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Impact of National Science and Technology (S&T) Policy Framework on Technology Transfer from Indian Academic Research Institutions

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India's evolving Science & Technology (S&T) and industrial policies have aimed to transform academic research into commercially viable technologies, yet their cumulative impact on university technology transfer remains underexplored. This study bridges the knowledge gap by systematically reviewing S&T and industrial policy milestones from 2013 to 2023 and combining this review with survey data from 289 Academic Research Institutions (ARIs), for understanding the influences of key interventions such as IPR (Intellectual Property Rights) reforms, the Startup India campaign, and the Atal Innovation Mission on institutional IPR practices, licensing activities, and spin-off incubation. Survey findings revealed that 57.6% of ARIs file five to ten patent applications annually, while 56.9% maintain dedicated technology-transfer teams of five to ten staff. Although 82.1% of institutions commercialized fewer than five technologies each year, 49.7% supported up to ten spin-offs or start-ups. Revenue from technology transfers ranged between ₹100,000 and ₹500,000 for 51.4% of respondents, and 30% identified funding support as the most critical enabler of commercialization. Further, linear regression analyses were conducted for universities of types - central, deemed-to-be universities, those of national importance, private, and state universities. A high R^2 is seen for institutions of national importance, evidencing their greater capacity to leverage policy measures. Our results demonstrate that stronger policy-industry linkages, targeted funding, and capacity-building efforts have significantly strengthened India's academic entrepreneurship ecosystem in consistent with the institution's innovation culture assessed as per NIRF (National Institutional Ranking Framework).

Keywords: Entrepreneurship, Innovation, Intellectual property rights, Spin-offs, Technology transfer

Introduction

Commercializing a new technology starts with upscaling and proving the technology, to satisfy the market needs, and also developing themarkets.[1,2] The activity of translocating innovations, optionally protected through "Intellectual Property Rights" (IPR) into goods and services marketable is called transfer of technology or simply technology transfer.[2]

Global Overview

Western nations like the US rely on industrial linkages for creative research, whereas developing nations like India use public funds.[3–5] The Western universities have mastered the art of patenting and licensing of Intellectual properties to the industries through their own Technology Transfer Offices.[4,6] In the United States of America, the enactment of the Bayh-Dole Act (1980) enabled many patented technologies arising from the federally funded academic research institutes to commercialize by collaboration with the industries.[2,7] International studies underscore the role of policy frameworks and Technology Transfer Offices (TTOs) in fostering academic spin-offs.[4,7,8]

Indian Context

In India, the government has recognized the significance of transfer of technology and commercialization in driving innovation and fostering entrepreneurship. As a result, a series of national policies and schemes have been introduced to facilitate the transfer of technology, particularly in the context of university research and university spin-offs.[3] It's imperative for the government to reinforce the universities and institutions in India with better incentive strategies and policies for desirable industrial partnership, vigorous Intellectual property rights policy for the transfer of technologies and commercialization of innovation from the universities, thereby nurturing a supportive innovation ecosystem as well as economic growth of the nation.[4,5]

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Bridging the Knowledge Gap

In India, researchers have highlighted structural gaps in university–industry collaboration and the under-utilization of IPR.[6,7] This study systematically link policy evolution with on-ground technology licensing and incubation outcomes across a sample of ARIs with survey evidence. So the objective of this study is to explore the evolution and recent advancement in Indian National Science and Technology (S&T) initiatives on transfer of technology from academic research institutions over the years and evaluate its impact on ARIs' IPR management, patent licensing and incubation support for spin-offs or startups using the survey data from 289 universities.

Methodology

A systematic review of national policies was conducted to explore the recent advancement in Science and Technology policy on transfer of technology from Indian academic research institutions. Due diligence of policy documents and legislative acts post-independence were coded for provisions related to IPR, patent licensing, grants and funds, industrial collaboration mechanisms, incubation and capacity building.

