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Exploring the Economic Impact of Commercialized Academic Patents: Assessing Mediating Effects and Spatial Spillovers

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ABSTRACT

This research explores the historical evolution of Science and Technology (S&T) policies in India, focusing on the disconnection between education, research, and economic production systems. It examines key initiatives such as the Science Policy Resolution of 1958, aimed at enhancing innovation and self-reliance within India's production systems, and the inception of the Department of Science and Technology's (DST) Fund for Improvement of S&T Infrastructure (DST-FIST). The study places DST-FIST in a global context, analyzing its role in strengthening S&T infrastructure alongside parallel Indian programs, highlighting the synergies and challenges these efforts face. The research utilizes a socio-legal methodology, with an extensive literature review of policy documents and primary sources like government reports, statistical analysis, and program reviews to assess the trends, funding patterns, and geographical distribution of DST-FIST grants. The findings indicate that DST-FIST, initiated in 2000 with a budget of Rs.75 crores, significantly enhanced research infrastructure in Indian universities, and its continued growth reflects India's broader S&T policy evolution. This paper concludes by emphasizing the importance of robust infrastructure in fostering S&T education and research, offering insights into India's trajectory toward technological self-reliance and global competitiveness.

Keywords: *S&T Policies, DST-FIST, Science Policy Resolution, Technology Policy Statement, R&D Infrastructure, Globalization, Technology Self-reliance.*

I. INTRODUCTION

There have been several attempts to close the gap between research, education, and economic production systems during the dynamic growth of Science and Technology (S&T) policy in India. The present socio-legal research study explores the historical evolution of these policies,

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following their emergence from pioneering endeavours to the current state of affairs. The fundamental finding of this investigation is the existence of a substantial historical gap between these domains, which has impeded the country's ability to innovate and become self-sufficient.

Furthermore, this research study places DST-FIST in the larger framework of international worries about S&T infrastructure. It looks at concurrent projects and programmes in India and abroad in order to find possible areas of cooperation and synergy. The research emphasises the significance of developing strong S&T ecosystems that may flourish on both local and global dimensions by looking at these interconnected frameworks. The socio-legal research study correlates the process of developing a vibrant and sustainable S&T ecosystem to help in the commercialisation of academic patents.

It is necessary to conduct a detailed examination into the multidimensional and dynamic phenomena that is the economic impact of commercialised academic patents. This research study aims to investigate the complex interactions that arise between the commercialization of academic patents, their mediating effects, and the spatial spill overs that they generate within regional economies.

Fundamentally, academic patent commercialization represents the process of converting intellectual breakthroughs into concrete economic benefits. This strategy encourages industry-academic relationships and innovation-driven entrepreneurship in addition to potentially creating revenue streams for academic institutions. This socio-legal research study aims to clarify the processes by which academic information is converted into commercially viable goods, services, and technologies by looking at the financial implications and policy initiatives of such commercialization measures.

II. Commercialisation of academic patents

First off, academic institutions may receive a substantial cash boost from the commercialization of their patents. Universities can use their intellectual property to make money through licencing deals, royalties, or equity investments in spin-off companies. This money can then be used to fund other research and instructional projects. This cash influx powers not only the academic endeavour but also the discoveries and advancements that lie ahead.

Additionally, the commercialization process encourages innovation and entrepreneurship at academic institutions. Scholars and researchers are encouraged to work on initiatives that have the potential to be profitable, which helps to match academic interests with market demands. The collaboration between academics and industry fosters a dynamic ecosystem where ideas can grow and find practical applications, in addition to quickening the pace of technological progress.

Moreover, the commercialization of academic patents acts as a stimulant for productive partnerships between academia and industry. Academic institutions can collaborate with businesses to launch innovative goods and services by licencing patented technologies or forming joint ventures. These partnerships help to speed up the commercialization process by facilitating knowledge exchange and providing invaluable resources and experience.

