Department of
Science and Technology

DST- Centre for Policy Research
at
Panjab University, Chandigarh

Sanctioned by the Department of Science and Technology (DST),
(DST/PRC/CPR-03/2013, Dated 09/01/2014)

Annual Report

(2017-18)

Coordinator: Prof. Rupinder Tewari

Email: ***rupinder@pu.ac.in***
dstprc2014@pu.ac.in

1. **Name of the Centre:**

   DST - Centre for Policy Research at Panjab University, Chandigarh

2. **Vision of the Centre:**

   To bring Academia and Industry closer for increasing the translation of laboratory research into commercial technologies, enhancing private sector participation in the R&D of government funded laboratories and production of industry ready skilled manpower.

3. **Major Objective/Deliverables:**

   - *Development of a new country specific model for promotion of Public Private Partnership (PPP) for R&D.*
   - *Identify areas of policy gaps for stimulation of private sector investment in R&D and suggest changes in policy environment.*
   - *Adopt evidence-based approaches for identifying and promoting areas for generation of intellectual properties.*

4. **Work Carried out during the period (April 2017-March 2018):** Please see **Annexure - I**

5. **Plans and Deliverables for the period April 2018 – March 2019**

   - Publication of a Book entitled 'Public Private Partnership (PPP) for R&D'. The book has around 600 pages and covers major PPP practices in R&D of 17 countries.
   - Preparation of 'White Paper Draft' on Best Practices/Guidelines for enhancing the R&D of public and private sectors.
   - Updating data on patents and publications of over 900 institutes (higher education institutes and national research laboratories)
   - Preparing an 'Intellectual Property Toolkit' for Higher Education Institutions.
   - Evaluating the performance of select Technology Business Incubators.
   - Policy informatics for enhancing R&D and I-A interactions.
   - Sector specific study on the R&D investment of industrial research units – Agriculture

6. **Contact Details of the Centre Coordinator**

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DST-Centre for Policy Research
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7. Website:

http://cpr.puchd.ac.in

8. Advisory Committee:

Members of Advisory Committee

S. No	Name	Designation
1.	Prof. Arun K Grover	Fmr. Vice Chancellor, Panjab University, Chandigarh
2.	Dr V M Katoch	Fmr. DG, Indian Council for Medical Research (ICMR), New Delhi
3.	Prof. G D Yadav	Vice Chancellor, Institute of Chemical Technology (ICT) (Deemed University), Mumbai
4.	Dr Neelima Jerath	Fmr. Exec. Director, Punjab State Council for Science and Technology (PSCST), Chandigarh
5.	Dr Anil Wali	MD, Foundation for Innovation and Technology Transfer (FITT), IIT-D, New Delhi
6.	Dr Arbind Prasad	Fmr. DG, FICCI, New Delhi
7.	Dr (Mrs) Manu Chaudhary	MD, Venus Remedies Ltd., Panchkula, Haryana
8.	Mr Ajay Davessar	Vice President and Global Head, Corporate Communications, HCL Technologies, Noida, UP
9.	Dr A K Puri	DG, Institute of Technology and Sciences, Ghaziabad
10.	Dr Amod Kumar	Chief Scientist, Deptt. of Biomedical Instrumentation, CSIO, Chandigarh
11.	Prof. Rupinder Tewari	Coordinator, DST-CPR, PU, Chandigarh

9. Details of the Project Staff: Designation, Remuneration, Duration etc

Sr. No.	Name	Designation	Salary/ month	Duration	
				From	To
1.	Dr. Ajit Singh Naosekpam	Sr. Scientist D	Rs. 60,500/-	18.11.2014	Till date
2.	Ms. Mamta Bhardwaj	Sr. Scientist C	Rs. 48,400/-	21.04.2015	Till date
3.	Dr. Navkiran Kaur	Sr. Scientist C	Rs. 40,000/-	06.04.2018	Till date
4.	Ms. Sukriti Paliwal	Scientific Officer	Rs. 30,000/-	18.04.2018	Till date
5.	Mr. Rohan	Data Entry Operator	Rs. 24,200/-	05.05.2014	Till date
6.	Mr. Ravinder Kumar	Sweeper Cleaner cum Helper	Rs. 12,747/-	01.03.2016	Till date
7.	Dr. Radhika Trikha	Post Doctoral Fellow	Rs. 80,000/-	03.08.2015	Till date
8.	Dr. Mansimran Khokhar	Post Doctoral Fellow	Rs. 80,000/-	04.10.2017	Till date

10. List of Publications (2017-18)

Research Publications (Published)

1 Mamta Bhardwaj, Radhika Trikha, Rupinder Tewari. (2018) "Mapping of Research Publications and Patents Portfolio of Top 100 NIRF Engineering Institutes in India", International Journal for Multi Disciplinary Engineering and Business Management, Vol.-6, Issue-1.

2 Mamta Bhardwaj, Ajit Singh Naosekpam, Rupinder Tewari. (2017) "Comparative study of Asian economies: lessons for India", Journal of Science and Technology Policy Management, Vol. 9 Issue: 1, pp.2-20.

3 Radhika Trikha, Suveera Gill, Rupinder Tewari. (2017), "A Comparative Analysis of Private Sector R&D Incentivisation: Lessons for India", International Journal of Current Research and Modern Education , Volume 3, Issue 1, 201.

Research Publications (Communicated)

1 Mamta Bhardwaj, Rupinder Tewari. "Research Publications and Patenting Profile of Institutions of National Importance in India", Journal of Intellectual Property Rights (JIPR-NISCAIR), Article ID-JIPR-549.

2 Mamta Bhardwaj*, Kulwinder Singh, Rupinder Tewari. "Research Publications and Patenting Profile of Top 100 NIRF Universities in India", Journal of Intellectual Property Rights (JIPR-NISCAIR), Article ID- JIPR-560.

Book(s)

"Mapping Patents and Research Publications of Higher Education Institutes and National R&D Laboratories of India" ISBN Number 81-85322-67-8. (Released during the Technology Day, 11th May 2018)

11. Seminars/ Conferences/ Workshops Organised

2017-2018	**1.** **A meeting on Industry-Academia** in association with **CII** was held on **7th July, 2017** at CII, Sector-30, Chandigarh. **2.** The Meeting of the **Advisory Committee (IPR)**, DST-Centre for Policy Research at Panjab University was held on **15 July, 2017** in the Seminar Hall, CIL, Panjab University Chd. **3.** Organised a "**review meeting of DST-Centres for Policy Research, Interviews/interaction of DST-STI fellows, BDTD Programme and Gamma radiation Plant for Medical Devices Reprocessing in Hospitals"** at Panjab University, Chandigarh was held on 17th – 18th August 2017. **4.** Round Table meet on **"Developing Country Specific Models for the**

	Promotions of R&D via PPP" at the Seminar Hall, CIL, Panjab University, Chandigarh was held on 19th August 2017. **5. MDIC Meet** at IMTECH was held on 10th Feb 2018
2018-2019	**1.** Organizing an Industry-Academia Symposium **"Working in Systems not Silos: Driving Growth and Innovation Through Industry-Academia Research Partnership" at** the Seminar Hall, CIL, Panjab University, Chandigarh was held on April 16th – 17th 2018 **2.** Convened meetings of **U-NRL** (Jan. 5th & Apr.26th 2018) at Panjab University, Chd. **3. Visit of PSA to** Panjab University was at the request of Co-ordinator, DST-CPR, PU, Chd. He was appreciative of the work being carried out at the Centre.

12. Major Achievements of the Centre (2017-18)

- Development of a CRIKC (Chandigarh Region Innovation and Knowledge Cluster) Industry-Academia Web-portal (https://iacrikc.puchd.ac.in/)
- Convener & Nodal Office *(University-National Research Laboratories Linkage Forum)*, established by Office of Principal Scientific Advisor (PSA) to GoI
- Development of U-NRL Web-portal (https://unrl.puchd.ac.in/)
- MoUs
  - MoU signed between Chandigarh Region Innovation and Knowledge Cluster, (CRIKC) and The IndUS Entrepreneurs (TiE), Chandigarh Chapter on 14th day of July 2018. DST – CPR at PU, Chd. was instrumental in the Signing of this MoU.
  - MoU signed between Andhra Pradesh MedTech Zone, Vishakapatnam and DST-CPR at PU, Chd., on March 10th 2018.
  - MoU signed between CII (Northern Region) and CRIKC, on July 7th 2017, for the promotion of Industry-Academia Interactions. DST – CPR at PU, Chd. was instrumental in the Signing of this MoU.
- Instrumental in the creation of Industry-Academia Clusters in Chandigarh region
  - Medical Device Innovation Cluster (MDIC)
  - Information Technology Cluster
  - Life Sciences Cluster

13. Outreach activities (participation in conferences, symposiums, workshops, training programs; 2017-18)

- Attended **National Workshop on Enforcement of IPR;** August 22nd -24th 2017, CIPAM, DIPP, New Delhi

- Lecture in **IMTechCON**, an Industry-Academia Meet; Oct. 4th – 6th 2017 at CSIR-IMTECH, Chandigarh.
- Attended **India-Canada Technology Summit**; Nov. 14th – 15th, 2017, DST & CII, New Delhi
- Participated in **Access to Technology for Innovation & Establishing a TISC Network**; Dec. 4th - 5th 2017, at Punjab State Council for Science & Technology (PSCST), Chandigarh.
- Lecture in **CSIR-NISCAIR-DST National Workshop: STI Policy: Optimizing Communication and Informative Research**. Januray 23rd – 25th 2018, New Delhi
- 12th Chandigarh Science Congress, CHASCON 2018; Feb. 12th – 14th, Panjab University, Chandigarh. Posters were presented from the Centre (DST-STI-PDF Fellow Dr. Radhika Trikha awarded 3rd Prize)
- Presentation in **Workshop-cum-Brainstorming Session on STI for 'Make in India': Promoting Manufacturing and Job Creation at District Level**, held on February 28th 2018, MGSIPA Complex, Chandigarh. Organised by Punjab State Council for Science & Technology, Chandigarh.
- Attended **WIPO Roving Seminar on the Patent Cooperation Treaty (PCT)** March 19th 2018, NITTTR & FICCI, Chandigarh

ANNEXURE I

A. Development of a new country specific model for promotion of Public Private Partnership (PPP) for R&D

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

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

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

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

PPP mode has become a phenomenon all around the world, including India, in the fields of infrastructure, transportation and urbanization as it provides not only essential capital (which a public sector alone cannot afford) but also professional competence in the work culture (focused approach, better management of finances and time bound projects). In addition, developed nations like, USA, U.K., Germany, Singapore and S. Korea have also built successful models of PPP for R&D. A study was conducted for understanding the strategic PPPs as an instrument of STI policy, which have aided in the advancement of the technological ecosystem of the nation and generated novel products/services, in foreign countries (seventeen).

