Challenges in Technology Commercialisation & Possible Solutions through Techplomacy: An Indian Perspective

Radhika Trikha
Senior Policy Fellow, DST-Centre for Policy Research, Panjab University, Chandigarh, India
E-mail: radhikat@iisc.ac.in

Introduction

The national progress of any country is primarily driven by technological growth rested on research and innovation. Research and innovation act as a breeding ground for technology development. It is of paramount importance that a supportive and conducive framework for commercialising technologies specially developed in academic and research institutes should be created.

In the global context, international relations are primarily defined by interactions around technology needs and evolution. Diplomatic channels, in return, are also having a strong influence on the development of technologies and their deployment. It has led to the emergence of the '*Technology Diplomacy*' concept that helps determine interactions and knowledge sharing mechanisms of international organisations, the private sector and the national governments/ public sector.

Technology commercialisation is the process of transferring a technology-based innovation from the developer to the organisation, utilising and applying the technology for marketable products.[1] There are three groups representing technology developers and commercialising organisations. These include universities and research institutes, startups (technology-oriented) that are founded for the sole purpose of developing (and in some cases also commercialising) technologies and established companies.[1] The universities and national research laboratories are the vital technology developers that can commercialise their technology by licensing or selling it or creating spin-offs.

Technology transfer in India has transitioned towards a large-scale, globally interactive market and is bound to have a tremendous impact on the economy through risk management, research income sponsored by the industry and exclusive licenses.[2] Though the Government of India (GoI) invested particular thoughts and efforts for improved commercialisation of technology, it failed to achieve the required momentum for sustainable and inclusive growth.[2,3] In India, the research and development (R&D) system is deficient in the following:

- Minimal or selective private sector involvement in R&D support programmes.
- Conservative and safe approach that discourages high-risk ventures.
- Scarcity of cooperative or professional education in academic institutions or universities.

- Lack of monitoring, accountability and utilisation of fiscal incentives by the industry and private sector.
- Lack of vision: for instance, research agenda in organisations with a primary focus on fundamental or essential research often gets diluted due to unreasonable expectations of commercialisation and *vice versa*.
- Lack of policy and decision-making ability of public institutions.
- Stringent bureaucratic resource allocation procedures.

India's upcoming 5th National Science, Technology and Innovation Policy (STIP) draft has strongly emphasised building technology competency. Therefore, proper measures, frameworks and models for promoting and commercialising the technologies should be laid out. STIP draft has addressed the changing STI landscape globally and the emerging challenges related to technology development and its governance, especially standards, ethics, ownership, transfer, market access, and dual-use. It calls for direct & dynamic, proactive international S&T engagements through technology diplomacy initiatives. Technology diplomacy will aid in bringing India's proactive role in agenda-setting and global STI governance.

The current article envisages the lack of technology commercialisation and successful translation of academic knowledge to marketable products in India.

Challenges in Technology Commercialisation

Technology commercialisation is an integral part of the innovation process,[4] which means that technologies and products cannot successfully enter the market without going through the commercialisation process. The success in technology/ product commercialisation depends on integrating research and innovative capabilities, including accessing financial resources, understanding market needs, employing highly-skilled forces and forming effective interactions with the other actors in the market.[5] The challenges in technology commercialisation can be categorised into four levels: individual-level, technology-level, organisation-level and national and policy-level.

Individual-level challenges	Technology-level challenges	Organisation-level challenges	National and Policy-level challenges
Scientists/ researchers face barriers during technology commercialisation.	The product generated is not ready for technology commercialisation.	The organisational culture hampers technology commercialisation.	The national policy on Science and Technology (S&T), lack of technical support, lack of Intellectual Property Rights (IPR) valuation, certification, and approvals are barriers to technology commercialisation.

Recommendations* for Enhancing Technology Commercialisation

1. The academic and research institutes engaged in active basic and translational research should have a vibrant Business Management Cell (BMC), which acts as a moderator between academia and industry. BMCs (or equivalents) are considered a vital component of promoting innovations and already exist in the

* Major recommendations are pulled out from the talk given by Prof. R.K. Sinha at an event organised by DST-CPR at Panjab University, Chandigarh.

