDO; https://www.drdo.gov.in/)	➢ The DRDO-FICCI Accelerated Technology Assessment and Commercialization (ATAC) Programme

13.	Principal Scientific Advisor to the Government of India (PSA; *psa.gov.in/)*	➢ **Accelerating Growth of New India's Innovations (AGNIi)**
14.	Indian Space Research Organization (ISRO; https://www.isro.gov.in/)	➢ Sponsored Research (RESPOND)
	Education Sector	
15.	Ministry of Human Resource Development (MHRD); www.mhrd.gov.in	➢ Institutes Innovation Council (IIC) ➢ Council for Industry Higher Education Cooperation (CIHEC) ➢ Research Parks ➢ Technical Education Quality Improvement Programme (TEQIP) ➢ IMPRINT India
	University Grants Commission (UGC; www.ugc.ac.in)	➢ University-Industry Inter Linkage (UIL) Centres
	All India Council for Technical Education (AICTE; www.aicte-india.org)	➢ Industry Institute Partnership Cell (IIPC) ➢ Innovation Promotion Scheme (IPS) ➢ AICTE-CII Survey of Industry-Linked Technical Institutes 2016
	Private Sector	
16.	Federation of Indian Chambers of Commerce and Industry (FICCI; www.ficci.com)	➢ DRDO - FICCI initiative for Accelerated Technology Assessment and Commercialization (ATAC) ➢ National Knowledge Functional Hub ➢ DST-Lockheed Martin-TATA Trusts India Innovation Growth Programme (IIGP)
17.	Confederation of Indian Industry (CII; www.cii.in)	➢ AICTE-CII Survey of Industry-Linked Technical Institutes ➢ CII-BESU Innovation Centre ➢ Global Innovation & Technology Alliance (GITA) ➢ Prime Minister Fellowship Scheme for Doctorate Research
18.	**National Associations of Software and Services Companies (NASSCOM; www.nasscom.in)**	➢ Centre of Excellence for IoT and AI ➢ India Innovation Fund
	Banking Sector	
19.	National Bank for Agriculture and Rural Development (NABARD)	➢ Credit Linked Capital Subsidy Scheme ➢ Corpus fund of ₹ 50 crores for R&D
20.	Syndicate Bank	➢ Syndicate Bank Entrepreneurship Research and Training Centre at IIT-Kanpur (SBERTC–IITK).
21.	Small Industries Development Bank of India (SIDBI)	➢ SIDBI Innovation and Incubation Centre (SIIC) at IIT Kanpur ➢ TIFAC-SIDBI Revolving Fund for Technology (SRIJAN Scheme)
22.	Industrial Credit and Investment Corporation of India (ICICI)	➢ Creation of Sponsored Research and Development Board (SPREAD) ➢ ICICI Bank's Technology Finance Group (TFG) ➢ ICICI Foundation for Inclusive Growth
23.	IDBI, ICICI, IFCI and SBI	➢ Creation of Entrepreneurship Development Institute of India with the financial support from conglomerate of banks

Annexure IV

A Report on

SPRU Training 2019

Science, Technology and Innovation Policy for Turbulent Times

Organized by

SPRU - Science Policy Research Unit

University of Sussex, Brighton, UK

on

June 17th – 21st 2019

Compiled by

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Preamble

In the year 2014, DST (GoI) established five 'Centres for Policy Research' (CPR) across India with the aim to i) provide evidence based recommendations for strengthening nation's STI Policy, and ii) enhance capacity building in the domain of Science-Policy. Each CPR is assisted by scientists, advisors/consultants along with STI-PDFs. All the five CPRs have attained a certain level of maturity and submitted many evidence-based reports and recommendations to DST (GoI).

In order to expose young STI-PDFs to the Science Policies of other countries, a 7 - member team comprising of 4 STI-PDFs, 2 Coordinators of CPRs and 1 DST Official (Annex.- I) attended DST (GoI) sponsored 5 Days (June 17-21, 2019) SPRU Residential Training Course on Science, Technology and Innovation Policy for Turbulent Times, held at University of Sussex, UK. The workshop was organized by Science Policy Research Unit, University of Sussex, Brighton, UK.

A report on the talks delivered by various experts during the workshop is discussed below. The 2019 SPRU Training Course was designed on the premises of the fact that transformations and changes, may be political, environmental, or technological in nature, have always lead to turbulence and unrest within the society. The global policy makers, therefore, ought to counter and respond to the novel sources of uncertainty and associated dynamics. On one hand where science, technology and innovation (STI) may be associated as being the driving forces behind such transformations, the response to unrest is also epitomized by them. The Training Course was spread over a duration of five days and each day had lectures from professors of SPRU and other invited experts.