Policy Analysis

The study was divided into two categories for better understanding the evolution and advancement on technology transfer in India –

i. Early Initiatives (before 2013)
ii. Recent Initiatives (after 2013),

For achieving the objective of this study and to response to the research questions the secondary data was collected from the government policy documents and the published literature from reputed journals. Initially the listing of the national policies was done to explore the policy framework. After that the Science and Technology (S&T) policies and schemes were shortlisted and categorized as early initiatives in technology transfer (before 2013) and recent initiatives (after 2013). Afterwards, the comparative analysis of National Science and Technology (S&T) Policy framework on technology transfer was performed, showcasing its effect in Indian academic research institutions as represented in the flow diagram for the steps devised for the research design in Fig 1.

Early Initiatives for Tech Transfer

For the ease of understanding and to visualize some of the important policies enacted by the government of India, a timeline for Early Indian Policy Initiatives in Technology Transfer was created by the author depicting the year-wise prominent steps taken by the government as shown in the Fig. 2. The prominence of technology was highlighted by its incorporation as a vital element in the first Scientific Policy Resolution of India legislated in 1958.[(1)] It was the initial science policy that mainly stressed upon the basic research in the field of science. This policy emphasized on the development and availability of the infrastructure for the growth of scientific research.[9] The government of India in 1953 established the National Research Development Corporation (NRDC) with the key mission to promote, develop and commercialize the patented as well as non-patented technologies originating from Indian universities. It is currently functioning under the direction and control of the Department of Scientific & Industrial Research, Ministry of Science & Technology.[10] Through a methodical approach, the Indian Patent Act of 1970 established the groundwork for innovative thinking and the idea of reverse engineering in the pharmaceutical industry.[2] In 1988, the Department of Science and Technology of the Government of India created the "Technology Information Forecasting and Assessment Council" (TIFAC), an independent organization. TIFAC's goal was to finance and promote the construction of commercialization-ready infrastructure.[2]