(A) Structural Symbiosis

Academic patents and their commercialization in India are significantly shaped by Science and Technology (S&T) policies. The origins of programmes such as the Fund for Improvement of S&T Infrastructure (DST-FIST) of the Department of Science and Technology (DST) have had a significant influence on research, academia, and the nation's innovation environment. The promotion of an innovative and high-caliber research culture at academic institutions is one of the main ways that S&T policies and DST-FIST have impacted academic patents. Research infrastructure, laboratories, and facilities have been enhanced because to funding infusions from DST-FIST. This has allowed researchers to perform high-caliber research that may result in valuable intellectual property (IP) in the form of patents. This can be witnessed in the year end 2023, report given by the DST. According to the Global Innovation Index (GII) 2023, India continued to rank 40th out of the world's most inventive economies. India is rated seventh in the world in terms of resident patent filing activity, according to the WIPO Report 2022. India moves up one spot in the Network Readiness Index (NRI) 2023 study, from 79th place in 2019 to 60th place in 2023. Regarding the use and effects of information and communication technology (ICT) in 134 economies worldwide, NRI is one of the top global indices[3].

Additionally, DST-FIST has been essential in improving industry-academia cooperation. Because of the enhanced facilities and research infrastructure provided by DST-FIST, universities are now more desirable partners for business partnerships. Joint research projects, technological transfers, and the commercialization of university patents have greatly increased. Furthermore, the IP ecosystem in India has been strengthened by S&T rules and initiatives like DST-FIST. These regulations have increased the amount of academic patents filed and granted in the nation by encouraging research and innovation. This has improved academic institutions in India's standing and made the climate more favourable for patent commercialization.

[3] Department of Science and Technology, Government of India. (2023, December). Year End Review 2023: Department of Science and Technology [Press release]. Retrieved from https://dst.gov.in/year-end-review-2023-department-science-and-technology

(B) Objectives

a. Tracing the historical trajectory of DST-FIST within India's S&T policies.

i. 1958 Scientific Policy Resolution

The first significant scientific policy dates back to 1958. The government of Jawaharlal Nehru, the Indian prime minister at the time, drafted the policy document. In India, scientific temper and enterprise were established by SPR 1958. Nehru had envisioned a welfare state in India.

Large-scale creation of a pool of excellent scientists was required to meet the nation's needs, particularly in sectors like defence and agriculture. SPR 1958 emphasised the significance of developing a system and culture that recognises citizens' creative abilities and provides possibilities for scientific research, knowledge acquisition, dissemination, and discovery. SPR 1958 was essentially a policy statement for science. Since it was believed that the study of science and its applications was the only path to technological growth, it was accorded secondary prominence. But after SPR 1958, significant funding for science led to the establishment of numerous national laboratories and scientific institutes. Strong groundwork was established in R&D and higher education by SPR 1958.

ii. Technology Policy Statement (TPS 1983)

Technological self-reliance through the development and promotion of indigenous technology was the main focus of TPS 1983. Adopting local technology would increase the use of available resources (both human and material) and lessen vulnerabilities in important areas. TPS 1983 acknowledged that effective adoption of foreign technologies should occur, but not at the expense of national security. It was necessary to identify outdated technologies and swap them out for new ones that use less energy and capital to increase productivity, efficiency, quality, and dependability of products. The main goal was to employ technology to the greatest extent possible to help every segment of society, with a focus on the weaker and more disadvantaged groups.

An implementation committee was established to produce comprehensive instructions for ministries and industries in order to accomplish the objective of TPS 1983. The Technology Development Fund (TDB) was created to support the development of domestic technology by giving Indian firms financial support. TPS 1983 emphasised the necessity for evaluation studies and ongoing, methodical forecasting of the future utility of current and emerging technologies (technology forecasting), particularly in ministries with significant investment and/or production value. The Technology Information Forecasting and Assessment Council (TIFAC) was founded with this in mind.

iii. Science and Technology Policy (STP 2003)

India had developed a strong institutional and human resource base for science and technology by the turn of the millennium. It was accepted, nevertheless, that there had been a significant shift in the ways that science and technology were generated, applied, and impacted society. Science was become increasingly transnational, including many fields and nations. As such, it necessitated the creation of institutional clusters and international cooperation. Even in fundamental research fields, significant investments in R&D were necessary.