Programme of the Training Course

	June 17th	June 18th	June 19th	June 20th	June 21st
TIMINGS	DAY 1 Introduction	DAY 2 Digging deeper	DAY 3 Grassroots innovation	DAY 4 Sectoral transformations	DAY 5 Policy instruments
MORNING	Introduction (Adrian Ely)	Infrastructural innovation for resilience (Ralitsa Hiteva)	Innovating around the city – insights and experience from Brighton and Hove (Rachael Durrant)	Energy system transformations & community resilience (Mari Martiskainen) *or* Biomedical innovation (Michael Hopkins)	Research evaluation (Jordi Molas-Gallart)
	Technology and turbulence (Ed Steinmueller)	Science, policy and social movements (Matias Ramirez)	Co-ordinating grassroots and hybrid innovations for sustainable food systems (Adrian Ely)	Governance of Artificial Intelligence (Simone Vannuccini) *or* Food and agriculture (Matias Ramirez)	How to make digital transformation more inclusive in labour markets (Maria Savona)
AFTERNOON	Governing dual-use technologies in the 21st century (Caitriona McLeish)	Multi-Criteria Mapping (Bipashyee Ghosh and Josie Coburn) *or*	BA i360 Field Visit: National Challenges and Policy Responses (Erik Millstone)	Group work based on the morning sessions	Final panel – selected SPRU faculty to respond to questions from the participants
	Handling uncertainty in science, technology and society (Andy Stirling)	Data visualisation with network analysis (Daniele Rotolo)	BA i360 Field Visit continued (Erik Millstone)	Group work continued	Closing session
EVENING	Countryside walk led by Andy Stirling, and evening meal	Free evening	Evening meal near Brighton seafront	Free evening	Departure

- **DAY 1 (June 17th 2019)**

Session I on the opening day was initiated with an Introductory Lecture by Dr. Adrian Ely, Senior Lecturer, SPRU, University of Sussex. Confining to the theme of the Training Course he first introduced the essence of the word 'turbulent' and how the present times are synonymous with it. While introducing the research undertaken at SPRU, he laid down a path for the upcoming days of the course. All the aspects that would be touched upon in the forthcomings days were pointed out by him. Dr. Ely familiarized the participants with a brief history about the industrial revolution in the United Kingdom and the idea of 'constructive destruction' as described by Schumpeter in 1942. A basic idea that with any activity related to innovation or entrepreneurship, some amount of unrest and instability is associated was clarified.

The challenges associated with technology are many and the governments are continuously struggling to make evolving policies and regulate the changes for the interest of the society and public. They are looking towards implementing coordinated approaches that can be synchronized across borders. The efforts have been particularly elusive and the latest technological trends have led to serious climatic and environmental changes. The evolutions in the scientific and digital domain have also altered the communications and relations between the humans, with the society and with the world. In totality all these developments have presented the present day government and policy makers with fundamentally uncertain circumstances of radical uncertainty that call for new approaches and actions. Dr. Ely emphasized that novel approaches of policy analysis, policy design and its implementation were required for dealing with issues associated with technological development in the field of green industrial transformations, artificial intelligence, infrastructural resilience etc.

He clarified how the course was designed to delve into such challenges and present insights for policy making and its implementation in different parts of the world.

The Second Session comprised of a lecture, delivered by **Dr. Ed Steinmueller**, Professor, SPRU, Univ. of Sussex, entitled '*Technology & Turbulence*'. This session introduced the concept of turbulence and its relation with technology. His talk emphasized on examining the relations between technology and turbulence in society, economy, and environment. He reflected upon, the origin of innovation and its effect; history of different concepts regarding the link between technology and turbulence; approaches for curbing turbulence and impeding unrests that will be caused by futuristic innovations. He voiced that "For some, these are about optimism for the opportunities provided. For others, scepticism or pessimism prevails".

Prof. Steinmueller discussed the concept of innovation at length, its terminology, endogenous and exogenous innovations, as an investment, motives behind innovation, along with the idea of 'Technological Determinism'. He articulated that "The combination of the views that technology influences society and the recognition that there is (at least for some) choice about these influences is called soft technological determinism." Going further the notion of technology enthusiasm and hype cycles was discussed, which tend to have influences on investors. Sources of turbulence, such as technological unemployment, displacement, resistance accompanying innovation etc. were also touched upon by Prof. Steinmueller.

In Europe, USA, Canada the resistance towards innovation was accompanied by the development of an intellectual tradition in innovation studies called Science, Technology and Society (STS). This brought forward a perspective questioning the freedom/right to innovate in entrepreneurial societies because certain technologies may lead to worsening the positions of workers. However, Europe has now adopted the precautionary principle[1]. Across the world majority of approaches employed for regulating innovation are ex post (after demonstrable harm). Thus, it is suggested to extend the participation of the stakeholders (who will be affected by the innovation) in the design and implementation of a regulatory approach. Democratizing innovations, mission led policy approaches for meeting Sustainable Development Goals (SDGs) were other concluding suggestions of the talk.

Take Home Points from Prof. Ed Steinmueller's talk:

- Extending the participation of the stakeholders (who will be affected by the innovation) in the design and implementation of a regulatory approach..
- Adoption of the Precautionary Principle i.e. It should be a social responsibility of the policy makers to protect the public from exposure to harm, when scientific investigation has found a plausible risk.
- While democratizing innovations, Anticipation and Foresight should be made a part of the process, as they suggest ex ante (before the fact) actions and these actions can have a participatory or democratic basis.

[1] The principle is used by policy makers to justify discretionary decisions in situations where there is the possibility of harm from making a certain decision (e.g. taking a particular course of action) when extensive scientific knowledge on the matter is lacking. The principle implies that there is a social responsibility to protect the public from exposure to harm, when scientific investigation has found a plausible risk. These protections can be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result.

Session III was opened with a lecture on '*Governing Dual Use Technologies in the 21st Century*' by **Dr. Caitriona McLeish**, Senior Fellow at SPRU. Her talk was centred on the awareness that S&T can be put to use for not only benefitting the society but also for causing harm.

Contemporary apprehensions around dual-use technologies appeared in concert with fears about the spread of nuclear arms & connected technologies. Her talk focussed on dual use issues in both the chemical and biological warfare environments and how to design effective mechanisms to prevent the misuse of legitimate science and technology.

