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Telecom Regulatory Authority of India

Consultation Paper

on

Encouraging R&D in Telecom, Broadcasting, and IT (ICT) Sectors

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Written Comments on the Consultation Paper are invited from stakeholders by 23.10.2023 and counter-comments by 06.11.2023. Comments and counter-comments will be posted on TRAI's website. Comments and counter-comments may be sent, preferably in electronic form, on the email ID: advisorit@trai.gov.in and ja.qos1@trai.gov.in.

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CHAPTER 1

INTRODUCTION

1.1. Research & Development (R&D) and Innovation

1.1.1. Research & Development (R&D) has played a crucial role in shaping today's world. The advent and evolution of R&D over the years has been pivotal in developing and applying new technologies, shaping economic systems, and improving people's lives through several industrial revolutions.

1.1.2. In the first industrial revolution (late 18th to early 19th century), R&D efforts focused on mechanization and steam power, resulting in innovations such as spinning jenny and steam engine, which revolutionized textile manufacturing, mining, and transportation industries. The second industrial revolution (late 19th to early 20th century) saw R&D efforts centered around electricity, steel, and mass production techniques. Innovations in telecommunication, electric power distribution, and internal combustion engine significantly impacted manufacturing, transportation, and communication industries. The third industrial revolution (mid-20th century) was marked by R&D advancements in computers, electronics, and automation. Developments in transistors, integrated circuits, and microprocessors drove the digitalization of industries and the emergence of the information age.

1.1.3. The current era is of fourth industrial revolution (began early 21st century), where R&D is focused on smart, connected systems and data-driven technologies. Innovations in the field of Internet of Things (IoT), Artificial Intelligence (AI), 5G connectivity, additive manufacturing (3D printing), cloud computing, and advanced robotics are shaping industries, enabling autonomous systems, predictive analytics, and real-time decision-making under the umbrella of Industry 4.0. R&D continues to be a driving force behind each industrial revolution, shaping the trajectory of economic, social, and technological progress, and it remains instrumental in addressing global challenges, improving efficiency, and unlocking new opportunities for innovation and growth.

1.1.4. According to Organization for Economic Cooperation and Development's (OECD) *Frascati Manual 2015*, "*Research and experimental development (R&D)*

comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge."[1] R&D activities are identified by a set of common features, even if they are carried out by different performers and can be directed towards specific or general objectives. R&D is always aimed at discoveries based on original concepts (and their interpretation) or hypotheses. It is largely uncertain about its outcome (or at least about the amount of time and resources required to achieve it), it is planned for and budgeted (even when carried out by individuals) and is aimed at producing results that could be freely transferred or traded in a marketplace. [2]

1.1.5. *Frascati Manual 2015* further states that for an activity to be classified as R&D, it must satisfy five criteria of being novel, creative, uncertain, systematic, transferable, and/or reproducible. The three types of activities covered under R&D are basic research, applied research and experimental development. Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view. Applied research is an original investigation undertaken to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective. Experimental development is systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes.[3]

1.1.6. In the context of R&D in Telecommunication, Broadcasting and Information Technology (IT) sectors, herein after referred as Information and Communication Technology (ICT) sector , "*Research*" refers to exploration and investigation of new knowledges, technologies, and methodologies that can be applied to improve existing products or processes or create new ones.[4] For example, researchers in the ICT sector may conduct studies on use of Artificial Intelligence to improve consumers' experience and to protect them from cyber-

[1]Source: Guidelines for Collecting and Reporting Data on Research and Experimental Development, OECD
[2]Source: Guidelines for Collecting and Reporting Data on Research and Experimental Development, OECD
[3]Source: Guidelines for Collecting and Reporting Data on Research and Experimental Development, OECD
[4]Source: Guidelines for Collecting and Reporting Data on Research and Experimental Development, OECD

attacks proactively. "*Development*" involves applications of results of research to create new or improved products or services or processes. The example of development may include a software development by using results of research on new programming languages to create new software applications that are more efficient and user-friendly.

1.1.7. The "*Innovation*" refers to the introduction of new or significantly improved products, services, or processes that add value or solve a problem in a new way.[5] Innovation often builds upon the results of research and development. For example, innovation of smartphones and mobile applications revolutionized the way people access and interact with information and services, and these innovations were made possible by R&D in ICT products.

1.1.8. Above discussions reveal that "*Research*", "*Development*", and "*Innovation*" are all interconnected and often build upon each other. "*Research*" is necessary to develop new knowledge, which is then used in the "*Development*" of new products or services. "*Innovation*" often results from the application of new knowledge or technology to create something new or improve existing products or services. From another perspective, Research and Development is said to be a component of Innovation, which is situated at the front end of the innovation lifecycle. Innovation builds on R&D and includes commercialization phases. Thus, it can be said that "*Research and Development*" is a necessary precursor to "*Innovation*".

1.2. Importance of R&D

1.2.1. R&D is said to influence citizens' quality of life positively by increasing the availability, accessibility, and affordability of products and services. Furthermore, R&D is also important for national security because it leads to the development of new technologies and capabilities that can be used to defend against threats and protect critical national infrastructure including ICT infrastructures. In the recent pandemic COVID 2019, R&D has proven its worth not only in getting people connected during lockdowns but also ensuring availability of livelihood goods and services at doorsteps, right kinds of

[5]Source: NITI Aayog's India Innovation Index 2021

medicines and protective devices for the citizens in the country and also across the world.

1.2.2. Expanding R&D capacity has been realised by the organizations and the nations as an important factor to increase efficiency in utilization of resources and promoting sustainable lifestyle. R&D also enable individuals and organizations to adopt sustainable practices, reduce the carbon footprint, and minimize the impact on the environment.

1.2.3. R&D encourages innovative manufacturing methods, lower costs, and improves product quality, and thus plays an important role in improving the capability of businesses and, eventually, the entire nation. Thus, development and application of new technologies can be treated as important factors contributing for country's economic growth.

1.3. R&D Lifecycle

1.3.1. The entire R&D lifecycle comprises of several stages. The R&D lifecycle starts from need assessment followed by idea generation, moving to project/program formulation, research and innovation, developing proof of concept, prototyping and field testing, product development and technology transfer for commercialization. Even after successful commercialization, the innovation process continues. Organizations invest in further R&D to enhance the product, address new challenges, and stay competitive in a rapidly changing market. In India, government initiatives, funding schemes, and collaborations with research institutions are very important in supporting various stages of the R&D lifecycle.

1.4. Linkage between R&D and Economic Growth

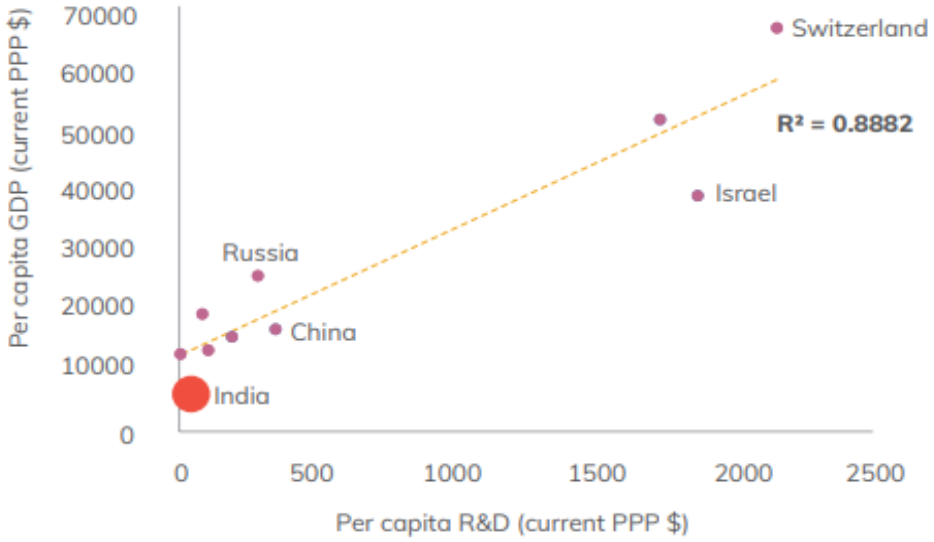
1.4.1. Both theoretical and empirical literature have shown that investment in R&D has a positive impact on the economic growth. On theoretical front, a number of models have illustrated the function of R&D as a growth engine, and demonstrated the reasons behind Governments' indispensable role in achieving an optimum level of R&D. On empirical front, several authors have highlighted the importance of the R&D returns. For example, Ram Chandra Das (2020)[6] in his work has highlighted interplay among R&D spending, patent

[6]Source: Das, R.C. Interplays among R&D spending, patent and income growth: new empirical evidence from the panel of countries and groups. *J Innov Entrep* **9**, 18 (2020).

and income growth based on new empirical evidence. About R&D expenses, he says, *"The short-run motive is to get patents, and the long-run motive is to influence income growth of the countries."* Accordingly, several Governments have taken initiatives to review their policy commitments with significant allocation for R&D expenditures in their countries, relying basically on the impact of science and technology on economic performance.

1.4.2. In the growth of developed countries, role of R&D has been found significant. Figure 1.1[7] indicates the relationship between per capita R&D expenditure and per capita GDP of some of the countries.

Figure 1.1: Correlation between Per Capita R&D Expenditure and Per Capita GDP across Countries



1.4.3. From above Figure 1.1, it can be seen that countries with high per capita R&D expenditure tend to have higher per capita GDP as well. Kaur and Singh (2016) in their work have analysed the impact of R&D expenditure on the GDP of 23 developing economies (including India) for the period 1991–2010 using panel data and showed that a 1% increase in R&D expenditure increases the economic growth by 0.30%.[8]

1.5. R&D in India and around the World

1.5.1. With rise in adoption of technology for production of goods and services, importance of R&D has increased further. Governments around the globe have

[7]Source: NITI Aayog's India Innovation Index 2021
[8]Source: NITI Aayog's India Innovation Index 2021

promoted R&D through formulation of appropriate policies in their countries. Likewise, Government of India has also focussed on R&D in several sectors through appropriate policies and measures. In the IT Sector, Government initiatives in Digital Platform Infrastructure (DPI) and its outcome in terms of world's biggest financial inclusion is noteworthy. Further, in the ICT sector in India, various service providers in the industry have managed to stay abreast in keeping up with global technological advancements. Expanding the scope of R&D in India will enhance opportunities available to the industry and promote idea of "*Atmanirbhar Bharat*", "*Make in India*" and "*Make for the world*".

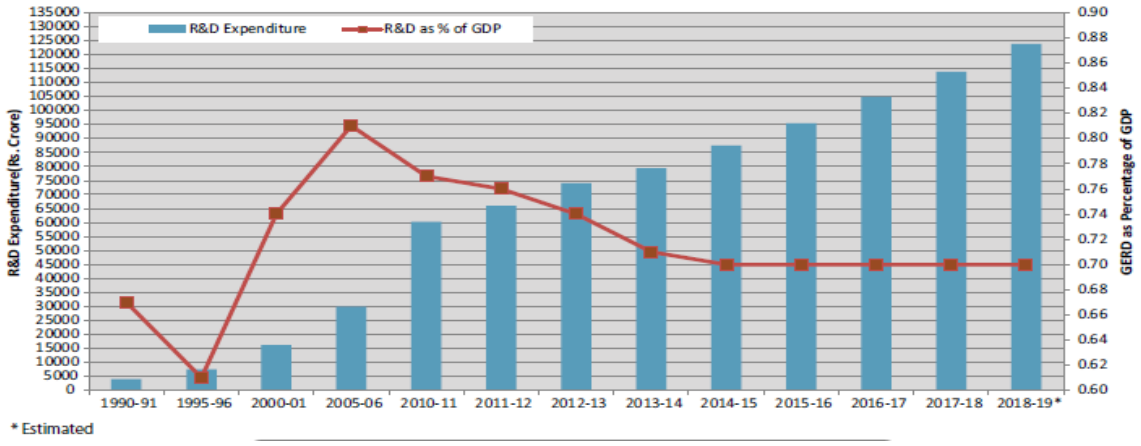
1.5.2. India's precise focus on R&D, specifically in the ICT sector, can act as a catalyst to achieve the objectives of the Digital India Program and shall further provide necessary impetus towards the efforts for becoming a $5 trillion economy. India's success stories such as accelerated digital inclusion and robust COVID response have been made possible due to contributions made by the ICT sector.

1.5.3. As indicated above, innovation through research and prosperity through development go hand in hand. Most of the developed countries spend a sizable amount of their GDP on R&D, and hence are well placed to accommodate future technologies. Such future technologies bring positive development not only to the country where R&D is taking place but also to the entire world.

1.5.4. In India, the spending on R&D is relatively low and is dominated by public spending. As shown in the Figure 1.2 below, national investment in R&D activities attained a level of ₹1,13,825.03 crore in 2017-18, which is nearly 0.7% of the GDP. "*This is lower than the world average of about 1.8%. Developed countries like United States, Sweden, and Switzerland spend about 2.9%, 3.2% and 3.4%, respectively. Among all nations, Israel spends the most, i.e., 4.5%, of its GDP on R&D.*" [9]

[9]Source: Reddy, K. & Subash, S. (2020). Will COVID-19 Change the Landscape of Financing Innovation in India? Economic & Political Weekly, 55(47), 22-24.

Figure 1.2: GERD trend in India (in % of GDP) [10]



1.5.5. The results of higher R&D spending by the countries mentioned above are visible in terms of the higher number of Intellectual Property Rights (IPRs) filed, higher manufacturing level and the better market share. In these countries, human development levels also reimpose the same narrative. Therefore, streamlining R&D activities in India is imperative. Bottlenecks in R&D activities in India need to be identified and eliminated, particularly in the ICT sector which would have a spill-over effect on other crucial sectors such as Finance, Education, Health, Agriculture, Defence, and Logistics among others.

1.6. Emerging Trends in the ICT Sector

1.6.1. The ICT sector is constantly evolving with new technologies and changing consumer needs. The way people communicate, consume digital content, and access information is continuously changing. Some of the emerging trends in the sector are 5G, 6G, Open-RAN, Internet of Things (IoT), AI and ML, Distributed Ledger Technology (DLT), Augmented Reality (AR), Virtual Reality (VR) and Metaverse, Quantum Computing, Cloud Services, Edge computing, Network Function Virtualization (NFV), Software Defined Networking (SDN), Over-The-Top (OTT) services and Hybrid Set Top Box (STB) etc.

1.6.2. Although emerging trends in ICT sector may be grouped under Telecom, Broadcasting, Information Technology (IT) and Convergence Technologies, but these trends are interdisciplinary and overlapping. For example, convergence of devices, services, and networks could be considered as an overarching trend that is driving the need for new network infrastructure and emerging

[10]Source: http://www.nstmis-dst.org/Pdfs/R&DStatisticsataGlance2019-20.pdf

technologies. Similarly, Augmented Reality (AR), Virtual Reality (VR) and Metaverse (MV) are relevant to all i.e., telecommunications, broadcasting and IT Sectors for providing an enhanced and immersive user experience to the users. Further, huge amount of data generated in communications through these emerging technologies may be used in analysing trends for various kinds of actions taken using these networks, for further strengthening business processes while protecting the privacy of the individuals through a robust data protection measure.

1.6.3. R&D in emerging areas in ICT sector is crucial for addressing traditional as well as modern challenges effectively and efficiently. These challenges may include but are not limited to lack of necessary infrastructure for connectivity, constraints of spectrum availability, limitations of one-way communication in broadcasting, shortage of power supply, risk of cyber-attacks, threats to data privacy, issue of piracy or plagiarism, the menace of disinformation (such as fake news and deepfakes), and a widening digital divide. Furthermore, R&D in ICT sector is critical for dealing with efficient management of reducing carbon footprint generated through massive energy-consumptions by the network elements and e-waste generations. Consistent and constructive R&D efforts would yield results in overcoming these challenges by increasing efficiency and decreasing overall costs.

1.7. Mandate of TRAI concerning R&D

1.7.1. As per the TRAI Act 1997 under section 11(1)(a)(vii), TRAI (hereinafter referred to as the Authority) has been mandated to make recommendations either suo motu or on a request from the licensor on measures for the development of telecommunication technology and the other matters relatable to the telecommunication industry. Accordingly, the Authority has decided to take up the issue of encouraging the growth of the R&D ecosystem in the ICT sector *suo motu* for consultation with the stakeholders with a view to make recommendations to the Government on this important subject matter.

1.8. Scope of the Consultation Paper

1.8.1. The consultation paper considers scope for enhancing R&D Framework in ICT Sector of the country, by developing an ecosystem, wherein there are well

established processes for generating a pool of R&D scientists/engineers, duly supported by the Government and Private Partners for development and innovation of ICT products for making India Atmanirbhar and promoting exports in the ICT Sector.

1.8.2. The Consultation Paper focuses on the ICT sector as a whole rather than discussing the telecommunication, broadcasting and IT sectors in isolation. This is primarily driven by the interconnected nature of modern technologies and services. As telecommunications, broadcasting, and IT are converging, traditional distinctions are becoming obsolete. Consumers now demand seamless integration of communication, entertainment, and information services across platforms. This integration challenges the effectiveness of sector-specific regulations and calls for a unified approach that addresses the broader ICT landscape. To effectively regulate this dynamic environment, there is a need to adopt a comprehensive perspective that promotes innovation, competition, consumer protection, and efficient resource allocation in the evolving ICT ecosystem.

1.8.3. Further to get a comprehensive understanding of the challenges related to R&D in ICT sector, TRAI conducted online brainstorming session wherein representatives of Prasar Bharti, C-DOT, TSDSI, IIT Kanpur, IIT Madras, IIT Delhi, Telecom Service Providers and Broadcasting and Cable Service Providers participated. TRAI also had discussions with individual stakeholders and visited some of the leading R&D establishments of the ICT industry in the country. Consultation was also done with Professors and experts from IITs and inputs received from IIT Madras, IIT Hyderabad and IIT Kanpur are considered in this Consultation Paper.

1.8.4. The broad objectives of the consultation paper are stated below:

i. to review the existing R&D ecosystem in India,
ii. to identify the bottlenecks in promoting R&D in the ICT sector,
iii. to recognize and learn from the international best practices in R&D and apply the relevant learnings in India, and

iv. to recommend the required interventions in terms of policies and incentives to improve the R&D in the ICT sector and help India emerge as a world leader.

1.9. Structure of the Consultation Paper

1.9.1. This consultation paper has four chapters. This chapter, that is, Chapter 1 is the Introduction which highlights the meaning and importance of R&D and sets the context for the consultation paper. Chapter 2 discusses the present-day scenario of the innovation system in India, delving into the education and training system, science system and regulatory framework. Chapter 3 attempts to identify the international best practices in R&D and compiles a list of the key learnings that may be incorporated into the Indian R&D ecosystem. Chapter 4 lists the issues open for consultation with the stakeholders.

CHAPTER 2

R&D ECOSYSTEM IN INDIA

2.1. Status of R&D and Innovation in India

2.1.1. The arrival of the new technological age and the subsequent rise of Industry 4.0, beckons the growing economies of the world to embrace the advent of R&D. Now more than ever, there is a constant need to develop R&D capabilities to keep up with increasing demand and the emergence of next-generation technologies. For a country like India, the dawn of the information era has opened myriads of possibilities for expanding current technological landscapes and transcending to newer generations faster than ever before.

2.1.2. ICT sector is the most important building block to lay a strong foundation of the R&D ecosystem. Digital Public Infrastructure (DPI) in India is a testament of India's prowess in ICT. DPI is basically shared digital platforms and services that enable citizens to access public goods and services, such as online financial transactions, access to health, education, social welfare schemes etc.

2.1.3. India with more than 850 Million internet users has seen surge in usage of DPIs. In fact, DPIs in India have revolutionized digital landscape, enabling financial and social inclusion across different sectors. The DPI ecosystem in India, consists of interconnected yet independent "*blocks*" that serve as identity, payment, data sharing, and consent mechanisms. Some of the most popular DPIs in India[11] are:

i. Digital Identity: Aadhaar[12], a biometric identification system, has transformed public service delivery by enabling efficient and secure identification for over a billion citizens, leading to streamlined welfare distribution and financial inclusion.

ii. Unified Payments Interface (UPI)[13]: A seamless and interoperable platform for instant money transfers, catalyzing a cashless economy and fostering financial accessibility for even remote populations.

[11]Source: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1932110
[12]Source: https://uidai.gov.in/en/
[13]Source: https://www.npci.org.in/what-we-do/upi/product-overview

iii. DigiLocker[14]: DigiLocker offers citizens a secure digital platform to store and manage their government-issued documents, reducing administrative hassle and enhancing accessibility to crucial records.

iv. e-NAM (National Agriculture Market)[15]: e-NAM connects agricultural markets across India digitally, enabling farmers to sell their produce online, ensuring better price discovery, reducing intermediaries, and fostering transparency in agricultural trade.

v. DigiYatra[16]: DigiYatra aims to enhance the passenger experience at airports by enabling a seamless and paperless travel process, including biometric-based boarding and security checks, simplifying air travel and reducing wait times.

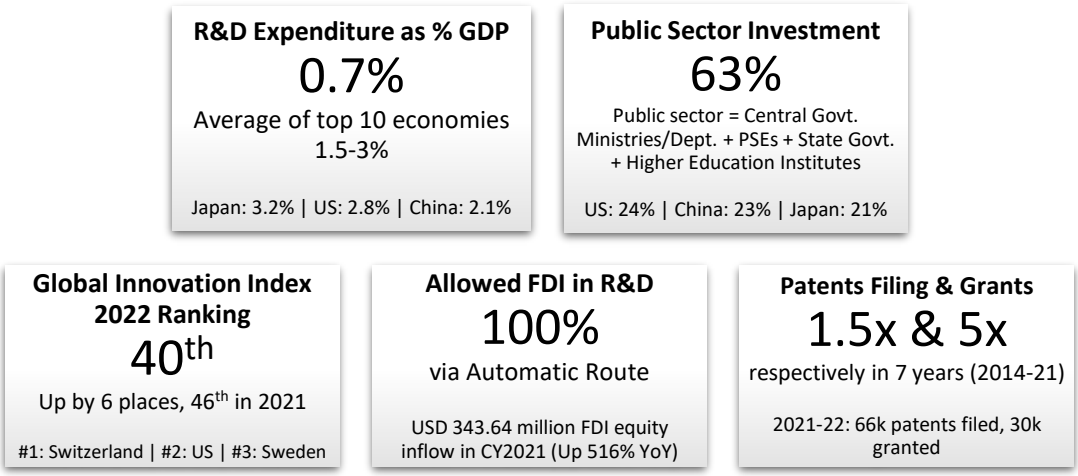
vi. PM e-VIDYA[17]: A comprehensive initiative called PM e-VIDYA is launched which unifies all efforts related to digital/online/on-air education to enable multi-mode access to education. It includes several initiatives such as Digital Infrastructure for Knowledge Sharing (DIKSHA), Study Webs of Active-Learning for Young Aspiring Minds (SWAYAM), SWAYAM PRABHA DTH channels, Special e-Content for Children With Special Needs (CWSN) etc. This will benefit nearly 25 crore school going children across the country.

2.1.4. The indigenously developed 4G & 5G technologies in India are worth mentioning. These largely refer to development of a core software that takes care of end-to-end call control over the network of telcos. This consists of core network, radio access network, and user devices like smartphones. The indigenous 4G and 5G core technologies are developed by C-DoT, which are open-source, cost-effective, and scalable. Such developments along with the development of AI, ML, IoT based use cases have transformative potential, positioning India as a telecom leader. It spurs R&D, startups, foreign investment, and job creation, with benefits like affordability, scalability, innovation, and global leadership. The indigenous 4G/5G tech marks a vital step toward telecom self-reliance, promising sector transformation and global prominence for India.

[14]Source: https://www.digilocker.gov.in/
[15]Source: https://www.enam.gov.in/web/
[16]Source: https://www.newdelhiairport.in/digiyatra
[17]Source: https://pmevidya.education.gov.in/

2.1.5. India is the world's fifth largest economy in terms of size[18] however it ranks 40th amongst 132 countries in the WIPO's Global Innovation Index 2022[19]. An overarching snapshot of India's R&D ecosystem is given below.

Figure 2.1: Snapshot of India's R&D Ecosystem



2.1.6. While the ICT sector in India has managed to stay abreast in keeping up with global technological advancements, still there is lot of ground to be covered for R&D in the sector to make India as lead exporter for ICT products and services. For the promotion of R&D and innovation in India, there are four focus sectors which encompass the gamut of ICT.

- **Telecom**: Telecom sector in India focuses on commercial deployment of the indigenously developed 5th Generation (5G) mobile networks through Enhanced Mobile Broadband (eMBB), Ultra Reliable Low Latency Communication (URLLC) and Massive Machine-type Communication (mMTC). 5G will further enable the development and deployment of emerging technologies like Artificial Intelligence (AI), Augmented Reality/ Virtual Reality (AR/VR), Machine-to-Machine (M2M) communication and robotics. The other emerging/ next generation technologies, which entail early mover advantage for India are developing 6G mobile networks and beyond, Internet of Space Things (IoST) enabled through CubeSat and Unmanned Arial Vehicles (UAVs), cell-free massive MIMO, Internet of Nano Things, quantum communications, and pervasive AI. Other key

[18]Source: https://www.imf.org/external/datamapper/NGDPD@WEO/OEMDC/ADVEC/WEOWORLD

[19]Source: https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2022-section1-en-gii-2022-at-a-glance-global-innovation-index-2022-15th-edition.pdf

advancements in ICT sector include Open RAN technology, Light Fidelity (Li-Fi), Software Defined Network (SDN) & Network Function Virtualization (NFV), Satellite Communication (SATCOM), Green Telecom, and Smart Street Furniture.

- **Broadcasting**: Indian broadcasting distribution system has seen a total shift in landscape from conventional Cable Television (TV) deliveries to Digital Cable Television and VSAT based Direct to Home (DTH) deliveries within a span of almost a decade. With the advent of digital television broadcasting technologies and adoption of smart TVs sets by the consumers, Over the Top (OTT) platforms have now made their pathways to reach to the consumers TV Sets. Emerging technologies in the broadcasting sector now have trends towards OTT technologies, Radio Communications including Emergency Radio Communications (ERCs), Digital Terrestrial Transmission, Direct to Mobile (D2M- 5G Broadcasting) and Satellite Broadcasting. AIML enabled technology is expected to form a critical component of 6G communication is quantum computing, with applications in site planning, Radio access network (RAN) development, Open-RAN, network security and network optimization. India has seen a growth in adoption of these technologies in recent times.
- **Information Technology**: The IT/ Information Technology enabled Services (ITeS) industry, have led to further advancements in the areas of Cyber Security, AI/ML, Cloud Computing, Data Centres, and Blockchain. DPI based citizen centric applications, centralised GST and Direct Taxes implementation and are few key highlights which have helped citizens and concerned organisations a lot.
- **Convergent Technology**: The convergence of technologies is happening at different levels, across Media, Platforms and Devices. One of the most common examples of convergence of voice, text and video on a common network using a common device are smartphones. The other examples are Internet of Things (IoT) or Narrow Band-IoT, Autonomous Vehicles which use Vehicle to Machine (V2M), Remote Service Unit (RSU) cell-to-cell or M2M communication, AR/VR etc.

2.1.7. Foreign Direct Investment (FDI) inflows in R&D in India have significant economic, technological, and social implications. It leads to creation of high-value jobs and increased employment opportunities. It also enables diffusion of knowledge from developed countries. India attracted USD 343.64 million Foreign Direct Investment (FDI) equity inflow in the R&D during Calendar Year (CY) 2021, which is 516% higher as compared to the previous CY 2020 (USD 55.77 million)[20]. However, a small sample set could prove to be misleading, thus, it is important to look at the development of trends in this aspect.

2.1.8. According to Working Paper 209 of the Institute for Studies in Industrial Development, New Delhi[21], inflow of FDI in R&D (RDFDI) data was compiled from September 2004 to March 2016. RDFDI inflows into India during the period of analysis was Rs. 54862.6 Mn. This constitutes 0.4 per cent of total FDI inflows into India. All FDI inflows in which the activity was mentioned as R&D or any combination of words which represent R&D activities is categorised as RDFDI. Some inflows, which do not explicitly mention R&D or related activities in the intended activity details, are likely to be related to R&D. For example, inflows into a firm, which is fully engaged in R&D, is in all likelihood RDFDI. Table below (Table 2.1) provides details of FDI and RDFDI inflows.

Table 2.1: FDI and RDFDI Inflows to India[22]

Year/Period	FDI (₹. Mn.)	RDFDI (₹. Mn.)	Share of RDFDI (%)
September-December 2004	112805.2	185	0.2
2005	192706	1047.1	0.5
2006	503572.1	1304.8	0.3
2007	654950.4	4844	0.7
2008	1351452.2	3986.8	0.3
2009	1309797.7	1922.6	0.1
2010	960149.4	3764.4	0.4
2011	1202384.9	4146.8	0.3
2012	1215914.4	2665.6	0.2
2013	1294825.1	7512.8	0.6
2014	1753133.7	7852.8	0.4
2015	2525614.7	14063.5	0.6
January-March 2016	513112.2	1566.3	0.3
All the years above	13590418	54862.6	0.4

[20]Source: https://www.pib.gov.in/PressReleasePage.aspx?PRID=1842760#:~:text=FDI%20is%20permitted%20under%20100,regulations%2C%20security%20and%20other%20conditionalities.
[21]Source: https://isid.org.in/wp-content/uploads/2019/08/WP209.pdf
[22]Source: https://isid.org.in/wp-content/uploads/2019/08/WP209.pdf

2.1.9. Further, the same paper quotes, "*Such inflows have been filtered in using various criteria such as the core business activity of the investee firm and core activity of the foreign investor. Our estimate shows that RDFDI constitutes only a very small share of total FDI inflows to India. This is very different from the estimates of Mrinalini et. al. (2013) and Pohit and Biswas (2016) who relied on the data provided by FDI Markets. This indicates that there is a big gap between the intended investment and realised investment in RDFDI.*" Thus, it is necessary to understand India's R&D ecosystem in detail.

2.2. R&D Lifecycle

2.2.1. As per ICT&E R&D and Innovation Framework 2013[23] of Ministry of Electronics and Information Technology (MeitY), R&D Lifecycle in ICT sector include the following steps:

i. Need Assessment i.e., identifying the needs and gaps in the market or within industries. This step involves understanding customer requirements, analyzing current technologies and products, and identifying areas where innovation is needed.

ii. Project/Program Formulation: Once the needs are assessed, organizations formulate R&D projects or programs to address those needs. This includes defining the project scope, objectives, goals, resource allocation, and estimated timelines. Collaboration with relevant stakeholders, both internal and external, is crucial during this stage.

iii. Research and Innovation is the heart of the R&D process, and it involves conducting in-depth research and innovation to develop new technologies, processes, or products. This can include fundamental research, applied research, and the exploration of new ideas, often in collaboration with research institutions and universities.

iv. Proof of Concept (PoC) demonstrates feasibility of the proposed innovative solution or technology through small-scale experiments or simulations to validate the concept's viability.

v. Prototyping & Field Testing: Once the PoC is validated, prototypes are developed to represent final product or technology. These prototypes

[23]Source: https://www.meity.gov.in/writereaddata/files/R%26D_Framework_final%281%29_0.pdf

undergo rigorous testing in controlled environments applicable in real-world field tests to assess their performance and identify issues, if any.

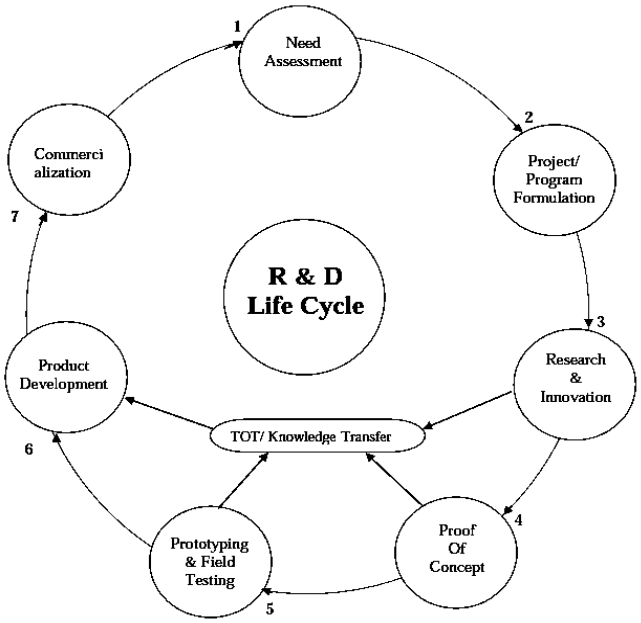
vi. Transfer of Technology (ToT)/ Knowledge Transfer: Depending on the context, transfer of technology or knowledge can occur after different stages. This involves sharing research findings, technical know-how, and methodologies with stakeholders, collaborators, or even for public dissemination. It can facilitate further innovation and adoption.

vii. Product Development: Based on the successful testing of prototypes or transfer of technology/knowledge transfer, R&D project proceeds to the product development stage. Here, the technology is refined, optimized, and scaled up for commercial production. This involves addressing any technical challenges, streamlining processes, and ensuring quality standards are met.

viii. Commercialization: Once the product is fully developed and refined, it is ready for commercialization. This involves creating a market strategy, setting pricing, identifying target customers, and planning the product launch. Intellectual property protection and regulatory approvals, if applicable, are also addressed at this stage.

ix. Feedback and Continuous Improvement: After the product is launched, organizations gather feedback from users, monitor its performance in the market, and collect data on how customers are using it. This information guides ongoing improvements and updates to the product.

Figure 2.2: R&D Lifecycle (ICT&E R&D and Innovation Framework 2013) [24]



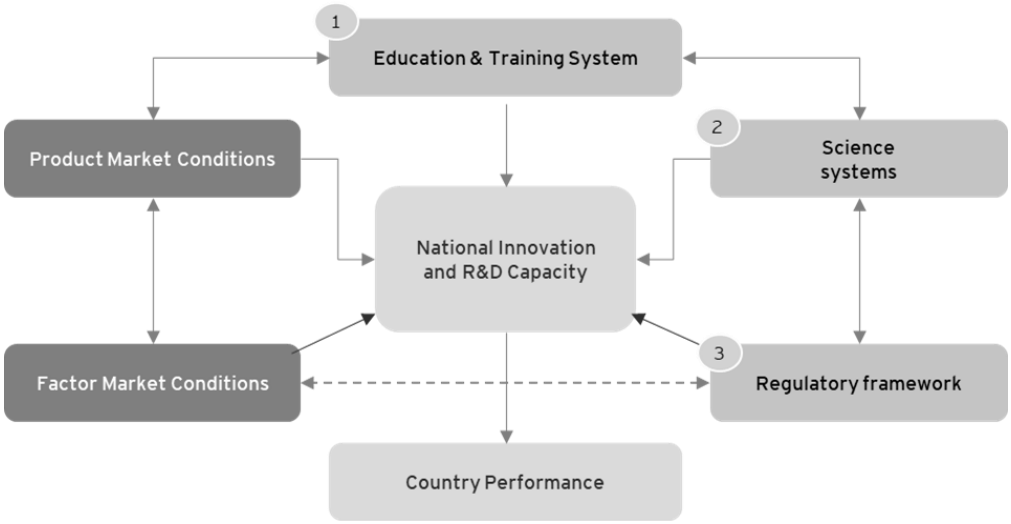
2.3. OECD National Innovation System Framework

2.3.1. National Innovation Systems (NIS) Framework[25] of the Organisation for Economic Co-operation and Development (OECD) provides a pathway to understand and develop R&D ecosystem in a country. This framework is the most prominent framework that came up in literature scans on innovation and national Science, Technology and Innovation (STI) policies. This is also used as the basis for most literature being generated on this area even today. Accordingly, the OECD NIS framework is looked into while analysing R&D ecosystem in India.

2.3.2. OECD NIS framework highlights key factors and flows of knowledge that impact success of a country's innovation system. The framework could be used to contextualize and assess various components of the R&D ecosystem in India.

[24]Source: https://www.meity.gov.in/writereaddata/files/R%26D_Framework_final%281%29_0.pdf
[25]Source: Managing National Innovation Systems by OECD (1999)

Figure 2.3: OECD NIS Framework in simpler form– highlighting three controllable focus elements



2.3.3. Focus elements of National Innovation System (NIS) framework that impact R&D ecosystem and could be controlled in the Indian context are:

i. Education and training system: A well-developed education and training system lays strong foundation for R&D and innovation system in a country.

ii. Science system: Science system plays a crucial role in improving technologies which lead to industrial improvements.

iii. Regulatory framework: Regulatory framework have a pivotal role in shaping the R&D and innovation system in the country. Key sub-areas include:

a. Policies and programs, and

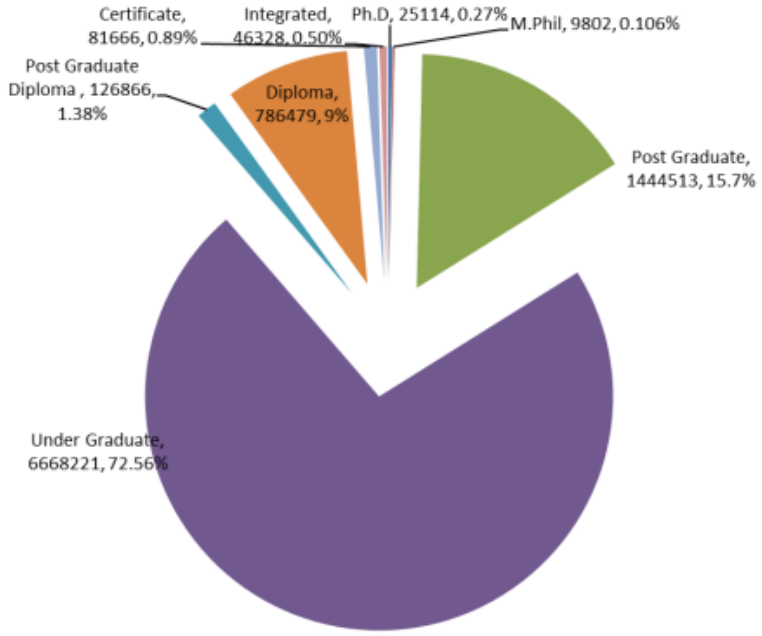
b. Intellectual Property Right (IPR) Regime.

2.4. Focus Element #1 – Education & Training System

2.4.1. Tertiary educational institutions form the bedrock of a country's future and are expected to be catalysts of innovation. These institutions play a crucial role in driving R&D based innovation by spearheading projects aimed at solving the most pertinent problems in society. However, unlike the leading R&D Countries in the world, research in India is concentrated in the autonomous government institutions rather than the universities. Therefore, it is crucial to introduce and nurture a conducive environment for research and development at educational institutions.