The rapid development of Information and Communication Technologies (ICTs) and the widespread accessibility of the internet have revolutionized the exchange of information and expertise, ushering in an era of unprecedented social and economic progress. The effects of science and technology on advancement were becoming increasingly pronounced, propelling nations towards fair and sustainable development in a rapidly globalizing world. However, alongside these advancements came new challenges, including concerns about cybersecurity, inequality, and privacy, which demanded innovative policy responses.

To address these challenges and harness the potential of science and technology for national development, the Government of India implemented the Science, Technology, and Innovation Policy (STP) in 2003. This policy aimed to keep pace with global advancements in science and technology, ensure competitiveness, and promote fair and sustainable development. It emphasized the need to modernize scientific and engineering facilities in universities, increase research and development (R&D) spending to 2% of GDP, and create additional funding sources for basic research.

As a result of STP 2003, India witnessed a significant increase in overall R&D investment, both from public and private sectors. Although the goal of reaching 2% of GDP investment in R&D was not fully achieved, India's R&D investment reached a globally competitive figure of 0.7% of GDP[4]. This increase in investment was accompanied by a rise in publication rankings, an increase in the number of PhD students, a higher number of patents filed, and a greater number of startups incubated, reflecting the policy's success in enhancing the country's scientific and technological capabilities.

iv. Science, Technology and Innovation Policy (STIP 2013)

The introduction of the term "innovation" marked a significant shift in the focus of this policy

[4] IndiaBioscience. (n.d.). Science, Technology, and Innovation (STI) Policies in India: A Flashback. Available from https://indiabioscience.org/columns/indian-scenario/science-technology-and-innovation-sti-policies-in-india-a-flashback

document. It aimed to cultivate a culture of science and technology-driven innovation in the country, aligning these efforts with key socio-economic goals. The Science, Technology, and Innovation Policy (STIP) of 2013 laid the groundwork for enhancing India's innovation landscape, particularly by encouraging private sector involvement in research and development (R&D).

This policy underscored the importance of directing scientific breakthroughs and technological advancements towards addressing crucial developmental challenges in sectors like agriculture, manufacturing, water management, healthcare, environmental conservation, and infrastructure development. Furthermore, it played a pivotal role in India's increased participation in prominent global scientific projects such as the Laser Interferometer Gravitational-Wave Observatory (LIGO), the Large Hadron Collider (LHC) at CERN, the International Thermonuclear Experimental Reactor (ITER), and the Square Kilometre Array (SKA).

Despite these advancements, a comprehensive assessment of the STIP 2013's impact is yet to be conducted to fully understand its effectiveness in fostering innovation. As we continue to navigate through the era of innovation, it is crucial to evaluate this policy's outcomes to inform future strategies effectively.

III. Impact of FIST Program

The first significant step in this direction was taken in 2000 with the launch of DST-FIST 1 (Fund for Improvement of S&T Infrastructure) with a budget of Rs. 75 crores. This initiative aimed to align with India's ambitions for a strong global presence, where technological superiority is paramount. The program aimed to enhance and bolster research and development (R&D) infrastructures in universities and higher education institutions.

Initially, the FIST program focused on specific research areas and institutions with established expertise. However, as it progressed, it expanded to include a broader range of priority areas, institutions, and increased funding. The investment in the FIST program has grown to over Rs. 2000 crores over the last two decades, reflecting its significant impact and expansion.

A comprehensive review of the program was conducted in 2008, assessing the impact of grants received during 2002-2005 and 2002-2007. This review aimed to evaluate the effectiveness and outcomes of the program, ensuring that it continues to meet its objectives and remains aligned with the evolving needs of the scientific and technological landscape in India[5].

[5] CHORD (NSTMIS) Division, Department of Science & Technology. (2021, January). Impact Evaluation Report: Funds for Improvement of Science & Technology Infrastructure (FIST) Scheme.