The speed and nature of contemporary scientific and technological change alongside turbulent local, national and international contexts is leading to renewed attention on the issue with concerns expressed that it is now easier and more likely that nefarious actors such as terrorists will exploit the dual use nature of advancing science and technology.

It was articulated, during the talk that apprehensions about propagation of biological weapons and the threat posed by bioterrorism have now gained greater political eminence. Thus, the governments are attempting at discouraging the diffusion of chemical and biological weapons and the technologies associated with them. Governments are introducing a wide range of measures to control access to materials, knowledge and technologies, however, this has also led to inhibition of dispersal of the necessary knowledge/technologies, which might have sincere and socially advantageous applications.

Governing dual use technologies therefore poses a serious policy design dilemma: the regulatory regime needs to balance the suppression of negative applications (in order to reduce the risk of germ warfare) without hindering the development of technology for positive purposes.

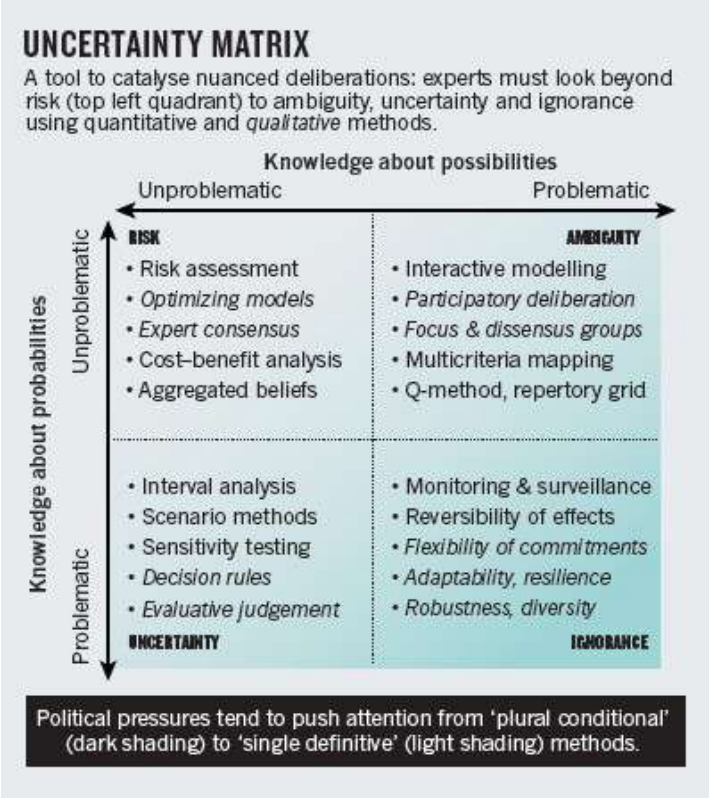
The vision articulated by her for governing the dual-use technologies encourages a more collaborative approach between government and stakeholder communities and focuses on building capacity in flexible and responsive ways so that structures which are sensitive to local contexts are developed to mitigate risks while maximising the benefits of science and technology advances.

The task at hand with the application of dual-use technologies is to define that which of the precautionary measures will optimize the benefit-risk profile of technology. Ethicists and funding bodies have identified a need for clear assignments of responsibilities for stopping misuse, and for principles to guide decisions about which measures to introduce, and when.

Take Home Points from Dr. Caitriona McLeish's talk:

- Employing a collaborative approach for regulating the applications of dual-use technologies, which takes into consideration the perspectives of the government as well as stakeholders.
- Identification and distinct assignment of responsibilities for preventing misuse, and for ideologies to guide decisions regarding the introduction of measures and their apt time.
- Strategies to prevent misuse could operate at the level of scientific practice, information dissemination or technology applications – raising awareness, conscious funding decisions, raising awareness, self-governance of information dissemination, bringing into force a code of conduct, controlling exports, analyzing the cost and benefits of publishing work related with dual-use technologies.
- Continuous evolution of the policies governing the application of dual-use technologies. Levels of risk assessment and ethical review should be set so that they do not impede research.
- In UK, the biosafety controls implemented were successful because - (1) pre-existing security and biosafety measures; (2) a responsive approach to regulation by the implementing body; and (3) a flexible and socially responsible reaction by the scientific community.

The final session of the day consisted of a talk delivered by **Prof. Andy Stirling**, Sr. Scientist, SPRU. In his talk entitled, '*Getting to Grips with Uncertainty in Science, Technology and Society*', Prof. Andy Stirling highlighted the fact that expertise and research are conventionally seen in contemporary 'democratic' societies as key ways to determine 'evidence based policy'. 'Sound science' is a standard for justifying complex political decisions. He emphasized that arguably the single most prominent – and most strongly driving – feature of science for policy, is that it is typically uncertain. In both strict and real-world implications of this word, this means that there can be little confidence in apparently precise 'probabilities' for the different possible outcomes. Individual expert policy reports or advisory committees might be pressurised into producing ostensibly straightforward singular prescriptive recommendations. But the wider peer reviewed science behind these 'closed down' pictures will typically hold many possible surprises. If policy processes are not to be vulnerable to their own political dynamics then, there is a very practical need to make deliberate efforts to 'open up' what are often dangerously-simplified 'evidence based' pictures.



Methods for addressing uncertainty were mentioned. These included methods like - Multi Criterai Mapping, interactive modelling and scenario workshops, Q-method and Dissensus method.