2.4.2. As per the Annual Report (2021-22) of the University Grants Commission (UGC), there are 13,032 colleges recognized under Section 2(f) and/or 12B of UGC Act, 1956. During the academic year 2020-21, there were 394.34* Lakh students enrolled (*Provisional Figures estimated on simple average increase during the last five years) in various courses (Regular & Distance Education Program) at all levels in Universities/Colleges/Standalone institutions of higher education.[26] In terms of graduates, India produced more than 66 lakh graduates in the 2020-2021.

Figure 2.4: Level wise Out turn/Pass Outs: 2020-21[27]



2.4.3. According to the Global Innovation Index 2022[28], India is among the top 15 countries, when it comes to Science, Technology, Engineering, and Mathematics (STEM) graduates as a percentage of all graduates (33.7%). This trend of inclination towards STEM continues when we look at more advanced degrees. More than 17 lakh PG students passed out from India in 2019, out of which 4.6 Lakh students (~27%) were pursuing PG courses in STEM fields. In the same period, the US had 8.3 lakh PG pass-outs, out of which 2.9 lakh students were pursuing STEM fields (~35%).[29] Thus, it is safe to say that STEM

[26] Source: UGC Annual Report 2021-22

[27] Source: UGC Annual Report 2021-22
[28] Source: India-Country Profile, Global Innovation Index 2022)
[29] Source: EY Analysis

has been a preferred choice for students attending tertiary educational institutions. However, it is noted that number of students enrolled in a degree course decreases as the level of education increases. According to a study conducted by EY, "*India had only 16 thousand candidates (within STEM) who got their doctoral degrees in 2019. This means that for every single PhD pass out in India, there are 27 PG graduates. In comparison, more than one lakh students (within STEM) got their doctoral degrees in the US and the ratio of STEM PhD to PG pass outs is approximately 1:3*". An analysis of the data presented in Figure 2.4, reveals that only a few graduates opt for a post-graduate course and only a minuscule post-graduates go for a doctoral or post-doctoral program. Further, an analysis of Table 2.2 which showcases year-wise: level wise students' out-turn data reiterates this inference.

Table 2.2: Year-wise: Level-wise: Out-turn/Pass-Outs* 2015-16 to 2020-21[30]

Level	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Ph. D	24171	28779	34400	40813	38986	25114
M. Phil	23124	26325	28059	25787	18220	9802
Post Graduate	1404996	1477919	1504403	1500064	1577704	1444513
Integrated	22604	26151	26409	31550	39064	46328
Graduate	6331999	6456386	6419639	6474715	6650071	6668221
Post Graduate Diploma	175353	129032	143176	159697	189608	126866
Diploma	788322	740561	737077	783914	807330	786479
Certificate	78788	67933	75383	75358	80927	81666
Total	**8849357**	**9E+06**	**8968546**	**9091898**	**9401910**	**9188989**

Thus, despite huge improvement in overall ranking in the Global Innovation Index in recent years (from 81st rank in 2015-16 to 40th in 2021-22), where India is ranked 11th in terms of graduates in science and engineering, it is ranked 82nd in terms of researchers/million population in Global Innovation Index 2022.

2.4.4. One of the reasons why India is not in the list of leading countries of the world in the field of research, development and innovation is low percentage of full-time R&D professionals. In 2018, India had nearly 253 researchers per million people as compared to 8,342 in Israel, 7899 in Denmark, 7,597 in Sweden, 5,304 in Japan, 5,003 in Germany and 4,821 in the United States of America (USA). However, total number of researchers in India was 3,41,818 as

[30]Source: UGC Annual Reports 2020-21/2021-22

compared to 17,40,442 in China, 13,71,290 in the USA, and 6,76,292 in Japan. The number of researchers in India increased from 152 per million people in 1996 to 252.7 per million people in 2018 growing at an average annual rate of 10.84%. Table 2.3 shows the Full-Time Equivalent (FTE) of manpower employed in R&D establishments as of 01.04.2018. According to this, a total of 341818 personnel were engaged in R&D activities, across Government institutions, Higher Education and the Industrial sector.

Table 2.3: Full-time Equivalent of Manpower Employed in R&D Establishments as on 01.04.2018[31]

	Name of Establishment	Personnel Engaged In			
		R&D Activities (1)	Auxilliary Activities (2)	Administrative Activities (3)	Total (1+2+3)
1	**INSTITUTIONAL SECTOR**				
	A. GOVERNMENT INSTITUTIONS				
	a. Major Scientific Agencies	53891	34149	34125	122165
	b. Central Government Ministries/Departments	8790	11495	10144	30429
	c. State Governments/UT	16376	9828	22590	48794
	Total Government Institutions (A= a+b+c)	79057	55472	66859	201388
	B. HIGHER EDUCATION SECTOR	124702	_	_	124702
	TOTAL INSTITUTIONAL SECTOR (1= A+B)	**203759**	**55472**	**66859**	**326090**
2	**INDUSTRIAL SECTOR**				
	a. Public Sector including Joint Sector	9291	1480	1264	12035
	b. Private Sector	107003	23741	24745	155489
	c. Scientific and Industrial Research Organisation (SIRO)	21765	18131	19459	59355
	Private Sector + SIRO (b+c)	128768	41872	44204	214844
	TOTAL INDUSTRIAL SECTOR (2= a+b+c)	**138059**	**43352**	**45468**	**226879**
	Total (1+2)	**341818**	**98824**	**112327**	**552969**

2.4.5. Scarcity of trained human resources with required skills underlines the situation of employment and employability in the country. As of September-December 2022, there were nearly 40 per cent of the workforce who were just

[31]Source: S&T Indicators Tables, R&D Statistics 2019-20, DST

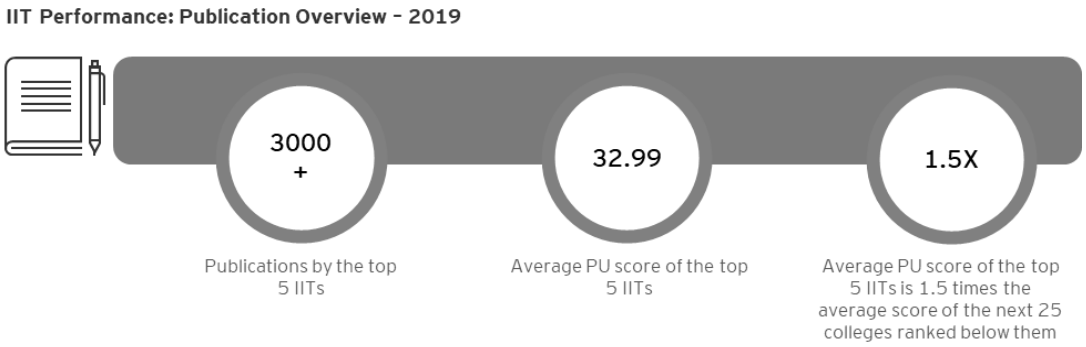
high school pass out, and thus, confined to low standard jobs. Only 12 per cent of the workforce were graduates or post-graduates.[32] The analysis indicates that, lack of jobs is not the only ordeal but also there are concerns about capability of the candidates applying for jobs.

2.4.6. As seen before, STEM majors account for over 33% of university graduates. The employability has increased from 34% in 2014 to around 47% in 2019. But still one in every two graduates remained unemployed. "*In technical fields, courses in electronics and communications engineering shared the highest employability rates (60.3%) with information technology (60.2%) in 2019, whereas civil engineering had the lowest."*[33] Despite focus on improving the quality of higher education, pass outs from Industrial Training Institutes and Polytechnics are less employable, primarily due to a lesser focus on alliances with industry and a dearth of core skills. Further, it is also noted that there is hesitancy in employees of the MNCs to make transition to R&D institutions.

2.4.7. Dependence on five IITs- As per data released by All-India Survey of Higher Education (AISHE) in 2020-21, there are 1,113 Universities, 43,796 colleges and 11,296 Stand Alone Institutions in the country. However, only a small fraction of these Universities/Colleges/Stand-alone Institutions have proved to be the flagbearers of India's R&D initiatives. (A list of top higher education institutions involved in research based on NIRF 2022 rankings is included as Annexure II). The five 'older' IITs — Bombay, Delhi, Kanpur, Kharagpur and Madras — remained the epicentre of most of the research in the country. They alone account for almost 10% of the total PhD pass outs in the country. These IITs provide a bulk of publications as well. Average PU score (A measure of the total number of papers published and the number of faculty members as calculated by NIRF) of these IITs is ~1.5 times the average score of the next 25 top engineering institutions.

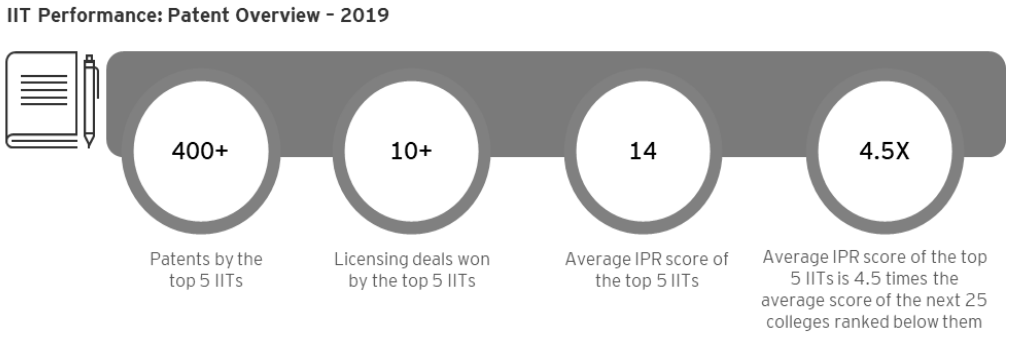
[32]Source: https://www.cmie.com/kommon/bin/sr.php?kall=warticle&dt=20230130153638&msec=643
[33]Source: UNESCO Science Report 2021

Figure 2.5: IIT Performance: Patent Overview – 2019[34]



IITs are also at the forefront of patent filing within the top engineering institutions and filed more than 400 patents in the 2019-20 academic session. In fact, the average IPR score (A measure of the total number of patents applied and granted calculated by the National Institutional Ranking Framework (NIRF)) of the top 5 ranked engineering institutions i.e., the five IITs is ~4.5 times the average score of the next 25 engineering institutions. Furthermore, these IITs have also been able to monetize/commercialize their patents. They have been able to win licensing deals for projects they have worked on and are even getting royalties from the same. IIT Delhi was able to win eight licensing deals in this period alone. Royalties accounted for INR 1.95 crore of the total project specific funds allocated to IIT Bombay for the 2020-21 academic year.

Figure 2.6: IIT Performance: Patent Overview - 2019[35]



2.4.8. Low education spending and traditional pedagogy- According to experts, India needs to spend at least 6% of its GDP on educating its population to efficiently utilize its demographic dividend. This target has been reiterated time and again

[34] Source: EY Study Paper
[35] Source: EY Study Paper

by committees and commissions. However, the actual spending has hovered around 3%. The low spending on education results in a shortage of educated workers, insufficient infrastructure, and limited access to new technology and stymies its R&D efforts. Additionally, traditional teaching methodologies which result in learning by rote and overemphasis on examination scores act as a deterrent to generate the interest among students for pursuing PhD and ultimately choosing R&D as a career. This has made difficult for India to stay up with the latest breakthroughs and innovations. During the pandemic, world saw that education is best imparted in a "*smart*" environment. The quality of education could be enhanced effectively by making use of modern technologies like Artificial Intelligence (AI), Augmented Reality (AR), Virtual Reality (VR) and Metaverse among other potential technologies. A simple change in the mindset from "*memory-and-recall*" to "*learning-by-doing*", as envisaged by the National Education Policy 2020 can prove to be a watershed moment in the history of India's education and training system, leading to the expansion and enhancement of scientific temper overall.

Key points emerged from above discussions include:

i. **Skewed PhD funnel:** While there is a great focus seen among younger students to pursue STEM-related graduate and post-graduate courses in India, the focus seems to deteriorate while pursuing doctoral courses. The PG to Ph.D. funnel for India is narrow as compared to their peers like the US.

ii. **Low employment and employability:** On one hand, the lack of suitable jobs result in brain-drain. It is also noted that there is hesitancy in employees of MNCs to make transition to R&D institutions. On the other hand, the future researchers' employability remains a lacuna with one in every two graduates in STEM remaining unemployed. Job aspirants are forced to undergo courses outside the curriculum to make them industry ready.

iii. **High dependence on IITs:** The five IITs located in Mumbai, Delhi, Kanpur, Kharagpur and Madras which remain the epicentre of most research in the country, account for almost 10% of the total Ph.D. pass outs and provide the bulk of the paper publication and patent filing.

Concentration needs to spread beyond IITs in terms of number of Ph.D. pass outs and the quality of research.

iv. **Low education spending:** The public expenditure on education in India has not come close to the recommended level of 6% of GDP, as envisaged by the 1968 National Education Policy, reiterated in the National Education Policy of 1986, and which was further reaffirmed in the 1992 review of the Policy. The recently launched National Education Policy, 2020 commits to significantly raising educational investment. However, the promises made are yet to manifest, as current public (Government - Centre and States) expenditure on education in India hovers around 3-4% of GDP.

v. **Traditional teaching pedagogy:** Learning based on traditional teaching methodologies result in building the skill of "*memory-and-recall*" rather than pragmatic problem-solving skills in the learners. The rote-based learning method fails when subject areas become more complex, and the problem areas expand horizontally or vertically.

Issues for Consultation

Q.1. Whether current education system adequately promotes scientific temper and skills among students encouraging them to contribute towards Research and Development activities in ICT sector? If yes, please indicate what additional measures are needed to make them effective contributors of innovations to the industry. If not, please identify areas which need to be strengthened to orient students towards research and development activities in ICT sector.

Q.2. What should be done to further strengthen the roots of R&D ecosystem in general and specially in ICT sector of the country, which allows:

a. Increase in number of post-graduates going for doctoral and post-doctoral programs in institutions other than IITs?

b. Assured career progression opportunities in the field of Research and Development for students graduating from tertiary educational institutions?

c. Researchers to continue entire career in advanced research.

d. Increase in employability and career progression skills of students enrolled in STEM courses?

Q.3. What measures should be taken pertaining to the tertiary institutions with a focus to encourage students towards advanced R&D at the university level?

2.5. Focus Element #2 – Science System

2.5.1. The 'science system' of a country refers to the network of public and private institutions involved in production and consumption of R&D and innovation. This includes research institutions (public and private), R&D labs in various industries, and public-private partnerships/ industry-academia collaborations aimed at R&D. Science system plays a crucial role in improving technologies which leads to industrial improvements.

2.5.2. Indian science system is primarily dependent on public investment, infrastructure, institutions, and bodies. Public investment makes up over 63% of total R&D expenditure whereas private investment makes up the rest (around 37%) to complete the pie. Table 2.4 showcases the trend appropriately.

Table 2.4: Public and Private Investment in National R&D and %age share in GDP[36]

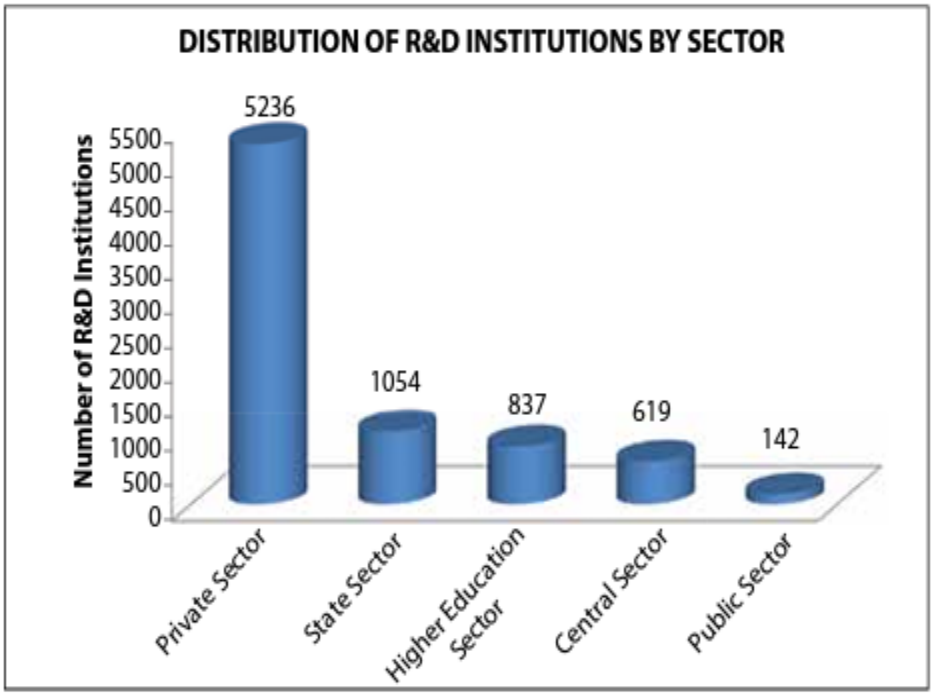
Year	Public Investment in R&D	% share of Public Investment in total R&D	Private Investment in R&D	% share of Private Investment in total R&D	Total Investment in R&D
2004-05	18078.28(0.5)	75	6038.96(0.2)	25	24117.24(0.7)
2005-06	21460.63(0.6)	71.7	8471.95(0.2)	28.3	29932.58(0.8)
2006-07	23752.81(0.6)	69.4	10485.58(0.2)	30.6	34238.39(0.8)
2007-08	26511.64(0.5)	67.2	12926.14(0.3)	32.8	39437.77(0.8)
2008-09	32987.98(0.5)	69.7	14365.40(0.3)	30.3	47353.38(0.8)
2009-10	37735.75(0.6)	71.1	15305.55(0.2)	28.9	53041.30(0.8)
2010-11	40859.73(0.6)	67.9	19337.02(0.2)	32.1	60196.75(0.8)
2011-12	42665.62(0.5)	64.7	23295.71(0.3)	35.3	65961.33(0.8)
2012-13	46886.28(0.5)	63.4	27096.51(0.3)	36.6	73982.79(0.7)
2013-14	48841.09(0.4)	61.5	30514.80(0.3)	38.5	79355.89(0.7)
2014-15	54935.05(0.4)	62.8	32538.39(0.3)	37.2	87473.44(0.7)
2015-16	59430.29(0.4)	62.3	36022.15(0.3)	37.7	95452.44(0.7)
2016-17	63974.55(0.4)	62.1	39124.71(0.3)	37.9	103099.26(0.7)
2017-18	71969.15(0.5)	63.2	41855.88(0.2)	36.8	113825.03(0.7)
2018-19*	78284.99(0.5)	63.2	45562.72(0.2)	36.8	123847.71(0.7)

2.5.3. Distribution of Science System- National Science and Technology Management Information System (NSTMIS), Department of Science and Technology (DST) has provided data of R&D institutions in the country. The share of various sectors in total number of R&D institutions is: Central Government 7.8%, State Government 13.3%, Higher Education Sector 10.6%, Private Sector including Scientific & Industrial Research organization 66.3% and Public Sector Industry including State Public Sector 1.8%. Maximum number of R&D institutions 1610 (20.4%) are in the State of Maharashtra. This is followed by Karnataka, Tamil Nadu, Gujarat, and Telangana with 754 (9.6%), 751 (9.5%), 717 (9.1%) and 611 (7.7%) respectively. In case of Central Sector, maximum number of R&D institutions 72 (11.6%) are in the State of Delhi. This is followed by Maharashtra and Karnataka with 65 (10.5%) and 59 (9.5%) respectively. The

[36] Source: S&T Indicators Tables, R&D Statistics 2019-20, DST

Sector-wise and State-wise number of R&D organisation is shown in the Figure 2.7 and 2.8 below.

Figure 2.7: Distribution of R&D Institutions by Sector[37]



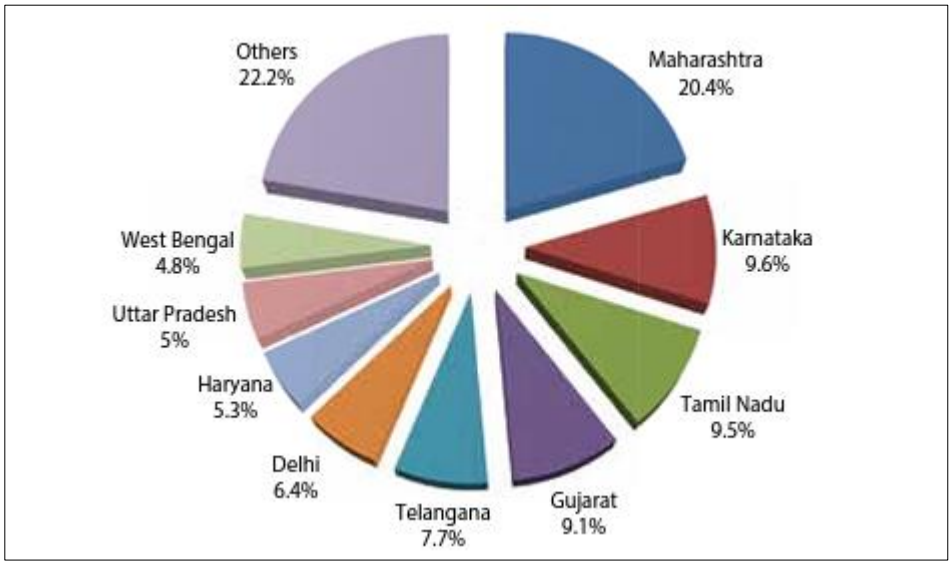
Note:

1. Higher Education comprises of Central, State, Deemed, Private Universities and Institutes of National Importance.

2. Private industry comprises of DSIR recognized in-house R&D units, Scientific and Industrial Research Organisations, Industries not recognized by DSIR performing R&D activities taken from CMIE database and Industries with potential for R&D.

3. Public Sector Industries comprises of Central Public Sector and State Public Sector

Figure 2.8: Distribution of R&D Institutions by various states[38]



[37]Source: R&D Directory 2021
[38]Source: R&D Directory 2021

2.5.4 Expenditure in Telecom Sector- Narrowing down to the science system in the telecom sector reveals the scarcity of resources in terms of investment, infrastructure, institutions, and bodies. According to the R&D Statistics 2019-20 and S&T Indicators Tables 2019-20 published by the Department of Science & Technology (DST), there is only a single R&D unit in the telecommunications industry group for public sector as compared to 103 total R&D units in the public sector. Additionally, there are 13 R&D units in the telecom industry group for private sector as compared to a total of 2,007 R&D units in the private sector. These 14 R&D units (1 Public + 13 Private) in the telecommunications industry group together comprise only about 0.54% of the total industrial expenditure on R&D in India i.e., ₹225.66 crore out of the total ₹41753.99 crore. Thus, it can be inferred that even though there is a greater number of telecom R&D units in the private sector, the public sector expenditure is more on telecom R&D.

Table 2.5: Industrial expenditure classified by leading industry groups during 2017–18[39]

Industries Groups	Public Sector		Private Sector		Industrial Sector		%
	R&D Units	R&D Exp (₹. Crores)	R&D Units	R&D Exp (₹. Crores)	R&D Units	R&D Exp (₹. Crores)	
Drugs & Pharmaceuticals	3	3.15	313	10159.11	316	10162.26	24.34
Transportation	2	0.85	100	6848.96	102	6849.81	16.41
Information Technology	–	–	34	3625.17	34	3625.17	8.68
Misc. Mechanical Engg Industries	–	–	76	3122.67	76	3122.67	7.48
Chemicals (other than fertilizers)	9	15.64	224	3004.56	233	3020.20	7.23
Defence Industries	18	2712.22	23	140.25	41	2852.47	6.83
Electricals & Electronics	10	102.3	215	1935.47	225	2037.77	4.88
Medical & Surgical Appliances	2	6.57	35	1277.97	37	1284.54	3.08
Fuels	13	1163.99	10	51.32	23	1215.31	2.91
Biotechnology	1	0.07	163	1071.3	164	1071.37	2.57
Industrial Machinery	1	646.64	63	201.52	64	848.16	2.03
Metallurgical Industries	10	208.64	58	263.9	68	472.54	1.13
Soaps, Cosmetics, Toilet Preparations	1	0.65	13	283.26	14	283.91	0.68
Telecommunications	1	22.76	13	202.9	14	225.66	0.54
Others	32	369.77	667	4312.38	699	4682.15	11.21
Total	**103**	**5253.25**	**2007**	**36500.74**	**2110**	**41753.99**	**100.0**

2.5.5 The data on industrial expenditure on R&D classified by leading industry groups during 2017-18, as shown above, doesn't specifically mention the expenditure of the broadcasting industry. However, it provides details about

[39] Source: R&D Statistics 2019-20, DST

the expenses on R&D made by the "*Information Technology*" industry. The R&D expenses made by the 34 concerned R&D units in the Information Technology industry account for ₹3625.17 crore, i.e., 8.68% of the total industrial expenditure on R&D in India.

2.5.6 Office of the Principal Scientific Advisor[40]- Established in November 1999, the Office of the Principal Scientific Adviser (PSA) aims to provide pragmatic and objective advice to the Prime Minister and the cabinet in matters of Science and Technology. The PSA is assisted by a Scientific Secretary and a team of scientific advisors, who are experts in various fields of science and technology, and by a secretariat that provides administrative support. Key initiatives undertaken by the PSA are given below.

i. Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC)[41]- An overarching council that facilitates the PSA's Office to assess the status in specific science and technology domains, comprehend challenges, formulate interventions, develop a futuristic roadmap, and advise the Prime Minister accordingly. The Office of PSA supported by the project management team at Invest India is facilitating the delivery and progress of all 9 national missions under PM-STIAC. PM-STIAC provides support to the Science & Technology (S&T) Clusters which are being established as formal umbrella structures for S&T organizations in various cities to have better synergy while retaining their autonomy. Additionally, there are 9 missions under PM-STIAC. Accelerating Growth for New India's Innovation (AGNIi) is one of the missions. The aim of AGNIi is to support the national efforts to boost the innovation ecosystem in the country by connecting innovators across industry, individuals, and the grassroots to the market and helping commercialize innovative solutions. It provides a platform for innovators to bring their technology-ready products and solutions to industry and the market thereby helping propel techno-entrepreneurship which can usher in a new era of inclusive socio-economic growth. The other 8 missions are:

   - Natural Language Translation

[40] Source: https://www.psa.gov.in/
[41] Source: https://www.psa.gov.in/pm-stiac

- Quantum Frontier
- Artificial Intelligence
- National Biodiversity
- Electric Vehicles
- BioScience for Human Health
- Waste to Wealth
- Deep Ocean Exploration

ii. Empowered Technology Group (ETG)[42]- The Empowered Technology Group (ETG) aims to proactively lay down, coordinate, and oversee national-level policies relating to procurement and induction of technologies, R&D in technologies that require large outlays in resources (both financial and human), and render sound and timely advice for determining direction and trajectory of Government's R&D and Technology Development Programs.

iii. Indian Science, Technology and Engineering Facilities Map (I-STEM)[43]: Over the years, the Government of India has been funding research and development efforts at academic institutions. However, the mapping of facilities based on availability and distance was not available. The government aims at bridging the gap, by converging information on facilities developed through government support and researchers who are qualified to utilise these facilities for research work. The I-STEM Web Portal assists users to locate the specific facility(ties) they need for their R&D work and identify the one that is either located closest to them or available the soonest. Booking of the concerned facility may be done by the user through an android or iOS application.

2.5.7. Public Institutions of Importance in R&D: Public institutions in the Indian Science system setup have gained immense importance over the past decades. They have been at the forefront of R&D in the ICT sector in India. In this regard, the major public institutions involved in R&D in the ICT sector in India are discussed in subsequent paras.

[42] Source: https://www.psa.gov.in/etg
[43] Source: https://www.psa.gov.in/i-stem

2.5.7.1 R&D in Convergence, Communications & Broadband Technologies (CC&BT) and Strategic Electronics, MeitY[44]

i. R&D in CCBT is one of the sub-divisions of the Research and Development Division of Ministry of Electronics and Information Technology (MeitY). In order to support digital ecosystem, R&D initiatives in Convergence, Communications, Broadband Technologies(CC&BT) and Strategic Electronics is aimed at developing indigenous capability in the thrust areas like Next Generation Networks (NGN) and Communication technologies, 5G and beyond, next generation mobile technologies, Broadband Wireless Technologies, Green Communications, Quantum Communication, Vehicular Communication, Cyber Physical System, Artificial Intelligence enabled Communication, Big Data Analytics and Internet of Things for societal applications & disaster management, Machine-to-Machine Communication and Strategic Electronics with applications in both Civil and defence domains and innovative backhaul Communication Technologies.

ii. Working Group on R&D in CC&BT and Strategic Electronics constituted with experts from relevant areas, provides advisory support in selecting the R&D proposals for implementing R&D activities through analysis of technology trends, identification of thrust areas, preparation of technology development plan as well as formulation and evaluation of projects for execution by R&D organizations/academia with financial support from MeitY. Projects are monitored regularly by the Project Review and Steering Group (PRSG) constituted by MeitY for each project.

iii. There are several ongoing projects under R&D in CC&BT and Strategic Electronics with different institutions acting as the primary implementing agency. Some of the ongoing projects are:

a. Next Generation Wireless Research and Standardization on 5G and beyond by Centre of Excellence in Wireless Technology (CEWiT) IIT Madras, Indian Institute of Science Bangalore, Indian Institute of Technology Bombay, Indian Institute of Technology Delhi, Indian Institute of Technology Hyderabad, Indian Institute

[44] Source: https://www.meity.gov.in/content/rd-ccbt

of Technology Kanpur, Indian Institute of Technology Kharagpur, Indian Institute of Technology Madras.

b. 5G+/6G Converged Terrestrial and Satellite IoT (5G+/6G-sIoT) by IIT Hyderabad
c. Metro Area Quantum Access Network (MAQAN) by IIT Madras, SETS-Chennai and CDAC Bangalore
d. Establishment of EMC Test facility for testing of Strategic Electronic Systems by SAMEER Mumbai
e. Development of SDN and NFV based agile Network Service Delivery Platform for Enterprise and Service Providers by C-DAC Thiruvananthapuram
f. AI-based 6G Network Slicing for multi-UAV prototype by IIT Patna
g. Visible Light Communication based LED Lighting Solutions by CDAC Chennai

iv. According to MeitY's Annual Report 2022-23, the Ministry of Electronics and Information Technology has allocated ₹600 crore for R&D in IT/Electronics/CCBT.

2.5.7.2 Centre for Development of Advanced Computing (C-DAC)

i. C-DAC is the premier R&D organization of the Ministry of Electronics and Information Technology (MeitY) for carrying out R&D in IT, Electronics and associated thrust areas such as:
   a. High Performance Computing, development of scientific computing applications on these platforms, and cloud computing.
   b. Multi-lingual Computing.
   c. Professional Electronics covering electronic devices and embedded systems.
   d. Information and Cyber Security.
   e. Health Informatics including hospital information systems, electronic medical records.
   f. Software Technologies including e-governance solutions, e-learning technologies, geomatics, open-source software, accessibility, etc.

ii. C-DAC has developed several indigenous hardware and software solutions in the areas of high-performance computing, cybersecurity,

and embedded systems that helped boost India's capabilities. As a key player in the National Supercomputing Mission (NSM), C-DAC has led to the development of several applications in areas such as weather forecasting, drug discovery, and scientific research. C-DAC has collaborated with several leading academic and research institutions in India leading to the development of technologies and solutions in areas such as artificial intelligence, machine learning, and data analytics. C-DAC has partnered with several companies in India leading to the development of several innovative solutions in areas such as healthcare, finance, and e-commerce. Further, C-DAC has been involved in education and training programs in advanced computing technologies for several years. These programs have helped build a skilled workforce in India, which has contributed to the growth of India's R&D ecosystem.

iii. According to C-DAC's Annual Report 2021-22, C-DAC's expenditure for the year ending 31st March 2022, was around ₹609 crore, up from nearly ₹421 crore spent in 2020-21. However, expenditure on R&D activities is not mentioned separately. More collaboration and partnership of C-DAC with industry is needed, which may ensure that C-DAC's research is aligned with the needs of the industry and lead to the development of commercially viable technologies and solutions. Other challenges to the functioning of C-DAC include attracting and retaining talent, industry relevance and commercialization of research.

2.5.7.3 Society for Applied Microwave Electronics Engineering & Research (SAMEER)[45]

i. SAMEER was set up as an autonomous R&D laboratory at Mumbai under the then Department of Electronics, Government of India with a broad mandate to undertake R&D work in the areas of Microwave Engineering and Electromagnetic Engineering Technology.

ii. It is an offshoot of the special microwave products unit (SMPU) set up in 1977 at the Tata Institute of Fundamental Research (TIFR), Mumbai. SAMEER, Mumbai was setup in 1984. Centre for Electromagnetics,

[45] Source: https://www.sameer.gov.in/about_sameer

SAMEER Chennai which was under Department of Electronics (DOE) was merged with SAMEER in 1987. Centre for Microwave & Millimeter wave, SAMEER Kolkata was set up in 1994. Electromagnetic Environmental Effects (E3) Laboratory, SAMEER Visakhapatnam was established in 2014. Centre for High Power Microwave Tube and Component Technology, SAMEER Guwahati was established in 2015.

iii. The vision of SAMEER is "*To be a Premier R&D Institution of International repute in RF/Microwave and Millimeter wave technology.*"

2.5.7.4 Research Department, Prasar Bharati[46]

i. Research Department of All India Radio (AIR) was set up in 1937 for propagation studies and scientific planning of broadcasting services in the country, R&D and paving way for introduction of latest technology in Indian broadcasting. The ongoing activities of the Research Department of Prasar Bharti includes the following:

- Development of Low Cost DTH, DVB-T2 and Customized Radio Receivers.
- Propagation studies related to DRM, DVB-T2, FM & AM and Satellite Radio and Interferences in Satellite TV.
- Web-based telemetry system for MW/FM transmitters.
- Test and Evaluations of Emerging Acoustic Materials.
- Development of Scalable Video Wall Solutions.
- 24X7 Broadcast Signal Monitoring of MW, SW, FM and DRM transmissions at IMRC, Todapur, Delhi.
- Development of High-Power FM Antenna.

ii. Broadcasting technology is constantly evolving, and keeping up with the latest advances is challenging. Smartphones' ability to provide "*on-the-go*" and "*interactive*" mobile solution may change broadcast media significantly for a more interesting, interactive and personalized broadcast experience. Mobile phones have complemented the ways of viewing. Some new trends in the broadcasting media in near future include use of AI-based, customized, and human-curated information,

[46] Source: https://prasarbharati.gov.in/r-and-d/#R-and-D-Home

voice-controlled devices and voice assistants, Augmented Reality Graphics (AR-GFX). Further, NextGen TV – Advanced Television Systems Committee (ASTC) 3.0 Technology is on the rise. With the use of this technology, consumers can watch broadcast videos on devices other than TV, such as smartphones and tablets. Research Department, Prasar Bharati may play a key role in this aspect.

2.5.7.5 Centre for Development of Telematics (C-DOT)[30]

i. Established in 1984 as an autonomous telecom R&D centre of the Department of Telecommunications (DoT), C-DOT has done revolutionary work in telecom network digitalization of rural India through its relentless R&D efforts in the indigenous design and development of telecom technologies. C-DOT has also been instrumental in the evolution of the telecom manufacturing ecosystem based on technology transfer model to facilitate manufacturers. C-DOT is currently engaged in development of latest technology products in areas such as Optical switching, wireless, M2M/IOT, 5G, AI & Quantum Computing Security Systems etc.

ii. C-DOT has framed C-DOT Collaborative Research Program 2022 (CCRP-2022), which aimed at fast-tracking the development of telecom and associated technologies in the country. The key telecom areas identified by C-DOT for collaborative research for taking forward existing product portfolio of C-DOT or developing new products are the following:

a. 5G/6G and Beyond Technologies
b. Wi-Fi and beyond products
c. Quantum Communication Technologies
d. Advanced Optical Access & Transport technologies
e. Advanced Packet Technologies
f. Advanced Telecom Security, Interception and Analytics
g. Artificial Intelligence and Cognitive Sciences
h. Advanced telecom applications
i. Software Defined Networks
j. Network Management System and Framework
k. IoT and M2M Solutions
l. Advanced Disaster Management Solutions
m. Satellite Communications, Broadcasting Solutions

iii. 5G development under C-DOT 'India 5G Alliance': 'India 5G Alliance', with C-DOT as a facilitator, undertakes research programs in 5G under guidance from DoT. The purpose of this alliance is to facilitate the design and development of indigenous 5G products through collaboration with various Indian companies and academic institutions that are working on 5G technologies. There are 10 consortiums under the alliance, each focusing on a particular key technology area in 5G.

iv. Centre of Innovation (CoI): CoI, a Centre of Excellence under C-DOT for IoT/M2M, assists in the development, integration and testing of innovative smart solutions based on M2M standards. They work with industry partners to register for engagement and create end-to-end IoT/M2M solutions. It will open standardized interfaces of the C-DOT Common Service Platform (CCSP) for the organizations (Start-ups/Industry) developing indigenous IoT/M2M applications for testing their IoT/M2M Solutions with CCSP and working out end-to-end solutions for various industry verticals.

v. According to C-DOT's Annual Report 2021-22[47], the organization has spent nearly ₹379 crore in total as compared to ₹309 crore in 2020-2021. These expenses include establishment expenses, operational expenses, other administrative expenses and depreciation. Further, according to DoT's Annual Report 2022-23[48], the C-DOT's Budget Estimate for 2022-23 is ₹500 crore, a major portion of which will be used to fund innovations in startups.

vi. Above discussions clearly indicate that C-DOT has played a key role in R&D in ICT sector, however, there are areas which may further need to be looked into for making it a leading R&D institution in technology advancement. Some of these areas are competitiveness, attracting and retaining talent, commercialization of research, and generation of IPRs etc.