Fig. 1.3a: Expansion of FIST projects over the years 2000-11 (trend using polynomial)

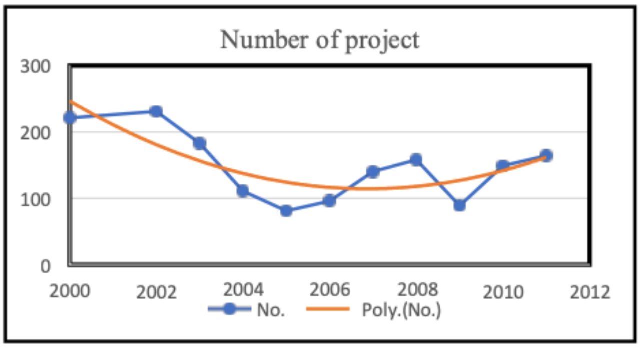
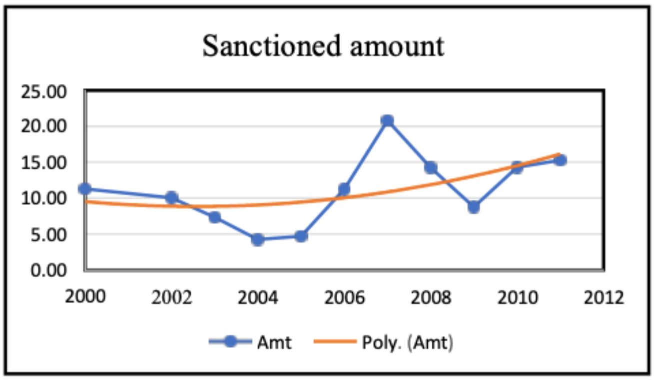


Fig. 1.3b: Size of the FIST grants over the years* 2000-11(trend using polynomial)



*Amount is not inflation adjusted

Fig.1.Showcasing the FIST grants sanction from 2000-2011. Source: CHORD (NSTMIS) Division, Department of Science & Technology. (2021, January). Impact Evaluation Report: Funds for Improvement of Science & Technology Infrastructure (FIST) Scheme.

In the year 2019, FIST support levels with financial limits: Level-0: up to Rs.150.0 lakhs Level -I: up to Rs.300.0 lakhs Level -II: up to Rs.1000.0 lakhs Level-III: up to Rs.2000.0 lakhs were sanctioned and Support (@100%) would be provided for pure Govt. organizations only for high quality research; teaching activities would be discouraged. For Private self-financed as well as Govt. aided organizations the sanctioned grant would be provided on 50:50 mode (i.e. 50% by Govt. and 50% by the Private/ Govt. aided organization) only for high quality research.

A comprehensive study conducted by the Academy of Business Studies in New Delhi for the Technology Information Forecasting and Assessment Council (TIFAC) has outlined its findings as follows[6]:

1. India has emerged as a key global hub for Research and Development (R&D), with investments totaling $1.13 billion expected to increase to $4.65 billion. The United States leads

[6] FDI in the R&D Sector, Study for the Pattern in 1998-2003, TIFAC Report (TMS 179), Academy of Business Studies, New Delhi.

in investment, followed by Germany, with India employing nearly 23,000 individuals in R&D. Notably, the cost of employing a scientist in India is approximately $10,000 per year, significantly lower than the $100,000 cost for a counterpart in the United States.

2. Computer-based R&D is predominant in India, with sectors such as pharmaceuticals, automotive, chemicals, and agriculture also making significant contributions. Indian entities have filed at least 415 patents in the United States, highlighting the country's growing innovation and intellectual property landscape.

These findings underscore India's growing stature in the global R&D landscape, its focus on key sectors for innovation, and the evolving nature of partnerships and ownership structures in the country's R&D ecosystem.

IV. Incubators and Industrial Partnerships

The Department of Science and Technology (DST) is revamping the highly successful Fund for Improvement of S&T Infrastructure (FIST) program to align with the goal of Atmanirbhar Bharat, focusing on creating R&D infrastructure not only for academic organizations but also for startups, manufacturing industries, and Micro, Small, and Medium Enterprises (MSMEs). To ensure optimal utilization of these resources, DST has communicated appropriate mechanisms, including the use of FIST facilities through multiple shifts, to the beneficiaries through a public notice.