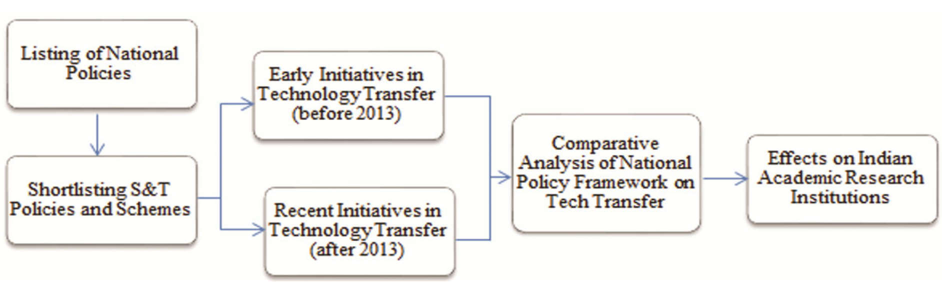

Fig. 1 — Steps devised for research design

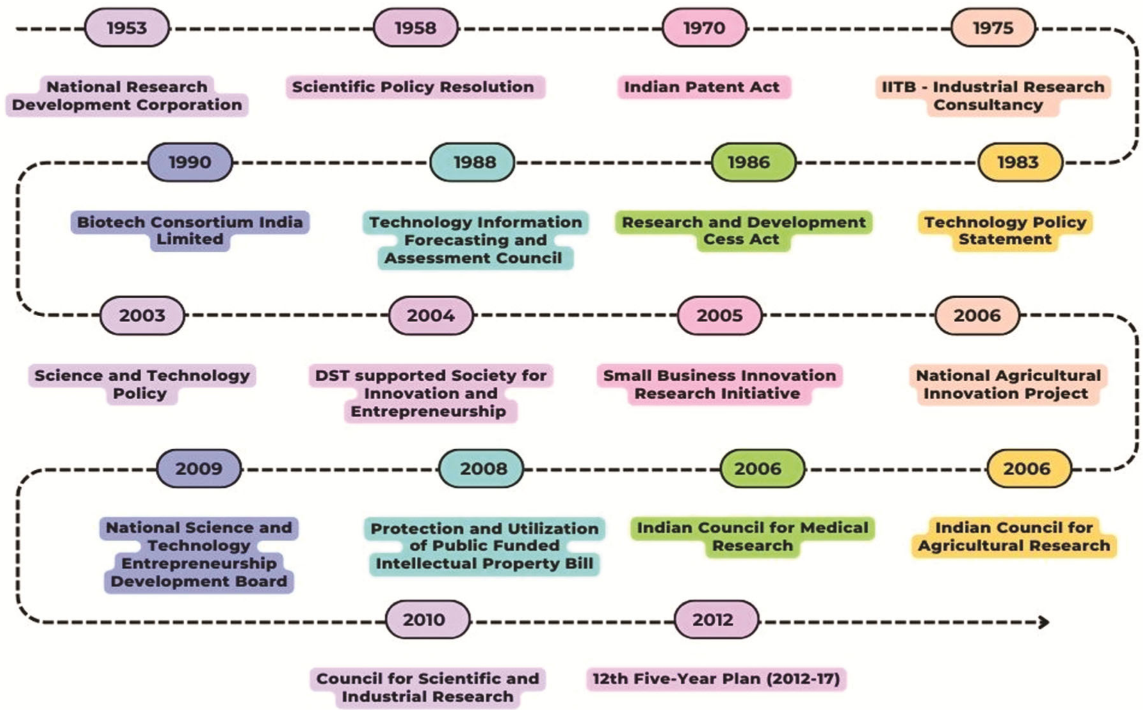

Fig. 2 — Timeline for early Indian policy initiatives in technology transfer

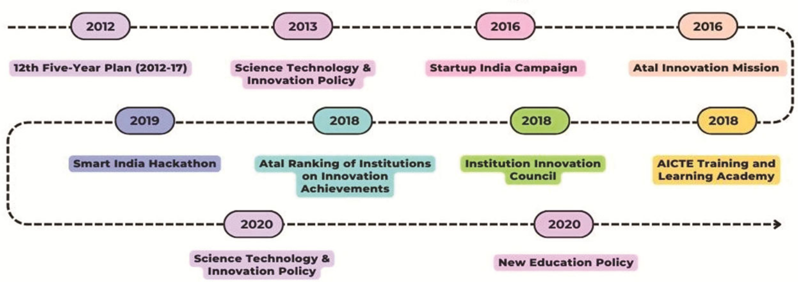

Fig. 3 — Timeline for recent Indian policy initiatives in transfer of technology

Recent Initiatives of the government for Tech Transfer

For the ease of understanding and to visualize some of the important policies enacted by the government of India, a timeline for Recent Indian Policy Initiatives after year 2012 by the central and state government agencies in Technology Transfer was created by the author depicting the year-wise prominent steps taken by the government as shown in Fig 3. The Indian government designs its policies regarding transfer of technology in a way that it benefits a wide range of stakeholders and encouraging young entrepreneurs to be job creators rather than job seekers, thereby creating a self-reliant nation – Atamnirbhar Bharat with indigenous technologies and popularizing the idea of Make in India concept to boost Indian economy. Some of the notable initiatives are of NITI Aayog by the government after transforming and dissolving the Planning Commission. By 2013, the paradigm set by the "Science, technology and innovation" (STI) policy for the people became the major drivers of national development. The Startup India initiative was officially launched by Prime Minister Narendra Modi on January 16, 2016. Since then, it has played a crucial role in fostering entrepreneurship, innovation, and job creation in India.[11] The Atal Innovation Mission (AIM) was setup in 2016 as one of India's flagship initiatives by the government to encourage a culture of innovation and entrepreneurship in the India.[2] Afterwards in 2018, "All India Council of Technical Education" initiated a program well-known as AICTE Training and Learning (ATAL) Academy.[2] This was initiated in all the technical institutes and universities of India to boost and upgrade the technical know-how and promote innovation to strengthen the competitiveness of the MSME sector.[12] Further to create a vibrant innovation ecosystem supporting spin-off and start-up companies in the higher educational institutions of India, the Institution's Innovation Council (IIC) was launched in 2018 in collaboration with the "All India Council for Technical Education" (AICTE) as an initiative by the Ministry of Education (MoE). Later on the "Atal Ranking of Institutions on Innovation Achievements" (ARIIA) was initiated by the Ministry of Education (MoE), Government of India in the year 2018. The purpose of ARIIA was to systematically rank major higher educational institutions and universities in India based on indicators related to "Innovation and Entrepreneurship Development" among students and faculties. In order to receive technical solutions to real-world problems a nation-wide initiative with the name of Smart India Hackathon (SIH) was started by the government in 2019. This initiative provided the students with a platform to solve some of the challenging problems we face in our daily lives, and thus instilled a culture of product innovation and a mindset of problem-solving. The Science Technology & Innovation Policy (STIP) 2020 aims to reshape India's approach to Science, Technology, and Innovation (STI) by reorienting priorities, strategies, and sectoral focus. It seeks to foster an ecosystem for an "Atmanirbhar-Bharat" (self-reliant India) through research, innovation, and technology development from academic universities across the nation. In July 2020, India's Union Cabinet sanctioned the new "National Education Policy" (NEP) which intends to establish a holistic system for higher education and vocational training. The vision was to create an India-centric education system that directly provide and contribute to the high-quality education to all.[13,14]

