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Innovation Ecosystem for Research, Innovation and Entrepreneurship in India: Analysis of the Role of Actors

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Background

Research, Innovation and Entrepreneurship are interconnected activities performed by the innovation actors operating within the innovation ecosystem (Granstrand and Holgersson, 2020)[1]. At present, the 'Innovation Ecosystem' for research, innovation and entrepreneurship in India is fragmented in nature despite the government's continuous efforts and initiatives, be it in the forms of setting up of institutions or implementing policies (Abhyankar, 2014). Although India has recently attained 46th position in Global Innovation Index (GII) released by WIPO in September 2021, which is a significant rise from rank 81 in 2015, the country is still lagging in creating the required ecosystem for innovation and in achieving an aspirational creative output. Therefore, to achieve a larger goal of 'Atmanirbhar Bharat' STI advances by promoting a need-based science-led innovation ecosystem for creating a conducive environment for conducting research, innovation and entrepreneurship need to be shaped.

In this context, this study attempts to analyze the existing ecosystem's strengths and weaknesses/challenges for research, innovation and entrepreneurship by analyzing the roles of innovation actors operating within the ecosystem. A secondary literature review method has been adopted based on available data from SCOPUS databases in published journal articles, scientific reports, etc., in the last five years. **Section II** analyses the actors and their roles within the existing innovation ecosystem for research, innovation and entrepreneurship in India in its five subsections (*a,b,c,d,e*) and **Section III** provides a conclusion followed by the main references in the study.

Analysis of Innovation Actors and their Roles:

Mainstream innovation literature revealed that there are three main structural components of an Innovation System, (1) Actors and/or networks of actors, (2) Institutions, and (3) Interactions between them. The performance of these structural components directly influences the development, diffusion and use of knowledge within the innovation ecosystem (Lundvall, 1992). Indian innovation system for research, innovation and entrepreneurship is broadly classified into the following major structural components guided by different innovation system performances.

1) Government
2) Science-based Actors
3) Translational based Actors
4) Industrial/user-based Actors
5) Actors operating within Informal Sector

In the following subsections, the study analyses performances of innovation actors under the subsections. These subsections deal with the current status of the innovation system with the identification of major actors and their functions, highlighting the strength and weaknesses/challenges.

a) Role of the Government:

The innovation system in India is mainly led by the government, attributing it to one of the largest public-funded R&D structures. These funds are facilitated through the various councils and research structures operating under government Ministries[2]. Introductions of various policies and initiatives guided by S&T policies/statements and Industrial

1. The evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors.
2. The prominent ones are: 1) Department of Science and Technology (DST), 2) Department of Scientific and Industrial Research (DSIR), 3) Department of Health Research(DHR), 4) Department of Biotechnology (DBT), 5) Defense Research and Development Organization (DRDO).

policies/statements have been the significant push for India's science, technology and innovation. The establishment of the Office of Principal Scientific Advisor, national STI Think Tanks and the introduction of the Science Technology and Innovation Policy, 2013, National IPR Policy, 2016 and National Health Policy, 2017 are the impactful efforts that have been made to provide a conducive environment for research, innovation and entrepreneurship.