2.5.7.6 Telecommunications Standards Development Society, India (TSDSI)

i. TSDSI is an autonomous, membership-based, standards development organization (SDO) for Telecom/ICT products and services in India. It

47 C-DOT's Annual Report 2021-22

48 DOT's Annual Report 2022-23

develops standards for access, back-haul, and infrastructure systems, solutions and services that best meet India-specific Telecom/ICT needs, based on research and innovation in India. It works closely with global SDOs to reflect Indian requirements into international telecom/ICT standards. TSDSI also encourages generation of Indian IPRs and get them incorporated into international standards. This in turn promotes indigenous research, product development and manufacturing. The objectives of TSDSI are:

a. Developing, promoting, and standardizing India-specific Telecom/ICT requirements and solutions.
b. Taking Indian requirements to global standards organizations.
c. Helping create standards-based manufacturing expertise in the country.
d. Providing guidance and leadership to developing countries.

ii. TSDSI through its members and Study Groups has carried out studies and standards development in the following areas:

a. Study Group – Networks:
   6G, 5G Enhancements, Spectrum Studies, Broadcast Offload, National Smart Grid Mission (NSGM), Use Cases,
b. Study Group – Services and Solutions:
   Cloud Interoperability & Portability, Application/Services Layer Standards (FinTech, NSGM, AI/ML, V2X-5Gi Field Test), Critical Communications, Services & Safety, Security & Trust, IoT/M2M, Drones

iii. TSDSI in its Roadmap 2.0 (2021-23) has chosen to focus on 5G use cases, 6G Vision, AI/ML in and for Future Networks, Quantum Security, Smart IoT, Spectrum Coexistence studies, Wireless-to-building (WTTB), UAV-based backhaul, Cloud Resource Management in Future Networks.

iv. TSDSI is Organizational Partner of 3GPP along with six other Regional Standardization bodies. This entitles TSDSI members to become individual members of 3GPP through TSDSI and to take their IP into the global arena. Membership of 3GPP enables members to contribute to the development of upcoming standards such as 5G.[49]

[49] Source: https://dot.gov.in/telecommunications-standards-development-society-india-tsdsi

TSDSI in collaboration with IIT Madras, IIT Hyderabad, and the Centre of Excellence in Wireless Technology (CEWiT) has developed local 5G standard, named 5Gi (also known as Radio Interface Technology or RIT) to improve 5G coverage in rural and remote areas. 5Gi offers more range at a lower frequency, which is an advantage over 5G. TSDSI's 5Gi standard has been formally merged with the 3GPP 5G Standard and implemented into the 3GPP Rel-17 NR specification.[50] The merger of the 5Gi requirements into 3GPP 5G standards, enables a single common specification going forward, as well as creating a single radio access solution for 5G deployments in India and globally. As Annual Report 2021-22 of TSDSI, it has published a total of 134 technical reports and 2855 technical standards. In 2021-22, TSDSI spent more than ₹8 crore, being its highest-ever expenditure.

2.5.8 Initiatives for R&D in PPP model: Apart from public institutions or government-funded autonomous bodies, Science System also include public-private partnerships programs, which is crucial to become an R&D leader. The same have been discussed in the paras that follow.

2.5.8.1 Software Technology Parks of India (STPI)

i. Established in 1991, STPI is promoting IT/ITES Industry, innovation, R&D, start-ups, product/IP creation in the field of emerging technologies like IoT, Blockchain, Artificial Intelligence (AI), Machine Learning (ML), Computer Vision, Robotics, Robotics Process Automation (RPA), Augmented & Virtual Reality, Animation & Visual effect, Data Science & Analytics for various domains like Gaming, FinTech, AgriTech, MedTech, Autonomous Connected Electric & Shared(ACES) Mobility, ESDM, Cyber Security, Industry 4.0, Drone, Efficiency Augmentation, etc. STPI is establishing CoEs/Technology incubators for building India's leadership in the above technology areas across the country in a collaborative manner. As on 31 March 2023, STPI has launched 22 Centres of Entrepreneurship (CoEs) across India.

ii. As envisaged in National Policy on Software Products (NPSP) 2019, STPI has evolved a collaborative model wherein government, industry, academia, and other stakeholders are playing a vital role in providing end-to-end support to startups. Aligned with this vision for promoting

[50] Source: https://tsdsi.in/tsdsi-5gi-standard-merged-with-3gpp-5gnew/

R&D, innovation, product & IPR creation, STPI is providing state-of-the-art infrastructure, skilling, mentoring, market connect and other necessary support pan-India to startups.

iii. STPI launched Next Generation Incubation Scheme (NGIS), a futuristic incubation scheme to offer comprehensive support and seed funding to start-ups from 12 STPI incubation facilities pan-India under a common umbrella. To strengthen the start-up ecosystem in the country, STPI has set up RF Lab, AV Lab, IoT Lab, Motion Capture (MoCap) Lab, AI/DA Lab, Innova IoT Lab, CV/AI Lab, Electronics System Design and Manufacturing (ESDM) Lab, Health Informatics Lab, Med Electronics Lab, VR/AR Lab, Fintech SandBox, FabLab, SMART Lab, and Atal Incubation Centre (AIC) to enable facilities for building innovative technology products and solutions in an indigenous manner.

iv. STPI has a notable impact in promoting development of software exports from India and creating a conducive environment for the growth of the IT industry by providing infrastructure support, legal and financial assistance, technology incubation, capacity building and market access to technology startups for developing and commercializing their products and services. STPI has also played a key role in creating a skilled workforce in the IT industry through training and capacity building initiatives. STPI has been expanding its regional reach to support development of IT industries in smaller towns in different states of the country. However, there are a few impediments to its success in the context of R&D. STPI primarily focused on providing infrastructure and support services to software companies, for promoting exports and not on core R&D activities. This limited the scope for research and innovation in the IT industry. Further, STPI has limited resources, thereby limiting entry for new startups and smaller companies who may not have the resources to access the services provided by STPI.

2.5.8.2 Telecom Centres of Excellence (TCOEs)

i. TCOEs have been established as a Public-Private Partnership (PPP) by the Department of Telecommunications (DoT) the objective to strengthen the R&D ecosystem in ICT where Government works as a

facilitator, industry as the ultimate user, and academia as the research unit. The scope of activities of TCOE India also includes the ICT domain, in view of the convergence of IT and Telecom technologies, and/or any other such future convergence technologies.

ii. Objectives of TCOEs:

a. Application oriented Telecom R&D and Innovation jointly with the industry.

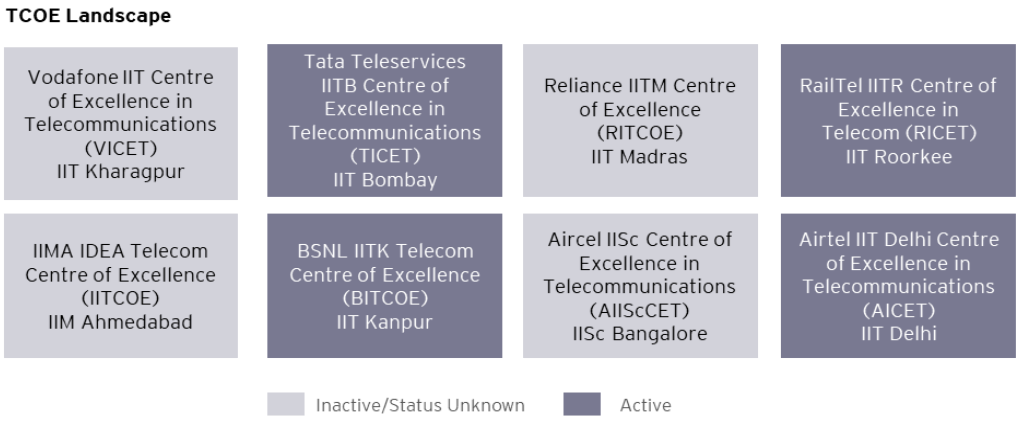
b. Capacity building through "*training the trainers*" and "*entrepreneurship development*".

c. Think tank activities for policy advocacy towards governance and regulation of telecom sector.

d. Influencing global standards to cater to Indian needs.

iii. Performance of TCOEs[51]- As part of initiatives, eight TCOEs were established. However, 50% of the COEs have become inactive.

Figure 2.9: TCOEs Landscape in India



iv. Key projects of TCOEs- Till 2022, COEs have worked on 14 technologies, of which only 3 have been commercialized. The details about these 3 technologies are given in the Table 2.6.

[51] Source: EY Analysis

Table 2.6: List of commercialized technologies by TCOEs[52]

Technologies	Developed by	Detail
NeXGeN Energy Management Solutions for Cellular Towers	TICET (Tata Teleservices - IIT Bombay Centre of Excellence) at IIT Bombay	Two products have been commercialized under this project:
		i. Optimization Tool: Provides site-focused recommendations on green & cost management initiatives, allowing the cellular operator to reap maximum benefit from industry innovations in this space.
		ii. Site Monitoring System: Enables tamper-proof collection of energy data points to bring transparency in energy billing & provide critical insights for decision making on green & cost management initiatives.
		The solutions have been successfully tested in pilot rollouts with several leading cellular operators and infrastructure providers.
Mobile Voice Banking	RITCOE (Reliance -IIT Madras Centre of excellence) at IIT Madras	Solution enables financial service providers to offer a low-cost voice-based mobile banking system to their customers. Key features:
		i. Multi-factor authentication with voice biometrics
		ii. Support for 11 Indian languages.
		iii. Human-like interaction with advanced speech recognition technology.
		iv. Services are provided over cloud.
		v. Facilitates balance inquiry, transfers, cash-in, cash-out, remittances, statements, loans, mobile top-ups and bill payments.
Digital Mandi Application for Indian Kisan	BITCOE (BSNL IIT-Kanpur Centre of Excellence) at IIT-Kanpur	It provides a registered farmer, alerts through SMS and/or voice on his mobile about selected mandi rates of selected crop. Key features:
		i. The system can provide information in Haryana and UP (Hindi), Punjab (Punjabi), and Karnataka (Kannada) currently.
		ii. An option for direct access is also provided. Thus, the guest users can also avail the text and voice response features.
		iii. An option called 'My mandi' is provided where the user can directly access his selected mandi and crop prices.

TCOEs have played a crucial role in building a skilled workforce in advanced telecom technologies. TCOEs have collaborated with several leading academic and research institutions in India, providing education and training in telecom technologies to students and professionals. These programs have helped build a pool of skilled talent, contributing to the growth of India's R&D ecosystem. TCOEs have encouraged innovation in advanced telecom technologies by providing funding and support to start-ups and entrepreneurs. TCOEs have helped incubate several telecom start-ups in India, providing them with the necessary resources and mentoring to develop innovative products and services. Overall, TCOEs have had a significant impact on India's R&D

[52] Source: EY Analysis

ecosystem by building a skilled workforce, encouraging innovation, fostering collaboration, and providing policy support. However, the lack of synergy amongst stakeholders and limited commercialization of research poses questions regarding the efficiency of the TCOEs.

2.5.8.3 IIT Madras Research Park

i. IIT Madras Research Park (IITMRP) was established in 2010, housing more than 70 R&D companies and has incubated more than 200 start-ups. Some well-known companies that operate R&D units out of the park include BHEL (Bharat Heavy Electricals Ltd.), Tata Consultancy Services, Saint Gobain, and Titan Industries. Initially, a large chunk of capital was provided by the Ministry of Human Resource Development (MHRD) as a loan. Later, ₹137 crore was also invested by the government in the form of grants-in-aid.

ii. A plan to recreate the IITMRP model in eight other institutions — IIT Kharagpur, IIT Bombay, IIT Gandhinagar, IIT Delhi, IIT Guwahati, IIT Kanpur, IIT Hyderabad, and IISc Bangalore — has been underway over the last few years. A budget of ~₹250 crore has been allocated to foster their ability to provide returns on this investment by way of promotion of tangible economic growth.

iii. The IITMRP Model provides a range of services to support R&D activities, including state-of-the-art infrastructure, access to funding, legal and financial assistance, and technology incubation services. The research park also promotes industry-academia partnerships, providing a platform for researchers to collaborate with industry experts and commercialize their research outcomes. However, the research park model primarily attracts large companies and multinationals, which limits the participation of SMEs.

2.5.8.4 Centre of Excellence in Wireless Technology (CEWiT)

i. The Centre of Excellence in Wireless Technology (CEWiT) is an autonomous research society of IIT Madras set up with support from Ministry of Communication and IT and the Indian telecom industry. CEWiT's vision is to provide technological leadership to the Indian wireless industry and address the needs of the Indian market through advanced R&D and value creation. CEWiT works as a neutral partner

to industry stakeholders and policymakers on various technological aspects of the wireless communication industry. The Center has several experts in Radio Access technologies, specifically focusing on latest wireless and mobile technologies.

ii. CEWiT conducts research in 5G technologies and participates in global standardization. It is engaging very closely with academic and industry research groups in India to focus on areas with strong potential for contribution to global standards while keeping in mind operator requirements and usage scenarios.

iii. CEWiT with its vast knowledge and experience base provides consultancy and technical services to Telecom companies in India in the areas of 4G technologies like Long-Term Evolution (LTE) and LTE-Advanced and the 5G technologies. It has built simulators and test beds which benefit the industry in its R&D and capacity building activities. CEWiT plays a key role in building a dynamic wireless R&D ecosystem in India.

2.5.8.5 5G Testbed in India:

i. In 2018, the Government of India allocated INR 224 crore to develop an indigenous end-to-end 5G testbed. The project was awarded to IISc Bangalore, IIT-Madras, The Centre of Excellence in Wireless Technology (CEWiT), IIT-Delhi, IIT-Kharagpur, IIT-Hyderabad, and Society for Applied Microwave Electronics Engineering & Research (SAMEER). The testbed, located partly in all these institutions, envisages close collaboration between the universities and start-ups and creating an ecosystem that closely resembles a real-world 5G deployment.

ii. Key subsystems being developed as part of 5G testbed are:
Sub 6 GHz full-digital Massive Multiple-Input Multiple-Output (MIMO) remote radio head

a. 64 Antenna systems (Sub 6GHz).
   - Radio, front end.

b. Integrated mmWave hybrid remote radio head (RRH)
   - Development of hybrid analog/digital architecture.
   - 256 antennas (with 4 streams).

c. 5G base band unit (BBU)

- 5G NR (3GPP38 series) compliant.
- Standalone (SA) mode.
- Supporting lower band (<6GHz) and higher bands (>6 GHz).

d. 5G core network
   - Software-Defined Networking (SDN) based.
   - Multi-Radio Access Technology using Wi-Fi.

e. Management layer for testbed management

f. End-to-end IoT network using a mix of commercial and prototype components

g. Security
   - Security for IoT will be a special focus.
   - Security for SDN and NFV architectures will be a new challenge to address.

h. Light Fidelity (Li-Fi)

b. Gigabits range high-speed Li-Fi system

iii. The aim of the testbed is to develop all components of a basic 5G system from the ground up in a production-grade standard-compliant manner and open these components to researchers and start-ups in India for their use in R&D efforts. The testbed operates using spectrum in both sub-6GHz and mmWave frequencies, and support enhanced mobile broadband (eMBB), ultra-low latency communications (URLLC), and massive machine-to-machine communications (mMTC) including narrowband internet of things (NB-IoT) services. The 5G testbed work breakup is shown in Table 2.7.

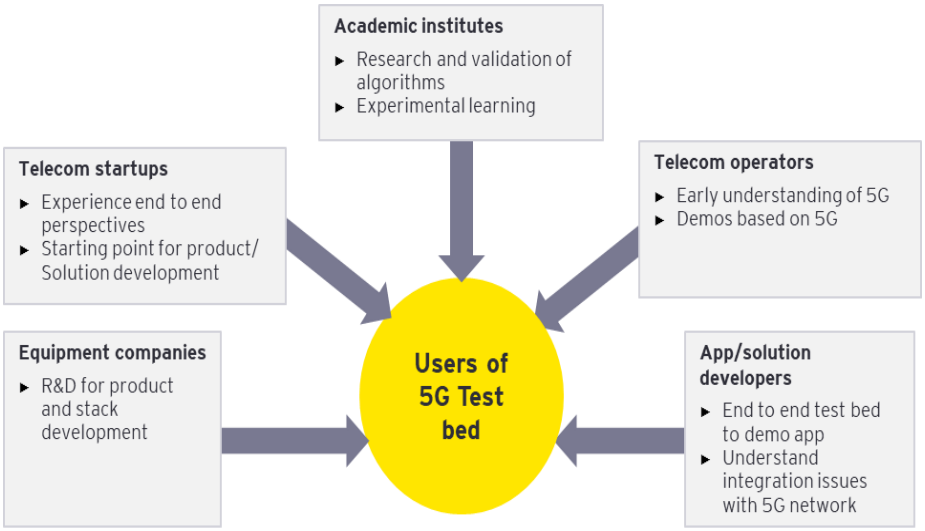
Table 2.7: 5G testbed work breakup[53]

Institute	Subsystem
CEWiT	UE L1/L2/L3, Baseband Algorithms, Core Network
IIT Bombay	Core Network
IIT Hyderabad	NB-IoT ASIC, gNB L1/L2/L3
IIT Madras	gNB/UE Hardware Platforms, gNB L1, Core Network
IIT Kanpur	gNB BBU Hardware Platform, gNB L1
SAMEER	Antennas, RF modules
IISc Bangalore	Baseband Algorithms, gNB L1 (open stack) IoT, LiFi
IIT Delhi	Baseband Algorithms, LiFi, Security

vi. Users of 5G Testbeds- The users of 5G testbeds in India are primarily researchers in academic institutes, technology companies, and startups who are working on developing and testing 5G technology and applications. The testbeds provide a platform for these stakeholders to experiment and innovate with 5G technology, create new use cases, and test the performance and scalability of their applications. In addition, the testbeds are also used by telecommunications companies and government agencies to evaluate and test 5G network infrastructure and services. After successful demonstration of the 5G technology during trials, TSPs have now successfully launched 5G network in the country with more than 210223 5G BTS, as on 25.05.2023. Overall, the users of 5G testbeds in India include a diverse range of stakeholders who are interested in developing and leveraging 5G technology for various applications and use cases.

[53] Source: EY Analysis

Figure 2.10: Users of 5G Testbeds



5G testbed provided a platform for researchers, startups, and technology companies to experiment and innovate with 5G technology, leading to the development of new products and services. Additionally, 5G testbeds have fostered collaboration among stakeholders in the 5G ecosystem and helped drive the development of standards and best practices. To further capitalize on the synergy thus established, TRAI in its "*Recommendations on Leveraging Artificial Intelligence and Big Data in Telecommunication Sector*" dated 20.07.2023 recommended that "*At least one Centre of Excellence for Artificial Intelligence (CoE-AI) should be established in each State/UT for facilitating educational institutions, startups, innovators, researchers and other public/private entities to develop and demonstrate technological capabilities. These centres should have access to high bandwidth, computational facilities and data sets for training AI models. All such centres should also be linked with proposed 5G/6G labs for sharing of resources and knowledge. To galvanize an effective AI ecosystem and to nurture quality human resources these CoE-AIs should allow industry players as well as startups to partner with Academia in conducting research, developing cutting-edge applications and scalable problem solutions in various fields such as agriculture, healthcare, education, smart cities, smart mobilities, etc.*"

2.5.8.6 5G Hackathon- Application Development: DoT launched 5G Hackathon with the objective to identify and promote applications relevant to India in different categories like healthcare, education & governance, banking, finance and insurance/ cyber-security/ enterprise transformation, Industry 4.0, AgriTech & livestock and smart cities & infrastructure etc. In 2022-23, from Phase 3, out of 30 winners 27 have developed their products. Based on evaluation, DoT shortlisted top three winners for an award of ₹10 Lakh each. With 5G Hackathon, DoT has been able to develop 56 applications/use cases using 5G technology.

2.5.9 R&D of MNCs in India: In the past, R&D centres used to be concentrated in developed countries, however, presently, many MNCs are gradually expanding their R&D base in developing markets to customise their products to meet the expectations of new customers. Likewise, large multinational enterprises have centres dedicated to design, engineering, or development in India. While these centres were started in pursuit of cost arbitrage opportunities, over time many of them improved their capabilities and started working with cutting-edge technology on products for their parent companies. As per the NASSCOM's Advantage India Report 2021[54], India is home to over 1,430+ Global Capability Centres (GCCs) across verticals that employ over 1.38 million people. Engineering R&D is leading the GCC growth story of India with 55 per cent market share.

2.5.9.1 As of 2020, more than 180 innovation centres in India belong to Fortune 500 companies, and 48 out of the top 50 Engineering R&D spenders have their centres in the country, reiterating India as a destination for engineering and innovation. Many MNCs are now increasingly outsourcing their corporate R&D efforts by investing in India's local start-up ecosystem to create breakthroughs in innovations that could help the parent companies. Further, India's talents have also played a pivotal role, with many of the leading global enterprises building their largest or second largest R&D hubs in India. Globally, India is one of the most diverse countries, offering skilled and diverse workforce spread out across the country. It has become a hub for digital talent with specialized

[54] Source: https://community.nasscom.in/communities/engineering-research-design/advantage-india-gateway-global-engineering-rd-and

skills in high demand technology areas such as IoT, AI, Machine Learning (ML), Robotics, etc.

2.5.9.2 To understand the contributions to and consumption of ICT R&D by the MNCs in the private sector, following case studies on Samsung, Intel, Qualcomm, Nokia and Ericsson provide the necessary insights.

i. Samsung- Samsung's strong R&D efforts demonstrate its ICT clout. Samsung originally entered India in 1995, opening its first manufacturing facility in Noida and its first R&D centre in Bengaluru a year later. At present, the manufacturing facility at Noida is its second biggest manufacturing facility in the world and the R&D centre in Bengaluru is its biggest R&D centre in the world. The C-Lab and Technology Lab of the company foster innovative ideas that grow into successful start-ups. By involving universities and external partners, open innovation speeds up product development. Innovative solutions have been developed by Samsung's Advanced Communication, Rich Multimedia, AI, and IoT CoEs. Samsung's investment in startups benefits India's startup ecosystem. Partnerships with Indus OS, InMobi, and gnani.ai demonstrate this. Academic collaborations such as IIT Patna and IIT Madras help to advance Natural Language Generation and protein modelling algorithms. Samsung also collaborates with IIIT Bangalore and IIT Kharagpur to provide students with cutting-edge training. Finally, Samsung's R&D strategy has shaped the ICT landscape through in-house innovation, open collaboration, technology CoEs, startup investments, academic alliances, and talent enrichment.

ii. Intel - With cutting-edge facilities in Bengaluru and Hyderabad, Intel India Pvt. Ltd. is the largest design and engineering centre outside of United States. The Engineering R&D department employs 9000 people. Intel is a major player in ICT research and development. Intel Incubation Program fosters innovative ideas and technologies within Intel by establishing a startup-like environment. It was significant to collaborate with IIT Madras to design Shakti, India's first indigenous microprocessor. This microprocessor has applications ranging from mobile computing to nuclear systems. Intel's collaborations with NITI Aayog and the Ministry of Electronics and Information Technology have resulted in the

establishment of tinker labs in schools and community centres to teach youth technology skills and foster innovation. Intel's involvement in the government's responsible AI for youth program demonstrates the company's commitment to closing the skill gap and preparing young people for AI. Intel's internal programs, startup, academic, and government collaborations all have a significant impact on R&D in the ICT sector.

iii. Qualcomm[55]- Qualcomm is a semiconductor and wireless telecommunications company that operates on a global scale. In 2004, first Indian R&D office was opened in Hyderabad. R&D setup of the Qualcomm in India is the largest outside of company's headquarters at San Diego, California. Over 10,000 employees operating at Bengaluru, Hyderabad, Chennai, and Noida account for a quarter of overall Qualcomm's workforce. In India, they specialise in wireless modem and multimedia software, DSP and embedded applications, and digital media networking solutions. Qualcomm has pushed R&D with several significant initiatives. The wireless technology Chair at the IIT, Madras promotes wireless innovations and high-quality research, demonstrating the company's academic partnerships. Qualcomm's Annual Innovation Fellowship program recognises and mentors winning research teams in semiconductor, communication, machine learning, and other fields. Qualcomm's Design in India Challenge encourages Qualcomm-powered hardware designs to strengthen India's startup ecosystem. Qualcomm's support for STEM education and talent development demonstrates the company's commitment to STEM diversity and gender equality. Qualcomm's Aqriti community outreach program promotes mentorship, awareness, and scholarships for underprivileged girls interested in STEM careers. Qualcomm's academic partnerships, startup empowerment, and talent upskilling all have a significant impact on R&D in the ICT sector.

iv. Nokia[56]- Nokia's R&D in ICT has aided India's technological advancement. In India, company has invested more than INR 38 billion (Rs 3800 Cr) in manufacturing sector. Nokia's largest R&D centre,

[55]Source: https://www.qualcomm.com/company/locations/india/design-in-india-program
[56]Source: https://www.nokia.com/about-us/company/worldwide-presence/india/#:~:text=One%20of%20the%204%20main,Optical%2C%205G%20and%206G%20Research.

located in Bengaluru, is known for its groundbreaking research in telco cloud, big data analytics, software applications, next-generation core, 5G, and 6G. Chennai's Fixed Networks and Broadband R&D Centre is also significant. Nokia also collaborates with academic institutions such as IIT Madras to improve broadband connectivity in rural India by utilising unlicensed spectrum. By bridging rural connectivity, this initiative contributes to the government's 'Digital India' vision. Nokia's 5G/IoT lab in Bengaluru creates smart city, public safety, and Internet of Things applications such as real-time city surveillance and smart parking. Nokia's significant R&D contributions, strategic partnerships with academia, and cutting-edge R&D facilities have helped to shape India's technological landscape, enabling widespread connectivity, and fostering future innovation.

v. Ericsson[57]- Ericsson's investment in ICT research and development has aided India's technological advancement. Ericsson's R&D facility in 2006 focused on value-added mobile phone applications, which was a watershed moment. The Global Artificial Intelligence Accelerator India (GAIA India) centre advances artificial intelligence (AI) and automation technologies for telecommunications and other industries. Ericsson Garage, a technology and business incubator, has used lean startup methodology to help transform innovative ideas into impactful solutions. With Indian telecom operators and academic institutions, the company developed, deployed, and tested 5G networks and use cases. Ericsson's artificial intelligence and incubator programs, as well as its 5G technology work, have advanced the ICT sector and propelled India's technological leadership.

2.5.9.3 Private Sector in India has the potential to make significant contributions to the country's research and development (R&D) ecosystem. However, there are several bottlenecks that hinder their ability to do so effectively. As mentioned above, private sector's contribution to the total expenditure on R&D in India has been stagnant and hovers around 37%. By addressing the concerns of the private sector, it has the potential to be leveraged further for growth in the R&D Sector more significantly. The shortage of skilled professionals, linking with

[57]Source: https://www.ericsson.com/en/about-us/company-facts/ericsson-worldwide/india

academic institutions over a long period, working in silos, weak intellectual property protection, and limited market access etc are few bottlenecks which may be needed to be addressed for sustainable growth of R&D in the Private Sector.

2.5.9.4 **Roles of MSMEs and Startups in R&D**: To understand the contributions and consumption by Indian startups and MSMEs, following case studies provide the necessary insights.

i. VNL[58]: Founded in 2004, VNL started as a telecommunication enabler that indigenously develops end-to-end telecom infrastructure products and solutions and became the first Indian company to realize the potential of research and development of telecom technology that led to marvellous simplification of telecom tech for rural ICT expansion. In the span of its lifetime to date, VNL has enabled mobile connectivity in the remotest parts of the world, empowering the lives of thousands living in rural and remote areas without any network. With over 350 engineers working to create new benchmarks in technological innovation across the country, VNL is India's first and only company to design and manufacture its own portfolio of end-to-end GSM, LTE & Broadband network solutions for commercial purpose as well as a wide range of solutions for tactical communications, wireless signal intelligence, surveillance and reconnaissance solutions.

ii. Saankhya Labs[59]: Established in 2006, Saankhya Labs is India's first fabless semiconductor solutions company. The company developed the world's first production Software Defined Radios (SDR) chipsets. Saankhya Labs' products and solutions are powered by their award-winning, patented, ultra-low power consumption, fully programable SDR chipsets. They have designed and developed a full spectrum of next-gen communication solutions for the present and the future. These include products and solutions for broadband, satellite and broadcast applications including 5G NR, Direct To Mobile (D2M) Broadcast, rural broadband connectivity, satellite communication modems for IoT applications and multi-standard DTV modulators and demodulators.

[58] Source: https://www.vnl.in/about-us/
[59] Source: https://saankhyalabs.com/aboutus/

iii. Tejas Networks[60]: With the goal "*to build a pioneering innovation-driven, global networking product company*", Tejas Networks was founded in the year 2000 in Bengaluru. It now has progressed to have offices in 10+ countries, employing over 900 people. The product portfolio of Tejas Networks includes Wireline Optical Transport, Wireless RAN, Fixed and mobile wireless access (4G/5G), Secure ethernet/IP switches, Network Management Software, among others.

iv. Sterlite Technologies Limited (STL)[61]: STL is a leading global optical and digital solutions company providing advanced offerings to build 5G, Rural, Fibre to the X (FTTx), Enterprise and Data Centre networks. The company, driven by its purpose of 'Transforming Billions of Lives by Connecting the World', designs and manufactures in four continents with customers in more than 100 countries. Telecom operators, cloud companies, citizen networks, and large enterprises recognize and rely on STL for advanced capabilities in Optical Connectivity, Global Services, and Digital and Technology solutions to build ubiquitous and future-ready digital networks. STL's business goals are driven by customer-centricity, R&D and sustainability. Championing sustainable manufacturing, the company has committed to achieve Net Zero emissions by 2030.

v. Lekha Wireless Solutions[62]: Lekha develops access technologies like 5G New Radio (NR), LTE, Worldwide Inter-operability for Microwave Access (WiMAX), Mobile Adhoc NETwork (MANET) Software Defined Radios (SDR) etc. and offer deep expertise in customizing them for specific applications and network topologies. Lekha wireless has a strong Research and Development team, combined with Engineering expertise in software and hardware for delivering complete system. Lekha provides data link solutions to private network operators, large defense and aerospace System integrators. Lekha's experience has always helped customers in creating quick proof of concept and accelerate technology adoption. Lekha also supports customization of hardware and software

[60] Source: https://www.tejasnetworks.com/company-history.php
[61] Source: https://stl.tech/about-us/
[62] Source: https://www.lekhawireless.com/company/about-us/

to suit unique customer needs. Lekha has several products and solutions in deployment through customers and partners.

2.5.9.5 Apart from these five case studies, there are several other startups which are working towards making India a proud leader in the ICT sector. These include Cyclops Medtech, Kaaenaat, Maxerience, Terrablue XT, Parkzap, QNu Labs, Cardiotrack, SwitchOn, Entropik Tech, Skincurate Labs etc. [63]

2.5.9.6 To leverage the further untapped potential of start-ups and MSMEs in the R&D in ICT sector, there may be a need to provide an impetus to ICT R&D by startups. In recent past, policies and programs of the government have been providing this impetus by allowing for larger availability, accessibility, and affordability of the required resources. There have been numerous attempts such as the Emergency Credit Line Guarantee Scheme (ECLGS) and Open Network for Digital Commerce (ONDC) to build not only a digitally inclusive but also a digitally empowered society. However, the ability of Start-ups to leverage these efforts has been limited. Some of the major bottlenecks in this regard include inability to find adequate financial resources, linkage with academic institutions on long term basis, poor revenue generation, lack of high-quality infrastructure, difficulty in procurement of equipment, weak IPR protection, non-competitive products and services and lack of mentorship. Further, many of India's brightest minds emigrate to other countries for better opportunities or tend to gravitate towards high-paid jobs in the MNCs, resulting in a brain drain that weakens country's research and development capabilities. Thus, startups in India, most of the times, find themselves preoccupied with firefighting these challenges and hence are unable to focus on R&D and innovation.

2.5.10 Semiconductor Industry in India

i. The Semiconductor industry, which is now an inseparable part of almost all sectors, has emerged as one of the most important industries. It forms an essential part of all electronic items. It defines how efficiently and smartly we live.

ii. In India nearly 2,000 chips are being designed per year and more than 20,000 engineers engaged in chip design and verification. India has seen

[63] Source: https://indiaai.gov.in/article/check-out-these-10-indian-startups-leading-innovation-in-hardware

growth in consumer electronics as a business and market, especially in the past decade, which witnessed growing demand and market for smartphones, intelligent vehicles, renewable energy (especially solar photo-voltaic), solid-state lighting (LEDs), electronics in the healthcare sector, tablets, increasingly sophisticated displays, etc. Local electronics consumption was expected to touch US$ 400 billion by 2020, which translates into a chip market of between US$ 50 billion and US$ 60 billion.

iii. India Semiconductor Mission[64]- India Semiconductor Mission (ISM) has been setup as an Independent Business Division within Digital India Corporation. ISM has all the administrative and financial powers and is tasked with the responsibility of catalysing the India Semiconductor ecosystem in manufacturing, packaging and design. ISM has an advisory board consisting of some of the leading global experts in the field of semiconductors. ISM is serving as the nodal agency for efficient, coherent and smooth implementation of the program for development of semiconductor and manufacturing ecosystem in India. ISM is important for R&D ecosystem in India and the following objectives of ISM reiterate the same:

   a. Enable cutting-edge research in semiconductors and display industry including evolutionary and revolutionary technologies through grants, global collaborations, and other mechanisms in academia/research institutions, industry, and through establishing Centres of Excellence (CoEs).
   b. Enable collaborations and partnership programs with national and international agencies, industries, and institutions

iv. Semi-Conductor Laboratory (SCL)[65]: SCL is an autonomous body under Ministry of Electronics & Information Technology (MeitY), Government of India. It is engaged in Research & Development in the area of Microelectronics to meet the strategic needs of the country. SCL has integrated facilities / supporting infrastructure all under one roof and

[64] Source: https://pib.gov.in/PressReleasePage.aspx?PRID=1885367

[65] Source: https://www.scl.gov.in/scl.html

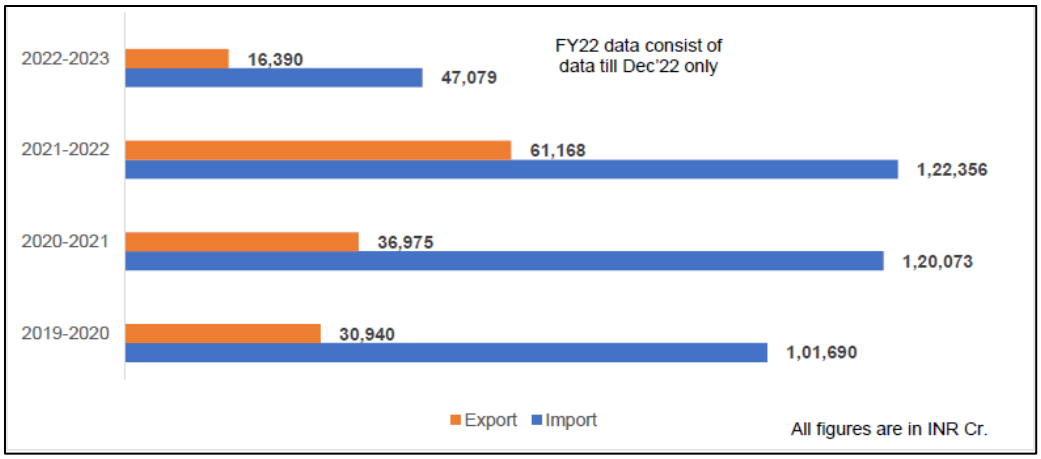
undertakes activities focused on Design, Development, Fabrication, Assembly & Packaging, Testing and Quality Assurance of Complementary Metal-Oxide-Semiconductor (CMOS) and Micro-electromechanical systems (MEMS) Devices for various applications. SCL is also engaged in Fabrication of Hi-Rel Boards, Radio Sonde Systems and indigenisation of electronic sub systems.

2.5.11 Foreign Direct Investment (FDI) and Trade Deficit in Telecom Sector

i. According to Invest India website, the Telecom sector is the third largest sector in terms of FDI inflows, contributing 6.43% of total FDI inflow, and contributes directly to 2.2 Mn employment and indirectly to 1.8 Mn jobs. Between 2014 and 2021, the FDI inflows in the Telecom sector rose by 150% to $20.72 Bn from $8.32 Bn during 2002-2014. In India, 100% Foreign Direct Investment (FDI) has now been allowed in the telecom sector under the automatic route. However, trade deficit remains an issue in the telecom sector.

ii. According to DoT website[66], in FY2021-22, the value of imports in telecom sector stood at ₹122356.30 (in crore) whereas the value of exports in telecom sector stood at ₹61177.57 (in crore). Thus, trade deficit amounts to more than ₹60,000 (in crore) in telecom sector.

Figure 2.11: Export and Import of Networking and Telecom Equipment in India[67]



[66] Source: https://dot.gov.in/sites/default/files/FY%202021-22%20Export%20and%20Import%20Data.pdf?download=1

[67] Source: Invest India Report

iii. There is a high demand for imported telecom equipment and electronics goods in India. India's domestic manufacturing capabilities in these sectors are limited, and country heavily relies on imports to meet its growing demand for ICT services. In the NATE (Networking and Telecommunication Equipment) sector, Indian manufacturers continue to be supply-constrained in fulfilling customer orders due to a shortage of certain critical chips. The lead time of some of the semiconductor chips is more than 52 weeks, which has resulted in an inability to fulfil orders from both domestic and foreign customers.

iv. India's contribution to the global telecom equipment market is only 1.4%-1.5%.[68] The USA, UAE, and Netherlands are the top 3 export markets for India, contributing around 25% to India's exports of telecom and network equipment. Exports[69] of telecom equipment from India primarily consist of Optical Fibre Cables, Printed Circuit Boards, Telephonic/Telegraphic apparatus, Multiplexers, SDH (Synchronous Digital Hierarchy) and ISDN (Integrated Services Digital Network) equipment. In the total exports from India, the share of equipment for radio access networks, IP networks, core networks and optical networks to support 4G and 5G technologies is currently minimal.

v. Additionally, piracy and counterfeiting result in an increase in the trade deficit through loss of revenues, increased imports, decreased export of services, and a negative impact on foreign direct investment. Further, lack of market access to domestic manufacturers, higher manufacturing costs, the depreciation of the Indian rupee (₹) against the US dollar has also contributed to the increase in the trade deficit. This deficit can be narrowed down if indigenous R&D in ICT sector gets the required push.

Key points emerged from above discussions include:

i. **Low number of organisations involved in R&D in telecom and broadcasting sectors:** The Directory of R&D Institutions 2021 mirrors the low number of public and private R&D units in telecom sector as compared to the total R&D units. Further, data on broadcasting sector is not mentioned separately.

[68] Source: Invest India Report
[69] Source: https://dot.gov.in/reportsstatistics/import-export-statistics-FY-2021-22

ii. **Limited government-industry-academia collaboration:** Linkage of Industry – Academia and Government on long terms basis may be one of the most essential items to promote R&D on sustained growth basis in India. To pursue the goal of $5 trillion economy, it's important to break the shackles and overcome the practice of working in silos.

iii. **Limited commercialization of research due to weak interlinkages:** Working in silos and lack of testing and standardization has resulted in a gap between the research being done at the university-level and the need of innovation at the industry-level. On one hand, the efforts put-in by the researchers are not rewarded appropriately and on the other hand, results of the research are not exploited by the industry.

iv. **Low private investment in R&D and MNCs focus on software instead of hardware, leading to lack of product development:** India's GERD is not only low but lopsided. The private sector's investment in R&D has been stagnant over the past decade at about 37%. This is in contrast to the private investment in the developed countries. Moreover, software products have been the focus of the private sector rather than the hardware sector, leading to job-less growth and huge trade deficit.

v. **Dormant TCOEs and limited involvement of industry therein:** Eight TCOEs were established in 2007, however, half of them have become inactive. Also, those which are active, have only limited involvement and interaction with the industry. Thus, leading to crippled progress in innovation.

vi. **Low indigenous R&D and manufacturing, leading to high trade deficit:** There is high demand for telecom, broadcasting, and convergent equipment in India. These equipment are imported in India rather than manufactured in India, due to low indigenous R&D and manufacturing capabilities. As a result, there is burgeoning effect on the overall trade deficit.