Empirical Survey

A structured questionnaire was developed based on established TTO (Technology Transfer Office) and USO (university spin off) literature and pre-tested with five domain experts to explore the impact of S&T policy framework on ARIs (academic research institutions). It comprised sections on-

1. Institutional IPR infrastructure (cells, policies)
2. Patent filings and licensing agreements
3. Incubation programs and funding sources
4. Collaboration metrics (joint R&D, consultancy)

Using convenience sampling across central, state, deemed, and private universities, targeting 300 institutions; 289 valid responses were obtained from April 2023 to May 2024, suitable for generalizing findings to the larger population.[15]

Results and Discussion

The Government of India through its various recent initiatives has revolutionized the culture of innovation by cultivating the new ideas through the vision of "Atmanirbhar-Bharat" (self-reliant India) by research, innovation, and technology development and thereby creating an ecosystem fostering the growth and development of startup / spin-off from universities. The translation of academic research into commercialization in a form of product and services leads to the economic growth. The data in Table 1 categorically represents the different initiatives and key provisions of Science and Technology (S&T) policies and relevant schemes by government which showcased its effect on Indian academic research institutions.

Impact on Indian Academic Research Institutions

Based on the survey responses, Fig. 4 presents the key metrics and perceptions related to technology transfer activities across participating Academic Research Institutions (ARIs) —

1. Average Annual Patent Filings Over half (57.6%) of ARIs submit 5–10 patent applications each year

Table 1 — Different aspects of recent initiatives (after 2013) in technology transfer

Initiative	Key provision(s)
12th Five-Year Plan (2012-17)	i. Large scale investment into mega science project aimed at the creation of the R&D infrastructure under partnership. ii. Government dissolved the "Planning Commission" which was replaced by the "NITI Aayog". Thus, there were no thirteen Five-Year plans.
Science Technology & Innovation Policy (2013)	i. Focused on establishing world class infrastructure for scientific research and development. ii. Created a robust national innovation system which ensures faster, sustainable, and inclusive development. iii. Aimed at promoting resource-optimization, cost-effective innovations across science and technology domain.

(*Contd.*)

Table 1 — Different aspects of recent initiatives (after 2013) in technology transfer (*Contd*.)