The present studies have been carried out to identify specific programmes/initiatives, and measures that, across the world (predominantly in developed countries), have persuaded and swayed the utilization of public sector research or business collaborations for its effective translation towards the economic and societal benefit.

Most of the measures of different countries can be classified under the following categories –

- Measures for enhancing collaboration between researchers of publicly funded research institutions (universities and NRLs) and industry.
- Measures initiated by the government for fostering and funding collaborative R&D and encourage engagement of public sector researchers with the private sector.
- Measures initiated by the government to lend support to the private sector particularly the SMEs.
- Establishment of specialized research institutions, industry-academia R&D centers, centers of excellence etc.
- Measures for establishment of clusters and consortia

A brief categorization has been presented in Table 1

Table 1: Categorization of Global PPP Initiatives

	Countries	Name of the Initiative
Specialized Agency	USA	• Defence Advanced Research Promotion Agency (DARPA)
Special Research Institutions	Germany	• Fraunhofer Society - For contractual research
	USA	• National Network for Manufacturing Innovation (NNMI)
	UK	• Catapult Centres
	France	• Translational Research Institute (IRT)
	Ireland	• Technology Gateway Institutes
	Netherlands	• Technological Top Institutes (TTIs)
I-A R&D Centres & Centres of Excellence	USA	• Industry/University Cooperative Research Centres (I/UCRC) • Engineering Research Centre (ERC)
	Canada	• Network Centres of Excellence
	Germany	• Research Campus (PPP for Innovation) - For funding high risk areas having great potential.
	South Korea	• Centres of Excellence (SRC; ERC and RRC)
	Taiwan	• Germination Programme
	Australia	• Cooperative Research Centres Program • ARC Centres of Excellence
	Sweden	• VINN Excellence Centres
	Finland	• SHOK Programme
Dedicated Programmes for Promotion of I-A R&D	USA	• Grant opportunities for Academic Liaison with Industry (GOALI)
	Canada	• MITAC (Mitacs-Accelerate; Mitacs-Elevate; Mitacs-Step) • Idea to Innovation (I2I) Programme
	UK	• Industrial Partnership Award • Higher Education Innovation Fund • Industrial CASE & CASE Plus
	France	• Industrial Chairs in Universities • Industrial Training Convention by Research
	Ireland	• Industry Research & Development Group (IRDG) • Industry Fellowship Programmes

	Israel	• Kamin Programme • Magneton Programme
	Japan	• A-STEP Programme • S-Innovation Scheme
	China	• Blue Flame Programme
	Taiwan	• I-A Cooperative Research Projects • PIONEER Grants for I-A Collaborations • I-A Bridging Program
	Australia	• Industrial Transformation Research Hubs
	Switzerland	• Collaborative Innovation Projects • SNSF Bridge Programme • Knowledge and Technology Transfer Programme
For Assisting SMEs	USA	• Small Business Innovation Research (SBIR) Programme • Small Business Technology Transfer (STTR) Programme
	Canada	• Industrial Research Assistance Programme (IRAP) • MITAC (Mitacs-Coverage)
	UK	• Knowledge Transfer Partnerships
	Singapore	• Gap Funding for Co-Development
	China	• Torch Programme
	South Korea	• Korea Small Business Innovation Research (KOSBIR) Programme
	Taiwan	• Small Business Innovation Research (SBIR) Programme
	Australia	• Industry Growth Centre Initiative
	Finland	• De Minimis Grant
Innovation Cheques/Vouchers	Ireland	• Innovation Vouchers by Enterprise Ireland
	Australia	• TechVouchers Programme (a state initiative) • Innovation and Technology Vouchers Programme (IVP and TVP)
Cluster & Consortia	UK	• N-8 Industry Innovation Forum
	France	• Competitiveness Clusters
	Israel	• Magnet Consortia
	South Korea	• Industrial Complex Cluster Program (ICCP)
	Japan	• Super Cluster Programme

	Singapore	• Technology Consortia
	Netherlands	• Top Consortia for Knowledge and Innovation Scheme (TKI)
Technology Transfer Companies and Offices	UK	• Technology Transfer Offices
	France	• Technology Transfer Acceleration Company (SATT)
	Israel	• Israel Technology Transfer Organization (ITTN)
	Netherlands	• TechnoPartner Programme
Industrial Set-up in Universities/Academia	France	• LabCom
	Singapore	• Corporate Laboratory@ University
	Taiwan	• I-A Technology Alliance Cooperation Programme
Web Portals	Japan	• J-Store • Portal Site for I-A-G Collaboration • I-A-G Collaboration Support Database

The detailed data on the specific initiatives of the countries has been attached along with as a separate file (Attachment 1).

B. Identify areas of policy gaps for stimulation of private sector investment in R&D and suggest changes in policy environment

A COMPARATIVE ANALYSIS OF PRIVATE SECTOR R&D INCENTIVISATION: LESSONS FOR INDIA

Introduction:

With the onset of the twenty-first century, the emerging need of knowledge and research-driven industries for the sustainable economic development of the nation is being widely realized. One of the major key drivers for the country's development is the generation and dissemination of scientific innovations. These innovations are the result of high-end innovative research practices undertaken by the public and the private sectors[1] (Federation of Indian Chambers of Commerce and Industry [FICCI] & Edelman India Private Limited, 2017). Developed and developing nations are continuously strengthening their national R&D ecosystem by revisiting R&D support mechanisms (Deloitte Touche Tohmatsu Limited, 2017). To enhance the competitiveness of a business, innovations have become an important driver for generating new genera of products, processes and technologies addressing socio-economic needs of the nations. Globally, most of the national governments have come up with the R&D incentivisation programs specific for the private sector in order to boost their productivity and contribution to the R&D to evolve as competitive companies (Deloitte Touche Tohmatsu Limited, 2017).

Globally, total R&D investments for the financial year 2016-17 have accounted for almost US Dollars (USD) two million in purchasing power parity (PPP) and the major contributor is the private sector (Advantage Business Media [ABM] & Industrial Research Institute [IRI], 2017), primarily composed of industrial units. In most of the developed economies like USA, U.K. and emerging technological economies like China, private sector investments in R&D are almost double in comparison to the public sector's investments in R&D (ABM & IRI, 2017). On the other hand, in India two-third of R&D investments is incurred by the public sector and the rest (one-third) by the private sector (FICCI & Edelman India Private Limited, 2017). India needs to strengthen and stimulate the private sector for investing in R&D to generate more competitive companies at par with foreign companies (Gopalakrishnan & Dasgupta, 2015, pp.121-130). The Indian Government has made efforts to stimulate the investment of the private sector in R&D by introducing a tax benefit regime for private sector

engaged in R&D along with funding support for pursuing R&D projects (World Bank, 2007). In spite of these efforts, the aim of the Indian government to achieve public to private investments in R&D under the one is to one range by 2017 (Department of Science and Technology [DST] & Confederation of Indian Industry [CII], 2013) is a far-off dream.

The governments of nearly forty countries across the globe are offering dedicated fiscal incentives to corporate businesses to increase their R&D strength in order to increase their productivity and growth (Deloitte Touche Tohmatsu Limited, 2017; OECD, 2015). These countries follow a set pattern of awarding incentives to private sector engaged in R&D, one, in terms of direct funding and two, through tax incentives by providing tax relief or allowance on a portion of R&D expenditure (OECD, 2015). In addition, each country has set norms for R&D incentives depending upon variables like innovation performance, industrial structure, corporate tax system, R&D growth, etc. (OECD, 2015). In countries like Germany and New Zealand, government mediated funding and subsidy support is the preferred mode for stimulating private sector R&D (OECD, 2015; Deloitte Touche Tohmatsu Limited, 2017), whereas in countries like USA, U.K., France and S. Korea, emphasis on R&D tax incentives is used as a mode to stimulate private sector R&D (OECD, 2016).

India is amongst the fastest growing economies of the world. In order to rub shoulders with developed nations, it has to address the issue of stimulating private sector investment in R&D, as million dollars of investment in R&D are required to promote national innovation ecosystem (ABM & IRI, 2017). No nation can set aside this kind of money for R&D activities, and thus the private sector has to be roped in, as is the practice in developed countries. To stimulate private sector engagement in the R&D ecosystem, India must review its R&D policy for the private sector and incorporate appropriate global R&D incentives for catching up with the stable economies of the world.

Global R&D Investments and Government Mediated Incentives:

The costs associated with R&D activities vary from country-to-country and year-to-year. In the financial year 2016-17, the total global share of the R&D expenditure was a little over USD two trillion for PPP (ABM & IRI, 2017). As can be seen from Figure 1, amongst various continents, Asia with twenty four countries is leading in R&D investments (more than forty two percent of global R&D expenditure), followed by Europe (thirty four countries), North America (twelve countries), Russia (five countries), Middle East (thirteen countries) and South America (ten countries). Asian countries such as China, Singapore S. Korea and India

for the past decade have undertaken impactful initiatives to enhance their R&D investments for building a self-reliant technological base for themselves.