Issues for Consultation

Q.4. Whether current science system (network of public and private institutions involved in the production and consumption of R&D and innovation) is sufficient to foster R&D and innovation in India in general and ICT in particular? If not, what additional measures

are required to strengthen science system of the country and ensure availability of adequate resources for the same? Please support your answer with justification and best practices being followed in India and abroad in this regard.

Q.5. How can the participation of public sector enterprises involved in R&D be augmented towards a synergized national effort in research, development, and innovation in ICT? Please support your answer with justification and best practices being followed in India and abroad in this regard.

Q.6. What should be the prerequisites and key characteristics of an effective next-generation technology testbeds in India? Will defining national-level mission and strategic objectives for ICT help in their effective utilization? Please support your answer with justification and best practices in India and abroad in this regard.

Q.7. What role do you envisage for the service providers and industry in facilitating indigenous R&D in the ICT sector respectively? How can industry participation in R&D in the ICT sector be further improved? Please support your answer with justification and best practices in India and abroad in this regard.

Q.8. How Telecom Centres of Excellence (TCOEs) can be made hubs of innovative product delivery to telecom industry? What can be done to further strengthen the TCOEs in order to provide an impetus to innovations in the telecom sector? Please support your answer with justification and best practices in India and abroad in this regard.

Q.9. Is there a need to establish new Centres of Excellence for the broadcasting sector? What can be done to synergize telecom and broadcasting sectors for the objective of convergence? Please support your answer with justification and best practices in India and abroad in this regard.

Q.10. What are the reasons behind MNCs primary focus on software rather than hardware in India? What measures can be taken to promote basic/applied research by MNCs strengthening the current R&D efforts in software and improving R&D efforts in hardware? Suggest

a suitable mechanism to establish a balanced R&D Science System in the country.

Q.11. What are the steps required to strengthen government-industry-academia linkages in the ICT sector on long terms basis? Please support your answer with justification and best practices in India and abroad in this regard.

2.6 Focus Element #3a – Regulatory Framework: Policies and programs

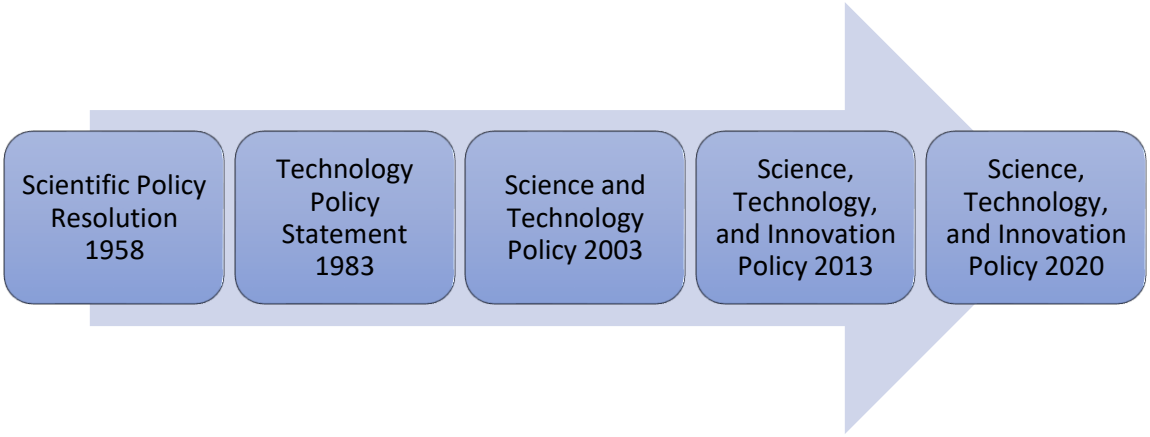
2.6.1. In India several initiatives have been taken to promote science, technology, and innovation and to establish a potent regulatory framework. Multiple policies, programs and schemes have been launched by the central government, state governments and autonomous bodies to cultivate an interest and facilitate scientific research and innovation in society. These policies and programs helped not only in establishing the education & training system and science system but also in generating synergy between them and the government.

2.6.2. Evolution of Policies & Programs in R&D

The below mentioned paras deliberate on policies and programs of the Government of India on promoting R&D framework in the country.

2.6.2.1 Science, Technology, and Innovation Policy (STIP) 2020[70]- The Figure 2.12 below indicates that over the period various science, technology and innovation policies have been formulated by the Government of India. Four major policies namely Scientific Policy Resolution (SPR 1958), Technology Policy Statement

Figure 2.12: Science, Technology, and Innovation Policies in India



[70] Source: https://www.psa.gov.in/stip

1983, Science and Technology Policy 2003 (STP 2003), and Science Technology Innovation Policy 2013 (STIP 2013) have been implemented.

2.6.2.2 STIP 2020 (draft) proposes that all the R&D activities in Science and Technology in India will be under the guidance of the Office of the Principal Scientific Adviser (PSA) to the Government of India (discussed in detail in subsequent paras). The salient features of STIP 2020 are:

i. A National STI Observatory, which will act as a central repository for all types of data associated with and generated from the STI environment, will be established. It will include a database of all the schemes and incentives of the Government of India.

ii. Complete data generated from government funded research will be available to the public under FAIR (findable, accessible, interoperable, and reusable) terms. A dedicated portal for providing access to the outputs of such government funded research will be created through Indian Science and Technology Archive of Research (INDSTA).

iii. New Universities will be established to promote multidisciplinary R&D to address community needs. Higher Education Research Centres (HERC) and Collaborative Research Centres (CRC) will be established to provide research inputs to policymakers and for bringing together all stakeholders. Research Excellence Framework for Higher Education Institutions (HEIs) in India (REFI) will be formulated for research assessment across the full academic spectrum within India's higher education ecosystem.

iv. For improving the STI ecosystem of the country, each department/ ministry of the central, state, and local governments, public sector enterprises, private sector companies and start-ups will be setting up an STI unit with a minimum earmarked budget for pursuing STI activities. To double the share of extramural R&D support of the central government agencies in the Gross Domestic Expenditure on R&D (GERD) in the next five years, the extramural funding shall be diversified and enhanced.

v. An institutional setup will be established for integrating traditional knowledge systems and grassroots innovation and to transform them into the overall education, research, and innovation system.

vi. Encouraging the grassroots innovators through support for registration, claiming the IPR, patent filing, or any other legal issues.

vii. The vision for STIP 2020 is as follows:

a. To accomplish technological self-reliance, and position India amongst the best three scientific superpowers of the world in the next decade.

b. To draw in, nurture, strengthen, and retain critical human resources through a 'people-centric' science, technology, and innovation (STI) environment.

c. To increase the number of Full-Time Equivalent (FTE) researchers, GERD, and make a two-fold increase to the private sector contribution to the GERD in every five years.

d. To build individual and institutional excellence in STI with the aspiration to attain the highest level of worldwide recognitions and awards in the decade to come.

STIP 2020 will provide the needed impetus to research, development and innovation in the country.

2.6.2.3. Other than the five Science, Technology, and Innovation Policies (STIPs), there have been other policies that have helped to shape the current regulatory framework, such major policies are discussed in the paras to follow.

2.6.3. National Digital Communications Policy (NDCP-2018)[71]- NDCP-2018 prepared a roadmap for the future of telecommunications and broadcasting sectors. It aimed to remove/minimize regulatory barriers and reduce the regulatory burden that restricts Indian and foreign investments, innovation and consumer interest in both telecom and broadcasting sectors.

The strategies adopted under NDCP 2018 for improving R&D in the Digital Communication Technologies include:

i. Restructuring C-DOT as a premier Telecom R&D centre.

ii. Simplifying approvals and processes for R&D procurements/imports.

[71] Source: https://dot.gov.in/sites/default/files/EnglishPolicy-NDCP.pdf

iii. Creating a framework for testing and certification of new digital products and services.

iv. Creating a dedicated fund for R&D in new technologies for start-ups and entrepreneurs.

v. Establishing Centres of Excellence, including in Spectrum Management, Telecom Security, and Next-Generation Access Technologies.

vi. Encouraging an IPR regime that promotes innovation by:

   a. Implementing key recommendations of the National IPR Policy-2016 pertaining to Digital Communications.

   b. Assisting start-ups and other innovators in filing copyright, patents, and trademark applications.

   c. Providing incentives for the development of Standard Essential Patents (SEPs) in the field of digital communications technologies.

   d. Promoting Indian IPR through international collaborations and active participation in standard development processes and IPR related events

vii. Simplifying the process of obtaining Experimental Licenses and establishing regulatory sandboxes by enabling creation of suitable infrastructure for testing of new products and services, facilitating allocation of trial spectrum for R&D and experimentation at affordable prices.

viii. Simplifying and fast-tracking approvals for products and services for experimental purposes through de-licensing and other mechanisms.

2.6.4. National Policy on Electronics 2019[72]- The National Policy on Electronics (NPE) 2019 of Ministry of Electronics and Information Technology (MeitY) aims to position India as a global hub for Electronics System Design and Manufacturing (ESDM) by encouraging and driving capabilities in the country for developing core components, including chipsets, and creating an enabling environment for the industry to compete globally. The key themes in the NPE 2019 include promoting industry-led R&D to develop electronic products, including associated design and creation of Intellectual Properties, for the domestic as well as global markets etc. Various provisions of NPE 2019 include:

i. Promote path-breaking research, grass root level innovations and early stage Start-ups in emerging technology areas such as 5G, IoT/ Sensors, Artificial Intelligence (AI), Machine Learning, Augmented Reality (AR) and Virtual Reality (VR), Drones, Robotics, Additive Manufacturing, Gaming and Entertainment, Photonics, Nano-based devices, as well as thrust areas such as medical electronics, defence and strategic electronics, automotive electronics, cyber security, power electronics and automation, having major economic potential, with a special focus on applying the outcomes, including frugal solutions, to solve real-life problems. Towards this, in addition to premier institutes like IITs, NITs, IIITs, and Central Universities, the institutes in small cities shall also be encouraged. Chairs in premier institutions will be established for focused research in the aforesaid emerging technology areas and thrust areas of electronics.

ii. Provide support for setting up of Incubation Centres/ Centres of Excellence (CoE) and strengthening/ re-orienting the focus areas of the existing centres to suit the current and future research requirements in the aforesaid emerging technology areas and thrust areas of electronics.

iii. Provide support for start-ups in these emerging areas/ technologies, from supporting the concept to development/ prototyping of products, including the complete value chain.

iv. Formulate joint strategy and action plan along with industry, academia, and R&D organizations to identify core technologies and develop,

[72]Source: NPE 2019

acquire/ pool Core and Peripheral IPs, and make them available to the industry.

v. Create Sovereign Patent Fund (SPF) to promote the development and acquisition of IPs in ESDM sector.

vi. Provide support for generation of Intellectual Property (IP) and Patents, including through outsourced R&D.

vii. Set up framework for creation of an ecosystem for promoting design and IP in the country.

viii. Facilitate interaction between academia [including Atal Tinkering Laboratories (ATLs) in schools across India, which aim to foster curiosity, creativity, and imagination in young minds; and inculcate skills such as design mindset, computational thinking, adaptive learning, physical computing, etc.] and industry to create and share IPs/ prototypes resulting from R&D programs. An agency to provide linkage between academia/ research institutes and industry shall be identified. After reviewing its progress, more such agencies would be set-up at regional levels.

ix. Set up a framework for incorporating principles of sustainability and environmentally sound management of electronic goods throughout their lifecycle, across all sub-sectors of electronics, from the design, production to end-of-life disposal.

x. Academia and freelancer-led R&D and innovation: Creation of facilities to house best-in-class fabrication, testing and analysis equipment, accessible to students, freelancers, and academicians to build, test and improve their prototypes.

xi. Promote R&D through PPP model with the funding support from industry and Government with specific focus on critical components/ subassemblies.

xii. Support systems for commercialization of technologies available with academic/ R&D institutions through exclusive/ non-exclusive mechanisms.

2.6.5. National Education Policy 2020[73] – The National Education Policy (NEP) 2020 contains several provisions for encouraging R&D in India. The policy seeks to create a culture of research and innovation by encouraging research-oriented education and promoting the development of critical thinking and problem-solving skills among students. The NEP 2020 provides for establishment of a National Research Foundation (NRF) to fund outstanding peer-reviewed research and to actively seed research in universities and colleges. It aims at providing the required impetus to grow the R&D by way of building a research ecosystem comprising the government, universities, research institutes and industry. According to the NEP 2020, primary activities of the NRF will be to:

i. fund competitive, peer-reviewed grant proposals of all types and across all disciplines;
ii. seed, grow, and facilitate research at academic institutions, particularly at universities and colleges where research is currently in a nascent stage, through mentoring of such institutions;
iii. act as a liaison between researchers and relevant branches of government as well as industry, so that research scholars are constantly made aware of the most urgent national research issues, and so that policymakers are constantly made aware of the latest research breakthroughs; so as to allow breakthroughs to be optimally brought into policy and/or implementation; and
iv. recognise outstanding research and progress. Further, the NEP 2020 promotes the integration of various disciplines and encourages interdisciplinary research to address complex problems.

2.6.5.1. On 28 June 2023, the Union Cabinet approved the introduction of National Research Foundation Bill, 2023[74] in the Parliament. According to Press Information Bureau, *"The bill, after approval in the Parliament, will establish NRF, an apex body to provide high-level strategic direction of scientific research in the country as per recommendations of the National Education Policy (NEP), at a total estimated cost of Rs. 50,000 crore during five years (2023-28). The Department of Science and Technology (DST) will be the administrative Department of NRF which will be governed by a Governing Board consisting of*

[73] Source: https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf
[74] Source: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1935895

eminent researchers and professionals across disciplines. Since the scope of the NRF is wide-ranging – impacting all ministries - the Prime Minister will be the ex-officio President of the Board and the Union Minister of Science & Technology & Union Minister of Education will be the ex-officio Vice-Presidents. NRF's functioning will be governed by an Executive Council chaired by the Principal Scientific Adviser to the Government of India." Further, the bill will repeal the Science and Engineering Research Board (SERB) established by an act of Parliament in 2008 and subsume it into NRF which has an expanded mandate and covers activities over and above the activities of SERB.

2.6.5.2 The NEP 2020 also proposes the establishment of research clusters and centres of excellence to promote interdisciplinary research. The policy emphasizes the need for greater collaboration between industry and academia to promote research and innovation. It proposes the establishment of industry-academia partnerships and encourages universities to set up technology transfer offices to facilitate the transfer of technology and knowledge to industry. The NEP 2020 also encourages international collaboration in research and innovation. It proposes the establishment of joint research programs and exchange programs for researchers and students to facilitate international collaboration. Lastly, the NEP 2020 reiterates the need to increase the funding for research and development in science and technology.

2.6.6 Bharat 6G Vision[75]**-** India is already looking beyond the adoption of 5G technology, to develop and deploy its faster and superior successor: the sixth generation of telecom network or 6G. The Bharat 6G Vision, created by Technology Innovation Group-6G (TIG-6G), aims to bring 6G technology to India by 2030. This vision is to develop and implement 6G network technologies that provide secure, intelligent, and widespread connectivity for high-quality living worldwide. The Vision statement emphasises India's commitment to socio-economic growth and the benefits of leading in 6G technology. 6G holds the potential to transform the Indian landscape through its offerings of faster data transfer speeds up to 1 terabit per second, ultra-low latency, improved security, and advanced features such as holographic communications and AI-powered networks. The first phase (2023-2025) of the Bharat 6G vision focuses

[75] Source: https://dot.gov.in/sites/default/files/Bharat%206G%20Vision%20Statement%20-%20full.pdf

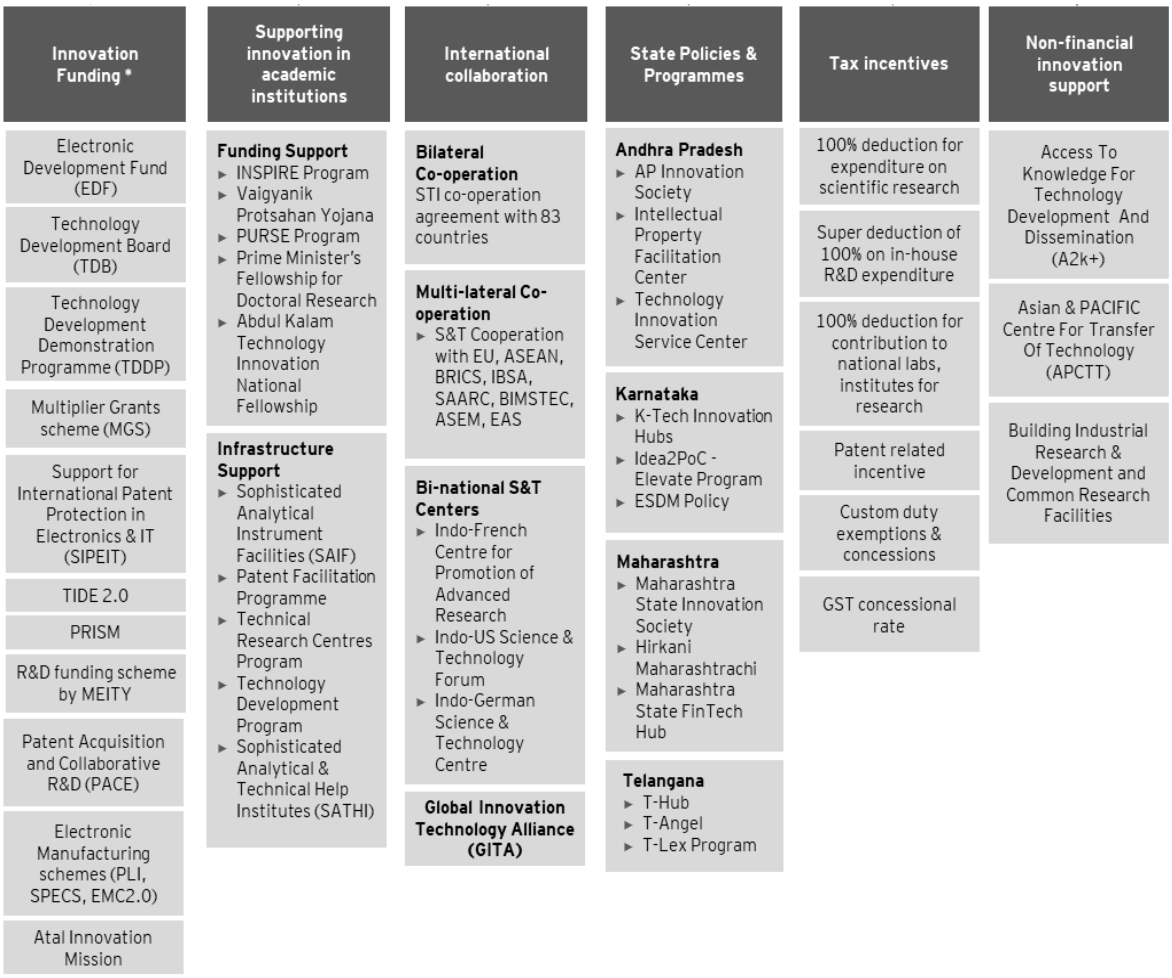
on explorative ideas, followed by the second phase (2025-2030), which lays emphasis on supporting ideas and concepts that show promise, and creating implementational IPs and testbeds leading to commercialisation. An Apex Council has been constituted and endowed with the responsibility of defining the phase-wise objectives, consulting the Bharat 6G Alliance, recommending research and innovation directions, monitoring progress periodically, conducting external evaluations, and proposing corrective actions if necessary. As part of Bharat 6G Vision, the government has proposed to invest ₹2,240 million in a new 6G Test Bed[76], co-developed by a consortium of Indian Institutes of Technology (IITs), to provide an R&D platform to start-ups, researchers, industry, and other broadband wireless applications.

2.6.7 **Programs encouraging indigenous R&D:** Apart from above policies, efforts in terms of various other policies and programs focussing on financial aspects like innovation funding, tax incentives and FDI inflow in the R&D sector, and non-financial aspects like infrastructural support and international collaborations have also been made. These policies and programs can be categorized into six broad categories, namely and listed in the Figure 2.13 below:

i. Innovation funding
ii. Support for innovation in universities
iii. International collaboration
iv. State policies & programs
v. Tax incentives
vi. Non-Financial innovation support

Figure 2.13: Category-wise list of programs for facilitating indigenous R&D

[76] Source: https://www.investindia.gov.in/team-india-blogs/bharat-6g-vision-indias-push-next-generation-telecom-technology



Source: EY Analysis

2.6.7.1. To understand the current R&D ecosystem in India in its entirety, it is pertinent to look closely at each of these program categories. The details of which have been included in Annexure III. Objectives and Goals, Process, Incentives and Eligibility could be taken as the assessment pillars to develop a deeper understanding of each of these categories:

i. Innovation funding- Programs in this category mainly focus on providing support during the later phases of the R&D lifecycle such as developing the proof of concept, prototyping and field testing, product development and technology transfer for commercialization. Measurable objectives of the programs in this category are clearly defined and the progress towards goals is being tracked and reported on regular basis for most of the programs. The application process is clearly defined. However, only few of the funds offer the facility of single window clearance along with defined timelines. Monetary and meaningful incentives are clearly defined but the information related to disbursement timelines and

related issues is not readily available. Eligibility criteria are clearly defined for most of the programs without any restrictive conditions related to exclusivity. Information related to the uptake of the program is not available.

ii. Supporting innovation in academic institutions- Key objective of these programs is to support research and innovation activities for high school students, graduates, post-graduates, and PhD fellows. These programs are mainly divided into two categories:

   a. Funding support – programs that provide monetary support to students/fellows or to educational institutes.
   b. Infrastructure support – programs that provide research infrastructure facilities to the educational institutes.

   Objectives for these programs are very clearly defined; however, they are not measurable for most of the programs and hence are not being tracked as a success measure. Application process is defined for majority of the programs along with a single window clearance facility and clear timelines. These incentives are funded by the Department of Science and Technology (DST). Monetary/non-monetary incentives are clearly defined for most of the programs. However, information related to disbursement timelines and related issues is not available. Eligibility criteria is clearly defined for most of the programs; however, some of the programs have restrictive conditions related to exclusivity. Information related to the uptake of the program is not available. It is also noted that the objectives, targeted applicants, and incentives for some of the programs are quite similar and repetitive in nature.

iii. International collaboration- In addition to multi-lateral collaboration with countries, these programs have bilateral collaborations as well with countries such as USA, Germany, France, etc. Objectives of these collaborations are mainly focused on supporting innovation and research in the areas of science and technology. Objectives are very clearly defined, and they are measurable as well in terms of number of projects, number of publications, number of fellowships, etc. These objectives are regularly tracked mainly through annual reports. Application process for

some of the programs is defined, while other programs do not give clear information of the same. There is no provision for single window clearance for the applications and timelines for approvals are not clearly defined as well. Monetary incentives are very lucrative and clearly defined for most of the programs. Eligibility criteria is clearly defined and doesn't have any exclusivity conditions. Information related to the uptake of the program is not available.

iv. State policies & programs- Programs offered by state governments of various states aim to provide incubation facilities, training programs, IP consultancy & filing assistance, mentoring initiatives, and infrastructure facilities to budding start-ups and technology innovation companies registered in the respective state. Overall goals of these programs seek to make the state a leader in the field of tech R&D and Innovation. Objectives were noted to be clearly stated and defined; they are measurable vide the number of start-ups or organizations enrolled under the scheme. Except for a few state-level programs, progress tracking of these schemes is largely not being reported. The application processes are clearly and expressly stated on the websites for most programs. However, there is no single window clearance available in more than half of the cases, and no fixed dates are mentioned for state programs. Incentives are meaningful and clearly defined. In two-thirds of the programs, the application processes are defined and expressly stated on the websites. Under these programs, the incentives provided range from monetary benefits such as seed funding to non-monetary incentives such as training/consulting services/mentorship programs/hackathons with lucrative rewards. Barring a third of the programs, there is no clearly defined fund for incentives. The eligibility criteria are not defined for some of the programs. The programs are largely restricted to state registered start-ups and natives. R&D technology innovation programs of the states often offer a similar set of incentives to budding/established start-ups vis-a-vis Incubation, Technology Hubs, IP consultancy & filing-support, Training & Mentoring, and Investment opportunities with Angel Investors. Only Maharashtra offers an R&D program for FinTech start-ups and Self-Help Groups; no such initiative was noted in other states.

Except for Andhra Pradesh's Idea2POC, no other initiative focused on Proof-of-Concept & subsequent commercialization of the technology developed indigenously.

v. Tax incentives**-** R&D tax incentives form an important part of the policies and programs under the regulatory framework in India's R&D ecosystem. These benefits are available across 3 different statutory acts i.e., Income Tax Act 1963, Customs Duty Act 1962, and Central Goods & Service Tax Act, 2017. Incentives are largely available to companies; the only incentive provided to a person is vide relaxation of Income Tax on income from Patent. They can be categorized into direct and indirect tax incentives.

vi. Non-Financial innovation support**-** Objectives of these program are to support studies in the emerging areas of technologies through research and knowledge base. Objectives of programs under this category are clearly defined; however, they are not measurable, and hence not being tracked. Additionally, the application process and approval mechanism are not very clear, and timelines associated with the same are not clearly defined. Incentives are of non-monetary nature, but they are meaningful since they provide access to knowledge base across technologies. Eligibility criteria are clearly defined and don't have any exclusivity conditions. Information is not available related to uptake of the program.

2.6.8 **Other key initiatives**: Apart from the policies and programs discussed above, there are a few key initiatives taken by the Government of India to boost India's R&D aspirations, specific to the telecom and broadcasting sectors. These include:

i. Make in India: The GoI launched "*Make In India*" in 2014 to encourage companies to manufacture their products in India and promote research and development. To attract companies to India, the scheme offers tax breaks, streamlined regulations, and infrastructure development. The scheme also supports R&D in these sectors, encouraging innovation and new technology. This should boost India's ICT sector and economic growth.

ii. Atmanirbhar Bharat**:** Department of Telecommunications (DoT) under Atmanirbhar Bharat initiative[77] aims to promote an ecosystem for research & development and make India a global hub of development of technologies and manufacturing of telecom equipment including core transmission equipment, 4G/5G Next Generation Radio Access Network and Wireless Equipment, Access & Customer Premises Equipment (CPE), Internet of Things (IoT), Access Devices, Other Wireless Equipment and Enterprise equipment like Switches, Routers, etc. Under Atmanirbhar Bharat initiative of DoT, the target is to deploy end-to-end indigenously developed telecom technology products. Efforts by the government and Indian industry members have led to the development of indigenous 4G stack for deployment of commercial network by Bharat Sanchar Nigam Limited. Further, with the objective to build a strong ecosystem for 5G, DoT has sanctioned 17 companies under design-led manufacturing. 5G Alliance & IoT Innovation Centre has been launched by Centre for Development of Telematics (C-DoT) to support multiple Indian Startups and MSMEs for developing open RAN compliant 5G equipment.

Similarly, Ministry of Electronics and Information Technology (MeitY) introduced Swadeshi Microprocessor Challenge[78]- Innovate Solutions for #Aatmanirbhar Bharat to provide further impetus to the strong ecosystem of Start-up, innovation and research in the country. Christened as SHAKTI and VEGA- a power-pack duo of indigenously developed 32-bit/ 64-bit Microprocessors has been rolled out by IIT Madras and CDAC, respectively using Open Source Architecture under the aegis of Microprocessor Development Programme of Ministry of Electronics & Information Technology (MeitY).

iii. Telecom Product-Linked Incentives (PLI) Scheme[79]: The PLI scheme for telecom & networking products was announced with an outlay of ₹12,195 crore for a period of five years until FY26. The government

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[77] Source: https://pib.gov.in/PressReleasePage.aspx?PRID=1883479#:~:text=Department%20of%20Telecommunications%20(DoT)%20under,Radio%20Access%20Network%20and%20Wireless

[78] Source: https://www.meity.gov.in/writereaddata/files/Swadeshi%20Microprocessor%20Challenge.pdf

[79] Source: https://dot.gov.in/pli-scheme#:~:text=The%20PLI%20Scheme%20will%20be,will%20be%20%E2%82%B91000%20Crores.

encourages both MSME and non-MSME firms—including domestic and global companies—and players that manufacture specified telecom and networking products in following four product categories in India:

a. Core transmission Equipment
b. 4G/5G, Next Generation RAN and Wireless Equipment Access & CPE, IoT
c. Access Devices and Other Wireless Equipment
d. Enterprise Equipment: Switch and Router

iv. Telecom Technology Development Fund (TTDF)[80]: USOF officially launched Telecom Technology Development Fund (TTDF) Scheme on 01st October 2022. TTDF aims to fund R&D in rural-specific communication technology applications and form synergies among academia, start-ups, research institutes, and the industry to build and develop the telecom ecosystem. Additionally, the Scheme aims to promote technology ownership and indigenous manufacturing, create a culture of technology co-innovation, reduce imports, boost export opportunities and creation of Intellectual Property. Under the scheme, USOF is also targeting to develop standards to meet countrywide requirements and create the ecosystem for research, design, prototyping, use cases, pilots, and proof of concept testing, among others. The scheme entails grants to Indian entities to encourage and induct indigenous technologies tailor-made to meet domestic needs.

v. Digital Communications Innovation Square (DCIS)[81]: Major objective of DCIS is to promote the ecosystem for research, design, development, proof of concept testing, IPR creation, pilot project and manufacturing i.e., complete value chain to make India a global hub for production of telecommunication equipment and a centre for digital communication services. Communication services in India are mainly provided by imported equipment and technologies. The scheme will promote indigenous innovation and incubation of future technologies and their deployment/manufacturing thereof, resulting in value addition for the telecom sector in India.

[80] Source: https://usof.gov.in/en/ttdf-proposal-2023
[81] Source: https://dcis.dot.gov.in/

vi. Production Linked Incentive Scheme 2.0 (PLI 2.0) for IT Hardware[82]: After the success of the First Round of Production Linked Incentive Scheme in attracting investments in mobile phone and electronic component manufacturing, the proposal for accepting applications under Second Round of the PLI Scheme has been approved by the Competent Authority. The PLI Scheme 2.0 for IT Hardware, launched in May 2023, is expected to result in broadening and deepening of the manufacturing ecosystem by encouraging the localisation of components and sub-assemblies and allowing for a longer duration to develop the supply chain within the country. The target segment for the purpose of this round shall be Specified Electronic Components. Additionally, the scheme provides increased flexibility and options for applicants, and is tied to incremental sales and investment thresholds to further incentivise growth. Furthermore, semiconductor design, IC manufacturing, and packaging are also included as incentivised components of the PLI Scheme 2.0 for IT Hardware. The Scheme shall extend an average incentive of around 5% on net incremental sales (over base year) of goods manufactured in India and covered under the target segment, to eligible companies, for a period of six (6) years. The Target Segment under PLI shall include (i) Laptops (ii) Tablets (iii) All-in-One PCs (iv) Servers and Ultra Small Form Factor (USFF).

Key points emerged from above discussions include:

i. **No centralized governance body overseeing R&D activities in ICT Sector in India:** There are a number of programs in ICT sector where monetary and infrastructure-related incentives are funded by different institutions. Many of such programs have a high degree of overlap and duplicity of efforts due to lack of coordination and synchronization between different agencies. There is no overarching body to track the progress of R&D projects in ICT sector. Further, there are no standard indicators which can measure the progress/outcome of various programs.

[82] Source: https://www.meity.gov.in/esdm/production-linked-incentive-scheme-pli-20-it-hardware

ii. **Mission or vision for R&D and innovation in the ICT Sector:** Channelizing the ecosystem towards a single goal has traditionally seen considerable success due to enhanced focus on a limited number of key objectives along with improved accountability towards achievement of goals. Defining national missions in strategic areas such as 5G use cases, 6G, AI, Blockchain, hardware convergence and telecom security tools etc. can help India to become a world leader in R&D.

iii. **No centralized repository of R&D artefacts:** The nodal department for R&D compiles and publishes data on R&D such as number of patents, R&D spend, manpower employed in R&D, publication output etc. However, the data is published with a lag and does not have reasonable level of aggregation.

iv. **Complex processes for Application and Approval**: Several steps have been taken by the Government to reduce delay, ease of application processing and approval in the R&D sector. These functions are being taken up at individual department-level as per standards developed at their end. There are no clearly defined timeframes for clearance of an application across all stages. There may be a requirement for a standard application process for R&D incentive programs (both at Central and State level) on a central portal which may work as single window clearance system for R&D programs. In case of the ICT sector, TRAI has already given its recommendations on "Ease of Doing Business" to streamline various processes in different organisations.

v. **Newly launched programs need time to mature and produce results, tracking is needed:** Initiatives taken to boost R&D takes time to mature in any country. Several programs like the establishment of National Research Foundation (NRF), Telecom Technology Development Fund (TTDF) and others are welcome steps. However, the success and results of these initiatives are time intensive.

vi. **Support for global expansion and programs to attract foreign entrepreneurs:** Support for global expansion and start-up visas to attract foreign entrepreneurs is at a nascent stage. The Government has already started international bridges program (under Start-up India

scheme) which supports start-ups going global. However, the outcome of the program is yet to be ascertained.

vii. **Additional tax incentives for R&D in emerging technology areas:** India does not offer additional tax incentives to support specific R&D activities being carried out in areas related to forward-looking / next generation technologies such as 5G, AI, Analytics, Blockchain, IoT, etc.

viii. **Lack of robust funding mechanisms:** Even though there are several schemes to fund R&D and innovation, there is a lack of synchronization amongst them, that may lead to duplicity of funding.

Issues for Consultation

Q.12. Whether the current institutional mechanism is adequate to cater to the needs of R&D in ICT sector in India? Is there a need to create a separate agency to coordinate and look after R&D functions specifically in ICT sector? If yes, suggest a suitable framework for the overarching agency.

If not, how can synergy between stakeholders be established to ease out processes and monitor timebound R&D outcomes? Please support your answer with justification and best practices being followed in other sectors nationally or internationally.

Q.13. What steps must be taken to ensure a transparent mechanism for adequate and timely disbursement of funds for R&D programs? What should be indicators for the tracking mechanism for the funds and outcomes of R&D programs? Please support your answer with suitable examples or frameworks and best practices in India and abroad in this regard.

Q.14. How can participation of private sector in R&D be encouraged? Which incentivization model(s) or combination thereof would produce better results:

(i) Tax-break model, or

(ii) Product-Linked Incentivization model,

(iii) Any other model.

Please provide details of the suggested model(s) in terms of structure, functioning, monitoring, and evaluation.

Q.15. Is there a need for a mechanism to promote research, development, and innovation at the state level? Will a ranking mechanism for the states help to promote the spirit of innovation? If yes, please comment on the structure of such a mechanism with key performance indicators.

2.7. Focus Element #3b – Regulatory Framework: IPR Regime

2.7.1. Intellectual Property Rights (IPRs) are legal rights that protect creations and/or inventions resulting from intellectual activity in the industrial, scientific, literary, or artistic fields. IP is protected in law by, for example, patents, copyrights, and trademarks, which enable people to earn recognition or financial benefit from what they invent or create.

2.7.2. At the global level, World Intellectual Property Organization (WIPO) is the forum for intellectual property (IP) services, policy, information, and cooperation. It is a self-funding agency of the United Nations, with 193 member states with the mission to lead the development of a balanced and effective international IP system that enables innovation and creativity for the benefit of all.

2.7.3. WIPO played a crucial role in the creation and implementation of the Patent Cooperation Treaty (PCT), which is an international patent law treaty concluded in 1970. The PCT assists applicants in seeking patent protection internationally for their inventions, helps patent offices with their patent granting decisions, and facilitates public access to a wealth of technical information relating to those inventions. By filing one international patent application under the PCT, applicants can simultaneously seek protection for an invention in many countries.

2.7.4. Valuing Intellectual Property Assets- Business assets fall into two broad categories: (a) Physical assets such as machines, equipment, buildings, finances, and infrastructure (b) Intangible assets including brands, know-how, designs, human capital, and other creative products. For many years, physical assets compromised most of a company's value. But with information technology development, IP and other intangible assets are more valuable than ever before. Many businesses derive their income not from factories and

warehouses, but from innovative ideas and powerful software. Because of the ever-increasing value of IP, protecting these assets is critical to preserving a company's value.

2.7.5. A well-developed Intellectual Property Rights (IPR) regime is a prerequisite for a knowledge-based economy. A strong patenting system is required for technological innovation and scientific research. India is experiencing a surge in start-ups and unicorns, and an effective intellectual property (IP) system is a necessary precondition for a thriving startup ecosystem. The subsequent paras describe the current IPR regime and identifies certain bottlenecks therein.

2.7.6. India has a Trade-Related Aspects of Intellectual Property Rights (TRIPS)[83] compliant and dynamic IPR regime. India is also a member of the World Intellectual Property Organization (WIPO). Additionally, India is a signatory to international IP agreements such as Paris Convention, Berne Convention, Madrid Protocol, the Patent Cooperation Treaty (PCT), Phonograms Convention, Marrakesh Treaty etc.

2.7.7. In India, the Department for Promotion of Industry and Internal Trade (DPIIT), Ministry of Commerce and Industry is the nodal Department for the administration of various laws related to IPRs such as Patents, Trademarks, Industrial Designs, Geographical Indications of Goods, Copyrights and Semiconductor Integrated Circuit Layout Designs[84]. The department also deals with international organizations pertaining to IPR such as World Intellectual Property Organization (WIPO).

2.7.8. National Intellectual Property Rights Policy 2016[85,86]- In May 2016, the Government of India approved National Intellectual Property Rights (IPR) Policy as a vision document to guide future developments of IPRs in the country. It encompasses and brings to a single platform all IPRs, considering all inter-linkages and thus aims to create and exploit synergies between all forms of Intellectual Property (IP), concerned statutes and agencies. The statutes governing different kinds of IPRs in India are Patents Act, 1970; Trademarks

[83] Source: https://www.wto.org/english/tratop_e/trips_e/ta_docs_e/8_bgd_trips_89_e.pdf
[84] Source: national-IPR-Policy2016-14October2020.pdf (dpiit.gov.in)
[85] Source: "Department for promotion of Industry and Internal Trade",national-IPR-Policy2016-14October2020.pdf (dpiit.gov.in),
[86] Source: "National IPR Policy", National IPR Policy – Official website of Cell for IPR Promotion and Management (CIPAM), Ministry of Commerce and Industries, Government of India

Act, 1999; Designs Act, 2000; Geographical Indications of Goods (Registration and Protection) Act, 1999; Copyright Act, 1957; Protection of Plant Varieties and Farmers' Rights Act, 2001; Semiconductor Integrated Circuits Layout-Design Act, 2000 and Biological Diversity Act, 2002. The Policy lays down seven objectives which are elaborated with steps to be undertaken by the identified nodal Ministry/Department. Key Objectives of NIPRP 2016 are:

i. IPR Awareness: Outreach and Promotion
ii. Generation of IPRs
iii. Stable & effective Legal & Legislative Framework
iv. Administration & Management of IPRs
v. Commercialization of IPRs
vi. Enforcement and Adjudication to combat IPR infringements.
vii. Human Capital Development for teaching, training, research, and skill building in IPRs

2.7.9. Patents Act[87]- Patents were first introduced to the realms of Indian business in the year 1911 with the passing of the Indian Patent and Designs Act, 1911. This Act was superseded in the year 1972 by the Patents Act, 1970. Later this Act, was amended in 2005 to be compliant with the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement and is now known as the Patents (Amendments) Act, 2005. The Amendment oversaw extension of product patent to all fields of technology including foods, drugs, chemicals, and micro-organisms.