Initiative	Key provision(s)
Startup India Campaign (2016)	i. Played crucial role in fostering entrepreneurship, innovation, and job creation in India. ii. Aimed to create a supportive ecosystem for start-ups by simplifying regulations, providing access to funding, and promoting innovation. iii. Eligible start-ups received tax exemptions for a specified period. iv. Encouraged the establishment of incubators and accelerators to nurture start-ups. v. Organized networking events, workshops, and mentorship programs. vi. Start-ups could access legal and technical assistance related to Intellectual Property Rights (IPR) support. vii. Startup India portal served as one-stop platform for start-ups to register, access information, and avail benefits
Atal Innovation Mission (2016)	i. India’s flagship initiative to promote a culture of innovation and entrepreneurship in the country. ii. Created an ecosystem of entrepreneurship in universities, research institutions, private and MSME sector. iii. Atal Tinkering Laboratories offer workspaces include meeting rooms and video conferencing facilities with tools and equipment to help students. iv. Atal Incubation Centres provide start-ups with guidance, tech support, infrastructure, and connect to investors, networking, and other services that may be required for scaling up.
AICTE Training and Learning Academy (2018)	i. Established in all technical universities to empower the technical knowledge of faculty members. ii. Promoted the entrepreneurship in India, foster grassroots level economic development. iii. Facilitated innovative businesses solutions for unmet social needs. iv. Promoted innovation to strengthen the competitiveness of MSME sector.
Institution Innovation Council (2018)	i. In collaboration with AICTE fostered the culture of innovation and created a startup ecosystem within higher educational institutions (HEIs). ii. Supported the pre-incubation of ideas and development of domestic innovation environment. iii. Functioned in identifying and rewarding innovations while sharing success stories. iv. Conducted various innovation, IPR, and entrepreneurship-related activities. v. Prepared institutes for the Atal Ranking of Institutions on Innovation Achievements framework.
Atal Ranking of Institutions on Innovation Achievements (2018)	i. To systematically rank major higher educational institutions and universities in India based on indicators related to “Innovation and Entrepreneurship Development”. ii. Encouraged institutions to be at the forefront in terms of innovation. iii. Critically evaluated institutions on parameters like patent filing and granted, number of registered students and faculty start-ups, fund generation by incubated start-ups, specialized infrastructure created by institutions to promote innovation and entrepreneurship, etc. iv. It is now known as NIRF-Innovation Ranking.
Smart India Hackathon (2019)	i. Inculcated a culture of product innovation and a mindset of problem-solving among especially engineering students from across India. ii. Provided students with a platform to solve technical problems of participating industries. iii. Fostered a culture of problem-solving and product innovation.
Science Technology & Innovation Policy (2020)	i. To foster an ecosystem for an "Atmanirbhar-Bharat" (self-reliant India) through research, innovation, and technology development. ii. Encourages transparency, collaboration, and sharing of scientific knowledge with adequate funding for research and innovation. iii. Indigenization and adoption of cutting-edge technologies by ensuring participation from diverse groups. iv. To create an environment conducive to research and development by engaging the public and promoting scientific awareness.
New Education Policy (2020)	i. Aimed at establishing a holistic system for elementary, secondary, and higher education as well as vocational training. ii. Encourages academic institutions to establish start-up incubation centers and technology development centers and nurture industry-academic linkages. iii. Promotes interdisciplinary research, including humanities and social sciences along with a dedicated IPR cell and IP policy in academic institutions.