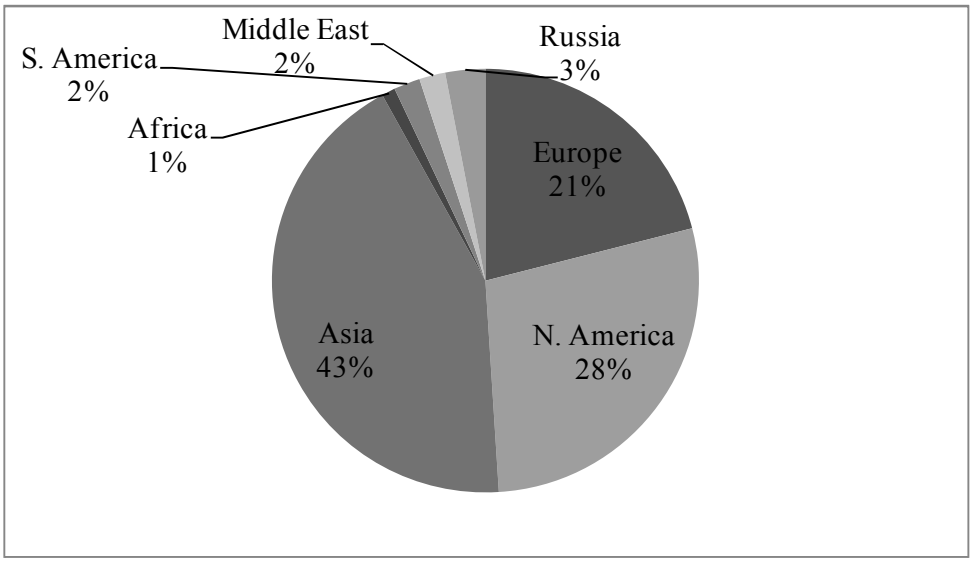

Figure 1: Percentage Share of Global R&D Expenditure of Continents in 2017
Source: ABM & IRI (2017)

Figure 2 represents the top ten nations of the world that significantly invest in R&D in terms of Gross Expenditure on Research and Development (GERD) value.2 The USA holds the topmost position in the chart with USD 527.46 billion PPP followed by China with USD 429.54 billion (ABM & IRI, 2017). For the past fifty years, USA has been outpacing other nations in R&D investments. The strapping network of academic institutions, research organizations along with numerous innovative industrial units and a number of federal programs to support R&D activities in the USA have led to technological advancement. On the other hand, China has shown a significant increase of seven point one percent in R&D spending in 2017 as compared to 2015. It is expected, China with the current growth rate of R&D investments will surpass USA numbers in R&D spending by 2026. Countries such as Japan and Germany fall in the bracket of USD 100-200 billion in PPP investments in R&D. Rest of the countries have less than USD 100 billion in PPP GERD numbers starting with S. Korea, followed by India, France, Russia, U.K. and Brazil. India ranks sixth globally in terms of GERD and is the first developing nation to compete with developed nations in R&D investments.

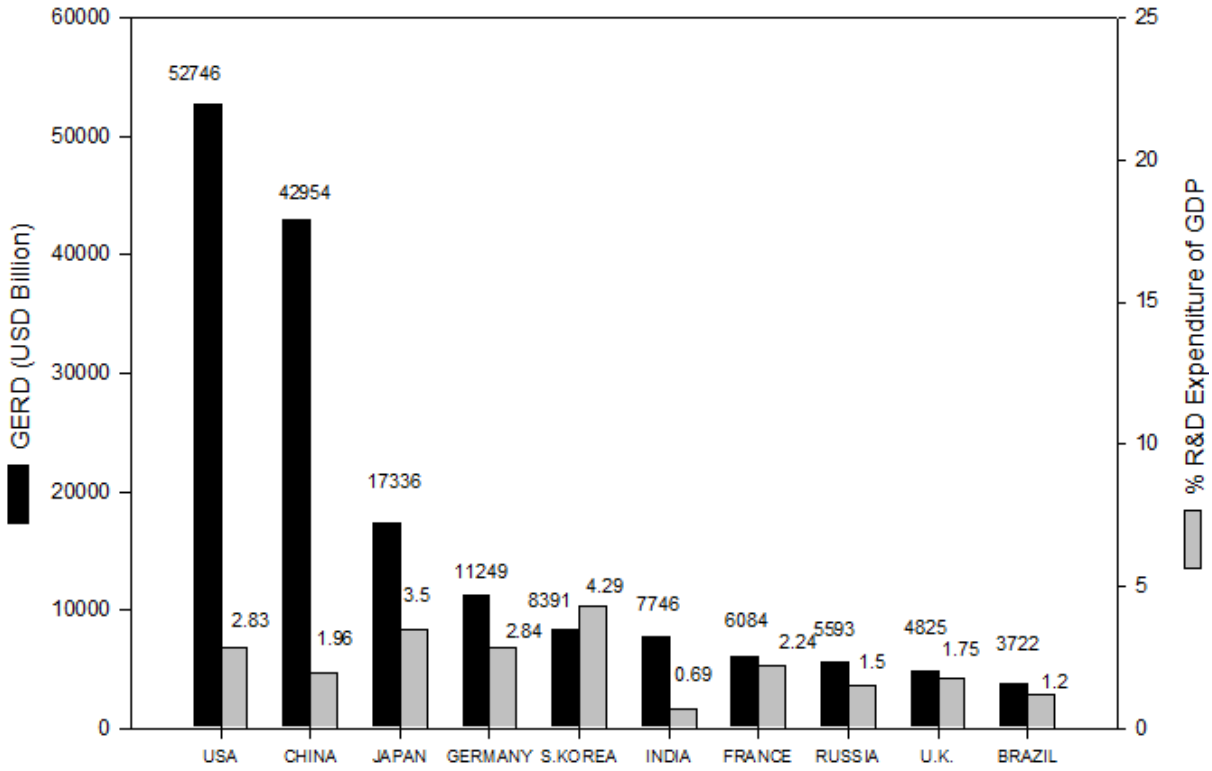

Figure 2: Top 10 R&D Spending Countries of the World and their R&D Expenditure as percentage of GDP
Source: ABM & IRI (2017); www.nstmis-dst.org/

In spite of India being in the top ten list of R&D investing countries, it has the lowest percentage of R&D Expenditure (0.69 percent) as part of total GDP of the country. S. Korea with 4.84 percent of R&D expenditure from its GDP, spends the highest globally for R&D out of its total.GDP value followed by Japan (3.50 percent), Germany (2.84 percent), USA (2.5 percent), France (2.24 percent), China (1.96 percent), U.K. (1.75 percent), Russia (1.50 percent) and Brazil (1.20 percent) (ABM & IRI, 2017).

The industry is the major propeller for R&D in most innovation-based countries worldwide (ABM & IRI, 2017; FICCI & Edelman India Private Limited, 2017). Innovative practices adopted by companies have led them to emerge as competitive and self-sufficient. Many industries (e.g. Volkswagen, Samsung, Novartis and Roche etc.) have rightly exploited their R&D potential for generating in-house Intellectual Property (IP) to evolve as a leader in their research domain. Along with the active participation of industry, the national governments have also put in substantial investment into R&D to endorse the technological growth of the country under the Public-Private Partnership mode (FICCI & Edelman India Private Limited, 2017). It is essential to review public to private sector contributions to R&D to determine the major R&D players and devise ways to strengthen them for national economic

development. The industry carries out business-related R&D, while basic research is carried out by different government agencies and academic institutes. The pattern of R&D funding under different heads such as government, industry and other nongovernment service organizations for select countries in terms of global R&D investments is presented in Figure 3.

Industry is the major influential force behind nation's R&D drive and contributes to the largest share in national R&D investments in countries such as Japan with seventy seven percent industrial share in R&D investments followed by China (75 percent), S. Korea (75 percent), USA (68 percent), Brazil (50 percent) and U.K. (48 percent) either through independent in-house research centres and/or through academic collaboration (ABM & IRI, 2017). In comparison, the pattern of R&D funding in India is totally reverse (Patil & Biswas, 2014). One-third of R&D is supported by the private sector and the rest is contributed by the public sector funded R&D investments. Moreover, only 0.69 percent of the country's GDP is targeted for R&D, which is quite low in comparison to the other countries such as S. Korea (4.21 percent), Japan (3.54 percent), USA (2.5 percent), U.K. (1.75 percent) and China (1.96 percent).

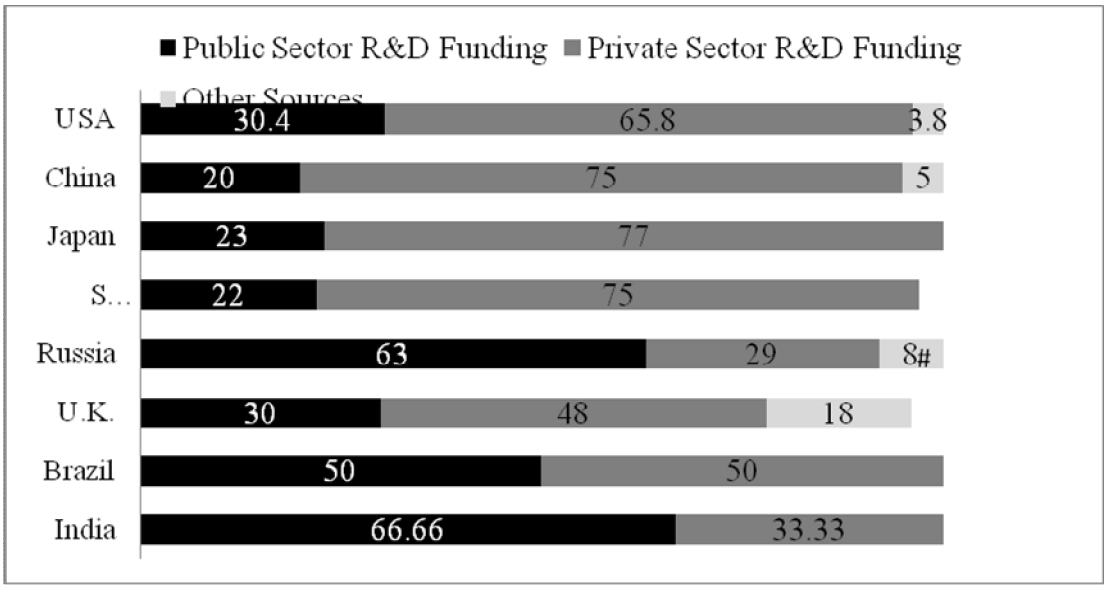

Figure 3: Pattern of R&D Funding in Leading Countries

Source: ABM & IRI (2017) and Patil & Biswas (2014)

Note: Other sources consist of NGOs, not-for-profit organizations, etc.; Data for Germany and France was not available.