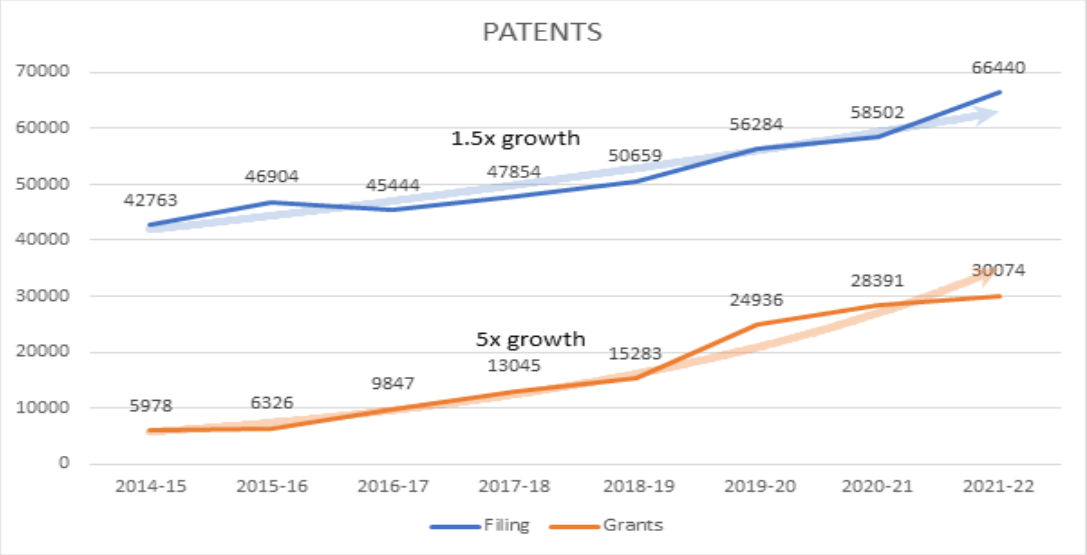
2.7.10. Standard Essential Patents- Technologies required to establish standards are more important. Given that these are core technologies with no alternatives, every product based on a standard requires mandatory access to these technologies. Patent rights granted over such standard establishing technologies are referred to as Standard Essential Patents (SEP). The base requirement for SEPs to be constructive is licensing under Fair, Reasonable And Non-Discriminatory (FRAND) conditions. Without FRAND, SEPs can cause costly conflicts. FRAND is sometimes called as RAND—Reasonable And Non-Discriminatory. According to the principles of FRAND licensing, patent owner must allow to take a license whose terms must not be illegal or anti-competitive, and the cost of the license must not be too high.

[87] https://ipindia.gov.in/writereaddata/Portal/IPOAct/1_31_1_patent-act-1970-11march2015.pdf

There is an inherent tussle regarding royalty rates between the company who spent its resources in R&D to develop standard and the company that seeks to license it. The implementation of FRAND licensing in India is still evolving and there have been some disputes between patent owners and licensees over the determination of FRAND terms. In particular, there have been concerns about the lack of clarity in the legal framework for determining FRAND terms, enforcement of FRAND obligations, and availability of injunctive relief for patent owners who have offered FRAND licenses but are unable to reach agreement with potential licensees.

2.7.11. **IPR Awareness**: The scenario of IPR awareness in India has been gradually improving in recent years, as evident from the data on IPR generation. There has been a gradual increase in the filing and granting of patents in India. As per World Intellectual Property Indicators 2022[88], India is on the 6th position in terms of patent applications filed globally. According to Press Information Bureau (PIB), in January-March 2022, the number of domestic patent filing surpassed the number of international patent filing in India, for the first time in 11 years i.e., of the total 19796 patent applications filed, 10706 were filed by Indian applicants against 9090 by non-Indian applicants. Patent applications surged by more than 50% in just 7 years, from 42763 in 2014–15 to 66440 in 2021–22. Further, there has been nearly a five-fold increase in the grant of patents in 2021-22 as compared to 2014-15.[89]

Figure 2.14- Patent filing and Grants



[88] Source: https://www.wipo.int/edocs/pubdocs/en/wipo-pub-941-2022-en-world-intellectual-property-indicators-2022.pdf
[89] Source: https://pib.gov.in/PressReleasePage.aspx?PRID=1815852

2.7.11.1. IPR landscape in India has been blooming which is evident from the Figure 2.14. Additionally, during the year 2020-21, total revenue generated from IP activities was Rs. 1027.27 Crore, which is about 4.67% higher than that of the previous year. The total revenue generated by the Patent Office was Rs. 623.84 Crore (including Rs. 0.487 Cr. received from International Bureau of WIPO as International Searching Authority fees)[90]. This may seem like remarkable progress when compared over time, however, India lags far behind its global peers. The number of patents applied and granted in India is still a fraction compared to the patents granted in China, the USA, Japan, and Korea. "*The number of patents filed in India is merely 3.8 per cent of China and 9.5 per cent of the USA in 2020.*" With a market and economy as diverse as India's it is imperative for the government to tackle the lack of awareness regarding IPR generation in India.

2.7.11.2. As a measure, the Government of India, in line with their National IPR Policy 2016, launched a myriad of initiatives and programs which sought to improve and generate awareness among the public vis-à-vis IPR. The initiatives are briefly explained below.

i. Creative India, Innovative India[91]- To take forward the National IPR Policy and to enhance creativity, innovation, competitiveness, and economic growth in India, IPRs generated in India are legally protected and exploited. This scheme aims to alleviate inadequate knowledge about the rights of individuals to protect their ideas and innovations and low awareness about the procedures involved in obtaining an IPR which has long hindered India's growth in Intellectual Property. Under this scheme, Cell for IPR Promotion and Management (CIPAM) was under the aegis of DPIIT. The salient features of this scheme include conducting IP awareness workshops/seminars and undertaking training programs at schools, MSMEs, startups etc.

ii. Centre of Excellence in Intellectual Property (CoE-IP)[92]**-** A robust ICT-IPR ecosystem can help capitalization on the growth-enhancing effects of

[90] Source: https://ipindia.gov.in/writereaddata/Portal/IPOAnnualReport/1_112_1_Final_English_AR_2020-21_for_Net.pdf
[91] Source: http://cipam.gov.in/wp-content/uploads/2017/07/Scheme-IPR-Awareness.pdf
[92] Source: IPR Initiatives | Ministry of Electronics and Information Technology, Government of India (meity.gov.in)

innovation vis-à-vis ICT. CoE-IP established under Technology Incubation and Development of Entrepreneurs 2.0 (TIDE 2.0) scheme and run by CDAC Pune, is one such initiative which was envisioned with the objective of helping innovators, start-ups and SMEs to understand the value of intellectual property (IP), offer Value Added Services and ensure adequate protection of the IPRs. CoE-IP is being implemented with a budgetary outlay of Rs. 323.77 Lakh over a period of 5 years. The aim of the project is to encourage the growth of IP in ICT by way of creating a conducive framework for identification, protection and monetization of IPRs.

iii. Patent Analysis and Management System (PAMS)[93]- This initiative is a sub-scheme under the CoE-IP and aims to provide a range of value-added intellectual property related services for IT industry and other technical sectors. PAMS provides precise information which is percolated from multiple databases maintained across the sub-channels of MeitY. PAMS is a single-window interface which provides features such as search services, invention analysis, IPR queries, landscape reports and latest updates on IPR awareness programs/success stories/blogs.

iv. IPR Facilitation for MeitY R&D Societies and Grantee Institutions[94]- The program aims at establishing a state-of-the-art R&D paradigm in the country's innovation and IPR division. The Facilitation program helps in filing IPRs which includes patents, copyrights, designs, and trademarks.

v. Support for International Patent Protection in E&IT (SIP-EIT) – II for Micro, Small and Medium Enterprises and Technology Start-up Units[95]- The scheme provides support to MSMEs and Start-ups that are trying to secure intellectual property rights on a global level. SIP-EIT scheme introduced in 2014 provides financial support to MSMEs and tech Start-ups for international patent filing to encourage innovation. It recognizes the value and capabilities of global IP and establishes competitive advantage. The scheme was for a period of 5 years[96] with the mandate to

[93] "MeitY",IPR Initiatives | Ministry of Electronics and Information Technology, Government of India (meity.gov.in)
[94] IPR Initiatives | Ministry of Electronics and Information Technology, Government of India (meity.gov.in)
[95] "MeitY",IPR Initiatives | Ministry of Electronics and Information Technology, Government of India (meity.gov.in)
[96] DeitY launches SIP-EIT Scheme to support MSMEs and Technology Startups - MyGov Blogs

support 200 international ICT patent applications, however, it is still going on. Salient features of the SIP-EIT II are as follows:

a. Providing financial support for international patent filing in the Information Communication Technologies sector.
b. Reimbursement up to INR 15 Lakh per invention or 50% of the expenses incurred in filing a patent, whichever is less.
c. The applicant can apply for support at any stage of international patent filing.
d. Facility to apply online through web-portal.
e. One application for foreign filing in all countries for a particular invention is considered under the scheme.
f. Option of 5 applications per financial year from a single entity.
g. A pure grant for R&D which is subject to approval by MeitY and no stake in the supported patent is envisaged under the scheme.

Current status as on April 2022:

- Total programs: 84
- Programs by Academia: 50
- Programs by industry body: 32
- International seminars: 02
- Total funds disbursed :170.46 lakh[97]

vi. IPR Awareness by MeitY[98]- This initiative seeks to increase awareness about IPR procedures and methodologies in a dynamic and complex ICT ecosystem. MeitY had initiated a scheme to provide financial support (Grant-in-Aid) to academic institutions (providing technical education in Electronics & Information Technology domain), industry bodies (such as Manufacturers' Association of Information Technology-MAIT, Electronic Industries Association of India-ELCINA, Confederation of Indian Industry-CII, National Association of Software and Service Companies-

[97] https://rajyasabha.nic.in/rsnew/Committee_site/Committee_File/ReportFile/13/159/169_2022_4_11.pdf
[98] "MeitY",IPR Initiatives | Ministry of Electronics and Information Technology, Government of India (meity.gov.in)

NASSCOM, Federation of Indian Chambers of Commerce and Industry-FICCI, India Electronics and Semiconductor Association-IESA, Associated Chambers of Commerce and Industry of India-ASSOCHAM etc.) and MeitY autonomous societies for conducting IPR awareness workshops. The funding, however, under this scheme shall be restricted as per following criteria:

a. Support for awareness programs in educational institutes will be limited to INR 2.0 Lakh per program.
b. INR 3.0 Lakh for awareness programs to be organized by industry bodies.
c. INR 5.0 Lakh for workshops to be organized by MeitY Societies and MeitY Autonomous bodies involving international experts.

vii. Other MeitY resources for IPR awareness include:

a. IP Panorama: It is a user-friendly e-learning multimedia toolkit that has been developed by CoE-IP. The prime purpose and focus of the IP Panorama are to create IPR awareness among the targeted stakeholders comprising tech start-ups, MSMEs, and academia belonging to the ICT domain. Divided into a total of 10 modules, IP Panorama delves into various facets of intellectual property rights and is attuned to Indian IP laws and systems.
b. Copyright, Trademark, and Patent Database: It is a detailed list of all the copyrights, trademarks and patents granted under initiatives undertaken by MeitY through various technical channels. These databases provide a static status of the IPR granted which may be used for perusal and understanding by a potential IPR seeker.

2.7.11.3. Rajiv Gandhi School of Intellectual Property Law[99]- Rajiv Gandhi School of Intellectual Property Law (RGSOIPL) in IIT Kharagpur is a unique law school that was set up in 2006 with a vision of training scientists and engineers to become Intellectual Property Lawyers. It was set up in collaboration with the George Washington University Law School, Washington DC and is the only law

[99] http://www.iitkgp.ac.in/department/IP

school within the IIT system. It is also the first law school in India imparting full-time Intellectual Property education along with other regular courses prescribed by the Bar Council of India. The School offers a three-year Bachelors of Laws (L.L.B.) program with a specialisation in Intellectual Property Law recognized by the Bar Council of India, the Master of Laws (L.L.M.) program in various disciplines of law and a doctoral program. The law school focuses on key research areas related to IP such as Competition Law and IPR, Entrepreneurship and IP, Implementation of IP Laws, Intellectual property law etc. The school also has a Legal Aid and Intellectual Property Facilitation Cell which offers free consultation over legal and IP matters to the general public, students and IIT community. This Law school under IIT Kharagpur has the distinction of being the first among all IITs to hold a technology law moot court which is a mock court at which law students argue imaginary cases for practice. It has witnessed good participation from law schools across the country.

2.7.11.4. Several initiatives have been launched by the Government of India to increase awareness regarding IPR generation amongst the residents of India. These steps have been taken in the right directions, however they are in nascent stage and there is still time for its fruition. Higher awareness levels would also help overcome the problem of lack of IPR monetization which refers to the process of generating revenue from Intellectual Property (IP). In India, IPR monetization can be a challenge as many companies and individuals may not be aware of the value of their IP or how to monetize it. For example, a company that holds a patent may not be aware of the licensing opportunities available to them, resulting in lost revenue. With adequate awareness about IPRs, not only IPR generation will increase but also help in protection of traditional knowledge and combating counterfeiting and piracy issues. Thus, causing a domino effect in attracting investments for Research and Development in India.

2.7.12. **Process of filing patents in India**- Under the current Governing Acts pertaining to patents in India, (The Patents Act, 1970 read together with Indian Patent Rules, 2003 & Indian Patent Rules (Amendment), 2018) there are two types of processes through which a patent can be filed with the Indian Patent Office (IPO). "*Under Rule 24B of the Indian Patents Rules, 2003 a normal process is provided which has a turn-around-time of up to 80 months; and Rule 24C of the Indian Patents (Amendment) Rules, 2018 provides an expedited process which has a turn-around-time of up to 08 months.*" [100] Eligibility criteria for applying a patent:

i. An application for a patent for an invention can be made by any of the following persons either alone or jointly with another:
   a. True and first inventor,
   b. His/her legal assignee

ii. For Foreign Filing License- A request for foreign filing license may be filed on a prescribed form with a detailed description of invention and drawings, if any, and the prescribed fee. No person resident in India shall, except under the authority of the written permit can file any application outside India for the grant of a patent unless:
   a. An application for a patent for the same invention has been made in India not less than six weeks before the application is filed outside India, and
   b. Either no secrecy direction has been given under Section 35(1) in relation to the application in India or all such directions have been revoked

2.7.12.1. Patent Application Process – Normal[101]**:** Provided under Rule 24B of the Indian Patent Rules, 2003, the various steps of patent application filing is explained in the figure below:

- Step 1 – Checking if the invention is patentable

  Before one begins the patent registration process, it is needed to check if the invention is patentable. This means that it needs to be checked if another individual has filed a patent for a similar technology for which

[100]Source: EY Study Paper

[101]Source: https://iptse.com/how-to-file-patents-understanding-the-patent-process-in-india/

one is filing. Performing an in-depth patentability search helps one understand whether the applicant has a chance of getting a patent.

- Step 2 – Drafting the patent application

  The main patent application process begins now. Indian applicants need to fill Indian Patent Application Form 1. For every patent filed, it is needed to mandatorily provide a Form 2 which includes the patent specifications. The applicant can choose between a provisional and complete patent application, based on the stage of invention. This means that if the inventor is still testing the invention, it is needed to apply for a provisional patent application. There is a period of 12 months to complete the invention and file for a complete patent. Special attention is to be paid when the applicant is drafting the patent application. Patent application should include clauses such as usability and outcome of the invention in detail. It should also include the necessary clauses such as the applicant's intention to license the invention and preventing competition from using and thereby, profiting from the invention.

- Step 3 – Filing the patent application

  Patent application needs to be submitted with several application forms. As per the patent filing procedure in India, one needs to submit all the below mentioned forms.

  - Form 1 – Application for patent grant
  - Form 2 – Patent specification form (provisional or complete)
  - Form 3 – Undertaking and statement with regards to foreign applications under Section 8 (mandatory only in case a corresponding application for patent is filed in a foreign country)
  - Form 5 – Declaration of invention to be filed with complete application
  - Form 26 – Form authorizing patent agent (applicable only if one opts for an agent to help file the patent)
  - Form 28 – Mandatory only if applicant is claiming small entity or start-up status
  - Priority Documents – It is needed to provide priority documents only if priority is being claimed from a foreign patent claim or application.

- Step 4 – Publishing the patent application

  After submission of all the documents, the patent application is safely secured by the Indian Patent Office. The patent is then published in an official patent journal after a period of 18 months approximately. However, inventors who wish to have their patent application published before this 18-month period can submit Form 9. This is an automatic process but if an inventor wishes to have his application published earlier, he/she needs to submit Form 9 (early publication request), in which case, the application will be published in the official patent journal within 1 month of making the request. However, there are certain scenarios in which patent application may not be published. These include incomplete applications, withdrawal requests made by the individual filing the patent and secrecy direction imposed under Patent Act wherein the invention is against the nation's interests.

- Step 5 – Examining the patent application

  Before the patent is granted, it needs to be examined substantively. As per rules of the patent application process in India, the patent is thoroughly examined based on the merits of the invention as claimed and described in the patent specification form. Unlike the publication process, this is not an automatic process, and the applicant needs to make a request to examine their patent application by submitting Form 18. The patent office queues the application for examination only after a formal request for examination is made. One can also expedite this process by filling and submitting Form 18 (A). The patent examiner is obligated to follow a few steps of his/her own while examining the application. They are as under:

  i. When the application lands on the examiner's desk, it is scrutinized according to the Patent Act and underlying rules.
  ii. The patent examiner searches for similar technologies to ensure the invention satisfies patentability criteria.
  iii. After reviewing the application, a first examination report (FER) is submitted in which, grounds for objections, if any, are also stated.

iv. The examiner lists his objections in detail. This can further extend the application process by another 6-9 months. Note that examiner objections are quite common in the case of patents.

v. If the inventor needs to make changes to his/her objection, he/she can file a request for a time extension by submitting Form 4.

- Step 6 – Decision to grant patent

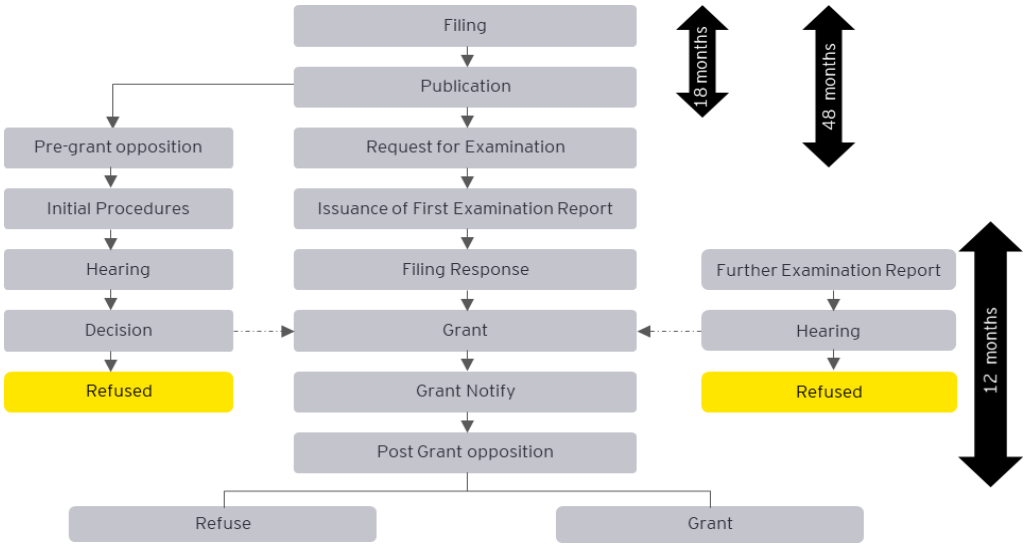
  Once the examiner finds no objections in the patent application, he grants the patent. The patent is then published in the official patent gazette.

- Step 7 – Renewing the Patent

  The patent holder also needs to renew his patent by paying an annual renewal fee. In India, it is possible to renew patent for a period of 20 years at maximum, from the date the patent was first filed.

A schematic block diagram on patent filing process is given below in Fig 2.15 for ready reference.

Figure 2.15- Patent Application Process- Normal[102]



2.7.12.2. Patent Application Process – Expedited[103]: The process of granting a patent can take anywhere between 5 to 7 years in India. In the National IPR Policy, the

[102]Source: EY Analysis
[103]Source: EY Analysis

Government aims to reduce the time taken to get a patent to just 18 months. As a furtherance of this objective, in the Patents (Amendment) Rules, 2016, Government introduced provisions for expediting patent examination in India. A request for regular or expedited examination can be filed at the time of patent application filing or within 48 months from the filing date. However, filing requests during application filing would eventually reduce the grant process timeline. Patents (Amendment) Rules of 2016 made the Expedited Examination process applicable to only two categories of applicants:

i. Applicants who opted the Indian Patent Office as the International Searching Authority or as the International Preliminary Examination Authority in their respective International Applications, or
ii. The applicant is a start-up.

However, Patent Amendment Rules 2019 expanded the applicability of expedited examination to more categories including:

i. Applicant who files a patent application under any specific arrangement between the IPO and a Foreign Patent Office which is similar to a Patent Prosecution Highway.
ii. A small entity, government undertakings (government departments; institutions established/owned/controlled by the Central/Provincial/State; government company; an institution wholly or substantially financed by the Government) and women applicants.

Draft Patents (Amendment) Rules, 2021 have proposed to add *"(ca) 'eligible educational institution' means an institution established by a Central, Provincial or State Act, which is owned or controlled by the Government and is wholly or substantially financed by the Government.*" Additionally, have added an explanation for the term "*substantially financed*" to have the same meaning as defined in Explanation to Section 14(1) of the Comptroller and Auditor General's (Duties, Powers and Conditions of Service) Act, 1971 which means that an institution which receives a grant/loan of more than 25 lakh in a financial year from the Consolidated Fund of India or from the State or a Union Territory having a legislative assembly and such amount is more than seventy five per cent of the total expenditure of the institution.

The rules governing the procedure of expedited grant of patent are laid down in Rule 24C of Patent Rules, 2003, as explained in the figure below.

- Step 1- Application for the patent via expedited route

  An applicant may file a request for expedited examination in Form 18A, along with the fee, only by electronic transmission, duly authenticated, within 48 months from the date of filing or Priority date, whichever earlier. If the application is not published or a request for early publication is not filed, the applicant shall file Form 9 with prescribed fee along with Form 18A.

- Step 2 – Publishing of the First Examination Report (FER)

  The Patent Office publishes such application within a period of one month provided the invention contained thereon does not relate to atomic energy or defence purpose. Under the expedited examination, the examiner is obligatory to give the First Examination Report (FER) within 1 month but not exceeding 2 months from the date of reference of the application to the Examiner for examination by the controller.

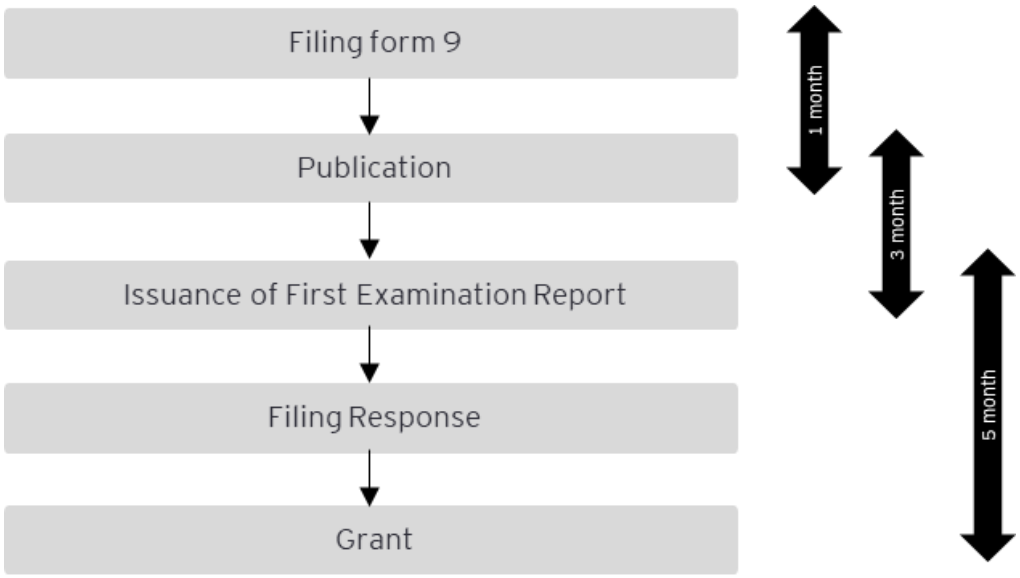
- Step 3 – Response to the FER

  Upon the receipt of the FER, the applicant must now respond with the requisite artefacts, evidence, submission et al. to the examiner within 1 month.

- Step 4 – Disposal of Application or Granting of Patent

  Final disposal of the application or the granting of the patent on expeditious basis, is required to be completed within 3 months from the date on which the applicant files the response to the FER. It is important to note that while the application process under Section 24C provides for a significantly reduced TAT in the patent application process; It is not a mutually exclusive process from the normal process. The possibility of post-grant opposition persists and must be tended to in such an advent. In case, the applicant receives post-grant opposition, the process listed under Rule 24B must be strictly adhered to for making representations in front of the IPO.

Figure 2.16- Patent Application Process – Expedited Process[104]



2.7.12.3. In this context, a Working Paper published by the Economic Advisory Council to the Prime Minister of India (EAC-PM) says, *"The time taken for first office action has reduced drastically over the last few years. In fact, the average time taken for the first office action has reduced from 18 months in 2020 to 4.8 months now, which is the fastest in the world. But this has not improved the final outcome as major delays happen after that. The time for final disposal had decreased from 64 months in 2017 to 42 months in 2020, however, it has started to increase thereafter and now stands at 58 months. In contrast, the average time taken for disposing of an application in China and the US is 20-21 months, which is almost 1/3rd of the time taken in India. The other 3 IP-5 offices, the European Patent Office, Japan, and South Korea also process the application in 25.4, 15 and 15.8 months respectively."*[105]

2.7.12.4. The delay in the process of patent filing and patent grants resulting in long patent approval cycle may be attributed to multiple factors. One of the major factors is the lack of trained personnel to handle IPR operations and issues. For example, a shortage of examiners in the Patent Office causes a backlog of pending patent applications, which can delay the granting of patents. According to the EAC-PM's Working paper, *"Only 860 people were employed in the patent office in India at the end of March 2022, including both examiners and*

[104]Source: EY Analysis

[105]Source: Economic Working Paper on "Why India needs to urgently invest in its patent ecosystem?"

controllers, as compared to 13704 in China and 8132 in US. Thus, approximately, 1.64 lakh applications were pending at the controller level as on 31st March 2022."[106] Apart from the shortage of manpower, certain other procedural bottlenecks have been identified in the patent application process. The first is the lack of fixed timelines for various steps, such as filing an opposition against any patent application, which causes delays. Second, there are some onerous compliance requirements, such as submitting information about the processing of foreign patent applications, which is no longer necessary in the case of PCT applications because India is a member of WIPO Centralised Access to Search and Examination, which already provides consolidated information about the status of PCT applications in a large number of jurisdictions. The complexity in filing a patent application not only makes the process time-consuming but also makes it expensive.

2.7.13. Cost of filing patents

2.7.13.1. The overall cost of obtaining a patent includes the fee paid to the patent office (statutory fee) and the fee paid to the patent service provider (professional fee). Drafting a patent specification is a highly skilled task that requires technical and patent law expertise. Further, a professional fee range (for premier patent firms in India) is provided as the professional fee can vary significantly from one firm to another. It should also be noted that certain patent firms may charge depending on the amount of work required, volumes, etc. The breakup of statutory fees and professional fees is given in Table 2.4.

[106]Source: Economic Working Paper on "Why India needs to urgently invest in its patent ecosystem?"

Table 2.8: Breakup of statutory fees and professional fees[107]

Process	Government fee (INR)			Professional Fee (INR)
Description	Individual(s)/ Startup	Small entity	Large Entity	
Drafting patent application	0	0	0	40,000 (25,000 to 75,000)
Patent application filing	1,600	1,600	8,000	8,000 (5000 to 12000)
Filing request for examination	4,000	4,000	20,000	8,000 (5,000 to 12,000)
Responding to examination reports	0	0	0	30000 (20,000 to 60,000)
Grant	0	0	0	1,000 (1,000 to 5,000)
Total (without professional help)	5,600	5,600	28,000	87,000 (56,000 to 1,64,000)
Total (with professional help)	92,600	92,600	1,15,000	
	(61,600 to 1,69,600)	**(70,000 to 178,000)**	**(84,000 to 1,92,000)**	

Therefore, in India the estimated amount of fees in applying for patents in three different categories are:

Individual(s)/Startup: INR 61,600 -INR 1,69,600

Small entity: INR 70,000 - INR 1,78,000

Large entity: INR 84,000 - INR 1,92,000

2.7.13.2. Fees for filing patent application – Expedited Process (under Rule 24C of Patent Rules Amendment 2018)[108]- In order to file patent application under the expedited process, the government fees required to be paid along with the application form (Form-9 or Form 18A) shall be as follows:

Table 2.9: Additional fees for expedited process[109]

Description	Natural Person (in ₹)	Small Entity (in ₹)	Other than small entity (in ₹)
Application for Expedited Examination (Form-18A or Form-9)	8,000	25,000	60,000

[107] Source: EY Analysis
[108] Source: What is the cost for requesting for expedited examination of patent application in India? - S.S Rana & Co (ssrana.in)
[109] Source: EY Analysis

It is important to note that the rest of the government fees professional charges for the remnant elements of the process shall remain the same.

2.7.13.3. The high cost of filing patents stifles innovation and makes it difficult for individuals and small businesses to access the patent system. This means that many potentially valuable inventions go unpatented, which can limit their commercial potential and overall impact. Moreover, it can also act as a barrier to entry for new businesses and startups. This can limit competition and innovation within a particular industry, which can ultimately harm consumers and stifle economic growth. Further, challenges due to laxity in enforcement of existing IPR laws pushes the expenses.

2.7.14. **IP Enforcement in India**: India has made significant progress in recent years in terms of strengthening the enforcement of IPRs. The current scenario of enforcement of IPRs in India has been discussed in the following paras.

2.7.14.1. Border Control Measures for Enforcement of IPR- The Government of India under Section 11 of the (Indian) Customs Act, 1962 is empowered to prohibit importation and exportation of goods of specified description if it deems necessary to do so. The provision, inter alia, empowers the government to prohibit the import or export of goods for "*the protection of patents, trademarks and copyrights*". The goods imported in contravention of the provisions of the Customs Act or any other laws for the time being in force are liable to be confiscated. In this regard, a customs officer is empowered to inspect any premises, conveyance, x-ray any person and effect search and seize in case where they have reasons to believe that the goods are of contraband nature. They can also investigate or interrogate any person and arrest him.

2.7.14.2. Additionally, India has notified the Intellectual Property Rights (Imported Goods) Enforcement Rules, 2007. The rules comply with border measures as required by the TRIPS Agreement empowering the Customs Officers to enforce IPR over the imported products. As per Rule 2(b) of the Intellectual Property Rights (Imported Goods) Enforcement Rules, 2007, Intellectual Property includes patents, designs, and geographical indications together with trademarks and copyrights. However, ambiguity in legal framework, inadequate protection of IPR (leading to counterfeiting and piracy), lack of awareness,

competition and market pressures, and international trade agreements lead to IPR disputes which require resolution.

2.7.14.3. Filing suits in court**:** In India, a suit may be instituted in any court of original jurisdiction, subject to their pecuniary and territorial jurisdiction. In relation to IPR litigation, the designation of the lowest court is "*District and Sessions Judge*". These cases can also be filed in the High Court, directly, if such High Court has original jurisdiction. The jurisdiction of the High Court can be invoked, subject to the payment of court fees. The structure of court fees payable varies from State to State. Certain State Governments have formed special Intellectual Property Cells, which deal with offences relating to infringement of IPR. Additionally, in case of infringement of Trademark, infringement of Copyright, Geographical Indication, Plant Variety and Semiconductor Integrated Circuits Layout Design criminal action can also be initiated.

2.7.14.4. Filing suits in courts for the resolution of disputes related to IPRs is not something which the stakeholders look forward to. The identified reasons behind this pertain to the lengthy legal proceedings, high legal fees, limited availability of legal experts and absence of specialized IP courts. Thus, the parties involved in a dispute often refrain from availing the services of the mainstream judiciary in India and seek Alternate Dispute Resolution (ADR) methods.

2.7.14.5. Alternative Dispute Resolution in IP Disputes: Alternative dispute resolution (ADR) such as Arbitration and Mediation are possible alternatives to court litigation. Alternative dispute resolution mechanisms are less time-consuming, efficient and provide flexibility to the right holder. Nowadays, contracts related to the transfer of intellectual property mostly include the "*arbitration-mediation*" clause. This highlights the weight of arbitration in commercial intellectual property transactions. The Arbitration and Conciliation Act, 1996 helps the parties to dissolve the issues calmly without going for the court process. The Civil Procedure Code, 1908 additionally accommodates appropriation of various models for speedy assurance of debates.

The most common ADR mechanisms for IP disputes include:

i. Arbitration: In an arbitration procedure, all parties agree to submit the dispute to one or more arbitrators who then make a binding

decision on the dispute. The arbitration procedure is private and less formal than court proceedings. An award of damages obtained through arbitration is also more easily enforceable internationally than an award through national court proceedings.

ii. Mediation: In a mediation procedure a neutral intermediary, the mediator, helps the parties to reach a mutually satisfactory settlement. Any settlement is recorded in an enforceable contract. An advantage of mediation is that parties retain control of the dispute resolution process. This can help to preserve good business relations with the other parties involved.

iii. WIPO ADR: The WIPO Arbitration and Mediation Center is a neutral, international, and non-profit dispute resolution provider that offers time and cost-efficient alternative dispute resolution options. The WIPO Rules contain explicit arrangements that are especially reasonable for IP and related debates, for example, those concerning secrecy and specialized proof and they have been effectively applied in different regions. The WIPO Centers are accessible to the seekers with ADR processes in various dialects and supports in model conditioning and understandings, who may use the same for presenting their debates to WIPO.

2.7.14.6. Role of Intellectual Property Appellate Board (IPAB) of India: Intellectual Property Appellate Board (IPAB) was constituted by the Central Government on 15 September 2003, to hear appeals against the decisions of Registrar under the Trademark Act, 1999 and the Geographical Indications of Goods Act (Registration and Protection), 1999. After four years, in 2007 the IPAB jurisdiction was extended to the Patents Act, 1970. Later through the Finance Act in 2017, it was further extended to the Copyright Act, 1957. IPAB was created with an objective to bring together the best set of expertise in the IP regime through technical members possessing technical and scientific knowledge due to which it has delivered various landmark judgement. However, it also experienced various difficulties due to lack of technical manners for various years, which lead to pendency and delay of matters.

2.7.14.7. Owing to such difficulties, on 4 April 2021, the Tribunals Reforms (Rationalisation and Conditions of Service) Ordinance, 2021[110] was promulgated, which dissolved various tribunals, including the IPAB, and transferred their functions to judicial bodies. As per the Ordinance, appeals against the decisions of the Registrar of Trademarks, the Registrar of Geographical Indications, and the Controller of Patents will be filed before the High Courts and appeals against the decision of the Registrar of Copyright before the Commercial Courts.

2.7.15. **Intellectual Property Finance**

2.7.15.1. At some point, most businesses require capital to expand, grow, and occasionally even survive. Yet, intellectual property, one of a company's most valuable assets, is rarely leveraged when seeking financing. This deficit in financial resources hinders their success and the growth of our economies. This gap could be reduced by intangible asset financing. When safeguarded by intellectual property, the value of a company's creations and investments is substantial. The strategic application of these intangible assets could be a game-changer for intangible-intensive companies. Governments and commercial enterprises are experimenting with a variety of initiatives and offerings to increase access to financing based on IP.

2.7.15.2. According to WIPO[111], Intellectual property rights can be used to secure financing, either by pledging them or transferring rights to cash flows derived from these assets. Alternatively, a company's intellectual property can provide an indicator of a firm's value and support financing decisions. For some businesses, intangible assets only represent a small portion of what a company is worth. For others, the bulk of their value may flow from their intellectual property. These companies must communicate the value of their intellectual property and other intangible assets to lenders and investors.

2.7.15.3. Further, WIPO report has also mentioned that, when IP is used as collateral, ownership may usually remain with the borrower. However, a lender may put certain conditions on how the IP can be used in the future. This could affect the ability to transfer to license the IP or transfer it to others. Lenders would

[110] Source: Ordinance 2 of 2021
[111] Source: https://www.wipo.int/sme/en/ip-backed-financing-for-policy-makers.html#:~:text=Using%20IP%20as%20collateral&text=If%20the%20borrower%20defaults%2C%20the,than%20other%20forms%20of%20lending.

file notice of their rights - known as a security interest - to the IP in the case of a borrower's default on a loan. Depending on a country's laws, a security interest may be filed through a local IP office or a movable collateral registry. If a lender uses IP as collateral that is held in multiple countries, this process may need to be completed multiple times.