As per the research and development statistics published by DST in 2019-20, The share of the various sectors in the total R&D expenditure for the year 2017–18 shows the following figures against each sector — central government including the public sector industry: 50.0%; private sector: 36.8%; the state governments: 6.4% and higher education: 6.8%. Further, the report also provided the percentage share of national R&D expenditure in 2017-18: Health 18.6, Defense 17.1, Development of Agriculture, Forestry and Fishing 12.6, Industrial Production and Technology 9.8, Exploration and Exploitation of Space 8.8 Transport, Telecommunication and other Infrastructure 8.7, Energy 7.3 General Advancement of Knowledge 7.2, Other Aims 5.5, Education 2.0, Exploration and Exploitation of the Earth 1.8, Environment 0.5, Political & Social Systems, Structures & Processes (including socio-economic services) 0.04. All these figures depict the uneven pattern of R&D expenditure by these sectors as well as by different objectives. This is well highlighted in the Economic Survey 2020-21 report which emphasized that there is an urgent need to push up the gross expenditure on R&D from 0.7% to the much-awaited and aspired 2% of GDP to get the country's innovation journey on the fast track. To achieve this, the survey recommends significant resource mobilization to scale up R&D personnel and researchers and to incentivize the private sector to increase their spending on R&D and innovation toward the country's specific needs. Hence, many expectations abounded with the announcement of the establishment of the National Research Foundation (NRF) which aimed to strengthen the research ecosystem with a focus on identified national priority thrust areas. Also, the nation is looking forward to the upcoming STIP 2020 that will lay the foundation for re-strategizing priorities, sectoral focus, and work on problem-solving approaches for larger socio-economic welfare.

b) Role of Science-Based Actors:

Science-based actors are one of the crucial structural components that serve as the precursor for idea generation or knowledge production. At present, in India, the structure of the science base is mainly constituted by (i) Universities/educational institutes, (ii) Research Institutes[3] and (iii)Institutes of National Importance[4]. The majority of these are supported by state governments and are broadly involved in the investment and promotion of system-building activities through the development of critical human resources and knowledge production. As far as the development of human resources is concerned, India has a strong base for its development that constitutes roughly around 900 universities, 39,000 colleges and 10,000 standalone academic institutes. However, India has produced only 216 researchers per million population, which is only 20% of China's and 4% of Japan's (World Economic Forum, 2019-20).

3. Performing under various ministerial departments like CSIR, DBT, DST, ICMR, DRDO, etc.
4. IITs, IISc, AIIMS, PGIMERs, NIPPERS, etc

Similarly, according to research and development statistics published by DST in 2019-20, the figures of R&D expenditure per capita in 2017 show that India spends 185$[5] on an average for R&D per researcher, which is insignificant in comparison to OECD countries and is discouraging in comparison to BRICS[6] countries where India stands at 4th position.

Further, the authors of this study undertook primary data analysis of publication activities from the Web of Science and patent activities from the Indian Patent Office (IPO) for the last three years (2018-20). The publication analysis showed only a 7% contribution from state universities. Similarly, the patent analysis revealed that 75% of patents belong to non-resident Indians which signifies a severe brain drain. To sum up, the status of innovation activities involved in developing the science base indicates an urgent need to increase research spending to create the required human capital and retain the country's talent pool. Also, the encouragement of state universities and promotion of industry needs to be fostered for the betterment of the scientific base of the country. Recently, National Education Policy (NEP), 2020, aims to restructure education at both school and higher levels, which will revamp the country's STI ecosystem. These steps will supplement in creating a strong research base under the nine national science missions[7] identified by the Prime Minister's Science, Technology & Innovation Advisory Council.

c) Role of Translation Research Actors

The translational research ecosystem caters to the translation of basic scientific findings and outcomes from the laboratory setting to the market. The knowledge flow from the knowledge producers to knowledge consumers requires the creation of channels and linkages through which knowledge can flow from academic and research institutions to enterprises. It is witnessed that in India several translational research actors such as incubators, accelerators, research parks, technology transfer offices, technology enabling centers and IP/legal cells are emerging in academic and research institutes facilitating knowledge diffusion. The government has also created dedicated institutions facilitating translation research such as Translational Health Science and Technology Institute (THSTI)[8].