Prof. Stirling also discussed the 'Pathways Approach' developed by the ESRC STEPS (Social, Technological and Environmental Pathways to Sustainability) Centre at University of Sussex. This Centre carries out multi-disciplinary comprehensive research that binds development studies with S&T. This approach identifies with the fact that each individual understands a system in distinctive ways. This was clarified by using the example of a farmer, a seed merchant, a member of parliament and a multinational food company and that all of them view the agricultural system in different lights and different understanding of it. Thus, the distinctive framings also lead to distinctive choices and voices. However, in a non-democratised system, often only the voice of powerful people is heard and becomes a decisive factor in the design of policy, its governance, thereby overrunning the voice of other stakeholders. The pathway approach takes into consideration all the pathways and is substantiated by a number of practical methods.

Take Home Points from Prof Andy Stirling's talk:

- Imperative to take into consideration all factors while designing a policy and also employ both qualitative and quantitative methods of analysis.
- Uncertainty, regarding policies, should be kept in mind at all times.
- Assumptions, if any, made while designing policies should be in accordance with the approach (qualitative or quantitative) utilized for assessment.
- Employing the 'Pathways Approach' can lead to a rather inclusive policy making decision.

➢ DAY 2 (June 18th 2019)

The first lecture of the day entitled '*Infrastructure and Innovation for Resilience*' was delivered by **Dr. Ralitsa Hiteva**. Infrastructure delivery and governance has long been a focal point of economic stimulus packages, and means of industrial and social change, such as transitioning towards low carbon living. Dr. Hiteva deliberated about infrastructure which is defined as "Those critical elements of infrastructure (namely assets, facilities, systems, networks or processes and the essential workers that operate and facilitate them), the loss or compromise of which could result in major detrimental impact on the availability, integrity or delivery of essential services – including those services, whose integrity, if compromised, could result in significant loss of life or casualties – taking into account significant economic or social impacts; and/or significant impact on national security, national defense, or the functioning of the state". Development of national/urban infrastructures and resilient cities has been a part of national level targets. This lecture introduced the core elements of infrastructure policy at national and urban level, and unpacked the role of business models innovation as a specific and key means of delivery at the infrastructure, innovation and resilience nexus.

A case study on UK was presented, which described it as Top Heavy (i.e. contains multiple layer of centralized institutions and actors) yet there is remarkable hidden gap in infrastructure and also presented the lack of opportunities for people to take part in the infrastructure decision making process. While discussing the case study she introduced the idea of **Piecemeal Approach** for formulating divisions between assets and services; economic and social infrastructure and between sectors.

A second case study was presented for discussing the Role of Infrastructure in Economic Growth of Country. A positive effect on economic growth by infrastructure was highlighted through the following points -

1. Enhanced productivity
2. Attracting investment
3. Providing short-term boosts to employment in construction and related

industries Thus, it was articulated that it is imperative to strike a balance between investment in social infrastructure & economic infrastructure because insufficient infrastructure investment constrains other investment and excessive infrastructure investment has no added value. In continuation, the following two deals related to infrastructure development in the UK were also

discussed - Roosevelt's New Deal and Green New Deal, which link to Economic Stability to more local production and distribution.

She also discussed about UK Industrial Strategy, which is supporting local growth" and "responding to local growth priorities", and "continue to strengthen local decision making on infrastructure. UK economic growth focused on industrial strategy for better economic infrastructure`, and non-economic benefits for social infrastructure which helps to frame Inclusive growth for intense investment in social infrastructure alongside investment in economic infrastructure.

In a discussion for a place-based approach to addressing the institutional gap in infrastructure, the following points were discussed -

- **Participatory budgeting**: Power to decide how to spend a pot of money so it can make the biggest difference to their lives. It engages communities in identifying their needs, discussing and agreeing priorities, and deciding about granting funding to address those needs.
- **Deeper listening:** The Early Action Neighbourhood Fund Ignite Project in Coventry has been looking at ways of introducing a different kind of conversation between service providers and local residents, moving away from 'dead spaces', such as formal meetings, in which real listening is often difficult.

With a discussion for numerous conceptualisations and interpretations of resilience, which is resulting in different goals for policy and governance interventions, (Resilience: a system-level capacity to persist and adapt ("magnitude of the disturbance that can be absorbed before the system changes its structure"). It is concluded that social infrastructure poverty and the institutional gap in infrastructure key barriers in achieving resilience.

Take Home Points from Dr. Ralitsa Hiteva's talk:

- Inclusive growth - investment in social infrastructure as an integral driver of growth, wellbeing and prosperity, where as many people as possible can contribute to growth
- This means intense investment in social infrastructure alongside investment in economic infrastructure
- Social infrastructure poverty and the institutional gap in infrastructure key barriers in achieving resilience
- Increasing focus on developing capacities to respond to a wider range of shocks and stresses, whilst making cities more liveable and socially just

The second lecture of the day was '*Science, Policy and Social Movements'* with **Dr. Matias Ramirez**. In this session, Dr. Ramirez discussed the important debate happening concerning the interaction between society social movements and the science, technology and innovation system. An important point put forward was that place-based social movements can facilitate unique local heterogeneous alliances with the key actors of the science and technology system. Moreover, these processes of engagement between civil society and scientists can be highly significant, underpinning quite radical changes in socio technical and socio-ecological systems. The lecture concentrated on four agendas -

- Relevance of social movements to Science Technology and Innovation policy
- How social movements contribute towards STI policy
- Social movements and places
- Measure and monitor impact of social moment on STI policy

In the discussions he described **Undone Science: Science which tends to be overloaded by mainstream and is not supported by large firms and would otherwise left incomplete.**

Dr. Ramirez articulated that social movements contribute to STI-Policy defining social moments and are often associated with challenging power relations. Social moments are areas in which individual and communities are bought together to express a desire for social challenges. This is conflict under condition of structural and inequality. For explanation he discussed about theory triangle (Hess 2016). He also discussed about bricolage which is network based on actors capacity to work with what is at the hand to create novel combinations to overcome two constrains (Two local capabilities) fragmented agendas and unwillingness of policy makers. He also discussed about organizational mechanism to build agency, protest and Bricolage. He gave underlying theory of Transitions and framework for accelerating urban sustainability transitions.