Table 1 represents top ten private sector R&D spenders in the world. Most innovative companies are based in the USA followed by Germany, S. Korea and Japan (PwC, 2017). The most innovative companies in the world such as Amazon, Alphabet, Volkswagen, Apple and many more are investing in R&D in the range of USD one to sixteen billion. These companies have taken transformative steps to enhance their R&D workforce and capabilities to develop highly impactful applications for customer use (PwC, 2016).

Table 1: Top 10 Private Sector R&D Investors in the World

Rank	Country	Company	Research Domain	R&D Spending (USD Billions)
1	USA	Amazon	Retailing	16.1
2	USA	Alphabet Inc.	Software and Internet	13.9
3	USA	Intel Corp.	Computing and Electronics	12.7
4	S. Korea	Samsung Electronics Co. Ltd.	Technology and Hardware	12.7
5	Germany	Volkswagen	Automobile	12.1
6	USA	Microsoft Corp.	Software and Internet	12.0
7	Switzerland	Roche Holding & AG	Pharmaceuticals	11.4
8	USA	Merck & Co., Inc.	Pharmaceuticals	10.1
9	USA	Apple Inc.	Technology and Hardware	10.0
10	Switzerland	Novartis AG	Pharmaceuticals	9.6

Source: Adapted from PwC (2017)

Although India ranks sixth in term of global R&D spenders none of its private sector companies invest significantly in comparison to the most innovative companies in the world as presented in Table 2. Indian origin companies are approximately investing 0.02 to 0.5 percent of world's most innovative companies. Indian companies need to enhance and modify their R&D infrastructure and capabilities to generate innovative

products in the market. Technology based innovative products will play a central role in the evolution of Indian companies from manufacturing to technology generators.

The twelfth five-year plan (2012-17) implemented and executed by the Planning Commission3 India, aimed at increasing the R&D investment percentage to two percent of GDP, which was hovering around less than one percent by the end of 2011. Further, it delineated the role of private sector in its contribution to R&D with the ratio of Government investment to private investment closer to fifty to fifty range by 2017 (Planning Commission, 2013). However, India has not witnessed the projected target of achieving equal participation of public and private sector in national R&D expenditure.

Table 2: Top 10 Private Sector R&D Investors in India

Rank	Company	Research Domain	R&D Spending (USD Billions)
1	Tata Motors Ltd.	Mechanical Engineering	0.40
2	Reliance Industries Ltd.	Electronics, Processing (others)	0.19
3	Bharat Heavy Electrical Ltd.*	Electrical	0.18
4	Mahindra & Mahindra Ltd.	Mechanical Engineering	0.16
5	Sun Pharmaceutical Industries Ltd.	Pharmaceutical	0.15
6	Lupin Ltd.	Pharmaceutical	0.14
7	Maruti Suzuki India Ltd.	Mechanical Engineering	0.14
8	Bharat Electronics Ltd.	Electronics	0.14
9	Dr. Reddy's Laboratories Ltd.	Pharmaceutical	0.13
10	Syngene International Ltd.	Pharmaceutical	0.12

Source: Adapted from DSIR (2016)

Note: *Government undertaking

Government is continuously seeking private sector participation in R&D as stated in various government released white papers, including 'Stimulation of Investment of Private Sector into Research and Development in India,' 2013 (DST & CII, 2013) and 'Sectoral Innovation Council on Industrial R&D,' 2013 (Department of Scientific and Industrial Research [DSIR],

2013)[4] and expert committee reports such as 'Report of the Expert Committee on Innovation and Entrepreneurship', 2015 (NITI Aayog, 2015) and 'Committee Report on Corporate Participation in Higher Education,' 2012 (Planning Commission, 2012)

The key reasons for low private sector involvement in Indian R&D are the inability of small scale industries to invest in R&D because of limited financial resources, trust deficit between the public and the private sectors, lack of risk taking approach in business, stigma over failure, acute dependency on foreign technologies and complex process of availing government incentives for R&D in Indian ecosystem (NITI Aayog, 2015). To stimulate private sector engagements in R&D, it is essential to review the present system of incentivisation of private sector by the government authorities to promote R&D and determine the gaps in incentivisation scheme by carrying out a comprehensive analysis of the incentivisation program executed by federal governments of select countries (Table 3).

Table 3: Overview of R&D Incentivisation Followed in Top 10 R&D Spending Countries of the World

Country	Funding support	R&D Tax	R&D Tax Credit	R&D Tax Deduction	Volume Based	Increm-ental Based	Refund-able	Carry Forwarded	Preferential Tax Incentives Collaboration		Patent Box	CAPEX Incentive*
									SMEs	Collabor-ation		
USA	✔	✔	✔ (14-20%)	×	×	✔	✔ (Payroll taxes for start-ups)	✔	✔ (for start-ups)	×	✔	✔
China	✔	✔	×	✔ (50%)	×	×	×	×	×	×	✔ (5 yr tax holiday; 50% tax rate)	×
Japan	✔	✔	✔ (6-17%)	×	✔	✔ (for high end R&D intensity)	×	×	✔	✔	×	✔
Germany	✔	×	×	×	×	×	×	×	×	×	×	✔
S. Korea	× (limited)	✔	✔ (30-50%)	×	×	✔	×	✔	✔	×	✔ (30% tax exemption)	✔
India	× (limited)	✔	×	✔	✔	×	×	✔ (only in case of losses)	×	×	✔ (10% tax rate)	✔
France	✔	✔	✔ (30%)	×	✔	×	✔	✔	✔	✔	✔ (10% tax rate)	✔

Russia	✔	✔	×	✔ (150%)	×	×	×	×	×	×	×	✔
U.K.	✔	✔	✔ (33.5%)	✔ (230%)	✔	×	✔ (for SMEs)	✔	×	×	✔ (10% tax rate)	✔
Brazil	×	✔	×	✔ (160-270%)	×	×	×	×	×	×	×	✔

Source: Compiled from Deloitte Touche Tohmatsu Limited (2017), EYGM Limited (2017) and PwC (2017); Note: *not specific for R&D

Each country has its own set of rules and guidelines for approving the R&D expenditure of industries eligible for availing R&D incentives. There are designated types of R&D expenditure such as purchasing land, equipments, materials, labour wages, cost of testing and trials etc. under qualified and non-qualified R&D expenditure. Moreover, location specificity for pursuing R&D work by companies who wish to avail R&D incentives also apply in most of the countries along with their respective IP jurisdiction. Table 4 presents the comparative analysis of the qualifying R&D expenditures and IP along with location-based jurisdiction for availing R&D incentives for the select countries.

In countries like USA, Japan, France, U.K. and Brazil all types of industries pursuing R&D can avail government mediated benefits and incentives on their R&D expenditure. Whereas in countries like China, Russia, Germany and India, set of industries as listed in Table 4 can avail government incentives that too after getting recognition and approvals by the central government authority. Ministry of Science and Technology, Government of India created a dedicated department 'DSIR' with a mandate to assist industries pursuing R&D in domains of science and technology. The department recognizes and accredits the private sector's in-house research units for the minimum period of three years in order to make them eligible for availing government incentives. For the most part of the world, expenditure incurred on R&D manpower, R&D supplies, developing products, processes, software and contract research by the private sector, comes under qualified R&D expenditure. For countries like China, Germany, France it also includes costs related to IP, amortization assets and depreciation value on R&D equipments and related assets. In most of the countries expenditure incurred on land and overhead expenses is generally not considered as R&D investment, except in France and Russia. In India, as specified in DSIR norms, R&D investments in the field of alcoholic spirits, tobacco, creams, toothpaste, chocolate, confectionary items and few more are classified under non-qualified R&D expenditure although, these industries are investing substantially in R&D in order to improve their product range. In almost every country, private sector availing government incentives should be located in that particular country whereas in terms of IP related product or technology generation, company can avail R&D incentives on product or technology generated from any foreign IP without any IP location specificity requirements. The only exception to this

requirement is China, as Chinese government mandates that a company to avail of the incentives should be set up in China and IP for the range of products should be primarily registered in China.

The government mediated major R&D incentives fall into two categories, namely R&D funding support as a grant, loan, equity or subsidy and tax incentives on R&D. In Table 5, major R&D funding support programmes to support R&D of the private sector are listed. As can be observed, countries like USA, Japan, Russia and Brazil have one single national agency that provides financial support in the form of loan or grant to the private sector for R&D projects. Whereas in countries like China, S. Korea, France and Germany, various departments under different Science and Technology ministerial heads has commenced a number of schemes for financially supporting R&D undertaken by the private sector. The countries selected in study have implemented dedicated programmes for supporting technology based targeted research (e.g. National High-Tech Research and Development programme of USA; Strategic Promotion of Innovative Research and Development Programme of Japan etc.), academic collaborated research (Funding for Collaborative Research Programme of France; Industry/University Cooperative Research Centre Program of USA, etc.) and growth of small business through innovation (Small Business Innovative Research Program and Small Business Technology Transfer Program of USA). Moreover, countries like USA, Japan and Germany have dedicated risk guarantee schemes for supporting companies performing high-risk R&D. Each country has introduced a set archetype of tax incentivisation for the private sector in order to stimulate their R&D efforts as presented in Table 6. Countries provide tax incentivisation in accordance to the scale of industry (large/medium/small enterprise) as in Japan, S. Korea, France and U.K., or on specified targeted research as in USA, China and Brazil and still others, like S. Korea and Brazil, on the basis of increment in R&D investments and manpower. Tax rebates on patent earned royalty income under patent box regime have also been initiated by these countries.