In the recent Global Innovation Ranking (GII), India's ranking on University-Industry Collaboration has miserably slipped to 61st global rank[9]. Further, India's positioning in Patent Protection nosedives to 51st position (International Property Rights Index 2020) despite being globally ranked amongst the top five countries of the world for Publication Documents (Global Rank 4th next to China, US, and the UK; with citation index of 0.76 and H Index of 691; https://www.scimagojr.com/countryrank.php?year=2020). This data clearly shows that India is good at research but not good at translating that research into commercial value. There are some recent activities

5. R&D per Researcher, FTE ('000 current PPP $)
6. Brazil-234$, Russia-102$, India, China-287-185, South Africa-220$
7. These nine missions were identified in 2019 to address major scientific challenges for ensuring India's sustainable development.
8. THSTI has been set up as an autonomous society by the Department of Biotechnology (DBT), GoI composed of a network of scientists, researchers, physicians and medical professionals from the public and private sectors and offers a numberof knowledge development and its diffusion associated services to both academiaand industry. There is a need to establish such translational research institutions with sectoral focus aligned with nationalpriorities. To enhance innovation efficiency and competitiveness, linkages between government, industry and academiahave to be reinforced.
9. This has laid concern over India's positioning on Industry-Academia linkages, especially since R&D is in its infancy. There are few stories of successful Industry-Academia partnerships in R&D, primarily limitedto IITs.

undertaken to strengthen the translational research ecosystem of the country, which include (i) the establishment of the Biotechnology Industry Research Assistance Council (BIRAC), aiming to bring all the relevant stakeholders of the thematic areas on one platform to speed up the process of technology development and its deployment, (ii) the announcement of 'Cluster Policy' for bringing STI actors on one platform, (iii) upcoming Science, Technology and Innovation Policy Draft 2020 which advocates for the establishment and nurturing of city-based STI clusters/thematic clusters, strengthening incubator and research park networks, bridging the gap between industry and academia, among many other proposed initiatives to stimulate knowledge development and its uptake.

d) Industrial/user-based actors

Economic liberalisation reforms of the 1990s transformed the Indian entrepreneurial market ecosystem. This fundamental policy push accelerated the slower growth observed in the post-independence era. Now, 21st century India is 5th among the largest economies globally. Out of the total employment, 75.8% of people are self-employed, working on their own or with a group of partners (World Development Indicators, 2019). 51% of India's total 63.38 million MSMEs are distributed in the rural region, and the rest, 49%, are in the urban areas (M/o MSME Annual Report, 2021). India is witnessing a whopping surge in unicorn start-ups by at least 48% so far in 2021, with the addition of 34 new start-ups worth USD 1 billion or more (Venture Intelligence, 2021).

Multi-stakeholder harmony is a key to a thriving entrepreneurial ecosystem. Most prominent actors include; (i) entrepreneurs who are willing to take financial risk to set up a business and facilitate the value and employment generation, (ii) communities and entrepreneurial societies who are responsible for the very existence of these ventures, (iii) governments who play a key role in emphasizing on boosting attractiveness and ease of pursuing start-ups, (iv) funding ventures and sources including angel investments, venture capitals, banks, among others who primarily influence economic factors,(v) ministry affiliated offices and statutory bodies such as BIRAC, NSIC Limited or NRDC which provide entrepreneurial assistance, (vii) industrial parks and SEZs like government initiatives promote entrepreneurial investments through tax incentive mechanisms that help reduce product & service related costs and fuelling competition in the market, (viii) technology and business incubation provide plinth for the establishment of technology-led start-ups in particular, (ix) legislators and regulators are essential players in the ecosystem that engage with entrepreneurs on the matters of business-related licenses and clearances, taxation, IPRs, equity and inclusion, and other legal provisions, and (x) research and academic organizations play a pivotal role in research and development, building new talent, skills transfer, among others (Franco-Leal, et al., 2020; UGC Working Group Report, 2019; Fuerlinger, et al., 2015).

Strengthening entrepreneurial activities inherently requires influencing cultural norms in the manufacturing and the services sector. The toolbox of policies and program-level activities have supported these sectors, evident from their rise in contributions over decades. India's service sector accounts for 54% of total Gross Value Added (GVA), which increased from 37% in 1991 (Economic Survey, 2020-21). However, the manufacturing industry contributes up to 17-18% as of 2021 (PIB, 2018) despite Make in India,Start-up India, PradhanMantri Kaushal Vikas Yojana (PMKVY), Micro Units Development and Refinance Agency Ltd. (MUDRA)scheme, among others.