Beneficiary organizations are required to prominently display a Public Notice featuring the FIST Logo, symbolizing the restructured program's identity. They are also encouraged to connect with the I-STEM (Indian - Science Technology and Engineering Facilities Map) portal to showcase the utility and availability of different facilities for sample analysis by researchers from outside the host organization. Several FIST-supported facilities are already connected with the I-STEM portal, enhancing their visibility and accessibility to the broader research community.

The restructured FIST program also introduces activities related to Scientific Social Responsibility (SSR), aiming to foster a more inclusive approach towards different sections of society. This initiative reflects the program's commitment to promoting social welfare and engagement beyond traditional R&D activities. Currently, the program has received over 703[7] fresh proposals across seven subject areas, which are undergoing evaluation, indicating a strong

[7] Department of Science & Technology, Government of India. (n.d.). Funds for Improvement of Science & Technology Infrastructure (FIST) Scheme. Retrieved from https://dst.gov.in/scientific-programmes/scientific-engineering-research/fund-improvement-st-infrastructure-higher-educational-institutions-fist

interest and participation in the revamped FIST program.

The figure below showcases the importance of academic patents filed by Indian University in both domestic as well as pertaining to the International Forums.

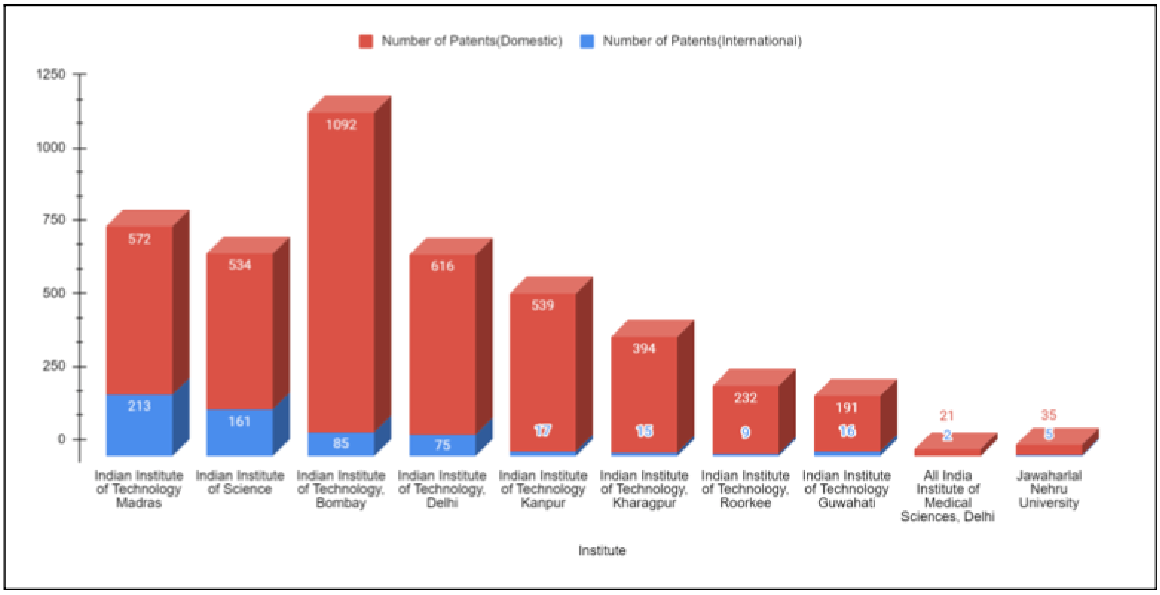


Fig 2.Patents filed by Universiyirs in India[8]*.. Source: WIPO STATISTICS 2022.*

DST-FIST has indeed been instrumental in fostering collaboration between academia and industry in India, leading to notable advancements and innovations. For instance, the collaboration between the Indian Institute of Technology (IIT) Bombay and the Tata Trusts resulted in the development of the world's first low-cost, multi-parameter water quality monitoring system called 'Easysense.' This innovative technology, supported by DST-FIST, enables real-time monitoring of water quality, benefiting millions in rural areas[9].