Table 4: Eligibility, Qualified Research Expenditure, Location Specificity and IP Jurisdiction for Availing R&D Incentives in Select Countries

Countries	Eligible Industries	Qualified Research Expenditure	Nonqualified Research Expenditure	Location Specificity	IP Jurisdiction
USA	All industries	➢ Wages for in-house labor ➢ 65% contract research ➢ R&D Supplies ➢ Costs incurred to construct a pilot model ➢ Expenses incurred for developing software	➢ Overhead expenditure ➢ Capital expenditure	Yes	No
China	All industries except negative list industries which are: ➢ Tobacco ➢ Hospitality and catering ➢ Wholesale and retail ➢ Real estate ➢ Rental and commercial services	➢ Labor expenses (including labor costs for external personnel) ➢ Direct expenses incurred in the R&D project ➢ Depreciation expenses (even if the equipment is not used exclusively for R&D) ➢ Amortization expenses ➢ Design and testing expenses (including testing expenses for trial products) ➢ Expert consultation	Expenses related to R&D activities carried out by contractors that are foreign organizations or individuals	Yes	Yes

	➢ Entertainment	➢ High and new technology R&D insurance ➢ IP application costs ➢ Travel and meeting costs. ➢ Up to 80% of fees paid to contractors to perform research on the taxpayer's behalf qualify			
Japan	All industries	➢ In-house labor costs ➢ R&D supplies ➢ Overhead ➢ Depreciation on fixed assets ➢ Contract costs	Any kind of R&D related expense that is funded by public sector, customers and other suppliers.	No	No
Germany	Industries in sectors- Manufacturing and production processes, Automotive and transportation, biotech and life sciences, Information and Communication technology, Energy and utilities	➢ Personnel Costs ➢ Materials ➢ Overhead ➢ Subcontracting ➢ Amortization ➢ Travel Costs	-	Yes	No

S. Korea	Dedicated corporate R&D center registered with the government authority	➢ R&D labor and staff expenses ➢ R&D material supply cost ➢ R&D equipment rental ➢ Consultation and commission charges for R&D work ➢ Cost related to R&D training ➢ Intellectual property related costs	➢ Legal and administrative activities related to IP protection ➢ Research activities on contract basis	No	No
France	All industries (Contractors performing research on a time/materials basis can claim tax credits for their qualified research expenses)	➢ R&D labour and staff expenses ➢ Expense related to administrative work of R&D unit ➢ Depreciation allowances on R&D assets ➢ Patent related costs ➢ Costs related to contract research ➢ Costs related to technological monitoring	Materials used in the research process	No	No
Russia	Industries which undertake R&D typically, such as oil and gas, telecommunication, transportation and IT.	➢ Cost incurred for developing new products, improvements in current production process, development of new services ➢ Labor costs ➢ R&D contract expenses ➢ R&D equipment depreciation ➢ Property associated with R&D work	-	Yes	No

U.K.	All industries	➢ R&D Staff wages ➢ Software or consumable items used in the R&D ➢ Costs related to clinical trial subjected volunteers ➢ R&D linked subcontracting costs especially for SMEs (up to 65% of total cost)	Expenditure on rent, land, patents, and patent protection	No	No
Brazil	All industries	➢ R&D Staff wages ➢ Cost related to R&D activities procured from third party	-	No	No
India	Some of the major tax incentives can only be availed by DSIR recognized industries	➢ R&D staff wages ➢ R&D Supplies and uutilities ➢ Expenses incurred in clinical drug trials which are pre-approved by the concerned regulatory authority and simultaneously patent application which were filed under the Patents Act (1970)	➢ General and administrative costs ➢ Depreciation values ➢ Overhead expenses ➢ R&D carried out under following fields alcoholic drinks and spirits, tobacco preparations, toilet and cosmetics preparations, aerated water and drinks, confectionary items, gramophones, photographic related equipment and projectors, and office machines	Yes	No

Source: Compiled from Deloitte Touche Tohmatsu Limited (2017), EYGM Limited (2017) and PwC (2017)

Table 5: Government Mediated Funding Support Available for Private Sector R&D

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

Japan	Japan Science and Technology Agency (JST)	➢ Collaborative Research Based on Industrial Demand ➢ Center of Innovation (COI) Program ➢ A-STEP (Adaptable and Seamless Technology Transfer Program through Target-driven R&D) ➢ S-Innovation (Strategic Promotion of Innovative Research and Development) ➢ Technology Development Program for Advanced Measurement and Analysis (Program-T) ➢ Software Development Program for Advanced Measurement and Analysis (Program-SW) ➢ Prototype Validation / Practical Realization Program for Advanced Measurement and Analysis (Program-P) *Risk Undertaking Guarantee Scheme:* Japan Bank for International Cooperation Loan Guarantee Scheme: Government organization guarantees and accepts the burden.
Germany	➢ German Research Foundation (DFG) ➢ German Academic Exchange Service (DAAD)	➢ Grants for R&D ➢ Kleine und mittlere Unternehmen (KMU)-innovativ ➢ Central Innovation Program for SMEs (ZIM) ➢ German Federal State Funding ➢ New High-Tech Strategy Programme ➢ Horizon 2020 For large enterprises, cash grants are awarded of up to 50% of eligible costs, with a 10% bonus possible for SMEs, depending on the specific calls. *Risk Undertaking Guarantee Scheme:* German United Loan Guarantees: Government provides financial guarantees for loans should the firm be unable to repay.
S. Korea	➢ National Research Foundation ➢ Korea Institute for Advancement of	➢ New Technology Purchasing Assurance ➢ Korea Credit Guarantee Fund ➢ Knowledge Partnership Korea Fund for Technology and Innovation ➢ Research funds under National R&D Program

	Technology (KIAT)- specifically working for industrial technology ➢ Korea Energy Technology Evaluation and Planning (KETEP) ➢ Small & Medium Business Administration (SMBA)	➢ Creative Research Initiative
France	➢ Agencies for research funding (ANR) ➢ Innovation agency (OSEO)	➢ SMEs Immediate Repayment ➢ The Estates General of Industry (EGI) ➢ The Competitiveness Cluster policy ➢ Funding For Collaborative Research ➢ National Fund for Research Promotion Company receiving financial support under R&D grant issued by government is subjected to different tax relief rates (25% tax relief rate for large scale and medium scale companies and 40% for small scale companies)
Russia	Russian Federation	➢ Innovation Enforcement initiative ➢ Innovation Development Strategy of the Russian Federation to 2020 ➢ Promote regional clusters, including special economic zones, techno-parks and innovation and technology centres. ➢ Technology Platforms Initiative
U.K.	-	➢ R&D grant (EU) ➢ R&D grant (national)

Brazil	➢ National Council for Industrial Development	➢ National Strategy in Science, Technology and Innovation (ENCTI) ➢ HABITARE ➢ Implementation of Innovation Law (2001) ➢ Programa Primeira Empresa Inovadora ➢ Juro Zero Programme ➢ Programme for Support of Research in Enterprise ➢ Brazilian Support Service for Small Enterprises

Source: Compiled from Deloitte Touche Tohmatsu Limited (2017), EYGM Limited (2017) and PwC (2017)

Table 6: Major R&D Tax Incentives Implemented by Select Economies

Select Country	Corporate Tax Rate	R&D Tax Incentive
USA	15-35 %	➢ Traditional Research Tax Credit: a 20% tax credit can be availed by tax payer on qualifying R&D expenditure from the base period of 1984-88. ➢ Alternative Simplified Credit: a tax credit of 14% can be availed by tax payer on qualified R&D expenditure which is 50% of the average value calculated for previous three year's R&D expenditure. ➢ Targeted Research Credits: US federal government offers targeted incentives for specified research such as 20% tax credit for undertaking basic research, 20% tax credit for research in energy consortium and 50% tax credit for clinical research and testing of orphan drugs.
China	25%	➢ Companies dealing with the use of energy-saving technologies are eligible for preferential tax incentives of enterprise income tax credit of 10% on the company's total investments.

		➢ Reduced tax rates are available to select high-technology oriented enterprises which can avail reduced enterprise income tax rate of 15% for the three-year period. These enterprises are also eligible for 50% super deduction on R&D expenditure. Technology areas supported under high and new technology enterprise status for companies are medical and biological, aviation, space, new materials, energy conservation, resources and environment, automation and advanced manufacturing. The reduced enterprise income tax rate of 15% is applicable for technology advanced service enterprises which are located in specified 21 cities in China. These enterprises are not granted with 50% super deductions on R&D expenditure. ➢ Companies dealing with R&D, research-based offshore outsourcing, technology transfers to foreign and domestic entities are eligible for availing VAT exemption or procure input VAT refundable. R&D centers established under foreign investments can also avail VAT, import duty, consumption based tax exemption for R&D required imports
Japan	30%	➢ A tax credit of 30% is available to companies for undertaking joint R&D with public research institutes or universities. A special tax credit of 20% is also applicable on royalty payments made to SMEs. ➢ SME with the stated capital of 100 M or less JPY can avail 17% tax credit on total R&D expenditure. On the other hand, large companies having stated capital of more than 100 M JPY can avail tax credit of 6-10% of total R&D expenditure. ➢ Incremental tax credits capped at 30% are available for both SMEs and large-scale companies on increment in current period R&D expenditure that exceeds more than 5% of annual average R&D expenditure of three preceding years.
S. Korea	11-24.2%	➢ SMEs can avail 50% tax credits for the current year R&D expenditure exceeding the average annual R&D expenditure of previous four-year period or 25% tax credit for the current year R&D expenditure. SMEs in the field of new growth engine or original source technology can avail 30% tax credit on current year R&D expenditure. SMEs can further avail 10% tax credits for IP purchase from Korean party. ➢ Medium-sized companies can avail 40% tax credit on current year R&D expenditure exceeding the average annual R&D expenditure of previous four-year period or 8% tax credit for the current year R&D expenditure. ➢ Large companies can avail 30% tax credit on current year R&D expenditure exceeding the average annual R&D expenditure of previous four-year period or 1% tax credit for the current year R&D expenditure. Large companies can also