Also, for the past five years, the manufacturing MSMEs are constantly contributing up to 33% to the total manufacturing Gross Value Output(GVO) at current prices (M/o MSME's Annual Report, 2021). India needs to improvise the policy frameworks on various fronts to strengthen its manufacturing footprint in the Indian MSME sector. The Indian scientific community (in academic and industrial settings)needs to be incentivized to encourage technology transfers, later-stage product/process developments, and translation. Governments can focus on incentive schemes for facilitating later-stage financing through private investments. Various studies have directed the need for policies affecting social values and attitudes of societies to reduce the stigma of failure and enhance appreciation in the entrepreneurial culture (Fuerlinger et al., 2015).

e) Informal sector and innovations in India

The literature on innovation has developed immensely from the studies done in the global North. The concept of the national innovation ecosystem is thus situated within the boundaries of the formal economy and its institutions, actors, and policies. However, the global south in general and India in particular is characterized by a vast informal economy that employs almost 81 percent of the workforce[10]. Lately, there has been a shift in academic thinking and the informal economy is also perceived to be a site of innovative activities[11].

In India, knowledge generation and innovative activities are said to lie at the core of the informal economy (Bhaduri, 2016). These notions helped develop a scholarship that is interested in further exploring the nuances of innovations in the informal sector of major emerging nations of the world (Muchie et al., 2017). A diverse community of scholars began investigating the nature of innovations in the informal sector which led to the emergence of different concepts and terminologies[12] (Pansera, 2013). One such term which became popular among both policy and academic circles in India are grassroots innovations[13]. Grassroots innovations are informal, need-based, user-led, self-generated, bottom-up and scarcity induced (Srinivas and Sutz, 2008) that can meet the people's demands and solve their problems by using traditional knowledge, localized skills and materials (Gupta,1998).

There has been a considerable push from the policy in India to institutionalize these innovations and diffuse them in the market through various pathways (Sharma and Kumar, 2019). One such attempt includes the formation of the National Innovation Foundation (NIF) in the year 2000 as an autonomous body of the Department of Science and Technology by the Government of India in the year 2000. To date, NIF claims to have pooled a database of more than 3,00,000 technological ideas, innovations

10. For more information on informal economy workforce, refer to the ILO report: Women and Men in the Informal Economy:A Statistical Picture available at: https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_626831.pdf
11. One can find several research papers in this area and books like Informal sector innovations: Insights from the Global South (Muchie et al., 2017) and The informal economy in developing nations: Hidden engine of innovation? (Kraemer-Mbula and Wunsch-Vincent, 2016)
12. These include frugal innovations, reverse innovations, "jugaad" innovations, BoP innovation, pro-poor innovation, and inclusive innovations.
13. Grassroots innovations are used as a broad term for a wide range of movements such as cooperatives, associations, and informal community groups (Seyfang and Smith, 2007). In the Indian context, grassroots innovations are defined as innovative products and practices that emerge from the knowledge skills embedded in an individual or community without any formal education and research (Bhaduri and Kumar,2011).

and knowledge practices from almost all the districts of India (NIF, 2021). NIF is supported in its activities by various other subsidiary organizations like Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI) and Grassroots Innovation Augmentation Network (GIAN). These institutions help scout, document, support and diffuse these innovations. This alternative discourse on innovations has led to the informal sector being recognized as a major source of ideas that are context-specific and a space where innovations are ideated and developed outside the formal realms of the economy.

Conclusion

Analysis of the ecosystem for Research, Innovation and Entrepreneurship reveals that performances of innovation actors under each category are found sub-optimal. India is still very far from attaining the status of a fully-fledged innovation ecosystem. There are substantial existing demands for target-oriented innovation activities to address context-specific needs. Although many speculations and expectations are built around the introduction of recent policies and initiatives that might strengthen the innovation activities, this will require setting up of a stringent performance evaluation mechanism.

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