Key points emerged from the above discussions include:

i. **Lack of awareness regarding IPRs in India**: The citizens of India have minimal awareness about monetary benefits of acquiring an IP right, commercialization of acquired IP rights, or the legal troubles that one might land in for using a pirated product. Rigorous corrective and preventive efforts are underway in this direction.

ii. **Limited implementation of FRAND licensing**: FRAND licencing is still a work-in-progress in India, and there have been some disagreements between patent owners and licensees regarding the determination of FRAND terms. Concerns have been raised about the legal framework for determining FRAND terms, the role of the CCI in enforcing FRAND obligations, and the availability of injunctive relief for patent owners who have offered FRAND licences but are unable to reach an agreement with potential licensees.

iii. **Long patent approval cycles in India**: The patent approval cycles are longer in India than in other leading countries. The normal patent approval process takes ~ four years in India as compared to average 2.5 years in leading countries. The expedited approval process is also comparatively longer, taking 0.8 years in India as compared to an average of ~0.5 years in leading countries.

iv. **Complex Process**: Filing a patent in India is still a cumbersome process and may require more clarity and simplification of processes for an easy access and filing patents. Further, there is no clarity on mechanism for royalty sharing.

v. **Absence of special IP courts/mechanisms for faster resolution of IPR related disputes**: Absence of special IP courts in India leads to longer duration for resolving patent related cases which further results into higher costs and higher risk of invention becoming obsolete. Most parties prefer Singapore as a destination to resolve their IP related disputes.

vi. **Lack of trained personnel in IPR operations and issues**: Availability of specialized ecosystem such as consulting firms, lawyers, technically trained judges to handle IPR operations and issues is limited, and their services are expensive.

vii. **Lack of IP-backed finance**: As the value of intangible assets including intellectual property increases, governments are recognizing the need for enterprises to proactively protect, manage and commercialize them to derive maximum benefit for enterprises and the overall economy. However, in India, banks do not consider intangible assets or intellectual property rights as collateral for debt financing.

Issues for Consultation

Q.16. How can awareness about IPR be increased among the researchers and industry in ICT sector? Suggest action points for making IPR as a part of syllabus in graduation /post-graduation level in colleges. Please support your answer with justification and best practices in India and abroad in this regard.

Q.17. What essential steps can be taken to further improve the speed and efficiency of the patent approval process for ICT in India? Please support your answer with justification and best practices in India and abroad in this regard.

Q.18. Is there a need to reduce the cost of filing patents in India? If yes, how can it be done? Please support your answer with justification and best practices in India and abroad in this regard.

Q.19. As far as the ICT sector is concerned, suggest measures to enhance filing of patents in India in general and by resident Indians in particular. Do we need a mechanism for handholding in patent filing? Do we need a mechanism of IPR sharing for collaborative research projects? Please support your answer with justification and best practices in India and abroad in this regard.

Q.20. (a) Is the Fair, Reasonable, and Non-Discriminatory (FRAND) mechanism for licensing of Standard Essential Patents (SEPs)

functioning satisfactorily and effectively? Is there a need for any reforms in this aspect?

(b) How can small innovators be protected from the predatory practices?

Please support your answers with justification and best practices in India and abroad in this regard.

Q.21. (a) What additional measures should be taken to strengthen IPR dispute resolution mechanism to ensure confidentiality of the innovation and time-bound disposal of IPR-related disputes?

(b) How can Alternate Dispute Resolution (ADR) mechanisms for IPR disputes be improved?

Please support your answer with justification and best practices in India and abroad in this regard.

Q.22. Whether there is a need to introduce IP-backed financing system in India for ICT sector? If yes, what could be the framework to recognize IP as a collateral? Please support your answer with suitable examples or frameworks and best practices in India and abroad in this regard.

CHAPTER 3

INTERNATIONAL BEST PRACTICES & KEY LEARNINGS IN R&D

3.1. Global leaders in R&D

3.1.1. According to Global Innovation Index (GII) 2022, India tops the list of innovation economies in the region of "*Central and Southern Asia*" and the "*Lower middle-income*" group. However, the feat seems to be diluted when the list is enlarged to include the economies belonging to the "*High-income*" and "*Upper middle-income*" groups from across the globe.

3.1.2. The stark contrast between the top-rankers of GII 2022 and India is conspicuous in terms of their Gross Expenditure on Research and Development (GERD), as shown in Table 3.1 below.

Table 3.1: List of countries with the highest GERD (as a percentage of GDP) and their GII 2022 Rank

Countries	R&D as % of GDP (Acc. to GII 2022)	GII rank (2022)
Israel	5.4%	16
South Korea	4.8%	6
US	3.5%	2
Sweden	3.5%	3
Japan	3.3%	13
Switzerland	3.1%	1
Germany	3.1%	8
Denmark	3.0%	10
Finland	2.9%	9
China	2.4%	11
India	**0.7%**	**40**

An in-depth analysis of the R&D ecosystem of the top ten spenders on R&D would help to identify the propellers to R&D and innovation. Thus, a summary of country profiles of global R&D leaders indicated above on following broad categories is given below:

- Overall Policy Framework for R&D and Innovation
- Role of Academia in Innovation
- Framework for incentivising Start-ups
- Tax Incentives
- IPR Framework

3.2. Country Profile #1 – Israel

3.2.1. According to the GII 2022, overall Israel is ranked at the 16th position, with the highest R&D expenditure as a percentage of GDP in the world, which is 5.4%. Additionally, in GII 2022, Israel is the top-ranked economy in the "*Innovation Linkages*" category. In Israel, private sector investment in R&D takes up a considerable share of GERD. As per World Economic Forum's 2016-2017 Global Competitiveness Report, Israel is the second most innovative country in the world. Israel has the largest number of start-ups per capita in the world, including more than 2,000 which were founded in the past decade. Israel is also home to more than 350 R&D centres of some of the world's largest multinational companies, such as Microsoft, Apple, and Google. The caveats of Israel's remarkable success on R&D front are explored in the paras that follow.

3.2.2. Israel Innovation Authority (IIA) is the main body which promotes R&D and innovation. The IIA, an independent public funded agency, was created to provide a variety of practical tools and funding platforms aimed at effectively addressing the dynamic and changing needs of the local and international innovation ecosystems. This included early-stage entrepreneurs and mature companies developing new products or manufacturing processes, academic groups seeking to transfer their ideas to the market, global corporations interested in collaborating with Israeli technology, Israeli companies seeking new markets abroad and traditional factories and plants seeking to incorporate innovative and advanced manufacturing into their businesses. To meet the various needs of its wide range of clients, the IIA developed a new internal structure focused on six primary innovation divisions. Each division offers a

unique "*toolbox*" of customized and comprehensive incentive programs. These divisions serve as a launch pad for successful innovative projects, providing entrepreneurs and companies with the most relevant plan for them to realize and implement their ideas, develop their products, and mobilize private investment. These divisions are:

i. Start-up division - offers tools to support the early development stages of technological initiatives.
ii. Growth division - offers incentive programs that promote technological innovation of early-stage and mature companies.
iii. Technological infrastructure division - focuses on collaboration between industry and academia.
iv. International collaboration division - responsible for coordinating international collaboration in innovative R&D knowledge and technology between Israeli companies and counterpart organizations abroad, thus offering various competitive advantages for the Israeli industry in the global market.
v. Advanced manufacturing division - focuses on promoting R&D in the manufacturing sector.
vi. Societal challenges division - focuses on technological innovation in the public sector and social organizations.

3.2.3. Israel spends close to 7% of its GDP on education. Over 45% of the adults in Israel complete tertiary education. The country stands #1 in terms of the number of researchers per thousand people employed, and in the number of engineers per ten thousand people. The MAGNET Consortiums[112] incentive program provides grants for R&D collaboration as part of a consortium (a group of industrial companies and research institutions developing technologies together). The goal is to assist in the development of generic technologies in important fields in the global market, in which Israeli industry has, or may have, a competitive advantage. Since this incentive program supports the funding of infrastructure technologies, it allows distribution of knowledge and cooperation between companies operating in the same field, which may be difficult to achieve otherwise. Further, the MAGNETON incentive program encourages the transfer of technological knowledge accumulated in academia

[112] Source: https://innovationisrael.org.il/en/program/magnet-consortiums

for the use of industry, by creating collaborations between Israeli companies and academic research groups. Technology Transfer Organizations (TTOs) assist in the entire process from the invention and patent protection stage to the licensing of commercial entities.

3.2.4. Large number of start-ups in Israel form the backbone of Israel's R&D ecosystem. The enablers of the start-up culture in Israel are mentioned below:

i. Yozma Scheme is a venture capital initiative, started in 1993 which leveraged public money to attract private investment including foreign investors in Israeli start-ups. The public money invested in the initiative was about $100 million in 1993 which quickly increased to $250 million by 1996. Yozma invests in all stages of company development with a primary focus on the early stage. Yozma executives sit on the Board of Directors of many of Yozma's portfolio companies. They play an active role in assisting the companies not only in formulating business strategies and identifying & recruiting senior managers but also raising additional capital from private and public markets. The success stories of the Yozma scheme include Telegate and E-sim.

ii. Tnufa program is a pre-seed fund that supports entrepreneurs in their initial efforts to build a prototype, register a patent, and design a business plan.

iii. Incubator incentive program provides entrepreneurs with administrative, technological, and business support, and helps entrepreneurs transform an idea into a start-up company.

iv. Open innovation lab incentivizes collaborations between technology companies and start-ups by financing both the construction of an innovation lab and the ongoing operation of the innovation lab in fields, such as FinTech and cyber, environmental & sustainability, and digital health.

v. Young Entrepreneurship Incentive Program educates young people in business entrepreneurship.

3.2.5. Israel's R&D ecosystem makes ample space for tax benefits to individuals and the industry. Key initiatives in this aspect include the following:

i. Innovation box regime provides reduced corporate income tax rate on IP based income and capital gains from a future sale of IP; and reduced

withholding tax on dividends. It aims to encourage global companies to set up their R&D centres in Israel.

ii. Tax Benefits to angel investors: Under Angel's law, tax benefits are provided to individual investors who invest in Israeli R&D companies. In Israel, a R&D company is a company which spends at least 75% of the amount on R&D.

iii. Deduction for the purchase of shares in other R&D companies, which provides that a company that purchases shares of a qualifying R&D company may deduct the purchase amount for a period of five years starting from the year following the year of purchase.

iv. Under R&D expense deduction scheme, companies can deduct their R&D expenses on a current basis in the tax year.

v. Under business asset rollover relief scheme, capital gains tax relief is provided to R&D intensive companies that transfer certain assets to another company to raise capital for R&D activity.

3.2.6. The number of patent applications filed by Israeli nationals is on a rise. The Israel Patent Office (ILPO), under Ministry of Justice is the authority in Israel which provides legal protection of industrial intellectual property, through the registration of Patents, Designs, Trademarks, and appellations of origin. Patent applications in Israel are automatically examined in the received order, and no request for initiation of this process must be filed. If the subject matter of invention is environmental technology ("*Green*" applications), it may go under fast-track application process at the applicant's request. There is no specialist patent court in Israel. However, patent disputes are usually brought before the district court of Tel Aviv-Jaffa, which has judges who are experienced in patent cases. Furthermore, Israel's Patents Law under Article Five[113] has provision of "*Patent of addition*". According to which, "*If a patent holder is the owner of an invention which is an improvement or modification of an invention for which a patent (hereafter: main patent) was granted, then he may request that a patent for the second invention be granted him as a patent of addition. The grant of a patent of addition shall be conclusive evidence that the subject matter of that patent is an improvement or modification of the main patent and that it is fit to*

[113] Source: http://corfa.or.kr/eng/main/?skin=intro_establish.htm

be a patent of addition. A patent of addition shall be in effect as long as the main patent is in effect, and no fee shall be payable for it under section 56."

3.3. Country Profile #2 – Republic of Korea

3.3.1. The Republic of Korea is one of the fastest-growing nations in R&D because of systemic reforms and strong investment. In GII 2022, overall rank of Republic of South Korea is 6th. The R&D expenditure as a percentage of GDP is 4.8%, which is second only to Israel. The R&D and innovation system of the Republic of Korea is explored in the following paras.

3.3.2. The high R&D intensity that helped South Korea become a global leader in information and communication technologies has emerged from a historically 'top-down' innovation system that promotes "*close collaboration between government, industry, and the academic community in the process of nation building*", says Tim Mazzarol from the University of Western Australia in Perth, who specializes in innovation and entrepreneurship. In South Korea, Council of R&D funding agencies (CORFA)[114] was established to improve the efficiency of planning, evaluation, and management of national R&D projects. Approximately 16 major research institutes are part of CORFA including the National Research Foundation (NRF) of Korea. The NRF of Korea funds international collaboration programs.

3.3.3. In South Korea, LINC (Leaders Industry-university Cooperation) programs focus on the amalgamation of industry and academia by providing training to start-ups. Further, improvement in research infrastructure is carried out by opening laboratories and COE in the major universities. There is 10+ dedicated programs to facilitate educational research activities. The Korea Technology Transfer Center (KTTC) was established to promote the commercialization of research through technology transfer. An important highlight of the South Korea's R&D ecosystem is that more researchers move from industry to academia compared to academia to industries. Also, in the Republic of Korea, special programs are run to empower women in R&D field and reduce the gender gap.

[114] Source: http://corfa.or.kr/eng/main/?skin=intro_establish.htm

3.3.4. The Ministry of SMEs and Start-ups (MSS) in South Korea supports the innovation of Small and Medium-sized Enterprises by providing domestic demand expansion and marketing infrastructure support. The MSS works with other ministries also to lower taxes and ease regulations for start-ups. Various schemes, which incentivize start-ups in the Republic of South Korea are:

i. Tech Incubator Program for Start-ups (TIPS) provides R&D supports to selected start-ups, which have highest potential.
ii. Safe Harbour for SMEs provides support to undertake research and commercialization abroad in partnership with a university through international collaboration.
iii. Support for global expansion and start-up visas to attract foreign entrepreneurs.
iv. Open-innovation platforms for collaboration of start-ups with global companies.

3.3.5. In the Republic of Korea, following key initiatives in terms of direct or indirect tax benefits are the crucial factors for the country's rapid advancement in the field of science, technology, and innovation:

i. Tax carry-forward provides that in case of insufficient tax liability, unused credits can be carried forward for 10 years under the hybrid R&D tax credit, and for 5 years under the R&D investment credit.
ii. The companies located within an R&D Special Zone (Technology Zones) as prescribed under the Special Law on the Promotion of R&D Special Zones can enjoy certain additional tax exemptions.
iii. The expenses incurred for innovative growth-related technology investments are covered under tax exemptions.
iv. Korean patent box regime provides that when SMEs and MMEs transfer qualified patents, technologies, etc. to a Korean resident then 50% of the transfer gain from such transfer is exempted from the tax.
v. Angel investing are 100% tax-free for investments up to 30 million won ($25,500).

3.3.6. In the Republic of Korea, Korean Intellectual Property Office (KIPO), a government body grants patents. The grant of patent in South Korea takes up to 2-3 years after filing an examination request. The process to file a patent in South Korea is very transparent and there is an independent IP search service

on the internet called KIPRIS. A quasi-judicial body of KIPO called the Intellectual Property Trial and Appeal Board (IPTAB) serves as the court of first instance for intellectual property related dispute resolution.

3.4. Country Profile #3 – United States

3.4.1. According to the GII 2022, the overall ranking of United States (US) is 2nd, and it spends 3.5% of its GDP on R&D. The R&D and innovation system of the US is indicated in the following paras.

3.4.2. In the US, there is a robust organizational structure to promote R&D in the country. The Networking and Information Technology Research and Development (NITRD) program is primary source of federally funded R&D in US. Further, National Science and Technology Council (NSTC), a cabinet-level council of advisers, advises the US President on matters of science and technology (S&T). In the US, establishment of multiple testbeds and improvement in research infrastructure has continued to lead the betterment in R&D activities. Further, Creating Helpful Incentives to Produce Semiconductors for America (CHIPS) Act includes a range of federal investments to advance semiconductor manufacturing in the US. Other crucial bodies and institutions in the US are:

i. American Association for the advancement of Science (AAAS) - a non-profit body that fosters education and training in science and R&D.

ii. NSF Public Access Repository (NSF-PAR) - a designated repository, where NSF-funded investigators deposit peer-reviewed, published journal articles and juried conference papers.

3.4.3. In US, National Science Foundation (NSF), through its bottom-up approach keeps close track of research around the US and the world, maintain constant contact with the university research community to identify ever-moving horizons of inquiry and provides funding for R&D. The National Council of University Research Administrators (NCURA), founded in 1959, which is a non-profit professional society is dedicated to advancing the profession of research administration through education and professional development programs, sharing of knowledge and experiences, and the fostering of a diverse, collegial, and respected global community.

3.4.4. In US, Enhanced Technology Transfer program leads to continuous pipeline of new inventions and technologies. The research at the UG level in the US is in very good shape because of visionary programs such as Harvard College Research program (HRPC), Mellon Mays Undergraduate Fellowship (MMUF), Undergraduate Research Opportunities Program (UROP) etc.

3.4.5. US offers near-perfect conditions to turn start-up ideas into a business. The US Small Business Association (SBA) promotes start-ups and supports SMEs. It has a tie-up with 15 leading universities for providing mentorship and training. Further, the Council on Underserved Communities (CUC) helps strengthen competitiveness and sustainability for small businesses in underserved communities. Other special efforts made to encourage start-ups in R&D include:

i. Collaboration between corporations and entrepreneurs to accelerate US entrepreneurs. For example, Intel committed a $200 Mn investment in US start-ups and Facebook launched Start-up Days to boost entrepreneurial businesses across the country.

ii. 'Start-up America' is the public-private initiative to remove unnecessary barriers to high-growth start-ups.

iii. The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR), collectively the Small Business Programs, are also known as America's Seed Fund.

3.4.6. The US has made provisions for tax benefits to be given in lieu of contribution to the nation's R&D efforts. Some of the key provisions are:

i. Tax Carry-forward: In case of insufficient tax liability, unused tax credits can be carried forward for 20 years. Unused research credits may be carried back for 1 year and carried forward for 20 years. Additionally, certain qualified small businesses may claim the credit against their federal payroll tax liability up to $250,000 annually. This is a favourable rule for certain eligible start-up companies that do not have a federal income tax liability because they may be eligible to use the credit to offset up to $250,000 of their federal payroll tax liability.

ii. The tax deduction is permitted for 100% of R&D expenses for federal and state tax purposes.

iii. Under SME, a company can gain relief of 230% of the qualifying expenditure. In certain circumstances, loss-making companies can surrender losses for a payable tax credit.

3.4.7. Intellectual property rights are fundamental to modern businesses. The USA is ranked second among 132 economies featured in the Global Innovation Index 2022. Key elements which helped the US to be the frontrunner in this aspect are:

i. U.S. Patent & Trademark Office (USPTO) - a federal agency for granting U.S. patents and registering trademarks, which provides a high-quality, efficient examination of patent applications by continuous improvement of patent products, processes, and services through collaboration with internal and external stakeholders of the intellectual property community.

ii. Dedicated IP High Court to accelerate IP infringement cases.

iii. Highly trained panel of Judges with technical training.

iv. Quick Path Information Disclosure Statement (QPIDS) program for compact prosecution and pendency reduction.

v. IPR Toolkits: Since the rights granted by the US patent extend only throughout the territory of the US and have no effect in a foreign country, an inventor who wishes patent protection in other countries must apply for a patent in each of the other countries or regional patent offices. IPR Toolkits provide detailed information about protecting and enforcing IPRs in specific markets, along with contact information for local IPR offices abroad.

vi. Continuation-in-part Application[115]: Under the US Patent Laws, there are several avenues available for continuing patents and seeking additional patent protection. One of these avenues is the continuation-in-part application. A continuation-in-part application is a new patent application that is filed during the pendency of an earlier-filed patent application, and that claims subject matter that is both new and related to the subject matter of the earlier-filed application. The continuation-in-part application must be filed before the earlier-filed application is

[115] Source: https://www.uspto.gov/web/offices/pac/mpep/s201.html#ch200_d1ff71_198a2_222

abandoned, and it must be filed in the same patent office as the earlier-filed application. The continuation-in-part application will have the same filing date as the earlier-filed application, and the term of the patent that issues from the continuation-in-part application will be the same as the term of the patent that would have issued from the earlier-filed application if it had not been abandoned.

3.5. Country Profile #4 – Sweden

3.5.1. Sweden ranked 3rd in the GII 2022 and shares the third position with the US as highest spenders on R&D as a percentage of GDP in the world. As a rule, Sweden invests more than 3 per cent of the country's GDP in R&D. The bulk of the research taking place in Sweden, which is around 70 per cent, is privately financed. These investments have helped companies such as ABB, Ericsson, Sandvik and the Volvo Group become leaders in their fields. The remaining 30 per cent of the R&D in Sweden is publicly financed. Sweden's long-term focus on education and research has a major impact on the country's capacity for innovation. An active research policy approach has enabled Sweden to acquire a leading position in several areas. The R&D and innovation system of the Sweden can be understood in the following paras.

3.5.2. At the heart of Sweden's R&D and innovation framework is the Triple Helix Model which brings together government, industry, and academia to work on innovative technologies. It has been the model of innovation for the defence sector since the end of WWII and featured prominently in product developments such as Gripen, the A26 submarine and GlobalEye multi-role airborne early warning & control (AEW&C) platform. Sweden has defined 17 strategic innovation programs for funding such as IoT, Production 2030, Smarter electronics systems et al. Further, the different regions in Sweden compete to get funding for the development of internationally competitive research in specific fields. Sweden's regulatory framework allows the set-up of R&D testbeds for the development, testing and introduction of new products for different business areas such as digitalization, smart cities, etc.

3.5.3. The spending in education in Sweden is significant, which is around 7.6% of the GDP. The Government in Sweden is taking significant steps to encourage R&D in the education sector and attract foreign students to pursue research in Sweden. One such initiative is the provision of free tuition for all doctoral

students and scholarships for foreign students. There are programs to provide seed funding for the commercialization of university-based knowledge. The PhD thesis work is tailored according to the needs of the government and the industry. Leading universities provide incubator programs and financing for start-ups. Further, there are VINN excellence centres at selected universities, where both academia and industry collaborate to work on basic and applied research. These centres are funded in stages for a 10-year period and regular evaluations are conducted.

3.5.4. The spirit of innovation is inherent in Sweden's R&D ecosystem. The same is conspicuous in the provision of "*Right to Leave to Conduct a Business Operation*" which gives an employee the right to request from their employer time off to go start a business and return if it doesn't work out. An employee is entitled to full leave from work for a maximum of six months to carry out business activities by himself or through a legal person.

3.5.5. Start-up Sweden National Program run by the Swedish Agency for Economic and Regional Growth provide support to entrepreneurs from an early stage to scale up business activities and work towards providing them with knowledge, network, and tools to succeed. This is achieved through:

i. The accelerator program helps at the early-stage and to scale up companies all over Sweden with the knowledge, network and tools needed to take the next essential step.

ii. Market Access Program helps businesses in phases. In the first phase it provides start-ups with market specifics on areas such as sales, marketing and legal and in the second phase it helps them to interact with potential clients and key partners to make sure that they have an effective market entry.

iii. Sweden Bootcamp provides trainings over a period of five days such as sessions on business development, funding law, how to raise a seed fund and pitch to some of Sweden's top investors, and matchmaking with media.

iv. Global Tech Events helps in networking through events around the year to support Swedish tech companies to fuel their growth and extend their network space.

3.5.6. Sweden incentivizes workforce/staff involved in R&D by providing a reduction of 20% in social security contributions. Employees must dedicate 50% of their working hours in R&D to be eligible for the incentive. Further under Expatriate Tax Regime, 25% of the salary and benefits are exempt from taxation and social security charges for key foreign personnel with scientific/ technical background that are scarce in Sweden. The period of assignment of such personnel should not exceed five years.

3.5.7. Sweden has a relatively streamlined patent application process. The Swedish Intellectual Property Office is the main agency that grants patents in Sweden. It is also an international patent office. The whole process from filing to grant takes up to two years from the time of fulfilment of the prerequisites. The enforcement of patent and IPR laws is done through the special courts established for the purpose and composed of both legally trained judges and technical experts competent in patent laws.

3.6. Country Profile #5 – Japan

3.6.1. Research and development became increasingly important to the Japanese economy through the 1970s and 1980s and obtained significant support from the Japanese government. Japan gradually grew independent of foreign research as its economy matured in the 1970s and 1980s. A key element in increasing Japan's competitiveness was its capacity for independent research and development. In the GII 2022, Japan ranked 13th in the world and is known to spend 3.3% of its GDP in R&D. A brief on R&D system of the Japan has been described in following paras.

3.6.2. In Japan there is a centralised R&D governance mechanism through agency called Japan Science & Technology (JST). Based on science and technology targets issued by the government JST fund basic research, commercialization of new technologies, distribution of science and technology information, promote international joint research and the foster next-generation human resources. The dedicated R&D strategy like Centre for Research and Development Strategy (CRDS) help to build a forward-looking R&D strategy which involves a public dialogue, trend analysis and networking. In Japan more than 20 public engagement programs are run to spread S&T awareness among people through science camps, contests, science museums, etc. In Japan a central repository called JIPSTI (Japan Information Platform for S&T

Innovation) is a one-stop portal site, which houses research articles, literature, researchers, patents, etc. A comprehensive gateway to link multiple scientific and tech databases named J-GLOBAL has been established. It is a database supporting the generation of ideas based on the concept of "*linking, expanding, sparking*". Further, J-STAGE is a platform for publishing and providing access to the electronic versions of academic journals released in Japan. J-STAGE provides 4.8 million articles from more than 2,800 titles and about 90% of the articles are free to read.

3.6.3. Role of academia in innovation in Japan has been unlocked due to several programs related to academia-industry collaboration like SUCCESS (Support program of Capital Contribution to Early-Stage companies), Superhighway, COI-NEXT etc. The open innovation platforms like COI, OPERA, A-STEP etc. support academia-industry collaboration. Further, in technology transfer programs like START, NexTEP etc., companies design their business plans based on research results of the universities. In Japan, Innovation Seminars are conducted regularly in which companies present their research-related needs to universities. Programs that focus on how to convert innovation into commercially viable start-ups through technical and business training have a positive impact on Japan's R&D ecosystem.

3.6.4. The Japanese have taken several steps to encourage start-ups, which include:

i. Ministry of Economy, Trade, and Industry (METI) promotes start-ups and supports the growth of existing businesses.
ii. J-Start-up is an initiative to support selected start-ups with the highest potential.
iii. Intensive support through dedicated recommenders, such as top-venture capitalists, accelerators, and representatives from large companies.
iv. Public sector support (through preferential funding, executive connects, and exhibition support) and private sector support (through expertise, facilities, referrals, and co-lab sessions).
v. Assist start-ups with global expansion using Go Global and JETRO Global Acceleration Hub.
vi. Start-up visa to attract overseas entrepreneurs.

3.6.5. R&D tax incentives are a cornerstone of Japanese industrial policy and are designed to increase the competitiveness of Japanese industry. Tax credits of

up to 10% are provided for general R&D expenses and credit for special open innovation R&D expenses. Tax credit for the special open innovation R&D expenses (joint research by R&D institutions or universities) regime aims to enhance innovation in Japan. Under certain conditions, the taxpayer can deduct up to 25% of the acquisition cost of specified shares. Additional tax credit incentives for the research activities related to 5G where the taxpayer will be entitled to a tax credit of 15% or special depreciation of 30% on the acquisition cost of qualifying facilities are also provided. Further, special measures are provided to promote digital transformation (business transformation-related digital investments i.e., connectivity, use of cloud computing, replacement of legacy systems, cybersecurity).

3.6.6. In Japan, the most common types of intellectual property rights are patent rights, utility model rights, design rights, trademark rights and copyrights. A patent is one of the most important forms of protection available. Japan is a signatory to the Patent Cooperation Treaty and the Paris Convention for the Protection of Industrial Property. Japan Patent Office (JPO) is responsible for patent management. Its mission is to promote the growth of the Japanese economy and industry. The procedures for registering a patent are very clearly defined and precautionary measures are taken before ultimately granting any patent. A dedicated IP High Court is available to accelerate IP infringement resolution and reduce the costs of patent litigation. There are 3 types of patent enforcement options: Civil enforcement, Criminal enforcement, and administrative enforcement. Further, enforcement by a third-party body is also available through mediation and arbitration.

3.7. Country Profile #6 – Switzerland

3.7.1. Switzerland tops the WIPO's GII 2022. It is among the countries with the highest spending on R&D in relation to their GDP, which is at 3.1%. The private sector accounts for more than two-thirds of R&D expenditure in Switzerland, which is currently over 3% of GDP or around CHF 22 billion. The R&D and innovation system of the Switzerland has been described in following paras.

3.7.2. Public funding for research and innovation in Switzerland is coordinated by the Federal department of Economic Affairs Education and Research (EAER) and the State Secretariat for Education, Research, and Innovation (SERI).

Switzerland follows a bottom-up approach in innovation funding, where the government doesn't dictate where investment should be made. In Switzerland, basic research mainly takes place at the federal institutes of technology and universities. Applied research, development and the transfer of knowledge into marketable innovations, however, is primarily the domain of the private sector and universities of applied sciences. The promotion of research is done on a competition basis by assessing funding applications according to excellence. The young researchers are supported and promoted. The projects are also evaluated to ensure that large research initiatives funded by third parties deliver the highest scientific quality. The joint projects with partners in other countries are financed. The fellowships to allow young researchers to strengthen their profile at a higher education institution abroad are provided. Between 2016 and 2020 there was a total of 3,336 mobility fellowships across continents. The centralized database for R&D projects has been created in Switzerland to ensure transparency. The Swiss National Science Foundation (SNSF) supports scientific research in all academic disciplines, from physics to medicine to sociology. By end of 2020, the SNSF has funded more than 6000 projects involving 20,000 researchers making it the leading Swiss institution for promoting scientific research.

3.7.3. Academia has played a vital role in Swiss innovations. The following factors have had a positive impact:

i. Vocational Training Model (VET) is dual model of part-time classes and part-time paid workplace training at the secondary level of education.
ii. Swiss Innovation Park works on knowledge and technology transfer between companies and education institutes.
iii. International cooperation in education provides vocational and professional education and training (IC-VPET).
iv. Support is provided for the acquisition of international competencies through exchange programs.
v. Apprenticeship Toolbox intends to provide detailed information about various dual-track VET systems in Europe. Activities are coordinated as needed with other federal agencies pursuing IC-VPET initiatives.

3.7.4. The start-up culture in Switzerland provides the required impetus to the Swiss R&D ecosystem. The enabling factors which contribute towards a start-up paradise are:

i. Grants to create new jobs: Swiss Cantons (district-level programs) offer grants to companies that create new jobs in the local community.

ii. Allowance for technical training: Local recruitment allowance is paid as a form of contribution towards employees' salary in new jobs (up to 50% of gross salary for six months).

iii. Support programs for bank loans: The government assist new small business by offering a commercial guarantee as back-ups up to 5 lakh CHF and government underwrites 65% of the debt exposure.

iv. Innosuisse Swiss Innovation Agency promotes collaboration between science and the market, through innovative projects, networking, training, and coaching.

3.7.5. The Swiss R&D tax incentive regime[116] is designed to recognize and reward companies investing in R&D projects. R&D tax relief is available for businesses in the pharmaceutical, biotechnology and MedTech industries primarily for expenses associated with qualifying personnel directly involved in R&D in Switzerland. Key initiatives in this aspect are listed below.

i. Tax breaks: Investment companies that invest 50% of their fund assets in establishing new Swiss companies are eligible to receive tax breaks against federal tax liability.

ii. Swiss tax holiday is granted if a new business is established or relocated to Switzerland. A maximum relief of 100% is available for 10 years.

iii. Patent box: R&D costs as well as income from Swiss or foreign patents enjoy privileged tax treatment at a maximum reduction of 90% (rate at cantonal discretion).

iv. R&D tax deduction provide up to an additional 50% deduction against taxable income on qualifying R&D expenses.

3.7.6. Switzerland currently holds leading positions in several international rankings in research and innovation, in terms of academic publications in relation to population size or in terms of patent applications, for example. In addition,

[116] Source: https://home.kpmg/us/en/home/insights/2022/05/tnf-switzerland-tax-incentives-pharmaceuticual-biotech-medtech-sectors.html

Swiss academic publications are highly regarded among the international scientific community. Switzerland's involvement in the competitive EU framework programs continue to produce successful results, with Switzerland taking a leading place in both success rates of approved applications and acquired funding.[117] The high level of competitiveness is maintained through:

i. Requirements for patentability: New invention should be inventive, and industrially applicable.
ii. Dedicated federal patent court to quickly resolve patent-related cases.
iii. Judges with technical training: The possibility of composing panels of qualified legal and technical experts from a given field ensures that panels are highly competent and able to dispose of technically complex cases in appropriate time and at reasonable costs.
iv. Enforcement of patents: Federal Patent Court has jurisdiction over cases involving the granting, denial, or withdrawal of IP rights.

3.8. Country Profile #7 – Germany

3.8.1. Germany is one of the world's leading countries in research and development due to its strong system of research support. Overall rank of Germany in the GII 2022 is 8. Germany spends about 3.1% of its GDP on R&D of which, around two-thirds are coming from the private sector. The enabling provisions which are the pillars of Germany's R&D ecosystem are discussed below:

3.8.2. Centralised governance of R&D programme by the Federal Ministry for Economic Affairs and Energy (BMWi) aims to foster Germany's innovation capacity by creating an environment that is conducive to investment and are targeted to the needs of the market. Four-Pillared Innovation Framework i.e., Foundation, Innovation Competence, Pre-competitive Research and Market Oriented R&D provide comprehensive coverage of the innovation journey and provides for every sect of the populace involved in R&D which includes students, start-ups, SMEs, companies, research institutes, and state innovation centres. The SMEs are given dedicated R&D schemes including the setup of incubation centres, R&D facilities, CoEs, and Training facilities. Other key initiatives are:

[117] Source: https://www.sbfi.admin.ch/sbfi/en/home/research-and-innovation/research-and-innovation-in-switzerland.html

i. The Mittelstand – IT Security initiative sensitizes the SMEs to cyber security concepts and seeks to train them to withstand cyber/digital threats.

ii. The WIPANO program serves as a key support initiative for funding, development, and exploitation of innovative R&D companies/start-ups/SMEs by enabling technology transfer, standardisation, and patent support.

iii. Central Innovation Program for SMEs (ZIM) is a funding program, which launches thousands of projects every year making it largest SME program in Germany. The ZIM provides funding for market-oriented R&D projects to innovative SMEs in any field of technology or sector.

3.8.3. In Germany, there is a strong academia departmental collaboration program through Physikalisch-Technische Bundesanstalt (PTB) - the National Metrology Institute of Germany and the Federal Institute for Materials Research & Testing (BAM). The program acts as a knowledge transfer hub which enables engaged companies to seek expert knowledge transfers on high-end R&D Projects vis-à-vis technology safety, innovative tech development, standardisation, accreditation and C2M journey. There is emphasis on R&D funding through institutes like the Fraunhofer-Gesellschaft Institutes (FHG), which offers contractual research programs primarily to scientists and engineers. The annual research budget of FHG is EUR 2.8 bn of which, EUR 2.4 bn is generated through contractual research projects/programs. The annual invention patent output of 753 (in 2020) and a patent family of 7,667 patents to its name is a testament to FHG's role in R&D activities led by the Germanic academia.

3.8.4. The foundation pillar of the R&D Framework in Germany are start-ups and young companies. Under the various programs, primarily start-ups are encouraged. Some of the programs and initiatives are:

i. EXIST program supports knowledge-based start-up projects in higher education institutions and research establishments. It is estimated that the start-ups have created more than 12,000 highly qualified jobs since the program began. There are three sub-modules under EXIST:

a. EXIST Potentials assist higher education institutes in operating specific projects at the local/regional/international level.

b. EXIST Business Start-up Grant offers grants to students, graduates and scientists wishing to start a company. The grants cover their living expenses before and during the start-up phase.
c. EXIST Transfer of Research provides grants towards the costs of investing in outstanding research-intensive start-up projects.

ii. INVEST program support private investors willing to acquire a stake in young and innovative companies. It aims to encourage business angels to invest more venture capital in innovative start-ups and young firms. INVEST offers investors a tax-free grant of 20% of the capital invested in the young and innovative company, which increases the equity base of the young or new company and improves its prospects. Private investors who invest in young innovation companies are eligible for the grant. They may employ up to 50 persons with a turnover of EUR 10 Mn. Subject to approval from Federal Office for Economic Affairs and Export Control (BAFA), eligibility confirmation needs to be obtained post which 20% of the stake invested in the start-up is reimbursed tax-free.

iii. High Tech Grant Funds (HGTF) is a fund grant scheme to provide extensive funding to start ups involved in high technology R&D. The scheme provides unconditional funding to start ups younger than three years.

iv. Coparion Venture Capitalist (VC) fund is one of the largest VC fund schemes in the world with dedicated earmarked fund of EUR 550 Mn to fund start-ups in the capacity of venture capitalism. The permissible funding per start-up is EUR 15 Mn, making it one of the best and most financially well-off state-run VC fund schemes in the world.

3.8.5. Tax incentives for R&D activities in Germany are majorly governed by the R&D Tax Allowance Act 2020. It is a central legal act, which allows the assessee to claim a 25% tax incentive for in-house R&D activities. The incentive is provided as a tax credit.

3.8.6. Germany has streamlined patent application process which comprises of three steps - Filing, Examination, and Grant. The IPR regime in Germany is governed by the German Patent Act. It is a robust legal act, which gives statutory precedence and protection to matters and governance around patent procedures, grants, and the lifecycle of the patent. Germany's supremacy in

innovation is supported by the expedited patent examination facility available at no additional cost/solicitor fee/legal application fees. Information on Patent Rights, judicial rulings, and IP rights status are available for free through a subscription-based service called "*DPMAKurier*". This facility provides free access to the patent gazette, trademark journal, and design gazette on a daily/weekly/monthly basis.

3.9. Country Profile #8 – Denmark

3.9.1. Denmark is one of the few countries in the EU that have reached Europe's 2020 target for R&D intensity of 3% of GDP. European Innovation Scoreboard (EIS) has ranked Denmark as an Innovation Leader. In GII 2022, overall rank of Denmark is 10th in the world. In Denmark, R&D expenditure as part of GDP is 3.0%. The various enabling provisions of Denmark's R&D ecosystem are discussed in the following paras.

3.9.2. Denmark has a decentralized R&D governance and funding system. Major research, development and innovation funding and programs come from independent research foundations and following funds established by the Danish Parliament or Ministry of Science and Higher Education.

i. Innovation Fund Denmark (IFD) invests in entrepreneurs, researchers and businesses involved in projects with high risk and potential with schemes like Innofounder, Innoexplorer, etc.

ii. Independent Research Fund Denmark (DFF) promotes international collaboration by funding researchers conducting R&D outside Denmark, sets up Innovation centres to support access to foreign knowledge.

iii. The Danish National Research Foundation (DG) provides grants to set up CoEs, and pioneer centres, and funds foreign professors to conduct R&D in Denmark

3.9.3. Currently, Denmark spends 7.8% of its GDP on education. The tertiary education enrolment is over 81% in Denmark. Denmark was also ranked 2 in Knowledge creation by Scientific and Technical articles/bn PPP$ GDP (GII 2021), that is the number of articles in ratio to the size of the population. Denmark Technological University (DTU) has set up DTU Science Park consisting of both start-ups and MNCs. It offers incubator programs like DTU X-Tech, Future Box, etc. and funding for start-ups via Pre-Seed-Ventures.