		avail additional rate of 50% on the R&D expense ratio of current year R&D expenditure by revenue earned by sales. ➢ Additional R&D tax credits are available for all the companies for pursuing research in the field of new growth engine and original source technology industry, purchasing IP developed by SMEs and purchasing R&D equipment. ➢ Tax Incentives for foreign investors in field of high technology areas and are eligible for avail exemption from corporate tax, property tax and acquisition tax for the period of five years starting from the first profitable year.
France	28%	➢ 30% tax credit on the first 100 million euro qualifying R&D costs incurred by the industries which can be carry forward and if not claimed can also be refunded. Subsequently, the tax credit is reduced by 5% for qualifying R&D expenditure. ➢ Innovation tax credits: an innovation-based tax credit of 20% is available for SMEs who do not qualify for 30% tax credit for prototype development, improved product or process, and creation of the pilot model. ➢ Tax Exemptions to the Young Innovation Companies which are investing 15% of their income on R&D are eligible to avail number of incentives such as, 100% exemption from corporate tax for two years and 50% exemption for the second year. These companies are also exempted from other service taxes for a period of seven years.
Russia	20%	➢ Companies having qualified R&D expenditure can avail 150% super deductions on computed profits tax liability. R&D incentives are made available to the companies even if they fail to deliver new product or process from R&D activities. In case of losses, 50% of operating losses can be attributed to the super deduction for next period.
U.K.	17%	➢ U.K. government provides super deductions of 230% to SMEs and R&D expenditure tax credit of 11% to large companies on their qualifying research expenditure. SMEs under loss position can avail cash credits up to 33.5% on their R&D expenditure.
Brazil	34%	➢ Brazil offers 160% super deduction on qualifying expenditure under R&D head of companies. The Super deduction is enhanced to 170% for a company if it increases the number of researchers by 5% for specific research projects undertaken by the company. Whereas companies dealing with IT and automation activities are eligible for 260% enhanced super deduction on their total R&D expenditure. For these companies also, if the number of researchers in dedicated research projects are increased by 5%, further enhancement of super deduction to 270% can be availed by the company on their

		total research expenses. ➢ Brazil offers extra 20% deduction on R&D costs associated with the patent development process for a registered patent.

Source: Compiled from Deloitte Touche Tohmatsu Limited (2017), EYGM Limited (2017) and PwC (2017)

Indian R&D Incentivisation Landscape:

India being the sixth largest spender on R&D in the world has emerged as one of the most favoured destination for pursuing innovation in Asia. The country has witnessed tremendous growth in multinational corporations based R&D centres from 721 in the year 2010 to nearly 1,000 in the year 2015 with an annual compound growth rate of five point two percent (India Brand Equity Foundation [IBEF], 2014). Nearly fifty percent of the global R&D corporates such as GlaxoSmithKline Ltd., Pfizer Ltd., Abbott Ltd., etc. are located in India.

In comparison with other developing nations, India has a high rate of corporate tax of thirty percent (plus surcharge and education cess) on an average for the last three fiscal years. As shown in Table 7, in order to attract more investment in R&D, in infrastructure and to promote industrial growth, the Indian government is offering various incentives such as R&D funding support[5] (cf. Panel A), tax incentives, rebates, exemptions (cf. Panel B) and investment allowances (cf. Panel C). The major incentives to promote R&D investments in India fall under R&D funding support and R&D tax incentives.

Table 7: R&D Incentives for Private Sector in India

R&D Incentives	Details
Panel A: R&D Funding Support	
27 ministries with various funding programs. Major funding programs initiated by the government are mentioned below:	
Department of Science and Technology (DST); http://www.dst.gov.in/	➢ Technology Systems Development Programmes (TSDP) ➢ National Science and Technology Entrepreneurship Development Board (NSTEDB) schemes ➢ Schemes for Funding Industry Relevant R&D (Under SERB) ➢ Drugs and Pharmaceutical Research Programme ➢ International S&T Co-operation: setting up of Indo-French Centre for Promotion of Advanced Research (IFCPAR / CEFIPRA), Indo-US Science & Technology Forum (IUSSTF) and Indo-German Science & Technology Centre (IGSTC)
Technology Development Board (TDB); http://tdb.gov.in/	➢ Seed Support Scheme ➢ Venture Capital Fund

Technology Information, Forecasting and Assessment Council (TIFAC); http://www.tifac.org.in/	➢ Advanced Composites Programme ➢ Revolving Technology Innovation Fund [under TIFAC-Small Industries Development of Bank of India (SIDBI) Programme] ➢ Technology Refinement and Marketing Programme (TREMAP) ➢ Collaborated Automobile R&D Core-Group
Global Innovation and Technology Alliance (GITA); https://www.gita.org.in/	➢ Bilateral programmes o Technology Acquisition and Development Fund o India UK Collaborative Industrial Research Development Programme ➢ Multilateral programmes o *The Enterprise Europe Network (EEN)* o *Innovation Driven Initiative for the Development and Integration of Indian and European Research (INNO INDIGO)*
Department of Scientific and Industrial Research (DSIR); http://www.dsir.gov.in/	➢ Building Industrial R&D and Common Research Facilities (BIRD-crf) ➢ Patent Acquisition and Collaborative Research and Technology Development (PACE) ➢ Promoting Innovations in Individuals, Start-ups and MSMEs (PRISM) ➢ Access to Knowledge for Technology Development and Dissemination (A2K+) ➢ Technology Development and Demonstration Program (TDDP) ➢ Technology Management Programme (TMP) ➢ Encouraging Development and Commercialization of Inventions and Innovations: A new impetus ➢ Consultancy Promotion Programme (CPP) ➢ International Technology Transfer Programme (ITTP)
Council of Scientific and Industrial Research (CSIR); http://csirhrdg.res.in/	➢ New Millennium Indian Technology Leadership Initiative (NMITLI) ➢ CSIR-Industry Sponsored Research Fellowship Scheme
Biotechnology Industry Research Assistance Council (BIRAC); http://www.birac.nic.in/	➢ Small Business Innovation Research Initiative (SBIRI) ➢ Biotechnology Industry Partnership Programme (BIPP) ➢ Contract Research and Service Scheme (CRS) ➢ Promoting Academic Research Conversion to Enterprise (PACE)
Indian Council of Agricultural	➢ Competitive Grant Scheme under National Agricultural Technology

Research (ICAR); http://www.icar.org.in/	Project (NATP)
Defence Research and Development Organization (DRDO); https://www.drdo.gov.in/drdo/English/index.jsp?pg=homebody.jsp	➢ The DRDO-FICCI Accelerated Technology Assessment and Commercialization (ATAC) Programme ➢ Extramural Research (ER) Scheme ➢ Grant-in Aid Scheme
Department of Industrial Policy and Promotion (DIPP); http://dipp.nic.in/	➢ Industrial Corridor Projects ➢ Invest India ➢ Modified Industrial Infrastructure Upgradation Scheme (MIIUS)
Ministry of Electronics and Information Technology (MeitY); http://meity.gov.in/	➢ Multiplier Grant Scheme ➢ Funding and Support to Industry and Academic Institutions through GITA ➢ Scheme for Financial Assistance to Select States/UTs for Skill Development in Electronics System Design and Manufacturing (ESDM) Sector
Indian Space Research Organization (ISRO); https://www.isro.gov.in/	➢ Sponsored Research (RESPOND) ➢ ISRO Technology Transfer Group ➢ Space Application Centre (SAC) Industry Portal and Industry Interface
Ministry of Human Resource Development (MHRD); http://mhrd.gov.in/	➢ Research Parks ➢ IMPRINT India
University Grants Commission (UGC); https://www.ugc.ac.in/	➢ University-Industry Inter Linkage (UIL) Centres
All India Council for Technical Education (AICTE); https://www.aicte-india.org/	➢ Industry Institute Partnership Cell (IIPC) ➢ Research Park ➢ Innovation Promotion Scheme (IPS)

R&D Incentives	**Details**

Panel B: R&D Tax Incentive				
Super deductions on R&D investments	Value of weighted tax deduction till 2017	Value of weighted tax deduction from 2017-20	Value of weighted tax deduction 2020 onwards	Referred section of Income Tax Act 1961
a. Super deduction for R&D expenditure incurred by DSIR recognized In-House R&D units	200%	150%	100%	35 2 (AB)
b. Super deduction on payments made to scientific research company/university/other institutions for scientific research and statistical research	125%	100%	100%	35 (1) (ii)
c. Super deduction on payments made to certain approved universities/colleges/scientific organization/research institutes for carrying out scientific research	175%	150%	0	35 (1) (ii)
d. Super deduction for R&D expenditure (not listed above but other than land purchase or rent) incurred by private company	100%	n.s.	n.s.	n.s.
e. Weighted tax deduction for sponsored research programmes in approved National Laboratories, Universities, and IITs	175%	n.s.	n.s.	35 (2AA)
f. Super Deduction on donations made by company to research institutions (social science & statistical research)	125%	n.s.	n.s.	35 (1)(iii)
Patent Box	The patent box was introduced in the Indian ecosystem from April 1, 2017. The income generated from patents developed and registered in India is taxed at 10% (plus			

	surcharge and education cess)
Accelerated depreciation allowance of 40%	Companies can avail accelerated depreciation allowance of 40% on investment made on plant & machinery of indigenous technology as per rule 5(2) of Income Tax act 1961.
Exemption from import duty and custom duty	The DSIR recognized industries procuring materials/equipments/machinery from abroad for R&D purpose is eligible for exemption of import duty and custom duty
Waiver of central excise duty	3 year central excise duty waive off on goods produced by wholly owned Indian company through research activities (R&D outcome should be patented in at least two countries either India, Japan, USA and any one European country).
Exemption of service tax	BIRAC supported bio incubator services offered to the incubatees will be exempted from service tax for period of three years
Tax Holidays for Start-ups	Start-ups will be exempted from income tax for 3 years provided they get a certification from Inter-Ministerial Board (IMB) incorporated on or after 1st
R&D Incentives	**Details**
Panel C: Investment Incentives*	
	April 2016 and before 1st April 2019 and total annual turnover should not exceed Rs 25 crore.
Location based tax incentives	100% deductions of profits generated from establishing and doing business in north eastern states of India for period of 10 years.
State level incentives to promote industrialization in states	State incentives such as rebates on land cost, power cost, VAT and infrastructure development is offered by various state governments at different rates for promoting state industrialization
Investment Allowance	15% investment allowance is provided to manufacturing companies subjected to enhance their manufacture