Take Home Points from Dr. Matias Ramirez's talk:

- Encouraging space-based movements and bricolage. These movements can facilitate the emergence of new resources, practices and policy oriented arrangements that can address and generate socio-technical changes.
- Scientists can help open up what might otherwise be closed policy processes and can have profound impacts in other social fields.
- Essential to develop relations between scientists and social activists as primary mobilizing source of scientific change (and learning) lies within these relational networks.

Post lunch session consisted of a session that provided hands on training on *Multi-Criteria Mapping* and was conducted by **Dr. Bipashyee Ghosh** and **Dr. Josie Coburn**. In this training session, they introduced the concept of Multi-Criteria Mapping (MCM) - what MCM is, why would one choose to use it, and how to do an appraisal using MCM. The first part of the session consisted of a brief introduction, followed by a hands-on second part to get to grips with using the MCM software tool. MCM is an interactive method for exploring contrasting perspectives on complex strategic and policy issues. The tool aims to help 'open up' technical assessment by systematically 'mapping' the practical implications of alternative options, knowledge, framings and values. It makes use of simple but rigorous scoring and weighting procedures to reveal the ways in which overall rankings depend on divergent ways of framing the possible options.

MCM also uniquely bridges qualitative and quantitative approaches, and enables more participatory analysis. It allows great flexibility, offering an appraisal method that is strongly grounded in theory but highly unconstrained in practice.

Take Home Points from the Hands-on-training session:

- Essential to identify the difference between qualitative and quantitative policy assessment methods and their apt applications.
- In a complex decision making scenario it is imperative to take into account all the diverse factors, people and their perspectives.
- Therefore, a tool like Multi-Criteria Mapping may be employed, which takes into account uncertainties, different perspectives, and ambiguities and also provides a balance between quantitative and qualitative evidences.
- It aims to help 'open up' technical assessment by systematically 'mapping' the practical implications of alternative options, knowledge, framings and values.

➢ DAY 3 (June 19th 2019)

Third day training program at SPRU included two sessions presented by Dr. Rachael Durrant and Dr. Adrian Ely respectively before lunch and the post lunch session by Prof. Erik Millstone. The afternoon session by Prof. Erik Millstone was proceeded by a field visit to British Airways i360, which is one of Brighton and Hove's most recognizable landmarks.

Session I was entitled '*Innovating Around the City - Insights and Experience from Brighton and Hove'* and pertained to the major question "How can provincial cities like Brighton and Hove accelerate the pace of change towards sustainability under conditions of public sector withdrawal?" During the session **Dr. Rachael Durrant** explained about successes and failures of local change-makers to innovate systemic solutions for urban transport, energy, food, water, waste and natural capital. Rachael also tried to explore some of the mechanisms by which it might be possible to both scale up innovative practices and embed these practices into local governance arrangements. Some of these included social innovation, eco-activism; through examples of Brighton and Hove food partnerships and Brighton bike hub etc. To summarize, the session speaker presented some key messages to the city government to accelerate endogenous and exogenous growth and development.

Take Home Points from Dr. Rachael Durrant's talk:

- Create 'institutional spaces' for bringing together urban change agents and developing partnerships for urban sustainability across sectors and domains.
- Engage with and capitalise on existing, diverse knowledge of transition initiatives in the city-region
- Enabling use of public urban areas and vacant spaces for experiments and innovative actions
- Develop capacities to navigate multi-level governance contexts within which local sustainability action takes places.

The second session by **Dr. Adrian Ely**, delved deeper upon the characterization of innovation, moving beyond the implementation of science and technology–based knowledge by firms to consider broader forms of innovation from the "grassroots". His talk was entitled '*Co-ordinating Grassroots and Hybrid Innovations for Sustainable Food Systems*'. The session considered how grassroots innovation movement links to more formal innovation systems and how they did they hybridize with technology-led, policy-driven initiatives. The speaker started

off with explaining the Science, Technology and Innovations policy framework (2019) in connection with grassroots innovation movement followed by a historical chronicle of UK transformation in food and agriculture research. Ely concluded his presentation by describing several economic and regulatory policy instruments and how could they support innovation for sustainable development. The session had a focus on the notion of grassroots and hybrid innovation in Brighton and Hove, in anticipation of afternoon field trip.

The after lunch session '*Innovation and Regulation for Food Security in Turbulent Times*' was presented by **Prof. Erik Millstone** with a special relevance to the current UK challenges of food poverty, food insecurity and regulatory aspects. Speaker referred to food poverty as a growing European problem and showed the data of 2016, where 118.0 million people in the EU-28 lived at the risk of poverty and hunger. Climate change, technological change and globalization were reported to be the drivers of 'turbulence' within global, national and local food systems as these factors tend to change the patterns of employment and livelihoods in agricultural and industrial regions. Erik explained that the issues of food poverty and securities are equally relevant to Brighton and Hove just like rest of the Europe. He explained the research carried out at SPRU to look at transformations of the region's food system specially the role of community-supported agriculture and supply chain innovations. Research highlighted the role of the Brighton and Hove City Council in coordinating the local authorities and agriculture landowners to participate in city's food system. Prof. Millstone stated that this multi-stakeholder partnership was responsible for service delivery associated with healthy diets, food banks and sustainable procurement and streamlined the processes to develop the city's food strategy.