Further, the programs under DFF and IFD that support education, research, and collaboration with industry, include:

i. Graduate Research Opportunity Worldwide (GROW) research program, which makes provisions for a supplementary grant to NSF's Graduate Research Fellows.
ii. Sapere Aude provides starting grants to young researchers for mobility internationally/nationally among research environments.
iii. Industrial Researcher Program is to establish closer ties between companies and the university, as well as to connect young researchers to the private business sector. This is done through a collaboration between company, university, and PhD student or post doc graduate.

3.9.4. Start-ups in Denmark benefit from the close collaboration between world-class universities, and research institutions through dynamic public-private partnerships. There are several programs designed to support early-stage start-ups and invest in high-risk projects, which includes the following:

i. Innofounder is a 12-month full-time course for entrepreneurs providing financing, that helps them build their early-stage ideas while attending workshops and mentoring sessions.
ii. Innoexplorer invests about DKK 500,000 to 1.5 million in early-stage entrepreneurship ideas, propelling them to a stage where they are ready to be introduced in the market or to attract further investments.
iii. Innobooster funds high-risk projects of SMEs and new/ promising start-ups reducing a company's risk. It invests a max of 35% of the expenses for a project (DKK 50,000 and DKK 5 million).
iv. Start-up Denmark is a visa scheme for non-EU/EEA entrepreneurs to establish their start-ups in Denmark.

3.9.5. The key features of tax benefits available for R&D activities in Denmark are:

i. R&D CapEx write-off or depreciation: Danish tax law allows for an immediate write-off of capital expenditures for R&D. Alternatively, the taxpayer may choose to take tax depreciation in the same year and the following four years on a straight-line basis.
ii. Patent costs: Costs related to the purchase of patents and know-how (including rights/licences to utilise patents or know-how) may either be

fully expensed in the year of the acquisition or amortised over a seven-year period on a straight-line basis.

iii. R&D expense super deduction: Introduced an increased deduction for R&D costs gradually increasing from 100% to 110% over a period of eight years. Additionally, they allow a 'super' tax deduction for R&D costs which amounts total to 130% of the qualifying R&D costs in both income years.

3.9.6. WIPO's GII successively ranks Denmark among the top 10 most innovative countries in the world. Sustainable innovation, rigorous research, and development, as well as a robust IP ecosystem play an important role in the Danish economy and society. Patents are processed and granted by Danish Patent and Trademark Office (DKPTO). The process and steps for registering a patent are very clearly defined. The average processing time before granting the patent is around one to three years. Further, there is a considerable focus to tackle IP infringement in Denmark. Protection of innovation is encouraged in Denmark by launching an IP Action Plan consisting of four focus areas: Value Creation, Better Knowledge of IP rights, Good IPR Knowledge, and International Engagement. Most patent proceedings, including proceedings for preliminary injunctions, are decided by the Maritime and Commercial High Court in Copenhagen with an appeal to the Eastern High Court. The Maritime and Commercial High Court is not a specialized patent court as such. However, since it is appointed as the main venue for intellectual property cases, it does have considerable expertise in patent matters.

3.10. Country Profile #9 – Finland

3.10.1. The Finnish government identified research and innovation as an important driver for future economic growth. According to the GII 2022, Finland ranks 9th in the world. The emphasis on R&D and innovation in its policy has made the Finnish innovation system one of the best-performing in the world. Finland spent 2.9% of its GDP on R&D and about 70% of R&D spending is financed by the private sector. The key factors of Finland's R&D ecosystem are discussed below.

3.10.2. In Finland, R&D and Innovation program is centralized with Business Finland (under the Ministry of Economic Affairs and Employment) being the main agency providing funding for R&D and Innovation projects to research

organizations, universities, SMEs, and large companies. Business Finland monitors and evaluates the results and impacts of the funded projects over their entire lifecycle. The organization also actively follows comparative international studies and surveys, such as the studies commissioned by the OECD, the EU, and various organisations, and conducts its own peer reviews about innovation activities in different countries. Additionally, funding to research institutes and universities for enhancing scientific research is provided by the Academy of Finland (a government agency under the Finnish Ministry of Education, Science and Culture). There are targeted R&D funding programs for supporting ecosystems and providing networking, internationalization & innovation funding in Finland. For example, ICT 2023 is a ten-year, 100-million-euro research, development, and innovation program for Finland, jointly coordinated & funded by the Academy of Finland and Business Finland. The annual budget of the program is around 10 million euros. The aim of the program is to further improve Finland's scientific expertise in computer science and promote the extensive application of information and communications technology (ICT).

3.10.3. Finland has maintained a strong focus on the education system. Currently, it spends 6.4% of its GDP on education. The tertiary education enrolment is over 90% in Finland.[118] Finland ranks 4th in the world (according to GII) in university–industry collaboration for R&D. In Finland, leading universities collaborate on flagship programs such as the 6G flagship, Finnish Center for AI, etc. The programs to promote industry-academia collaboration are:

i. Co-Creation funding[119] provides fund for a Co-Creation project, where research organisation(s) and the companies work together on a new research idea. They define a research problem and a path to resolve it and prepare a project plan. The projects further progress to become Co-Innovation project.

ii. Co-innovation funding[120] provides funding for joint projects between research organisations and companies in which they jointly develop new knowledge and innovations for business needs. All research projects are expected to have international collaboration to be eligible

[118] Global Innovation Index 2021 (wipo.int)
[119] Co-Creation - Business Finland
[120] Co-Innovation - Business Finland

for funding. Further, priority is given to high-quality projects and ecosystems supporting the growth and internationalization of SMEs.

iii. Research to business funding[121] is intended for public research organizations for projects in which research groups and researchers aim to develop their research into new businesses and to commercialize their research results. As part of the funding, it also provides networking opportunities that support commercialisation preparation with investors and other teams.

iv. Growth Engines: Companies and academia collaborate to jointly work together on business activities generating Euro 1 billion worth of business.

3.10.4. Business Finland supports start-ups through its funding programs, digital platforms and advising them to grow internationally.[122] The funding programs support start-ups in terms of preparing their internationalization strategy and test the business concept (Tempo funding); buying expert services (innovation voucher, market explorer); explore joint business opportunities in a group of 4-10 enterprises. Digital platforms such as "*Dealfow*" provide visibility to investors whereas the program, "Finnish suppliers" provide visibility to buyers. The internationalization programs support start-ups to grow in international markets through international accelerator programs; soft landing networks (build a business in Asia and the US without setting up local offices); and high-level delegation visits in target markets through Team Finland. Additionally, there is a "*Start-up permit*", that enables international entrepreneurs to build a start-up in Finland (initially for two years).

3.10.5. The tax relief provisions enabled by the Finnish government act like the cherry on the cake. The key provisions for tax relief include:

i. Tax deduction of 150% for joint R&D projects: Entities that are conducting R&D activity with a research organization can make a 150% deduction on R&D subcontracting costs. The super-deduction is available for all companies operating in Finland, both domestic and international.

[121] Research to Business - Business Finland
[122] Finnish startup environment - Business Finland

ii. Accelerated depreciation for building used for R&D: Accelerated tax depreciation of 20% applies for buildings and construction used exclusively for R&D purposes.

iii. Depreciation of R&D expenditure: Instead of a deduction, a taxpayer may choose to capitalize the R&D costs and depreciate them over a two-year or longer period.

3.10.6. In Finland patents are processed and granted by the PRH- Patent and Registration office. The process and steps for registering a patent are clearly defined. It takes about 2.5–3 years on an average to process the application and grant a patent in Finland. A patent infringement suit can be filed with the Market Court, which has exclusive jurisdiction in patent matters. A patent owner could also initiate criminal proceedings in exceptional situations however, it is normal for corporate entities to proceed by way of civil proceedings. In urgent situations, an application for an injunction can be filed before the patent infringement suit.

3.11. Country Profile #10 – China

3.11.1. According to the GII 2022, China ranks 11th in the world. The emphasis on R&D and innovation in its policy has made the China R&D and innovation system one of the top-performing in the world. China spent about 2.2% of its GDP on R&D and about 77% of R&D spending is coming from the private sector. The key factors of China's R&D and innovation ecosystem are discussed below.

3.11.2. China's success in R&D is based on the centralized governance, with the Ministry of Science and Technology (MOST) as the main body which promotes R&D & innovation by providing funding platforms. In China, there are dedicated key R&D programs with specific focus areas such as Torch Program (Tech industries), Spark program (agriculture), 973 programs (basic research) etc. The National strategic plan i.e., Made in China 2025 aims to reduce reliance on foreign technology imports and invest in Chinese technology companies. The purpose of "*Made in China 2025*" is to change its perception from a low-end manufacturer to a high-end producer. Other key initiatives in China are:

i. Forced Technology transfer, which requires foreign companies to form joint ventures with local companies, with whom they must share their technology in return for market access.
ii. China National Knowledge Infrastructure (CNKI) is a repository that acts as a Chinese knowledge information gateway website for databases of journals, doctoral dissertations, and yearbooks.
iii. National Guidelines for Development and Promotion of the Integrated Circuit (IC) provides:
    a. Establishment of a national IC Fund endowed with $150 billion funds from the central and provincial governments.
    b. This fund was tasked with acquiring companies throughout the semiconductor supply chain.
    c. Provide incentives to support its domestic semiconductor sector such as grants, free trade zone, reduced utility rates, favourable loans, significant tax breaks, and free or discounted land.
iv. Artificial Intelligence Development Plan (AIDP) to make China the world centre of AI innovation by 2030 and make AI 'the main driving force for China's industrial upgrading and economic transformation'. China intends to create an AI industry worth more than 150 billion yuan (ca. 21 billion dollars). It seeks to establish initial ethical norms, policies, and regulations for vital areas of AI.

3.11.3. In 2020, public expenditure on education in China was around 4.22% of the national GDP. China has focused on education reforms to increase enrolment both at elementary and higher education levels. Due to this, it has observed an increase in enrolment rate at the elementary level from 20% in 1949 to 99.95% in 2018, and at the higher education level from 0.26% to 48.1% in 2018. China has setup institutes for technical training and skill building such as Industry and trade technicians colleges providing on-the-job training, and skill enhancement; finance international study tours; partner with companies to train students. National Technology Transfer Centres act as an intermediary between universities and industry to manage universities IP and technology transfer activities. Further, university Science parks encourage technology transfer initiatives and provide an environment where cutting-edge businesses

can grow along with universities. (TusPark has 1,000 sci-tech companies and R&D institutes.)

3.11.4. The first wave of force for innovation in China during the last few years has been the so-called frugal innovation, which started around 20 years ago. This concept refers to the first wave of Chinese innovators, who developed cheap and reliable solutions for most of the Chinese people, a huge, but low-income, population. In 2003 BYD Co. Ltd. (Build Your Dreams) created an automotive subsidiary, it took Japanese cars as a benchmark and adapted them to Chinese tastes through a process of reverse engineering. They became a symbol of the success of frugal innovation by absorbing key technologies from the developed world to encourage start-ups in China. Incubators set up by private entities such as Shanghai Idea Tree Technology Business Incubator and Shanghai Software Pudong Software Park support start-ups by providing working space, cyberspace, and consulting services along with facilitating funding from angel investors. On the other hand, the government initiatives for start-ups include:

i. Seed Funding (Innofund) to provides loans, grants, or equity investment to technology-based SMEs.

ii. Venture Guiding Fund encourages VCs to focus on funnelling more VC money into growing start-ups.

iii. Innovation Clusters: Create national Science and Technology Industrial Parks (STIPs), Software Parks, and Productivity Promotion Centres. China has set up 53 additional industrial parks and in them are ~60,000 companies with 8 million employees. Industry or technology-specific versions of these clusters have been set up. The Science and Technology Industrial Parks contributed 7% of China's GDP and close to 50% of all of China's R&D spending.

iv. Technology Business Incubators (TBIs) supports start-ups with office space, free rent, access to university technology transfer, etc.

v. Chinese Government Guidance Funds facilitates public-private investment into industries. They focus on investment in industries with emerging and high-potential technologies, including AI and robotics, as well as the digital transformation of traditional industries. [123]

[123] https://cset.georgetown.edu/publication/understanding-chinese-government-guidance-funds/

vi. Entrepreneur Visa allows foreign businessmen to live in China while they carry on with their business endeavours.

3.11.5. The major tax incentives to encourage R&D and technology innovation in China include:

i. R&D Expenses Super Deduction, which includes increased R&D expense deduction from 150% to 175%. It is applicable only to state-owned and collectively owned industrial enterprises.

ii. CIT exemption or reduction Qualified Technology Transfer Income is fully exempted if income does not exceed RMB 5 million and a half exempted if income exceeds RMB 5 million.

iii. For Technologically Advanced Service Companies (TASC), CIT rate is reduced to 15%. To be eligible for this, the minimum revenue from qualified technologically advanced services should be 50% of the annual total revenue.

iv. High New Technology Enterprise (HNTE) are entitled to tax holidays for 2 years and a half deduction for 3 years from the 1st year in which it derives operating income. Thereafter, a reduced CIT of 15% is imposed.

v. For angel investors: Of the total investment in start-ups by angel investors, 70% of the investment amount can be offset against taxable gains arising from disposals of equity in the technology start-up in which the investment has been made. Any unused balance may be carried forward and used against further future disposal gains from the equity in the same invested technology enterprise.

3.11.6. In China, patents are granted by the China National Intellectual Property Administration (CNIPA). It is a vice-ministerial-level state agency under the State Administration for Market Regulation of China. On average, it takes 22 months from the start of the substantive examination for an invention patent application to be granted. Thus, the applicant may expect to obtain an invention patent approximately three years after filing if the request for substantive examination is filed in a timely manner. In China, patent enforcement is done in three ways: Civil enforcement, Criminal enforcement, and administrative enforcement. The Beijing Intellectual Property Court is a standing judicial organ that hears cases on appeal over patents and other intellectual property rights. Further, for litigation analysis, CIELA is an

innovative IP litigation tool based on deep statistical analysis. It enables IP owners and their counsel to evaluate and compare IP litigation venues across China and includes a free-to-use web service.

3.12. India and the Rest of the World

3.12.1. Review of country profiles of the top ten spenders on R&D as a percentage of GDP helped us to understand global R&D scenario. Based on this study, key takeaways that add up to make a robust and successful R&D ecosystem can be customized as required and adopted by Indian counterparts.

Issues for Consultation

Q.23. What measures should be taken to strengthen international collaborations in the field of STEM by the Government of India? Please support your answer with suitable examples or frameworks and best practices in India and abroad in this regard.

Q.24. What are the best practices which need to be adopted by India to promote private sectors investment in R&D activities? Please support your answer with suitable examples or frameworks and best practices in India and abroad in this regard.

Q.25. Is there a need to introduce avenues for continuing patents in India such as provisions like "*Continuation-in-part Application*" in the USA? Please support your answer with justification, strategies and best practices in India and abroad in this regard.

Q.26. In view of the best practices being adopted by the global leaders in R&D in general and ICT in particular, which are the policies, programs and incentives which need to be adopted by India? Please support your answer with suitable examples or frameworks and best practices in India and abroad in this regard.

3.14. Key learnings from international experience

3.14.1. An in-depth comparison of R&D ecosystem in India against the benchmarked top-achievers of the world identifies key bottlenecks in R&D ecosystem of the country. These include low expenditure on R&D, low private sector investment

and involvement in R&D, lack of university-industry collaboration, and untapped potential of the demographic dividends. For easing out these bottlenecks require a strategy with increased focus and targeted efforts. On this note, it is pertinent to explore these bottlenecks further and find out the key takeaways from international best practices to encourage indigenous R&D in the ICT sector. As mentioned earlier, these can be divided into following five buckets:

i. Overall R&D Policy Framework
ii. Role of academia in innovation and its relations with industry for product commercialization
iii. Incentives for start-ups
iv. Tax Incentives
v. IPR Framework

3.14.2. Overall R&D Policy Framework

3.14.2.1. An enabling regulatory framework with streamlined and simplified regulatory processes, robust guidelines, high predictability, increased capacity, and strong governance is one of the building blocks of a strong innovation ecosystem for the ICT sector. Some of the key frameworks derived from above discussions include:

i. Centralized governance and monitoring of all R&D programs- Amongst the top-ten countries discussed in above paras, eight of them (except US and Denmark) comply with this key feature of an R&D ecosystem, making it an essential best practice. Currently, in India there are several programs under multiple institutes in ICT sector, providing either monetary or infrastructural support. A single governing body/ umbrella organization would help in overseeing the universe of R&D funding programs smoothly. A lack of coordination between R&D projects undertaken by different stakeholders under different Ministries handling ICT is evident in their implementation. Additionally, there is no well-defined single window monitoring mechanism to measure the impact of R&D expenditure by the stakeholders.
ii. Top-down approach for R&D strategy and direction- The Office of Principal Scientific Advisor (PSA) was established in India with the main aim to provide pragmatic and objective advice to the Prime Minister and

the cabinet in matters of Science and Technology. However, specifics are generally defined in different policies and strategy documents by various ministries and departments, such as National Policy on Electronics 2019, National Education Policy, National Policy on IT, draft STIP 2020, National strategy on AI, NDCP-2018, Policy to catalyse R&D and innovation in the Pharma-MedTech Sector, etc. A favourable policy landscape through coherent policies across scientific research, technology commercialization, IPR, etc is another building block to a strong innovation ecosystem, in general and particularly in the ICT Sector. However, there is lack of overall mission or vision defined by a central agency for R&D and innovation in the ICT sector. On the other hand, this practice is followed by eight of the top-ten global leaders in R&D, expect US and Denmark.

iii. High degree of academia-industry-government collaboration- This is an essential feature present in all the top-ten countries studied earlier in this chapter. However, the same is not adequately addressed in India. There is only a limited degree of collaboration between the academic institutes, industries, and the government for the purpose of promoting R&D and innovation activities. TCOEs, 5G testbeds and several science & technology clusters were setup with collaboration of the stakeholders, but their outcomes are yet to be ascertained. While efforts have been in right directions, there has been lack of institutional mechanism for tripartite collaboration of academia-industry-government. Moreover, the research outcomes and impact of industry-academia-government collaboration are not monitored systematically. Majorly in fact, all three of them run independently creating silos for majority of the R&D programs thereby restricting the impact of such programs. There is a need to forge symbiotic relationship between universities and industries to have coordinated efforts for better outcomes.

iv. Centralized repository of R&D artefacts, researchers, patents, etc. - Six out of the ten global leaders in R&D have a centralized repository which had resulted excellent R&D outcomes in these countries. On the other hand, In India, even data on R&D such as R&D expenditure, manpower employed in R&D, publication output, etc. are compiled and published

though with a lag and does not have reasonable level of disaggregation. This makes it difficult to formulate suitable policy interventions. Draft STIP 2020 envisions developing a National STI observatory (open centralized database platform for all financial schemes, programs, grants, and incentives) and Open Science Framework (provide access to scientific data, information, knowledge, and resources) to tackle this situation. These initiatives, when implemented will result in building conducive environment for R&D.

Issues for Consultation

Q.27. What should be the regulatory framework for R&D efforts in the ICT sector for establishing an outcome-based measurable system? Please suggest changes required in the present laws or creating new policies or regulatory frameworks with regard to carrying out R&D, testing of products allotment of spectrum and commercializing of products in ICT Sector.

Q.28. In the context of India, whether top-down or bottom-up approach, or combination thereof should be preferred to facilitate indigenous R&D? Please support your answer with suitable examples or frameworks and best practices in India and abroad in this regard.

3.14.3. Role of academia in innovation

3.14.3.1. Academia is an important pillar in any nation's R&D ecosystem. The key learnings identified pertaining to the role played by educational and training research institutes are given below.

Key Learnings

i. High education spending and pragmatic teaching pedagogy**:** The percentage of GDP spent on Education in India is 2.9%.[124] It is relatively low as compared to other leading countries. For example, the percentage of GDP spending on Education in leading countries indicate Israel- 7%,

[124] Source: Economic Survey 2022-23

Sweden - 7.6% and Denmark - 7.6%. Further, the teaching pedagogy inclines towards traditional methods, in form of instructor-led or content-led teaching with examination and grades as end goals. It is more theoretical than practical due-to syllabus-driven approach. The National Education Policy 2020 (NEP) tries to address these issues and as a part of a holistic education program, students at all Higher Education Institutes (HEIs) will be provided with opportunities for internships with local industry, businesses, artists, crafts persons, etc., as well as research internships with faculty and researchers at their own or other HEIs/research institutions, so that students may actively engage with the practical side of their learning and further improve their employability. Another positive step taken in this direction is the setting up of Atal Tinkering Labs (ATL) under the Atal Innovation Mission. However, these interventions are still at a nascent stage to show any significant impact.

ii. Continuous involvement with Centres of Excellence (CoE) in universities: Most global leaders including Israel, China, Japan and the US gained traction in their R&D efforts due to the establishment of coherent CoEs in universities with the help of the industry. Similarly, the Government of India has been setting up COEs at academic institutes under different schemes to encourage R&D in specific areas. For example, the Telecom Centres of Excellence (TCOEs) established at eight academic institutes under a Public Private Partnership (PPP) model in which the Government acts as a facilitator, academia acts as a research unit and industry acts as the ultimate user. However, the experience has not been encouraging as till recently only three technologies have been commercialized out of 14 technologies on which the approval to work was issued. Additionally, half of the TCOEs have become inactive.

iii. Open innovation platforms for academia-industry collaboration: Open innovation platforms allow researchers from universities and industries to collaborate by providing research equipment, data, and other required resources on need basis. They are at very embryonic stage in India. 5G testbed was one of the initiatives where academia and the Government collaborated for developing such platform. However, industry

involvement was very limited in this case. On the other hand, almost all the benchmarked countries, have prudent open innovation platforms encouraging such collaborations and have given fruitful results. For example, Japan has open innovation platforms to support academia-industry collaboration like Centre of Innovation program and Open Innovation Platform with Enterprises, Research Institute and Academia (OPERA).

iv. Commercialization of research is a crucial function to sustain the R&D landscape of a country. The global leaders depend on technology transfer programs to commercialize the research that takes place in their academic institutions. There has been limited quantitative and qualitative success of such programs in India. One of the main reasons for this is the non-alignment between the demand in the industry and the research and innovation taking place in the universities. On the contrary, Technology Transfer Organizations and incubator programs in leading countries have helped them gain immensely from commercialization of research. Thus, providing an impetus to translational research i.e., "*putting research into action*" is required.

Issues for Consultation

Q.29. Apart from the measures indicated under New Education Policy what additional measures should be taken to establish a framework at initial stages of education to encourage students for opting experiment-based learning (learning by doing), rather memory-based learning? Please provide your answer quoting the best practices being followed internationally.

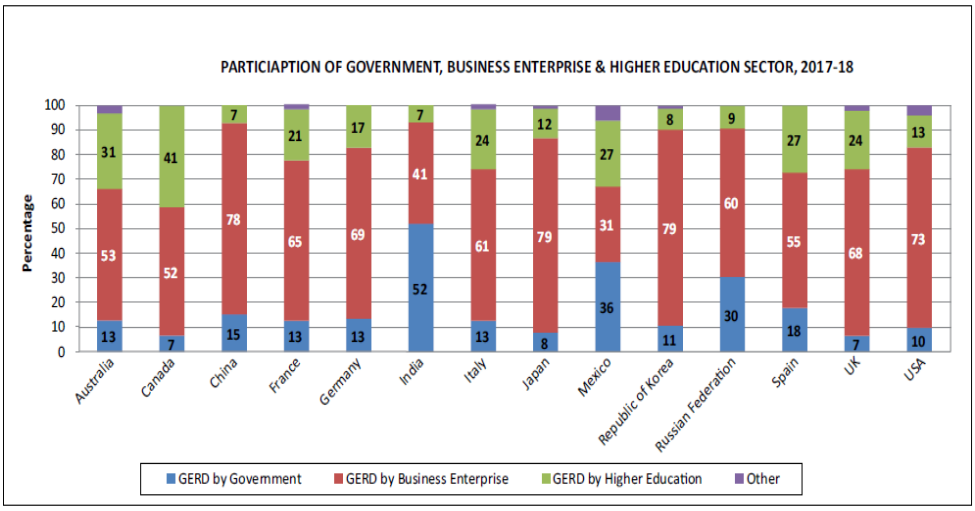
Q.30. What interventions are necessary at policy or governance level to facilitate the growth of knowledge-based industries in India with respect to ICT sector?

Q.31. How educational institutions can be linked with industries on long term basis for basic R&D, development and commercialization of innovative products on self-sustainable model? Is there any policy intervention also needed? Please support your answer with the best practices being followed in India, or internationally.

3.14.4. Incentives for start-ups

3.14.4.1. Gross expenditure on R&D(GERD) required to create a sustainable impact cannot be fulfilled by the governments alone. The contribution from the private sector is of utmost importance. Figure 3.3 showcases expenditure on R&D by government, business enterprise, higher education institutes and others across the globe.

Figure 3.3: GERD on R&D by stakeholders[125]



3.14.4.2. An increasing number of Governments are offering special fiscal incentives to business to increase spending on R&D, largely because R&D and innovation are considered key to productivity and growth performance. Many Governments in countries at the helm of innovation are redesigning their R&D tax incentives to make them more effective for budding entrepreneurs. This has led to remarkable results for them. On comparing the situation with India, key learnings identified to boost indigenous R&D in this bucket are given below.

Key Learnings

i. Funding programs for the entire innovation lifecycle (Ideation, POC, Prototype, Commercialization)- This is a trademark feature for achieving heights in the domain of research, development, and innovation in all benchmarked countries studied in the previous chapter. Although funding programs cater to all stages of an innovation lifecycle (ideation, proof-of-concept, prototype, commercialization) in India, the required guidance/mentoring on how to commercialize an invention is missing. Most inventions continue to only remain as patented research output instead of getting commercialized through start-ups or existing industries.

ii. Training and mentorship programs to support new start-ups- Under "Startup India", the Government of India provides a platform for connecting with mentors to seek guidance from experienced

[125]Source: https://static.psa.gov.in/psa-prod/publication/1571900991_R%26D%20book%20expenditure%20ecosystem.pdf

professionals from the Indian business landscape. It also provides online courses for entrepreneurs to develop business and technology skills, and a Startup guidebook. In addition to this, under Atal Innovation Mission, Atal Incubation centres have been set up at universities, institutions and corporates which support entrepreneurs by providing technological facilities and advice, initial growth funds, network and linkages, co-working spaces, lab facilities, mentoring, and advisory support. However, all these initiatives are at an incipient stage to create any significant impact whereas the above referred ten frontrunners in R&D are bearing the fruits of efforts put in this aspect in the past. Programs designed to support early-stage start-ups like "Innofounder", "Innoexplorer", "Innobooster" in Denmark have given good results in this aspect.

iii. Networking opportunities with Venture Capitalists, experts, vendors, etc.- Most of the global leaders in R&D space provide the businesses with the opportunities to network and connect with potential investors, accelerators, incubators, corporates, and relevant departments and ministries in the government. The Government of India has made efforts to replicate the same in India through the "Startup India" initiative but it's still too early to gauge its success.

iv. Support for global expansion and start-up visa to attract foreign entrepreneurs- A spirit of innovation in the native population of a country is indispensable but contributions from foreign nationals are also welcome in most global R&D leaders. For example, South Korea provides a dedicated support for global expansion and start-up visa to attract foreign entrepreneurs. However, the practice is not so common in the United States and Switzerland. In India, as a part of "Startup India" program, Government launched international bridges program which supports local start-ups in going global. India has also established "Startup bridge" with 13 countries including Canada, Singapore, Israel, Sweden, Korea, Japan, etc. The "Startup bridge" aims to enable start-ups, investors, incubators, corporates, and aspiring entrepreneurs of both countries to connect and provide them with resources to expand and globalize. It provides go-to market guide on regulations, visa process, company incorporation, opportunities in the market. The program is yet

to mature and produce any quantifiable result. Additionally, the lack of attractive and friendly policies and programs make only a few NRIs and foreigners to come to India and start a business.

Issues for Consultation

Q.32. Start-ups are carrying out some outstanding work in all kinds of industries. What additional incentives can be given to start-ups to take up R&D activities in the ICT sector? In this regard, will establishing an exclusive venture capital (VC) fund for ICT help start-ups in the ICT sector to flourish and prosper in India? If yes, please provide a mechanism for the same.

Q.33. Suggest ways and means to improve the acceptance of Indian technological innovations globally? Do you envisage the need for a Technology Transfer Organization at the national level to help towards commercialization of innovations in ICT? Please support your answer with justification, frameworks and best practices in India and abroad in this regard.

Q.34. ICT sector is enabler for fin-tech, health-tech, ed-tech and a host of other applications. In such a scenario, what should be the specific focus areas for R&D in ICT sector? Please support your answer with justification, frameworks and best practices in India and abroad in this regard.

3.14.5. Tax Incentives

3.14.5.1. Tax relief provisions are one of the favourable ways that top ten R&D spenders adopt to facilitate the growth of research, development, and innovation. Incentives like Tax Carry Forward, Tax Breaks, Tax Holidays and Tax Credits have become a common practice in these countries. The best practices adopted by the global leaders and the key learnings found therein for India are enumerated below.

Key Learnings

i. Tax deduction/rebate on R&D expenses is a prevalent feature of nine of the ten benchmarked countries, with Sweden opting out. India provides 100% tax deduction under Section 35 of Income Tax Act (Revenue

expenditure on scientific research pertaining to business of assessee is allowed as deduction (subject to certain conditions)) on in-house R&D expenditure, expenditure on scientific research, contribution to national labs or institute for research.[126]

ii. Tax incentives for investments made in start-ups by angel investors- Global frontrunners in R&D like the United States, China, Israel, and the Republic of Korea have incorporated incentives for angel investors investing in R&D, in their taxation laws. India provides angel investors 100% tax exemption on the investments that are made in start-ups above the fair market value. The angel investor must have minimum net worth of INR 2 crore or average returned income of more than INR 25 lakh in the previous three financial years to be eligible for benefits. The benefits provided in this aspect in India are complex and unintelligible.

iii. Reduction in social security contributions for personnel engaged in R&D- Sweden and Switzerland have adhered to the practice of such type of tax incentives and have garnered good response. However, no specific regulations or practices to provide social security (Provident Fund/ National Pension Scheme (NPS)) based benefits for personnel engaged in R&D are present in India.

iv. Additional tax incentives for 5G and digital transformation related research have featured in the taxation regime of South Korea and Japan. The two global leaders in R&D have seen a positive impact of such incentives. As of now, India does not offer additional tax incentives to support R&D activities being carried out in the areas related to forward looking/next generation technologies such as 5G, Artificial Intelligence (AI), Analytics, Blockchain, Internet of Things (IoT), etc.

Issues for Consultation

Q.35. Is there a need for additional tax or fiscal incentives to support R&D activities in emerging technologies in ICT sector? If yes, please give suggestions with justifications and best practices in India and abroad in this regard.

[126] Deductions allowable to taxpayer https://www.incometaxindia.gov.in

3.14.6. IPR Framework

3.14.6.1. Intellectual property rights (IPR)—the copyrights, patents, trademarks and similar rights upon which the lion's share of creative and innovative products and services rely—have had a vital role in growing the economies of the benchmarked countries, in spurring innovation, in giving large and small firms a range of tools to help drive their success, and in benefitting consumers and society through a continuous stream of innovative, competitive products and services and an expansion of society's overall state of knowledge. Several best-practices and the key learnings for India therein have been identified under this domain.

Key Learnings

i. Shorter cycles for patent approvals- Normal process duration for granting patent is around 5-6 years in India which is longer than other leading countries like Denmark, Sweden and South Korea which provide approvals within 1 to 3 years. The expedited patent process duration (earliest possible time) is approximately 0.8 years in India which is longer than other leading countries which provide expedited approvals within about 0.5 years. Moreover, Germany offers expedited patent examination facility at no additional cost/solicitor fee/ legal application fees.

ii. Special IP courts for quicker resolution of cases- Majority of the top ten frontrunners in R&D sphere have provisions for adjudication through the special IP courts, which lead to fair and faster dispute resolutions. For example, the US has a dedicated IP Court to accelerate IP infringement cases. Absence of special courts in India makes it difficult to manage patent related cases. This leads to longer duration for resolving patent related cases which transcends into higher costs and higher risk of invention becoming obsolete due to rapid change in technologies.

iii. Subject Matter Experts/ Trained Judicial Experts for valuation of infringement- Barring Germany, all the other nine global leaders in R&D have technically trained judges to handle the disputes related to IPRs. For example, Israel has judges who are experienced in patent cases. On the other hand, in India, IPR-related disputes are handled by generic courts. There may be requirement for the courts to be equipped with

domain experts to understand and evaluate various aspects of IPR-related disputes and resolve them in time-bound manner.

iv. Multiple ways of patent enforcement: civil, criminal, administrative- Global leaders including Sweden, Switzerland, Japan, Denmark, Finland, and China have multiple provisions for enforcement of patent laws. However, in India, in the absence of specialist courts to address these issues, enforcement of patent laws is done under civil law through the regular courts only. This results in delays and higher cost, causing the hesitation to the entrepreneurs to enter the Indian market.

Issues for Consultation

Q.36. What should be the best practices followed in India to make it a favourable destination for IPR and Patent award nation? Please support your answer with justification, frameworks and best practices in India and abroad in this regard.

Q.37. What measures should be taken for quick disposal of IPR or Patent related disputes? Is there a need to create a specialised legal platform for the same? If so, what steps may be taken to adopt them?

Please provide your answers for above questions, quoting the best practices being followed globally.

Q.38. Please comment on any other related issue to promote R&D in the ICT sector in India. Please support your answer with suitable examples and best practices in India and abroad in this regard.

CHAPTER 4

SUMMARY OF ISSUES FOR CONSULTATION

4.1. For enhancing the R&D ecosystem in the country in telecom and broadcasting sectors the comments of stakeholders on the following issues are solicited. The consultation paper is aimed at understanding the present ecosystem of R&D in India, identify and learn from practices adopted by R&D leaders across the globe and account for issues to be consulted with the stakeholders for enhancing the R&D scenario in India. Keeping the same in mind this consultation paper has been prepared.

4.2. The response to the consultation paper may be given with rationale and justification. Any other issue which is not discussed in this paper but is of importance in improving R&D ecosystem in country may also be brought to notice as sought under Q.33. of the paper.

4.3. The summary of the issues for consultation in form of questions to the stakeholders are given as below:

Questions

Education and Training System

Q.1. Whether current education system adequately promotes scientific temper and skills among students encouraging them to contribute towards Research and Development activities in ICT sector? If yes, please indicate what additional measures are needed to make them effective contributors of innovations to the industry. If not, please identify areas which need to be strengthened to orient students towards research and development activities in ICT sector.

Q.2. What should be done to further strengthen the roots of R&D ecosystem in general and specially in the ICT sector of the country, which allows:

a. Increase in number of post-graduates going for doctoral and post-doctoral programs in institutions other than IITs?

b. **Assured career progression opportunities in the field of Research and Development for students graduating from tertiary educational institutions?**

c. **Researchers to continue entire career in advanced research.**

d. **Increase in employability and career progression skills of students enrolled in STEM courses?**

Q.3. What measures should be taken pertaining to the tertiary institutions with a focus to encourage students towards advanced R&D at the university level?

Science System

Q.4. Whether current science system (network of public and private institutions involved in the production and consumption of R&D and innovation) is sufficient to foster R&D and innovation in India in general and ICT in particular? If not, what additional measures are required to strengthen science system of the country and ensure availability of adequate resources for the same? Please support your answer with justification and best practices being followed in India and abroad in this regard.

Q.5. How can the participation of public sector enterprises involved in R&D be augmented towards a synergized national effort in research, development, and innovation in ICT? Please support your answer with justification and best practices being followed in India and abroad in this regard.

Q.6. What should be the prerequisites and key characteristics of an effective next-generation technology testbeds in India? Will defining national-level mission and strategic objectives for ICT help in their effective utilization? Please support your answer with justification and best practices in India and abroad in this regard.

Q.7. What role do you envisage for the service providers and industry in facilitating indigenous R&D in the ICT sector respectively?

How can industry participation in R&D in the ICT sector be further improved? Please support your answer with justification and best practices in India and abroad in this regard.

Q.8. How Telecom Centres of Excellence (TCOEs) can be made hubs of innovative product delivery to telecom industry? What can be done to further strengthen the TCOEs in order to provide an impetus to innovations in the telecom sector? Please support your answer with justification and best practices in India and abroad in this regard.

Q.9. Is there a need to establish new Centres of Excellence for the broadcasting sector? What can be done to synergize telecom and broadcasting sectors for the objective of convergence? Please support your answer with justification and best practices in India and abroad in this regard.

Q.10. What are the reasons behind MNCs primary focus on software rather than hardware in India? What measures can be taken to promote basic/applied research by MNCs strengthening the current R&D efforts in software and improving R&D efforts in hardware? Suggest a suitable mechanism to establish a balanced R&D Science System in the country.

Q.11. What are the steps required to strengthen government-industry-academia linkages in the ICT sector on long terms basis? Please support your answer with justification and best practices in India and abroad in this regard.

Regulatory Framework: Policies and Programs

Q.12. Whether the current institutional mechanism is adequate to cater to the needs of R&D in ICT sector in India? Is there a need to create a separate agency to coordinate and look after R&D functions specifically in ICT sector? If yes, suggest a suitable framework for the overarching agency. If not, how can synergy between stakeholders be established to ease out processes and monitor timebound R&D outcomes? Please support your answer

with justification and best practices being followed in other sectors nationally or internationally.

Q.13. What steps must be taken to ensure a transparent mechanism for adequate and timely disbursement of funds for R&D programs? What should be indicators for the tracking mechanism for the funds and outcomes of R&D programs? Please support your answer with suitable examples or frameworks and best practices in India and abroad in this regard.

Q.14. How can participation of private sector in R&D be encouraged? Which incentivization model(s) or combination thereof would produce better results:

(i) Tax-break model, or

(ii) Product-Linked Incentivization model

(iii) Any other model.

Please provide details of the suggested model(s) in terms of structure, functioning, monitoring, and evaluation.

Q.15. Is there a need for a mechanism to promote research, development, and innovation at the state level? Will a ranking mechanism for the states help to promote the spirit of innovation? If yes, please comment on the structure of such a mechanism with key performance indicators.

Regulatory Framework: IPR Framework

Q.16. How can awareness about IPR be increased among the researchers and industry in ICT sector? Suggest action points for making IPR as a part of syllabus in graduation /post-graduation level in colleges. Please support your answer with justification and best practices in India and abroad in this regard.

Q.17. What essential steps can be taken to further improve the speed and efficiency of the patent approval process for ICT in India?

Please support your answer with justification and best practices in India and abroad in this regard.