150% weighted deduction for skill development	Manufacturing and production companies (other than alcohol and tobacco producing companies) can avail 150% weighted deduction on expenditure incurred for skill development projects
150% weighted deduction for agriculture extension projects	Agriculture companies can avail 150% weighted deduction on extension projects for improving agriculture productivity. The 150% weighted deduction will be reduced to 100% from 2020 financial year.
100% tax exemption for five years	New companies set up in special economic zones can avail 100% tax exemption on profits earned due to export activities for first five years and subsequently 50% tax exemption for next five years.
Modified Special Incentive Package Scheme (M-SIPS)	MeitY has introduced M-SIPS to encourage investments in field of Electronic System Design and Manufacturing (ESDM) as per the listed products issued by M-SIPS. The incentives are applicable in form of cash subsidies to the related companies.
Investment incentives for infrastructure development and power generation	100% tax holidays on profits generated by companies for first 10 years. From 2017, 100% deduction on capital expenditure to develop infrastructure facility is introduced.

Source: Compiled from Deloitte Touche Tohmatsu Limited (2017), EYGM Limited (2017) and PwC (2017)

Note: n.s. means not specified, *not limited to only R&D related Investments

The tax structure of any country has a long term impact on the country's R&D growth. Higher corporate tax rate and meagre tax incentives reduce private sector participation in R&D. In order to stimulate private sector investments in R&D in India, there is a need to modify and enhance the R&D incentive landscape by strengthening and consolidating R&D funding schemes for the private sector and introducing more generous tax incentives. Indian R&D incentivisation scheme was introduced in '1970s' and has played crucial role in stimulating private sector R&D in past three decades (DSIR, 2016). However, R&D incentives provided to the Indian industries are not that lucrative and promising in comparison to the R&D incentives availed by private sector in technological advanced nations. In India, the incentives in form of funding support and tax incentives are limited to

the government recognized companies which are few in number in comparison to the total number of companies registered in India. Although, Indian government has transformed its R&D incentivisation pattern from time-to-time, such as addition of patent box regime, start-up incentives and target based funding support needs to overview and restructure its R&D incentiviztion scheme to encourage enhanced private sector engagements in R&D.

Relevant Lessons for India:

A comparative analysis of the R&D incentives availed by private sector in select countries (USA, China, Japan, Germany, S. Korea, France, Russia, U.K. and Brazil) in relation to the Indian system of R&D incentivisation has brought up relevant lessons for India in order to improve upon its R&D incentivisation landscape in stimulating private sector to actively participate and contribute to national R&D ecosystem. Some of the relevant lessons that need to be looked upon are discussed below:

Increasing the Scope of Qualified Research Expenditure: In India, expenditure incurred on the manpower, materials and equipment, utilities and services is qualified for R&D incentives by the government. There is a need to enhance the scope of qualified expenditure in research as depicted in Table 8.

Table 8: Inclusion of Various Types of R&D Expenditure under Qualified Research Expenditure

R&D Expenditure	Reference Country
Investments for availing R&D Insurance in the domains of high technology investments	China
Investment cost for IP filling and maintenance	China
Investments incurred for performing contract research work	USA, China, Japan,
Overhead expenses	Japan, Germany
Expenses incurred in constructing and maintaining pilot plant facility	USA, France

India has a set list of negative products which do not fall under R&D incentives such as, alcoholic drinks and spirits, tobacco preparations, toilet and cosmetics preparations, aerated water and drinks, confectionary items, gramophones, photographic related equipment and

projectors, and office machines (e.g. calculators and cash registers). Certain products ranging from cosmetics to dental creams and powders, toothpaste, toilet preparations, confectionary items and electronic products like projectors and office machines are continuously evolving in their standards in accordance with the consumer's budget and quality expectation by implementing R&D activities. These products may be qualified for the R&D incentive scheme. In accordance with the recommendations of the Joint Committee on Industry and Government (JCIG), presented in the white paper entitled 'Stimulation of Investment of Private Sector into Research & Development in India' released by government of India in 2013, private sector R&D investments should also cover up costs incurred for translating R&D work involving test designing and development, standardization and field testing along with a pre-commercialization trial (DST & CII, 2013).

Eligibility Criteria: This entails simplifying the process of granting eligibility status to the industries to avail R&D incentives. Most countries implementing the R&D incentive program have simplified the process of availing R&D incentives provided by the government. In most of the countries such as USA, S. Korea, Japan, France and U.K. there is no requirement for the pre-approval of companies for availing R&D incentives. The Indian system involves the long and complicated system of granting government accreditation to industries through 'DSIR', an autonomous organization under the Ministry of Science and Technology. DSIR provides a recognition certificate that has to be renewed after every three years (minimum) subjected to the lengthy process of government evaluation and assessment.

Enhancing R&D Tax Incentives: Majority of the industries recognized under DSIR are availing tax incentives and only a few of them are dependent on R&D public funds. Figure 4 outlays the amount of tax foregone by the government in comparison to the R&D undertaken by the private sector. It can be observed that the private sector R&D investments have followed a growing trajectory from 2010 to 2014 with more than 100 percent increase in R&D investments. From the past ten years, Indian private sector has been credited with a minimum of thirty three percent of total R&D expenditure as a tax relief under R&D tax incentivisation scheme.

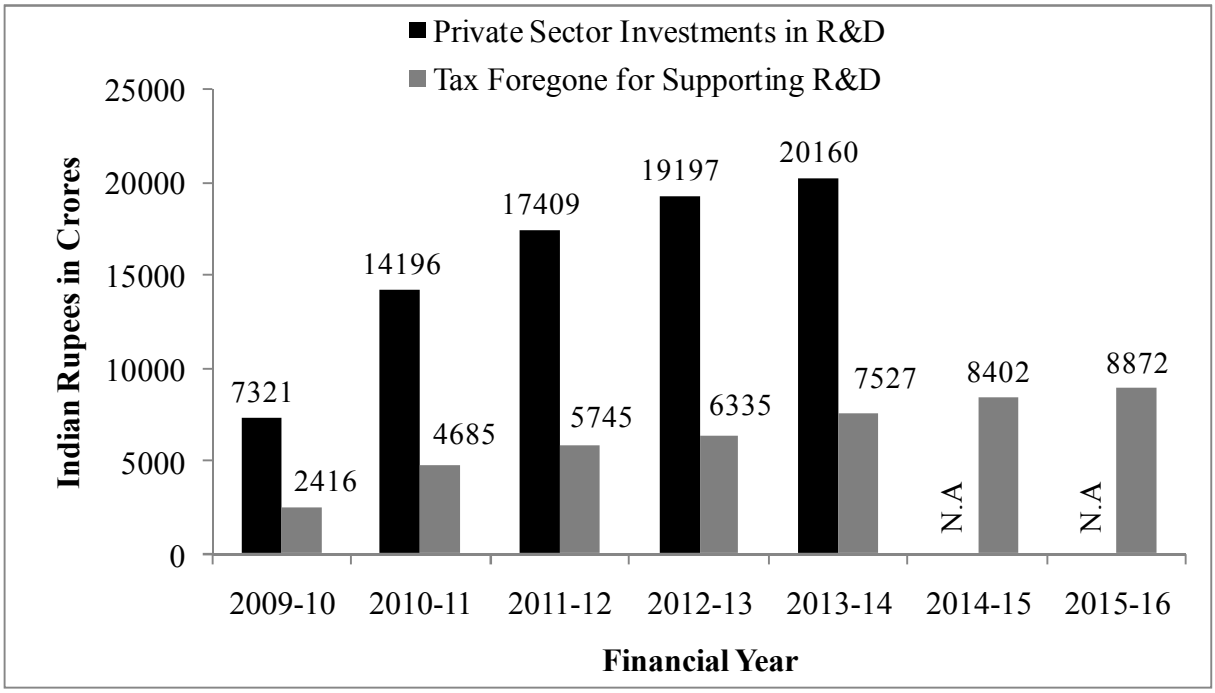

Figure 4: Tax Foregone by Indian Government for Supporting R&D (2009-13)

Source: Mani & Nabar (2016); Note: N.A. means not available

India can improve its private sector R&D incentive drive by taking a cue from the R&D tax benefits offered by other countries as mentioned in Table 9. India should learn lessons from other developed countries for modifying its R&D tax incentivisation scheme. India should introduce a system of tax reduction through either tax credit scheme or through weighted tax deduction in accordance with the industrial firm category (large-, medium- and small-scale). In most of the developed countries like USA, China, S. Korea and Japan, greater incentives are made available to Small and Medium Enterprises (SMEs), so as to boost their innovation ecosystem in comparison to the large scale enterprises and multinational companies. Moreover, companies which have shown promising increase in its R&D investments and R&D outputs should be provided with greater tax rebate in comparison to the companies which are only marginally investing in R&D domains. Further, in Indian ecosystem there is greater requirement of promoting industry-academia collaborative R&D and to enhance these collaborations for R&D, Indian government should come up with special tax exemptions on the collaborative R&D undertaken by companies to attract in wide knowledge from the academic sector.