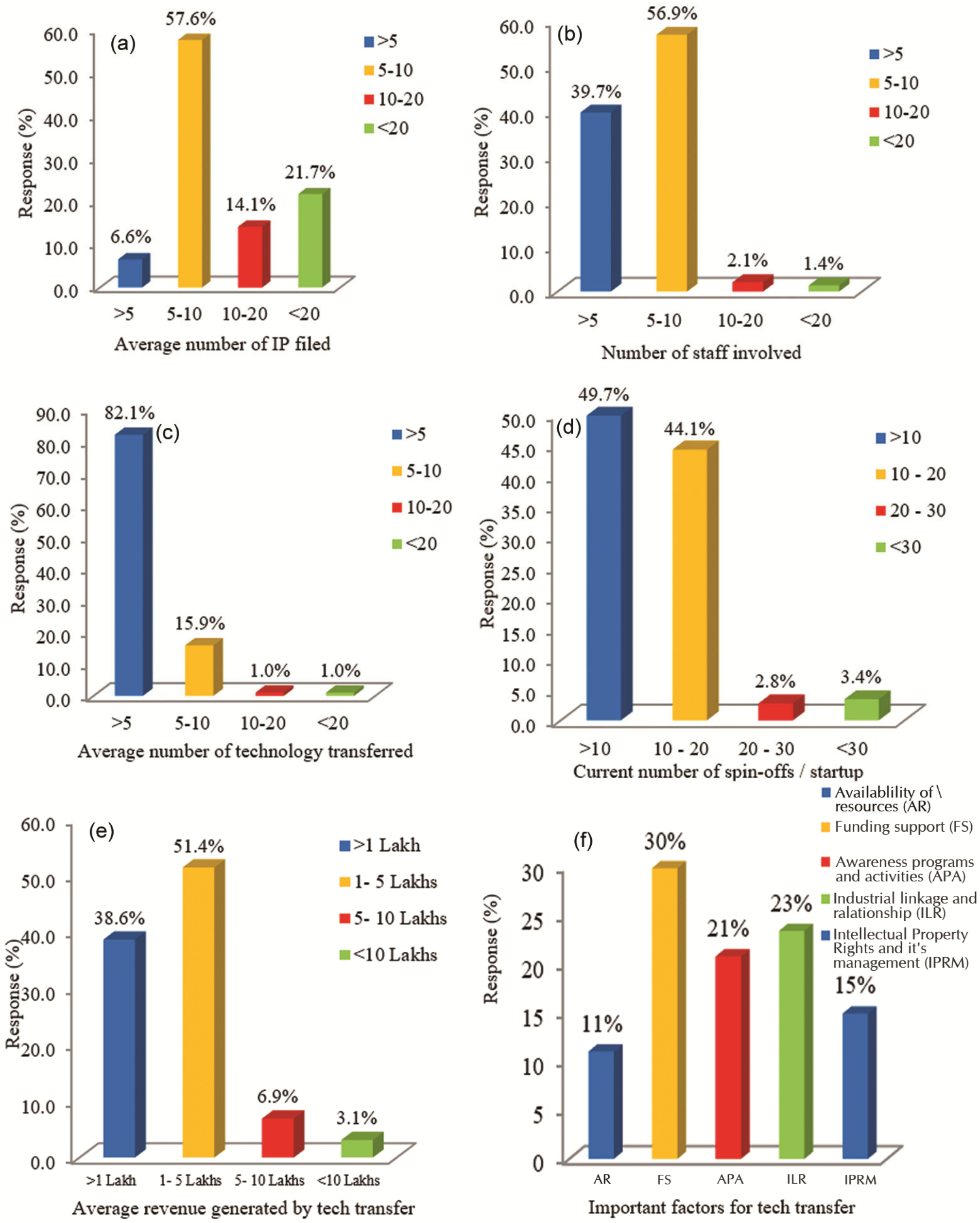

Fig. 4 — key metrics and perceptions related to technology transfer activities across participating Academic Research Institutions: (a) Average number of IP filed per year by universities, (b) Number of staff involved in technology transfer and commercialization in universities, (c) Average number of technology transferred and commercialized per years by ARIs, (d) Current number of spin-offs / start-up companies supported at ARIs, (e) Average amount of revenue generated by tech-transfer and commercialization activity per year, (f) Important factors for technology transfer and technology commercialization from ARIs

(Fig. 4a), indicating a healthy level of invention activity and institutional support for IP generation.[16]

2. Technology Transfer Personnel A majority (56.9%) of universities report having 5–10 staff members dedicated to technology transfer functions (Fig. 4b), suggesting that institutions are building substantive teams to manage commercialization processes.
3. Technologies Commercialized Most ARIs (82.1%) transfer and commercialize fewer than five technologies annually (Fig. 4c). This highlights a gap between invention output and market delivery, underscoring the need for enhanced licensing and industry outreach.[17]
4. Spin-off and Start-up Support Nearly half (49.7%) of institutions have supported up to 10

spin-off or start-up ventures (Fig. 4d), reflecting growing but still modest incubation activity within university ecosystems.[17, 18]

5. Revenue from Tech Transfer Annual revenues of ₹100,000–₹500,000 from technology transfer and commercialization are reported by 51.4% of ARIs (Fig. 4e). While indicative of monetization potential, these figures also suggest significant room for scaling financial returns.[2, 17]
6. 30% of respondents rank funding support as the most crucial enabler for effective technology transfer and commercialization (Fig. 4f), highlighting the ongoing need for targeted financial resources to bridge the "valley of death" between invention and market adoption.[17, 18]

To assess how India's overarching national policy measures and specifically the implementation of the S&T National Innovation and Startup Policy influence perceptions of policy effectiveness and overall satisfaction with the technology transfer framework, we ran separate linear regressions for each institution type (Table 2). The explained variance (R^2) in respondents' ratings of policy effectiveness and satisfaction by these combined policy drivers was:

1. Central Universities: $R^2 = 0.538$
2. Deemed-to-be Universities: $R^2 = 0.441$
3. Institutions of National Importance: $R^2 = 0.788$
4. Private Universities: $R^2 = 0.372$
5. State Universities: $R^2 = 0.352$

These figures indicate that, for institutions of national importance, nearly 79% of the variation in perceived policy effectiveness and satisfaction can be attributed to the suite of national policy initiatives and the successful roll-out of the startup policy. Central universities also show a strong relationship (54%), whereas deemed-to-be, private, and state universities exhibit more moderate dependencies, accounting for 44%, 37%, and 35% of variance respectively.