Take Home Points from Prof. Erik Millstone's talk:

- A robust food strategy action plan could be framed and implemented in India, taking inputs from that of Brighton and Hove, UK 2018-2023 action plan. India may try to take a preventative 'upstream' approach to food poverty and ensure equal access to healthy food. These approaches can start with local administration under the aegis of state government. Major stakeholders including farmers, food activists, policymakers, restaurants and volunteers must come on a same ground to tackle the issues of food poverty in India.
- Establishment of community kitchens might help alleviate the issue of unhealthy and unsafe eating habits within the poorer sections of the society.

Field visit to i360

The field visit on day 3 of training program took place at British Airways i360; which presented a magnificent view of cities of Brighton and Hove. The major landmarks viewed from i360 included Downland Estate and sea across to the South Downs National Park and the Brighton-Lewis Downs Biosphere. The discussions here hovered around Brighton and Hove Food Partnership, food technology, innovation and regulation etc.

The field visit was followed by a presentation from 'IOGRU', company providing high-tech solutions to agriculture solutions. The presenter explained barriers across the world to improve sustainability in food production such as lack of value, knowledge, education, co-operation and funding etc. The presentation could be perceived as information about the automated platform designed by the company IOGRU for providing healthy and natural like environmental conditions for the growth of food plants. The platform could monitor the conditions of plant grown in a green-house through a smart phone or laptop. The speaker also reported barriers in automation of agriculture in terms of cost, mindset of authorities, profit etc., and stated that automation could help in saving money and energy as compare to naturally grown plants.

All of the sessions and presentations on day three, hovered around the current turbulent times faced by Britain, especially after 'Brexit' and the subsequent austerity measures adopted by the UK authorities.

➢ DAY 4 (June 20th 2019)

Session 1: **Dr. Michael Hopkins** delivered a talk on '*Financing Biomedical Innovation in Turbulent Times*' drawing from the United Kingdom's experience with financing biomedical research. The talk was structured in three parts – beginning with a brief introduction about financing biomedical research and innovation, followed by a closer examination of 6 policy instruments used to stimulate investment in biotechnology firms in the UK, and concluding with a brief discussion of Prof. Hopkins' recent book titled 'science, the state, and the city'.

The core agenda from the talk was two-fold:

1. Explore financing of innovation using UK biotechnology firms investing in therapeutic research and development as core study
2. Discuss how policy instruments are used to stimulate investment in biotechnology

firms Options for financing R&D in firms, based on UK's investment in biotechnology sector, are:

- Internal funding drawn from revenues
- External funding such as loans, collateral etc.
- Equity financing

Further, by comparing US and UK biotechnology sectors we observe that US biotech firms have been the biggest winners in the past 30-40 years far outperforming firms from other regions (including the UK). This leads us to the central question from first part of the talk: Why are there so few big successful firms in the UK (or, consequently, outside the US)? Some common explanations are – lack of risk appetite or 'market failure', poor management or lack of talent, flawed financial system tending towards investor short-termism.

The discussion of whether and how raising finances in the biotechnology (and high-tech) sector is a market and/or a system failure is of central concern to the second half of Dr. Hopkins' talk. We discussed various policy instruments and functions through which the governments carve a niche for governance interventions to stimulate innovation funding. We identified six policy interventions in UK's biotechnology sector and classified them based on the 7 functions outlined in Hekkert et al. (2007). The six policy instruments are:

1. State funded DBF (Dedicated Biotechnology Firms)
2. Tax incentives for Venture Capital investors
3. Grants for public-private R&D collaboration
4. Technology-focused Hybrid Capital Funds
5. Technology Innovation 'Catapult' Centres
6. Sector specific Industrial Strategy and associated 'Sector Deals'

Take Home Points from Dr. Michael Hopkin's talk:

- Definitive approaches to governance are bold and provide certainty and Tentative approaches to governance are adaptive and flexible. Policies can and should have a blend of both.
- Early and effective IP and technology transfer arrangements led to a successful biotechnology innovation ecosystem in USA. The existence of a strong pharmaceutical industry i.e. a source of partnerships and management expertise also triggered the industry.

Session 2 consisted of a talk delivered by **Dr. Simone Vannuccini** delivered a talk on '*Coping with Turbulent Technological Change: On the Nature and Governance of Artificial Intelligence*' drawing on similarities, differences, and lessons from two other kinds of turbulence, namely – industrial dynamics and patterns and linked payoffs & General-Purpose Technologies (GPTs). The talk concluded with a discussion on the various policy responses, emergent issues, and dilemmas in the governance of artificial intelligence (AI). Industrial dynamics and patterns, the first kind of turbulence, is characterized by statistical regularities in the structure of their industrial dynamism – such as creative destruction and/or creative accumulation, market entry, exit, and survival etc. – and are broadly regarded as natural laws of economics systems. These 'natural laws' illustrate structural properties and help in prediction.