Table 9: Major Tax Incentives Proposed to be Included in Indian R&D Tax Incentivisation

Proposed Tax	Brief Details	Reference Country

Incentives		
Introduction of research credit scheme	Tax credits are more favourable than tax deductions/ exemptions because tax credits reduce tax liability on actual expenditure on R&D. While a deduction reduces the final tax liability on an individual's marginal tax rate. Deductions reduce the taxable income and tax credits reduce the actual amount of tax to be paid.	USA, Japan, S. Korea
Incremental tax incentive	In India, volume-based tax incentive is executed that benefits large tax deduction for large investments and low tax deductions for low investments. Under incremental tax incentives, the incremental amount of research expenditure in comparison to the base amount is calculated and based on increment in research expenditure tax incentive is provided.	USA, Japan, S. Korea
Target based tax incentive	Targeted research credits/deduction should be available in India for different subject areas depending on national needs and societal improvement. In USA different tax credit slabs are functioning for research in different areas such as 20% tax credit for basic research and energy research and 50% tax credit for clinical research of orphan drugs. In China targeted group of high-new technology enterprise is provided with enhancing tax deductions. On similar lines, GoI should identify key priority areas and provide special incentives to stimulate R&D investments in these identified areas. Moreover, the government should release specified are funds from its budget to promote public-private partnerships for addressing the national key challenges of the country.	USA, China, Japan
Different tax incentive rates for large, medium and small enterprises	Industrial research mainly comprises of large scale, medium scale, and small scale industries. Different tax incentive slabs depending on the scale of industries should be introduced in Indian R&D tax incentive schemes. As observed in South Korea tax credit of 50% for SMEs, 40% is for medium sized companies and 30% for large sized companies is practiced. Similarly, Japan follows 17% tax credit rates for SMEs and 6-10% for large sized companies.	S. Korea, Japan, U.K.

	Implementation of such incentives will stimulate research undertaken by SMEs. Moreover, as in U.K., a special tax incentive to SMEs is provided that face loss situations.	
Patent-related incentives	From March 2017 onwards, patent-related incentive at a fixed tax rate of 10% is available for royalty income generated from patenting activities in India. Whereas in other countries cost incurred in the patent filing and patent maintenance and amount spent in acquiring a patent is also considered for tax incentive.	S. Korea, Brazil
Incentives for angel investors	India has come up with start-up based tax incentives including 3-year tax holiday. In order to promote participation of private sector in start-ups through angel investing, special incentives may be provided to them.	USA, UK.
Special tax incentives for academic collaborated research	Industries pursuing collaborative research with academic institutions should be eligible for getting additional tax incentives on R&D expenditure in collaborative research work in order to strengthen Industry-Academia research participation in India. Moreover, service tax waiver for I-A research projects should be introduced in India.	Japan
Incremental tax incentives corresponding to R&D investments and manpower	Companies which are regularly increasing their contribution to R&D in terms of R&D investment and recruiting R&D manpower should be provided with the higher rate of tax incentives.	Brazil, S. Korea, USA, Japan

Monitoring and Enhancing Public Funding Support to the Private Sector: In India, majority of the funds for R&D are contributed by the Department of Science and Technology (DST); Department of Biotechnology (DBT); Council for Scientific and Industrial Research (CSIR); Indian Council of Medical Research (ICMR) and many more as listed in Table 7. In addition, the Ministry of Medium Small Sized Enterprise (MSME) and autonomous organizations like Biotechnology Industry Research Assistance Council (BIRAC), Technology Development Board (TDB), DSIR and Ministry of Electronics and Information Technology (MeitY) have come up with dedicated schemes for enhancing the R&D of the private sector with special emphasis on small scale industries. The R&D regime of the private sector can be given a further boost by looking at the similar schemes or programmes floated by other countries.

In India, nearly half of the fifty seven ministries of the Government of India have set up various departments and/or R&D labs and are doling out funds for research being carried out in public institutions/organizations. However, only a few of them have dedicated autonomous bodies for providing assistance to private sector's R&D, namely BIRAC (by DBT) and TDB (by DST) as well as incubators and academies set by MeitY. It is suggested that a fixed percentage of funds in each ministry should be allotted to support private sector R&D on the lines of the USA, China, France and Germany. It is necessary to introduce financial guarantee scheme on the lines of the USA-State Small Business Credit Initiative; Japan-International Cooperation Loan Guarantee Scheme; Germany-German United Loan Guarantees and Cash Subsidy Scheme and S. Korea- Korea Credit Guarantee Fund, etc. to provide guarantee in order to secure the huge amount of money invested by industry in R&D. Funding programs introduced by Germany and China based on target specific and country needs should also be introduced in the Indian system to support and strengthen the innovation ecosystem as per the industrial, societal and economic needs. Horizon 2020 program initiated in Germany and National High-Tech Research and Development Programme in China can act as a role model for introducing funding programs in support of future innovations through the private sector. Especially to encourage MSMEs for contributing in R&D, a special guarantee scheme should be introduced by the government through which banks can give a loan to MSMEs by considering IP as the mortgage able asset (DST & CII, 2013).

Other Measures: In addition some additional measures should be undertaken by Indian government to stimulate private sector engagements in R&D. First, the government should come up with a specific set of guidelines for surveying private sector participation in R&D on a regular basis. It should be a mandate that all companies engaged in R&D should disclose details of R&D expenditure in their annual reports in order to provide a ready access to information on the private sector engagement in terms of R&D investments and desired outcomes. Secondly, government should take additional initiatives to write off loans given to private sector in case of genuine failure along with providing risk assessment scheme for the private sector research projects, especially, for the small and medium enterprises who are at a greater risk of loss due to failure of research project. Thirdly, government should introduce specific grants and tax rebates on the technology commercialization activity related costs incurred by the in-house research centres of companies. In addition to it government should fix right mix of loan and grants to leverage Indian industries for technology up gradation and technology commercialization. Fourthly, government should strongly execute the policy of

promoting indigenous technologies and products by implementing at least fifty percent government mediated purchase of indigenous products and technologies developed by Indian companies. Lastly, government should include expenses made on R&D as part of their corporate social responsibility initiative that will promote and enhance the private sector contribution to the national R&D ecosystem.

Conclusion and Suggestions:

India has tremendously progressed in terms of its scientific and technological advancement, since the time of its independence. In order to progress in the frontiers of science and technology and make India self-reliant economy, there is a need for a robust R&D ecosystem that should be coupled with an increase in R&D investments from both public and private sectors in India. The dismal position of R&D investments undertaken by the private sector needs to be tackled for strengthening the R&D base of India that primarily relies upon private industry in India. In order to match other developing and developed nations of the world, India should invest at least two percent of its GDP in R&D which is impossible without the increased percentage share of R&D investments from the private sector. Moreover, India is one of the diverse markets for supporting R&D due to the presence of affordable manpower, young pool of talent, technical competence and resources to pursue R&D activities. There is a need to introduce new initiatives and streamlined government mediated cash support to private sector encouraging them to invest more in R&D either independently or through participation and alliance with public sector entities.

Worldwide, various R&D incentives have been provided for stimulating private sector R&D investments. The present study provides valuable insights on initiatives that the Indian government can take to stimulate the industry participation in R&D. First, the scope of eligibility and qualified research expenditure by the private sector can be expanded to technology translation process, IP management and to the research costs associated with products such as cosmetics, dental creams, confectionary items and electronic products like projectors and calculators. Second, a simplified process of applying and renewing the DSIR certification for availing government mediated R&D incentives can be launched. Third, the percentage of super deduction can be enhanced so as to encourage more and more private R&D investments. Fourth, tax incentives can be especially introduced to target SMEs on the lines of USA, U.K., Japan and S. Korea. Fifth, special incentives can be introduced to promote industry-academia collaborated research under public-private partnership mode.

Last, efforts should be made to generate awareness regarding government funding support to the private sector. There is an urgent need of modifying the present R&D incentive landscape to address the gap between private sector R&D investments and R&D portfolio that is best for the nation.

Notes:

1. 'Public' refers to government and academia, while 'private' relates to the industrial sectors.
2. In order to compare country wise investment in R&D, term Gross Domestic Expenditure on R&D (GERD) is applied universally. The term can be explained as total R&D expenditure incurred by government laboratories, academia and research institutes, resident industrial units, etc. The expenditure incurred by domestic company on R&D investments outside the resident country is not calculated under GERD. In the present document, GERD is expressed In US Dollars (which is adjusted for purchasing power parity).
3. The Government of India, in keeping with its reform agenda, constituted the National Institution for Transforming India (NITI Aayog) to replace the Planning Commission through a resolution of the Union Cabinet on January first, 2015. The Twelfth Five Year Plan (2012-17) was appraised as a follow up of the decisions taken at the first meeting held on February eighth, 2015 of the NITI Aayog's governing council.
4. Department of Scientific and Industrial Research was established by Ministry of Science and Technology through presidential notification by Indian Government in 1985. It is working with a mandate to support indigenous technology development and promotion of industrial research in the country. DSIR is the only agency in India that recognizes R&D carried out by private sector and imparts DSIR certification making them eligible for government mediated R&D incentivisation.
5. A detail overview of a number of funding schemes for promoting Industrial R&D in India has been presented by Tewari, Trikha, Khokhar, Bhardwaj & Naosekpam (2017).

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C. Identify areas of policy gaps for stimulation of private sector investment in R&D and suggest changes in policy environment

1. The data collected on research publications and patents (published and granted) for 904 institutions was analyzed on the basis of various fields of science to find out potential institutions in both the parameters (research publications and patents).
2. Case study was conducted on those institutions (HEIs and Universities), which were performing well in research publications and patents.
3. Indian Patents data was updated from the CGPDTM annual reports and also detailed study was conducted on international organization WIPO activities.
4. Members of Advisory Committee constituted for 3rd Objective was requested to write the invited chapters regarding IPR activities of their respective organizations.
5. Extracted list of Patents, which was extracted for the 904 institutes, was classified based on the IPC classification from WIPO.

All the above mentioned information are compiled in the form of a book entitled "**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).