The markedly higher R^2 for Institutions of National Importance suggests that these entities often equipped with better resources and stronger governance structures are more responsive to policy signals and more capable of translating them into meaningful incubation support. Central universities similarly benefit from direct central funding and clearer policy directives, which likely boosts their confidence in national frameworks. By contrast, the lower R^2 values for private and state universities may reflect uneven resource allocation, variable administrative capacities, or less alignment with federal initiatives.

These results underscore the need for tailored policy outreach and capacity-building in privately managed and state-run institutions. Enhancing communication channels, providing dedicated implementation support, and adapting incentive mechanisms to local contexts could help elevate their responsiveness to national policy objectives, thereby strengthening India's overall technology transfer ecosystem.

The key impact of national science and technology (S&T) policy structure on innovation and technology transfer from Indian universities are-

i. The Smart India Hackathon encouraged the product innovation and inculcated a problem-solving mindset among the engineering students.[2]
ii. Institution Innovation Council exhilarated and supported the pre-incubation of ideas and development of national innovation environment and fostering the startup / spin-off companies from academic institutions.[2]
iii. The NIRF Innovation formally ARIIA, a framework to rank institutes and universities in India on metric of "Innovation and Entrepreneurship Development" encouraged Indian institutions to be globally competitive in relations to innovation and entrepreneurship.
iv. Many universities have formulated their intellectual property policies, established IP protection cells, and increased awareness amongst researchers and faculty members to protect the rights and interest of the inventors from the university. These patented inventions and

Table 2 — Regression Analysis

Type of ARI	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Central University	1	0.733[a]	0.538	0.480	0.504
Deemed to be University		0.664[a]	0.441	0.429	0.375
Institution of National Importance		0.888[a]	0.788	0.782	0.232
Private University		0.610[a]	0.372	0.367	0.680
State University		0.593[a]	0.352	0.340	0.516
Overall		0.726[a]	0.528	0.526	0.564

a. Predictors: (Constant), Overall National Policy Initiatives & adoption of the S&T national innovation and start-up policy in the ARIs technologies can later be transferred and commercialized to industries on license basis.[17]

v. Many successful Public-Private Partnership (PPP) models have emerged due to the conducive environment created by the various technology transfer initiatives by the government of India.
vi. The efforts have the collateral benefit of promoting economic growth through the creation of companies around academic technologies, job creation, and attendant economic multipliers.[17,18,19]
vii. Atal Incubation Centres provide the start-ups and spin-offs with guidance, technical hand-hold support, infrastructure, and investors connect, networking, and other services that may be required for scaling up across all the technical universities.
viii. Science Technology & Innovation Policy nurtures the ecosystem for an "Atmanirbhar-Bharat" (self-reliant India) through research, innovation, and technology development with the indigenization and adoption of cutting-edge technologies by ensuring participation from diverse groups.[17,20,21]

Conclusions

This study highlights the evolving dynamics of technology transfer within Indian academic institutions, revealing both progress and persistent structural challenges within the S&T policy framework. While institutions have demonstrated intent through IP generation and team formation, the limited scale of commercialization underscores the need for strategic reinforcement. A key limitation lies in the reliance on self-reported data and convenience sampling, which may affect generalizability. Additionally, the cross-sectional design restricts insights into longitudinal policy impacts. Future research should adopt longitudinal and mixed-method approaches to better capture institutional transformations over time. Strengthening institutional capacity, aligning incentive structures with regional contexts, and fostering sustained industry-policy linkages are essential for enhancing technology transfer outcomes. The findings offer actionable insights for policymakers and institutional leaders aiming to build resilient innovation ecosystems. With targeted support and adaptive frameworks, Indian higher education institutions can play a pivotal role in translating academic research into scalable, market-ready solutions that contribute meaningfully to national development.

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