Furthermore, DST-FIST has facilitated partnerships such as the one between the Indian Institute of Science (IISc), Bangalore, and General Electric (GE) to develop advanced manufacturing technologies. This collaboration led to the establishment of the John F. Welch Technology Centre (JFWTC) in Bangalore, focusing on research in areas such as aircraft engine components and renewable energy technologies[10].

Additionally, DST-FIST has contributed to the commercialization of academic patents through

[8] Khan, S., Sharma, S. K., & Laha, A. K. (2023, April 24). From Misalignment to Synergy: Analysis of Patents from Indian Universities & Research Institutions. [Submitted manuscript]. arXiv. https://arxiv.org/abs/2304.12176

[9] The Economic Times. (2021, August 31). IIT Guwahati, Bombay, European partners building sensor to check Indian water quality. Retrieved from https://economictimes.indiatimes.com/tech/technology/iit-guwahati-bombay-european-partners-building-sensor-to-check-indian-water-quality/articleshow/96524256.cms?from=mdr

[10] Manufacturing Today India. (n.d.). The mammoth ecosystem created by GE's John F Welch Technology Centre. Retrieved from https://www.manufacturingtodayindia.com/sectors/6475-the-mammoth-ecosystem-created-by-ges-john-f-welch-technology-centre

initiatives like the Technology Business Incubator (TBI) at the Indian Institute of Technology (IIT) Madras. This TBI has supported numerous startups in transforming academic research into market-ready products. This showcases the impact of DST-FIST in nurturing entrepreneurial ventures[11].

A grant of Rs. 100 lakhs was given to the Department of Ocean and Naval Architecture at IIT Kharagpur in 2004. During the period of this FIST award, Prof. D. Sen served as the project coordinator. All of the money that was received went towards buying equipment. The Wave Generation System that the department purchased is currently listed as being in good operating order. This equipment has managed to create funds of 102.3 lakhs, even if no AMC was received[12].

These examples underscore the pivotal role of DST-FIST in enhancing collaboration between academia and industry, leading to tangible outcomes in the form of innovative technologies, successful startups, and impactful solutions addressing societal challenges.

V. Conclusion

Establishing a robust industry-academia partnership from the outset of a research project is crucial for translating some projects into successful licensing or technology transfer endeavours. The government, as a facilitator, plays a key role in enhancing these collaborations by creating facilitating mechanisms and developing frameworks. Drawing from technology transfer practices in developed countries, the paper proposes a conceptual model tailored for university-industry technology transfer in India.

The Funds for Improvement of Science and Technology Infrastructure (FIST) scheme has had a significantly positive impact on the operational environment, academic, and research outputs of recipient departments and institutions in the science and technology sector across the country. This success underscores the importance of continuing the FIST scheme.

This program has notably benefited less developed regions and institutions, sparking expectations for support to more institutions in remote and underprivileged areas. This updated vision signifies a shift towards a more ambitious and proactive approach to position India as a global leader in science, technology, and innovation, with a focus on achieving self-sufficiency and excellence in cutting-edge technologies.

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[11] The Indian Express. (2022, February 17). IIT Madras' focus on deep tech startups has paid off. Retrieved from https://indianexpress.com/article/technology/iit-madras-focus-on-deep-tech-startups-has-paid-off-9107594/
12 CHORD (NSTMIS) Division, Department of Science & Technology. (2021, January). Impact Evaluation Report: Funds for Improvement of Science & Technology Infrastructure (FIST) Scheme.

To address issues related to financial, social sustainability, and global competitiveness of developed technologies, a new organization called the Centre for Studies on Technological Sustainability (CSTS) could be established. This entity would be similar to programs like CREATE in Singapore or Innovate UK. Achieving self-sufficiency necessitates ownership of technological inventions and patents. Therefore, it is imperative to invest in emerging technologies such as artificial intelligence, deep learning, and biotechnology to facilitate and bridge the gap between emerging nations.

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