Linked payoffs and GPTs, a second kind of turbulence, is characterized by multiplicity of outcomes due to interlocking technology dynamics. GPTs are a class of radical innovations with numerous downstream applications. In simple terms, in linked technologies and GPTs the degree and extent of investment in R&D of firms depends on how much others innovate and not just on the cost and profit of the firms. AI, defined as virtual machines executing tasks that are usually associated with human intelligence such as vision, speech recognition, pattern identification/ classification etc., economizes on prediction and is beginning to be widely regarded as a GPT. Furthermore, AI is technologically dynamic and has effects on hardware and chip manufacturing industries. Like other GPTs, AI is subject to coordination failures and dual inducements in its constituent domains, and therefore increasingly being regarded as a GPT.

Current proposals and academic debates around governance of AI are to create new institutions such as a robotics commission or to create cross-institutional functions to regulate and govern AI policy. Dr. Simone Vannuccini's talk concluded with an open-ended discussion of issues such as bias and explainability, accountability, justice and equity, privacy and power, and disruptions to taxation and labour due to ubiquitous use of AI.

Take Home Points from Dr. Simone Vannuccini's talk:

- Establishment of new governance institutions for regulating upcoming technological fields like AI.
- Appropriate safety and certification imperative in newer technologies like AI.

The post lunch session witnessed a Group Discussion led by Prof. Ed Steinmueller and Dr. Jordi Molas-Gallart, which foccused on addressing general questions about STI policy from SPRU training course participants.

Take Home Points from the Panel Discussion:

- Create a broader base for innovation policy funding aimed at innovative, potentially high-growth ventures in emerging technologies.
- Create coordinated policy interventions aimed at increasing innovation in emerging technologies in India.
- Create a mechanism for greater cooperation and coordination amongst all the agencies of the Indian govt. involved in science, technology and innovation.
- Create an autonomous regulatory bodies like robotics commission or artificial intelligence council to regulate and govern emerging technologies (such as AI/ML/robotics).

➢ DAY 5 (June 21st 2019)

Session 1 on the last day started with a talk on 'Research evaluation' with **Prof. Jordi Molas-Gallart**. This session discussed that how while evaluation is becoming an increasingly relevant policy component, its methods and practices are struggling to keep pace with the profound changes in the modes of knowledge production and use, and with the emergence of new approaches to science and innovation policy. The session first reviewed the challenges that the approaches pose to the evaluation practice. Current policies are evolving towards approaches that explicitly seek solutions to specific social and economic problems, and open up the research and innovation processes to wider stakeholder communities.

Yet, evaluation methods continue to be anchored in models that focus on the generation of research outputs and the assessment of the economic impact of innovation policies. These models are not concerned with how policy objectives are defined or with the ways in which knowledge and innovations are generated and diffused. Processes are a minor concern because, implicitly, the processes that lead to the generation and application of new knowledge are considered unproblematic.

Moving on the discussion was shifted towards the evaluation methods that can be used to align evaluation with current concerns about wider participation in research and innovation and its contribution to the solution of social and economic problems.

Take Home Points from Prof. Jordi Molas-Gallart's talk:

- Approaches for policy formulation include – linear, systematic and transformative approaches.
- Indicators may be used in different evaluative methods i.e. for justifying decisions as well as opening debates.
- Indicators should be scrutinized regularly and evaluation criteria should consider their evolving properties.
- Employment of 10 principles for the measurement of research performance: the Leiden Manifesto for Research Metrics.

The second session was entitled '*How to Make Digital Transformation More Inclusive in Labour Markets*' with **Prof. Maria Savona**. Prof. Savona, in her lecture discussed about how the disruptive impact of digital transformations on the labour market can be effectively reduced or prevented is a relevant and timely policy challenge. It brings the technological anxiety of the mechanization of labour and declining working conditions back onto the policy agenda. Therefore, it is imperative to identify suitable directions for digital transformations to reduce unemployment, underemployment and the alienating part of jobs, while maximising potential for prosperity and inclusion at the European level. It was discussed that for exploring potential solutions to these policy challenges, the European Commission in September last year convened an high level expert group (HLG) on the impact of the digital transformation on EU labour markets, that followed an international competition. Prof. Savona was also a part ofthe group. The lecture covered the background and the policy recommendations put forward in the report. The recommendations cover three grand areas: a new social contract, new labour relations, and a skilled workforce.

Take Home Points from Prof. Maria Savona's talk:

- Setting up of intermediary agencies that can invest in providing in-job trainings and then recoup the training costs from the employers who will benefit from trained workers.
- Enable personnel to acquire relevant skills throughout their careers so that they can transform with the digitally evolving labour markets.
- Scaling up career counselling and creating innovative learning environments for enabling better career choices and active pursuit of relevant training for all.

The two main takeaways are:

1. There are a multiplicity of views on innovation policy and its place in economic development - ranging from it follows macro global/national trends to it is a grassroots local movement - and even within SPRU not everyone agrees with everyone else. In concluding remarks, it did appear that everyone appreciated the diversity in disciplinary background within SPRU and the importance of diversity in innovation policy.
2. R&D expenditures and their country targets, while critical in defining the extent of the role of the state in innovation policy, is but one of the many factors in innovation policy making.