Q.18. Is there a need to reduce the cost of filing patents in India? If yes, how can it be done? Please support your answer with justification and best practices in India and abroad in this regard.

Q.19. As far as the ICT sector is concerned, suggest measures to enhance filing of patents in India in general and by resident Indians in particular. Do we need a mechanism for handholding in patent filing? Do we need a mechanism of IPR sharing for collaborative research projects? Please support your answer with justification and best practices in India and abroad in this regard.

Q.20. (a) Is the Fair, Reasonable, and Non-Discriminatory (FRAND) mechanism for licensing of Standard Essential Patents (SEPs) functioning satisfactorily and effectively? Is there a need for any reforms in this aspect?

(b) How can small innovators be protected from the predatory practices?

Please support your answers with justification and best practices in India and abroad in this regard.

Q.21. (a) What additional measures should be taken to strengthen IPR dispute resolution mechanism to ensure confidentiality of the innovation and time-bound disposal of IPR-related disputes?

(b) How can Alternate Dispute Resolution (ADR) mechanisms for IPR disputes be improved?

Please support your answer with justification and best practices in India and abroad in this regard.

Q.22. Whether there is a need to introduce IP-backed financing system in India for ICT sector? If yes, what could be the framework to recognize IP as a collateral? Please support your answer with suitable examples or frameworks and best practices in India and abroad in this regard.

Global Leaders in R&D

Q.23. What measures should be taken to strengthen international collaborations in the field of STEM by the Government of India? Please support your answer with suitable examples or frameworks and best practices in India and abroad in this regard.

Q.24. What are the best practices which need to be adopted by India to promote private sectors investment in R&D activities? Please support your answer with suitable examples or frameworks and best practices in India and abroad in this regard.

Q.25. Is there a need to introduce avenues for continuing patents in India such as provisions like "*Continuation-in-part Application*" in the USA? Please support your answer with justification, strategies and best practices in India and abroad in this regard.

Q.26. In view of the best practices being adopted by the global leaders in R&D in general and ICT in particular, which are the policies, programs and incentives which need to be adopted by India? Please support your answer with suitable examples or frameworks and best practices in India and abroad in this regard.

Key Learnings from International Experience

Q.27. What should be the regulatory framework for R&D efforts in the ICT sector for establishing an outcome-based measurable system? Please suggest changes required in the present laws or creating new policies or regulatory frameworks with regard to carrying out R&D, testing of products allotment of spectrum and commercializing of products in ICT Sector.

Q.28. In the context of India, whether top-down or bottom-up approach, or combination thereof should be preferred to facilitate indigenous R&D? Please support your answer with suitable examples or frameworks and best practices in India and abroad in this regard.

Q.29. Apart from the measures indicated under New Education Policy what additional measures should be taken to establish a framework at initial stages of education to encourage students

for opting experiment-based learning (learning by doing), rather memory-based learning? Please provide your answer quoting the best practices being followed internationally.

Q.30. What interventions are necessary at policy or governance level to facilitate the growth of knowledge-based industries in India with respect to ICT sector?

Q.31. How educational institutions can be linked with industries on long term basis for basic R&D, development and commercialization of innovative products on self-sustainable model? Is there any policy intervention also needed? Please support your answer with the best practices being followed in India, or internationally.

Q.32. Start-ups are carrying out some outstanding work in all kinds of industries. What additional incentives can be given to start-ups to take up R&D activities in the ICT sector? In this regard, will establishing an exclusive venture capital (VC) fund for ICT help startups in the ICT sector to flourish and prosper in India? If yes, please provide a mechanism for the same.

Q.33. Suggest ways and means to improve the acceptance of Indian technological innovations globally? Do you envisage the need for a Technology Transfer Organization at the national level to help towards commercialization of innovations in ICT? Please support your answer with justification, frameworks and best practices in India and abroad in this regard.

Q.34. ICT sector is enabler for fin-tech, health-tech, ed-tech and a host of other applications. In such a scenario, what should be the specific focus areas for R&D in ICT sector? Please support your answer with suitable examples or frameworks and best practices in India and abroad in this regard.

Q.35. Is there a need for additional tax or fiscal incentives to support R&D activities in emerging technologies in ICT sector? If yes, please give suggestions with justifications and best practices in India and abroad in this regard.

Q.36. What should be the best practices followed in India to make it a favourable destination for IPR and Patent award nation? Please support your answer with justification, frameworks and best practices in India and abroad in this regard.

Q.37. What measures should be taken for quick disposal of IPR or Patent related disputes? Is there a need to create a specialised legal platform for the same? If so, what steps may be taken to adopt them?

Please provide your answers for above questions, quoting the best practices being followed globally.

Others

Q.38. Please comment on any other related issue to promote R&D in the ICT sector in India. Please support your answer with suitable examples and best practices in India and abroad in this regard.

Annexure I

List of Acronyms

S. No.	Acronyms	Description
1	3GPP	Third-Generation Partnership Project
2	AI	Artificial Intelligence
3	AICs	Atal Incubation Centres
4	AIM	Atal Innovation Mission
5	AIR	All India Radio
6	AISHE	All-India Survey of Higher Education
7	AR	Augmented Reality
8	ATLs	Atal Tinkering Labs
9	BMWi	Federal Ministry of Economics and Technology (Germany)
10	C-DAC	Centre for Development of Advanced Computing
11	C-DoT	Centre for Development of Telematics
12	CPSEs	Central Public Sector Enterprises
13	CRC	Collaborative Research Centres
14	DoT	Department of Telecommunication
15	DSIR	Department of Science and Industrial Research
16	DST	Department of Science & Technology (India)
17	EAC-PM	Economic Advisory Council to the Prime Minister
18	ESDM	Electronics System Design and Manufacturing
19	ETG	Empowered Task Group (of the PSA)
20	FRAND	Fair, Reasonable And Non-Discriminatory
21	FDI	Foreign Direct Investment
22	FTE	Full-Time Equivalent
23	GDP	Gross Domestic Product
24	GERD	Gross Domestic Expenditure on R&D
25	GII	Global Innovation Index

S. No.	Acronyms	Description
26	I-STEM	Indian Science, Technology and Engineering Facilities Map
27	ICT	Information and Communication Technology
28	INDSTA	Indian Science and Technology Archive of Research
29	IoT	Internet of Things
30	IPO	Indian Patent Office
31	IPR	Intellectual Property Right
32	IT	Information Technology
33	IIT	Indian Institute of Technology
34	ISM	India's Semiconductor Mission
35	ITU	International Telecommunication Union
36	Li-Fi	Light-Fidelity
37	M2M	Machine-to-Machine
38	MEITY	Ministry of Electronics and Information Technology
39	ML	Machine Learning
40	MNCs	Multinational corporations
41	MoU	Memorandum of Understanding
42	MSME	Micro, Small and Medium Enterprises
43	MV	Metaverse
44	NASSCOM	National Association of Software and Service Companies
45	NDCP	National Digital Communications Policy
46	NEP	National Education Policy
47	NFV	Network Function Virtualization
48	NPE	National Policy on Electronics
48	OECD	Organisation for Economic Co-operation and Development
49	OTT	Over-The-Top Services
50	PCT	Patent Cooperation Treaty
51	PLI	Production-Linked Incentive

S. No.	Acronyms	Description
52	PM-STIAC	Prime Minister's Science, Technology, and Innovation Advisory Council
53	PPP	Public-Private Partnership
54	PPP$	Purchasing Power Parity
55	PSA	Principal Scientific Adviser
56	R&D	Research and Development
57	R&E	Research and Experimentation
58	RDFDI	Foreign Direct Investment in R&D
59	RITCOE	Reliance IITM Telecom Centre of Excellence
60	S&T	Science and Technology
61	SAMEER	Society for Applied Microwave Electronics Engineering & Research
62	SDN	Software Defined Networks
63	SDGs	Sustainable Development Goals
64	SEPs	Standard Essential Patents
65	SEZs	Special Economic Zones
66	SMEs	Small and Midsize Enterprises
67	STB	Set-Top-Box
68	STI	Science, Technology, and Innovation
69	STEM	Science, Engineering, Mathematics & Engineering
70	STEP	Science & Technology Entrepreneurship Park
71	STIP	Science, Technology, and Innovation Policy
72	STPI	Software Technology Parks of India
73	TCOE	Telecom Centres of Excellences
74	TRAI	Telecom Regulatory Authority of India
75	TRIPS	Trade Related Aspects of Intellectual Property Rights
76	TSDSI	Telecommunications Standards Development Society, India
77	TSPs	Telecom Service Providers
78	UGC	University Grants Commission
79	USD	United States dollar

S. No.	Acronyms	Description
80	USTR	United States Trade Representative
81	VC	Venture Capitalist
82	VR	Virtual Reality
83	WIPO	World Intellectual Property Organization
84	WTO	World Trade Organization

Annexure II

List of Top Higher Education Institutions in Research

Name	City	State	Score	Rank
Indian Institute of Science	Bengaluru	Karnataka	88.62	1
Indian Institute of Technology Madras	Chennai	Tamil Nadu	86.38	2
Indian Institute of Technology, Delhi	New Delhi	Delhi	82.16	3
Indian Institute of Technology, Bombay	Mumbai	Maharashtra	80.21	4
Indian Institute of Technology, Kharagpur	Kharagpur	West Bengal	74.05	5
Indian Institute of Technology Kanpur	Kanpur	Uttar Pradesh	72.47	6
Tata Institute of Fundamental Research	Mumbai	Maharashtra	66.63	7
Indian Institute of Technology, Roorkee	Roorkee	Uttarakhand	66.29	8
All India Institute of Medical Sciences, Delhi	New Delhi	Delhi	62.48	9
Vellore Institute of Technology	Vellore	Tamil Nadu	59.71	10
Homi Bhabha National Institute	Mumbai	Maharashtra	58.65	11
Indian Institute of Technology Hyderabad	Hyderabad	Telangana	57.96	12
Jadavpur University	Kolkata	West Bengal	56.81	13
Jawaharlal Nehru University	New Delhi	Delhi	56.75	14
Banaras Hindu University	Varanasi	Uttar Pradesh	55.61	15
University of Delhi	Delhi	Delhi	55.51	16
Indian Institute of Science Education & Research, Pune	Pune	Maharashtra	55.39	17

Academy of Scientific & Innovative Research	Ghaziabad	Uttar Pradesh	53.21	18
Jamia Millia Islamia, New Delhi	New Delhi	Delhi	53.14	19
Indian Institute of Technology (Indian School of Mines)	Dhanbad	Jharkhand	53.07	20
Anna University	Chennai	Tamil Nadu	52.85	21
Bharathiar University	Coimbatore	Tamil Nadu	51.18	22
National Institute of Technology, Tiruchirappalli	Tiruchirappalli	Tamil Nadu	51.14	23
National Institute of Technology Rourkela	Rourkela	Odisha	50.94	24
Institute of Chemical Technology	Mumbai	Maharashtra	50.81	25
Indian Institute of Technology Indore	Indore	Madhya Pradesh	50.73	26
University of Hyderabad	Hyderabad	Telangana	50.52	27
Aligarh Muslim University	Aligarh	Uttar Pradesh	50.16	28
Panjab University	Chandigarh	Chandigarh	50.15	29
Manipal Academy of Higher Education, Manipal	Manipal	Karnataka	49.96	30
Amrita Vishwa Vidyapeetham	Coimbatore	Tamil Nadu	49.42	31
Indian Institute of Science Education & Research, Kolkata	Mohanpur	West Bengal	48.08	32
Birla Institute of Technology & Science - Pilani	Pilani	Rajasthan	47.65	33
Indian Institute of Technology, Gandhinagar	Gandhinagar	Gujarat	47.3	34

Thapar Institute of Engineering and Technology	Patiala	Punjab	46.38	35
S.R.M. Institute of Science and Technology	Chennai	Tamil Nadu	46	36
Indian Institute of Technology Bhubaneswar	Bhubaneswar	Odisha	44.09	37
Amity University	Gautam Budh Nagar	Uttar Pradesh	42.13	38
Indian Institute of Technology, Mandi	Mandi	Himachal Pradesh	41.92	39
Indian Institute of Engineering Science and Technology, Shibpur	Howrah	West Bengal	41.36	40
Indian Institute of Technology, Patna	Patna	Bihar	41.19	41
National Institute of Mental Health & Neuro Sciences, Bangalore	Bangalore	Karnataka	41.14	42
Alagappa University	Karaikudi	Tamil Nadu	41	43
Shanmugha Arts Science Technology & Research Academy	Thanjavur	Tamil Nadu	40.4	44
Siksha `O` Anusandhan	Bhubaneswar	Odisha	40.06	45
Malaviya National Institute of Technology	Jaipur	Rajasthan	39.82	46
Kalinga Institute of Industrial Technology	Bhubaneswar	Odisha	39.64	47
Saveetha Institute of Medical and Technical Sciences	Chennai	Tamil Nadu	39.58	48
Indian Institute of Science Education & Research Bhopal	Bhopal	Madhya Pradesh	39.51	49

National Institute of Technology, Silchar	Silchar	Assam	38.67	50

Source: NIRF 2022 Rankings

Annexure III

Details of Policies & Programs

i. Innovation Funding

S. No.	Dept.	Program/Policy	Eligibility	Sector	Incentive	Validity
1	MEITY	**Electronic Development Fund (EDF) Policy**	Daughter fund which is registered in India and abides with relevant rules and regulations	Electronics, Nano-electronics, and Information Technology (IT)	Participate in professionally managed "Daughter Funds" which provide risk capital to companies developing new technologies	Valid
2	Technology Development Board (TDB), DST	**Project finance through Technology Development Board**	Commercial enterprises/ R&D institutions/ Start-ups	Across sectors	Provides financial incentive in form of equity, loans, grants, seed scheme, venture capital funds	Valid
3	Department of Science and Industrial Research (DSIR)	**Technology Development and Demonstration Program (TDDP)**	A registered companies three years old; preference to companies having in-house R&D units recognised by DSIR	Across sectors	Partial financial support to research, development, design and engineering (RDDE) projects	Valid

S. No.	Dept.	Program/Policy	Eligibility	Sector	Incentive	Validity
4	Ministry of Electronics and Information Technology (MEITY)	**Multiplier Grants Scheme (MGS)**	Start-up, Incubator/ Academia/ Accelerator	Electronics and IT	Funding grant: ▸ Individual industry up to INR 2 Crore; Industry Consortium up to INR 4 Crore	
5	MEITY	**Support for International Patent Protection in Electronics & Information Technology (SIPEIT)**	MSMEs and Technology Start-up units	Electronics & IT	Reimbursement limited to a total of INR 15 Lakhs per invention or 50% of the total expenses incurred in filing and processing of patent application.	
6	MEITY	**Technology Incubation and Development of Entrepreneurs (TIDE 2.0)**	MSMEs and Technology Start-up units	Electronics & IT	Support for start-up at various stages: Entrepreneur-in-residence: For Idea to proof of concept, up to INR 4 Lakh Grants: for prototype development up to INR 7 Lakh Investment: for product development and market reach up to INR 40 Lakh	
7	DSIR	**Promoting Innovations in**	Student/govt. institution/ agency, public	Green technology, Clean energy,	**PRISM Phase I:** Category I: Max. INR 2.00	

S. No.	Dept.	Program/Policy	Eligibility	Sector	Incentive	Validity
		Individuals, Start-ups and MSMEs (PRISM)	funded – R&D institutes/ autonomous institutions/ laboratories/ academic institutes	Industrially utilizable smart materials, Waste to Wealth, Affordable Healthcare, Water & Sewage Management, and any other technology area	lakh or 90% of the total project cost whichever is lower. Category II: Max INR 20 lakh or 90% of the total project cost whichever is lower. **PRISM Phase II:** Max INR 50 lakh limited to 50% of the project cost whichever is lower. PRISM - R&D proposals: Max INR 50 lakh limited to 50% of the project cost.	
8	DSIR	**Patent Acquisition and Collaborative Research and Technology Development (PACE)**	Industry, R&D institutions, academic institutions	Energy and Environment. Affordable healthcare. Agriculture, food and nutrition. Engineering. Specialty Chemicals	Support up to 50% of the project cost to industry in form of secured loan	Valid
9	MEITY	**R&D funding scheme by MEITY**				

S. No.	Dept.	Program/Policy	Eligibility	Sector	Incentive	Validity
10	NITI Aayog	**Atal Innovation Mission (AIM)**	universities, research institutions, private and MSME sector	Across sectors	Supported in developing : Atal Tinkering Labs at school level: Receives a grant in aid of INR 12 lakh in the first year, and up to INR 2 lakhs per year for subsequent 4 years for maintenance. Atal incubation centers for startups: Receives grant in aid up to INR 10 crore over 3-5 years in tranches per year	Valid
11	MEITY	Production Linked Incentives Scheme for Large Scale Electronics Manufacturing	Companies engaged in manufacturing of mobile phones (global companies and domestic companies), specified electronic components. Eligibility subject to thresholds of incremental investment and incremental sales of manufactured goods	Electronics	Scheme total outlay: INR 40,951 Cr. Provides incentive of 4% to 6% on incremental sales (over base year) of goods manufactured in India and covered under target segments. The disbursement of incentives is in the form of Direct Bank Transfer through Public	2020 - 2025

S. No.	Dept.	Program/Policy	Eligibility	Sector	Incentive	Validity
					Financial Management System (PFMS).	
12	MEITY	Production Linked Incentive (PLI) scheme for telecom and networking products	Companies engaged in manufacturing of telecom and networking equipment (MSMEs and Non-MSMEs - domestic and global companies) who satisfy min. revenue criteria	Telecom and networking equipment	Scheme total outlay: INR 12,195 Cr Provides incentive of 7% to 4% on incremental sales (over base year) of good manufactured in India. The disbursement of incentives is in the form of Direct Bank Transfer through Public Financial Management System (PFMS)	2021–2026
13	MEITY	Production Linked Incentives Scheme for IT Hardware	Companies engaged in manufacturing of IT Hardware. Eligibility shall be further subject to Incremental Sales of Manufactured Goods over the base year and incremental investment	IT Hardware	Scheme total outlay: INR 7,300 Cr Provides incentive of 4% to 2%/1% on net incremental sales (over base year of FY 2019-20) of goods under target segments that are manufactured in India	2021 - 2025
14	MEITY	Scheme for Promotion of	Applicable to investments in	Electronics	Scheme total outlay: INR	2020-2025

S. No.	Dept.	Program/Policy	Eligibility	Sector	Incentive	Validity
		Manufacturing of Electronic Components and Semiconductors (SPECS)	new units as well as expansion of existing units in segments such as Electronic Components, Semiconductors, Specialized Sub-Assemblies and Capital Goods		3,285 Cr Provides financial incentive of 25% on capital expenditure to the units making investment for the goods that constitute the supply chain of an electronic product under the scheme	
15	MEITY	Modified Electronic Manufacturing Cluster Scheme (EMC 2.0)	State Government or State Implementing Agency (SIA) or Central Public Sector Unit (CPSU) or State Public Sector Unit (SPSU) or Industrial Corridor Development Corporation (ICDC)	Electronics	Scheme total outlay: INR 3,762 Crore Provides financial assistance for setting up of EMC projects, Common Facility Centres (CFC), expansion of existing EMCs/CFCs, Ready Built Factory, Sheds/Plug and Play facilities **Incentive** **EMC projects:** Financial incentives of up to 50% of project cost subject to a ceiling of INR 70	2020-2025

S. No.	Dept.	Program/Policy	Eligibility	Sector	Incentive	Validity
					Crore for every 100 acre of land **CFC projects: Financial** Assistance will be restricted to 75% of the project cost subject to a ceiling of INR 75 Crore.	

ii. Supporting innovation in academic institutions

Funding Schemes:

S. No.	Dept.	Program/Policy	Eligibility	Sector	Type of Support	Incentive	Validity
1	DST	Innovation in Science Pursuit for Inspired Research Program Kishore (INSPIRE)	Researchers /Scientists	Across Sectors	Funding	Each selected INSPIRE Faculty Fellow will be eligible to receive a consolidated amount of INR 1,25,000/month as fellowship. In addition, a Research Grant of INR 7.0 lakh/year for 5 years will also be provided to each successful candidate	Valid
2	DST	Fund for improvement of S&T Infrastructure	Researchers/Scientists	Across Sectors	Funding	Active PG Colleges shall be considered for a maximum support of up to INR 1.5 Crore to INR 5 Crore for establishing research facilities for 5 years	Valid

S. No.	Dept.	Program/Policy	Eligibility	Sector	Type of Support	Incentive	Validity
3	DST	Core Research Grant (CRG)	Researchers /Scientists	Across Sectors	Funding	The CRG scheme provides research support for a period of 3 years. National Laboratories and Research Institutions should share 50% of the non-recurring cost of the project. For projects with total cost more than INR 80 lakh, 50% of the non-recurring and consumables cost should be shared by the Lab/Institution.	Valid
4	DST	Vaigyanik Protsahan Yojana	Students	Across Sectors	Funding	Provides monthly fellowships - INR 5000 for B.Sc. students and INR 7000 for M.Sc. students	Valid
5	DST	Swarna Jayanti Fellowships Scheme	Researchers /Scientists	Across Sectors	Funding	Provides monthly fellowships - INR 25000 in addition to the salary drawn from the parent Institute for a period of 5 years	Valid
6	DST	Start-up Research Grant (SRG)	Researchers /Scientists	Across Sectors	Funding	Research grant of INR 30 lakh plus overheads for a period of 2 years	Valid
7	DST	Prime Minister's Fellowship for Doctoral Research	Researchers /Scientists	Across Sectors	Funding	INR 8.7 lakh/ year/candidate, i.e., a monthly stipend of between INR 55,000 to INR 72,800	Valid
8	DST	Abdul Kalam Technology	Researchers /Scientists	Across Sectors	Funding	Research grant is INR 15 lakh per	Valid

S. No.	Dept.	Program/Policy	Eligibility	Sector	Type of Support	Incentive	Validity
		Innovation National Fellowship				annum. Fellowship Amount in INR 25,000 month. An overhead of INR 1 lakh per annum will be provided to the host institute	
9	DST	SERB Overseas Postdoctoral Fellowship	Researchers /Scientists	Across Sectors	Funding	The Program sends candidates to top institutions around the globe, other than USA and to institutions where internationally acclaimed scientists are working	Valid
10	DST	National Post-Doctoral Fellowship	Researchers /Scientists	Across Sectors	Funding	The fellowship is a temporary assignment and is tenable initially for a period of 2 years. Fellowship - INR. 55,000, Research Grant - INR. 2,00,000, Overheads - INR. 1,00,000	Valid
11	DST	Promoting Opportunities for Women in Exploratory Research (POWER)	Researchers /Scientists (Women)	Across Sectors	Funding	Research funding in various S&T programs in Indian academic institutions and R&D laboratories	Valid
12	DST	Visiting Advanced Joint Research (VAJRA)	NRI Researchers /Scientists	Across Sectors	Funding	The VAJRA Faculty is provided a lump-sum amount of US$ 150,000 in the first month of residency in a year and US$ 10,000 p.m. in the other two months the	Valid

S. No.	Dept.	Program/Policy	Eligibility	Sector	Type of Support	Incentive	Validity
						residency period would be for a minimum of 1 month and a maximum of 3 months a year.	
13	DST	Technology Watch and Fore sighting	Researchers /Scientists	Across Sectors	Research	Close watch on current/emerging technologies globally in various relevant sectors	Valid
14	DST	National Mission on Interdisciplinary Cyber Physical Systems	Researchers /Scientists	Across Sectors	Infrastructure + Funding	Network of 15 Technology Innovation Hubs (TIHs), 6 Sectoral Application Hubs (SAHs) and 4 Technology Translation Research Parks (TTRPs). The financial support for each TIH under NM-ICPS would be about INR 115 crore in a project mode for a period of 5 years.	Valid
15	DST	Promotion of University Research and Scientific Excellence (PURSE)	Researchers/ Scientists	Across Sectors	Funding	Support Amount for 3 years from INR 6 crore to INR 30 crore	Valid
16	DST	National Science & Technology Management Information System (NSTMIS)	Researchers /Scientists	Across Sectors	Research	Collection, collation, analysis and dissemination of information on resources devoted to S&T activities in the country	Valid

Infrastructure Schemes:

S. No.	Dept.	Program/Policy	Eligibility	Sector	Incentive	Validity
1	DST	Sophisticated Analytical Instrument Facilities (SAIF)	Researchers/Scientists/Start-ups/Manufacturing Units	Across Sectors	Providing facilities of sophisticated analytical instruments to researchers	Valid
2	DST	Sophisticated Analytical & Technical Help Institutes (SATHI)	Researchers/Scientists/Start-ups/Manufacturing Units	Across Sectors	Setting up a S and T infrastructure facility, which can be readily accessible to academia, start-ups, manufacturing units, industries and R&D Labs	Valid
3	DST	Technical Research Centres Program	Researchers/Scientists	Across Sectors	This program aims at establishing Technical Research Centres	Valid
4	DST	Technology Development Program	Researchers/Scientists	Across Sectors	Convert PoCs into advanced prototypes	Valid
5	DST	Patent Facilitation Program	Researchers/Scientists	Across Sectors	24 Patent Information Centres (PICs) for creating awareness and extend assistance on protecting Intellectual Property Rights (IPR)	Valid

iii. International Collaboration

S. No.	Dept.	Program/Policy	Eligibility	Sector	Type of Support	Incentive	Validity
1	DST	STI co-operation agreement with 83 countries	STI Academic Institutes/ Govt. Agencies/Indian Industry Associations	Across sectors	Non-Monetary	Joint collaborations with countries for Knowledge sharing vis-a-vis Science, Technology and Innovation	Valid
2	DST	S&T cooperation with EU, Association of Southeast Asian Nations (ASEAN), Brazil, Russia, India, China, and South Africa (BRICS), India, Brazil, South Africa (IBSA), South Asian Association for Regional Cooperation (SAARC), Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), ASEM, East Asia Summit (EAS)	S&T Foundations, Societies, Departments and ministries of partner countries	Across Sectors	Financial Incentive	**Multi- lateral programs:** Program incentivizes joint collaborations with countries and are lucrative in nature.	Valid
3	TDB, DST, CII	Global Innovation Technology Alliance (GITA) Programs:	Commercial enterprises/ start-ups	Across sectors	Financial incentive	**Bilateral Programs:** Provides funding equivalent to 50% of project	Valid

S. No.	Dept.	Program/Policy	Eligibility	Sector	Type of Support	Incentive	Validity
		► Bilateral programs ► Scientist Exchange Program ► National Programs (TAFP (Technology Fund Program (TAFP), TDF (Technology Development Fund) with DRDO)				costs (max. INR1.5 Cr) if the project is in collaboration with Canada, Finland, Israel, Korea, Italy, Spain, Sweden **TAFP:** One time grant up to 25% of the cost of Technology (max. INR 10 Cr) Acquisition of each technology **TDF:** Max. INR 10 Cr per project	
4	DST	Indo-French Centre for Promotion of Advanced Research	Indian and French biotech start-ups and SMEs	Across sectors	Financial incentive	Supports high quality research groups through collaborative research projects Promotes linkages between Industry and Academia of France and India Enables knowledge-sharing on science and technology in areas of current relevance.	Valid
5	DST	Indo-US Science &	Bi-national teams of	Across sectors	Financial incentive	Incentives are lucrative in	Valid

S. No.	Dept.	Program/Policy	Eligibility	Sector	Type of Support	Incentive	Validity
		Technology Forum (IUSSTF)	Entrepreneurs and Innovators (e.g., incorporated companies including start-up companies; or Nonincorporated entities; or Individuals or consortia from academia, government laboratories, non-government R&D institutions)			nature for joint collaborations i.e., significant financial aid provided under this scheme, grants size up to INR 25 million or $400,000	
6	DST	Indo-German Science & Technology Centre (IGSTC)	Applicants must build a consortium (minimum 4 partners) consisting of one research / academic institute and one public / private industry from both India and Germany. Principal investigators should be holding a regular/permanent position.	Across sectors	Financial incentive	Funding Grant: up to € 450.000 per project for German applicants and up to ₹ 230 Lakh per project for Indian applicants for the period of three years	Valid

iv. State policies and programs

a) Government of Karnataka

S. No.	Program/Policy	Eligibility	Sector	Type of Support	Incentive	Validity
1	K-Tech Innovation Hubs	Researchers/ Scientists	Across Sectors	Infrastructure	58 K-Tech Innovation Hubs established by Department of Electronics, IT, Biotechnology and S&T	Valid
2	Idea2PoC - Elevate Program	Start-ups	Across Sectors	Funding	Grant of up to INR 50 lakh for product development to early-stage ventures.	Valid
3	ESDM Policy	Companies based in Karnataka	Electronics	Funding	GoK's Electronics, System, Design and Manufacturing (ESDM) Policy offers INR 2 crore as R&D grant per entity per year	Valid
4	IT Policy	Companies based in Karnataka	IT	Funding	The Policy offers R&D grants of up to INR 1 crore.	Valid

(b) Government of Telangana

S. No.	Program/Policy	Eligibility	Sector	Type of Support	Incentive	Validity
1	T-Hub	Start-ups	Across Sectors	Infrastructure + Collaboration	Incorporated in 2015, it has provided over 1800+ start-ups with access to better technology, talent, mentors, customers, corporates, investors and government agencies	Valid
2	T- Angel	Start-ups	Across Sectors	Collaboration	Start - ups which are part of this 3 - month program will receive guidance and knowledge-sharing sessions from mentors, access to a range of investor networks, and funding from angel investors.	Valid
3	T-Lex Program	Start-ups	Across Sectors	Mentorship	Bootcamps focusing on Intrapreneurship Mindset, Business Model Design, Experimental Design Training etc.	Valid
4	HACK2HIRE	Start-ups	Across Sectors	Collaboration	T-Hub has partnered with multiple MNCs to organize hackathons to identify potential talent/partners for the MNCs.	Valid

(c) Government of Andhra Pradesh

S. No.	Program/Policy	Eligibility	Sector	Type of Support	Incentive	Validity
1	AP Innovation Society (APIS)	Start-ups	Across Sectors	Infrastructure + Mentorship	It comprises of 4 Technology Business Incubators and 1 Technology Business Accelerator. For Startups and Entrepreneurs, Services consist of Mentorship support, provision of Co-Working spaces, Accounting as well as help with IP rights, Patent filing.	Valid
2	Partnership with FICCI	Start-ups	Across Sectors	Collaboration	incubation and acceleration programs to nurture the growth of incubator managers, innovators and technology startups	Valid
3	Partnership with National Research Development Center (NRDC)	National research and development institutions universities	Across Sectors	Collaboration	promote, develop and commercialise technologies/ know-how/ inventions/ patents/ processes	Valid
4	Partnership with NASSCOM	Start-ups	Across Sectors	Collaboration	an incubator program in Visakhapatnam to provide incubation and funding support to warehouse startups in India.	Valid
5	Partnership with Govin Capital	Start-ups	Across Sectors	Collaboration	accelerator and incubation facility to startups at the Sunrise Incubation Center in Visakhapatnam	Valid

S. No.	Program/Policy	Eligibility	Sector	Type of Support	Incentive	Validity
6	Partnership with Gasotrope	Start-ups	Across Sectors	Collaboration	The agreement between the state and Gastrotope is to jointly start an acceleration programs called Fortissimo. The main objective of the programs is to develop a technology ecosystem for agriculture and food processing sectors	Valid
7	Partnership with DCF Ventures and Axis Innovation	Start-ups	Water Supply, Agriculture and Cyber-Security	Collaboration	Two-nation hackathons (Israel & India) were focused on finding solutions to the problems faced by Water Supply, Agriculture and Cyber-Security departments.	Valid

(d) Government of Maharashtra

S. No.	Program/ Policy	Eligibility	Sector	Type of Support	Incentive	Validity
1	Maharashtra State Innovation Society (MSIS)	Start-ups	Across Sectors	Infrastructure + Mentorship + Collaboration	Established under Department of Skill Development and Entrepreneurship, Government of Maharashtra, the society aims to foster innovative approaches and create conducive environment for innovative businesses to operate in Maharashtra	Valid
2	Hirkani Maharashtrachi	Start-ups	Across Sectors	Funding + Mentorship	mentorship and financial support to women entrepreneurs working under Self Help Groups to transform their innovative	Valid

S. No.	Program/ Policy	Eligibility	Sector	Type of Support	Incentive	Validity
					ideas to scalable and sustainable businesses	
3	Maharashtra State FinTech Policy	Start-ups	Fintech	Infrastructure + Mentorship + Collaboration	The "Mumbai FinTech Hub" has been established by Government of Maharashtra for implementing Maharashtra State FinTech Policy. The policy addresses the following factors - space, access to capital, ecosystem, market access, global corridors, and Fintech skill.	Valid
4	VC fund with Small Industries Development Bank of India (Sidbi)	Start-ups	Across Sectors	Funding	A venture capital fund with Sidbi, where it has invested in over 20 start-ups.	Valid

v. R&D Tax Incentives

R&D tax incentives can be categorised into direct and indirect tax incentives.

i. Direct tax incentives[127]

a. Deductions for expenditure on scientific research

- 100% deduction is available to all industries on revenue and capital expenditures (other than expenditures incurred for the acquisition of land) paid out or expended on scientific research related to the business.
- This deduction is available even for companies that opt for the concessional tax rate of 22% or 15% recently announced by the Government.

[127] https://incometaxindia.gov.in/Rules/Income-Tax%20Rules/103120000000007105.htm

- The incentive is applicable to current and retroactive investments.
- Where any revenue expenditure is incurred within three years before business commences to pay salaries to employees engaged in scientific research or to purchase materials used in scientific research shall be allowed as a deduction in the year in which business commences.[128]

b. Deductions for expenditure on scientific research by manufacturing entities

- The super deduction of 150% available earlier for in-house expenditure incurred on scientific research has been reduced to 100% with effect from 01 April 2020 onward.
- The deduction is available for scientific research on in-house R&D expenditures as approved by the DGIT(E) and DSIR, including capital expenditures (other than land and buildings) by companies engaged in manufacturing and the production of articles.
- Companies opting for the concessional corporate tax (22% for existing domestic companies and 15% for new domestic companies incorporated on or after 01 October 2019) are not permitted to claim the tax deduction as mentioned above and set-off of carried-forward losses from earlier years pertaining to R&D expenses.
- The incentive is applicable to current and future investments.
- Specific DSIR approval is required to take advantage of super deduction benefits.
- The company will be eligible for the super deduction only if it enters into an agreement with DSIR for cooperation in an R&D facility and for audit of the accounts maintained for that facility.

c. Deductions for contributions for R&D

Deduction of 100% is granted to assessees for any sums paid to:

- A national laboratory, university or institute of technology, or specified persons with a specific direction that the said sum would be

[128] https://www.indialawoffices.com/legal-articles/income-tax-benefits-of-research-and-development-in-india

used for scientific research within a program approved by the prescribed authority.

- Approved institutions (e.g., research associations, universities, colleges) to be used for scientific research.
- Any company engaged in scientific research. However, the following conditions must be satisfied to claim the deduction:
  - The company must be registered in India.
  - The main object of the company must be scientific R&D.
  - The company must be approved by the Chief Commissioner of Income Tax.
- Approved institutions (e.g., research associations, universities, colleges that undertake research in social science or statistical research) to be used for research in social sciences or statistical research.

d. Patent-related incentive[129]

- Income earned by royalty in respect of patents developed and registered in India will be taxable at a concessional rate of 10% (plus applicable surcharge and tax) without deduction of any expenses.

e. Tax exemption for angel investors

- Angel investors with the minimum net worth of INR 2 crore or the average returned the income of more than INR 25 lakh in the previous three financial years will be eligible for 100% tax exemption on the investments that are made in the start-ups above the fair market value if the below conditions are fulfilled.
- Angel investors are eligible for angel tax exemption under Section 56(2)(viib) of the Income Tax Act. It means that they will have to pay taxes only on the amount by which the sum total received from the issues of the start-up's shares overtakes the fair market value. The comprehensive sum of the paid-up share capital and the share

[129] https://incometaxindia.gov.in/Acts/Income-tax%20Act,%201961/2021/102120000000077016.htm

premium of the start-up must be contained within INR 25 crore for this rule of exemption to be enforced.

ii. Indirect tax incentives

a. Tax holiday on export profits earned by units set up in (Special Economic Zones) SEZs

- Incentives are available for companies engaged in providing R&D services under a service arrangement by way of export of services to a foreign principal. Such companies may set up their units in SEZs to secure the tax holiday.
- SEZ units engaged in the export of goods and services from 01 April 2006 to 31 March 2021 are eligible to claim a 15-year, phased tax holiday (see table below) on all export-linked profits earned.

Amount of deduction to SEZ unit	Period of deduction
100% of export profits	First five years
50% of export profits	Next five years
50% of export profits, provided the profits are transferred to a Special Economic Zone Reinvestment Reserve Account for the purposes of acquiring plant or machinery within three years	Next five years

Table A: *Amount and Period of Deduction to SEZ unit*

- Export profits of SEZ units are calculated as follows:
  - Profits of SEZ unit x [Export turnover of unit/Total turnover of unit]
- However, the SEZ unit will not be eligible to claim the super deduction on research and development expenses as mentioned above.
- Companies opting for concessional corporate tax rates are not permitted to claim the tax holiday as mentioned above.

b. Customs duty exemption and concessions

- Customs duty exemption is available on the import of equipment, instruments, raw materials, components, pilot plant and computer software when imported into India for a project by a company having an in-house research and development unit, subject to conditions.

c. Good and Service Tax (GST) concessional rate (research institution)

- A concessional rate of GST is applicable to research institutions for procurement of specified goods subject to fulfilment of certain conditions.

d. Depreciation Allowance on Plant and Machinery Set-up Based on Indigenous technology

- Higher rate of depreciation is allowed for the plant and machinery installed for the manufacturing of products using indigenous know-how as per provisions of rule 5(2) of IT Rules

vi. Non-financial innovation support

S. No.	Dept.	Program/ Policy	Eligibility	Sector	Type of Support	Incentive	Validity
1	Department of Scientific and Industrial Research (DSIR)	Building Industrial Research and Development and Common Research Facilities	Institutions	Across sectors	Infrastructure	Extends grants to institutions for setting up of hubs/centres, which include R&D facilities/infrastructure, analytical test facilities, design centres, pilot plant and prototype development	Valid

S. No.	Dept.	Program/ Policy	Eligibility	Sector	Type of Support	Incentive	Validity
2	DSIR	Access to Knowledge For Technology Development And Dissemination (A2K+)		Across sectors	Research, holds events	Study and analyse developments in emerging technology areas; holds events to provides platform for exchange of ideas across industry	Valid
3	DSIR	Asian & PACIFIC Centre for Transfer of Technology (APCTT)		Across sectors		Provides information sharing platforms, policy insights platform, conducts Workshops, expert group meetings and trainings for policy makers, and technology promotion and transfer institutions	Valid