Annexure I

List of Participants for 2019 SPRU Residential Training Course on Science, Technology & Innovation Policy for Turbulent Times, 17th to 21st June 2019, at Univ. of Sussex, UK

Participants from India -

S. No.	Name	Place of Work
1.	Prof. Rupinder Tewari, Coordinator	DST-CPR, PU Chandigarh
2.	Dr. Venkatesh Dutta, Coordinator	DST-CPR, BBAU, Lucknow
3.	Dr. Akhilesh Mishra	DST, New Delhi
4.	Dr. Richa Panwar	DST CPR, IIT Delhi
5.	Dr. Mansimran Khokhar Sandhu	DST-CPR, PU, Chandigarh
6.	Dr. Venkata Krishna Nadella	DST-CPR, IISc Bangalore
7.	Dr. Sumya Sharma	DST-CPR, BBAU, Lucknow

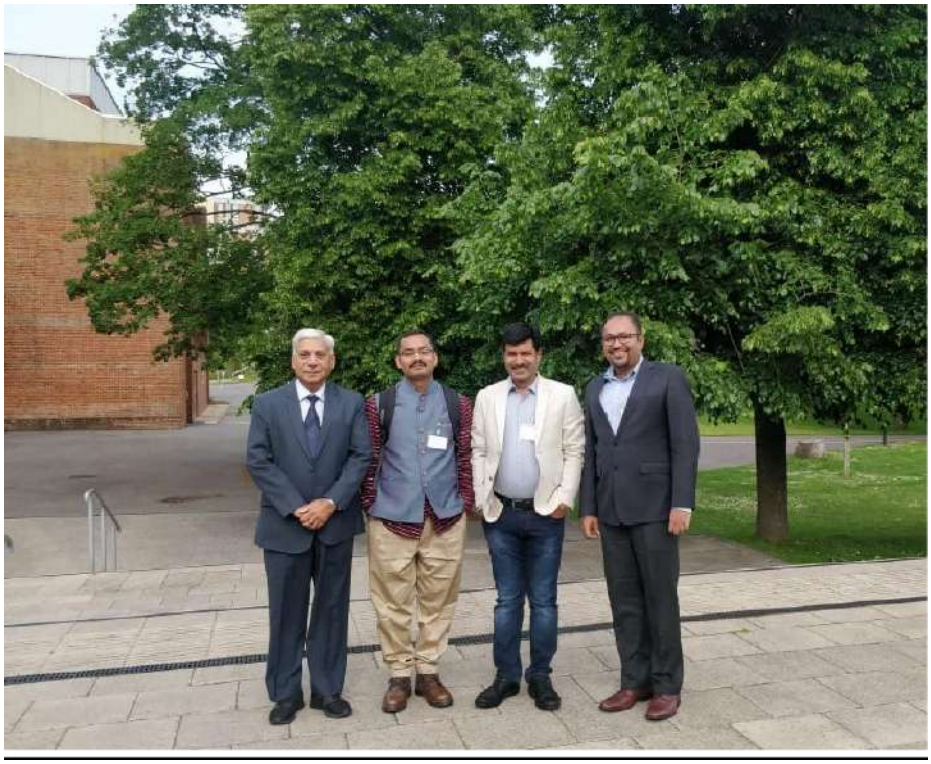
Participants from Other Countries -

S. No.	Name	Affiliation
1.	Mr Henry Green	Senior Policy Advisor, Economic & Domestic Affairs Secretariat, UK Cabinet Office, UK
2.	Dr Muktar Namadi Muhammad	Coordinator, Intellectual Property and Technology Transfer Office, Nigerian Defence Academy, Nigeria
3.	Dr Philip Boucher	Policy Analyst, Science and Technology Options Assessment Panel (STOA), European Parliament, United Kingdom
4.	Dr Se-bong Chon	Research Fellow, Regional Science and Technology Innovation Policy Team, Korea Institute of Science and Technology Evaluation and Planning (KISTEP), Republic of Korea
5.	Dr Sea-hong Oh	Senior Research Fellow, Centre for Future Growth Policy, Korea Institute of Science and Technology Evaluation and Planning (KISTEP), Republic of Korea
6.	Dr Sun Yanhong	Associate Research Fellow, Institute of European Studies, Chinese Academy of Social Sciences, China

Few glimpses of the Training Course

Participants from different countries along with the Indian participants and SPRU Team.

Lectures during the Training Course.



Prof. Rupinder Tewari, Coordinator, DST-CPR at PU, Chd., Dr. Venkatesh Dutta, Coordinator, DST-CPR at BBAU, Lucknow, Dr. Akhilesh Mishra, DST, New Delhi and Dr, Venkat K Nadella, DST-STI-PDF at DST-CPR, IISc, Bangalore

Dr. Venkatesh Dutta and Dr. Akhilesh Mishra with DST-STI-PDFs from DSt-CPRs at PU, Chd., IISc, bangalore, BBAU, Lucknow and IIT Delhi

Meeting with Officials from ESRC and Innovate UK, UKRI

A meeting was conducted on Tuesday, June 18th 2019, with **Ms. Melanie Knetsch**, Deputy Director - Impact and Innovation, Economic and Social Research Council (ESRC), UKRI and **Ms. Janet Geddes**, Janet Geddes, Head of Asia and Emerging Economies, Innovate UK, UK Research and Innovation.

Prof. Rupinder Tewari, Coordinator, DST-CPR at PU, Chd., Dr. Akhilesh Mishra, Scientist E, DST, GoI, New Delhi and Dr. Mansimran Khokhar, DST-STI-PDF at DST-CPR at PU, Chd. attended the meeting at the Office of Medical Research Council, 1 Kemble St, Holborn, London WC2B 4AN.

Ms. Janet Geddes, Ms. Melanie Knetsch, Prof. Rupinder Tewari and Dr. Mansimran (From left to right)

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