Indian premier academic institutes, such as the Indian Institute of Science (IISc). Many Indian Institutes of Technology (IITs) and foreign universities are also known for generating R&D-led innovations. BMC primarily consists of personnel adept in business management, marketing, innovation and industry-ecosystem. These BMCs can serve as facilitative channels for technology diplomacy and strategic international engagements in line with a particular technological domain.

2. Although there are many funding programmes available for generating new technologies/ innovative products, there are limited schemes for updating the technologies created in the universities/ research labs. In the present era, technologies become obsolete within a couple of years after hitting the market. These days Internet of Things (IoT) enabled technologies are preferred over analogue-based technologies. Hence, it is imperative to introduce schemes for updating the existing technologies. This will also aid in modernising the current technologies and future-ready ones. Furthermore, diplomatic institutionalised mechanisms can be explored for the necessary support for technology development and its commercialisation. The prime examples are three international centres: Indo-French Centre for Promotion of Advanced Research (IFCPAR/ CEFIPRA); Indo-US Science & Technology Forum (IUSSTF) and Indo-German Science & Technology Centre (IGSTC) established by the Department of Science and Technology (DST) with their foreign counterparts, France, USA and Germany, respectively to aid in joint research, innovation and technology development.
3. An adequately certified technology [high Technology Readiness Levels (TRLs)] stands a high chance of success to be taken up by the industry. The companies trust and rely on certified technologies. Unfortunately, most scientists are unaware of TRLs and there are not enough testing/ certification centres to evaluate technologies created in the R&D labs. The automobile and aviation sectors have suitable testing/ certification centres, but the situation is not encouraging in other domains. The policymakers should look into this matter and set up sector-specific testing/ certification centres in R&D labs.
4. Many innovative technologies are lying on the shelves of R&D labs. Not much emphasis is laid on marketing the technologies by research labs and universities. Besides, the stakeholders (industries and entrepreneurs) are unaware of these technologies. Each lab should create an interactive web platform where the technologies designed and available for licensing should be marketed. The Council for Scientific and Industrial Research (CSIR) under the Ministry of Science and Technology, GoI has come up with a Fast Track Commercialisation (FTC) funding scheme that has started paying dividends. Such an initiative can contribute to the self-sustenance of at least 25% of the R&D budget of each lab. Other funding agencies may set up similar schemes for the speedy commercialisation of technologies lying unsold.
5. It has been noted that having experienced industry R&D personnel in the academic sector positively influences the scientific environment. The universities may consider setting up a position of 'Chair-Professor' for retired R&D personnel from the industry. This initiative will equip academic scientists with an industrial R&D mindset. The model is working well in the Indian state of Orissa.
6. For stimulating technology commercialisation, engaging Masters of Business Administration (MBA) interns for the market study will act as a progressive approach. The R&D labs and research-oriented universities should engage MBA students in technology marketing through internships or short-term training programmes that will create MBAs with knowledge of both domains and would provide better job opportunities.
7. Scientific leadership is also one of the critical parameters for success in translational research. Scientists oriented towards technology development must be nurtured for leadership qualities by the Management Gurus. Business cells created in universities and research labs should be led by experienced scientific leaders accompanied by a team with science and management backgrounds.
8. Developing technology is far more challenging than publishing a research paper. Nonetheless, promotion-evaluators give more emphasis to articles published than to patents granted. In case of failure, the hard

work and time invested in technology development are not considered and do not find favours with evaluators. As a result, the current mindset of Indian scientists is more towards research projects (for publications) than technology-oriented projects. Therefore, more avenues need to be created for scientists engaged in translational research and should be incentivised, which can be in the form of promotion, awards, R&D grants, etc.

9. In the majority of the universities, there is no provision of relaxation in the teaching load of a professor/ scientist excelling in R&D. It takes a heavy toll on the scientist. The Ministry of Education (MoE), GoI may look into this aspect. Also, it is suggested that MoE introduces positions of Research-Professor, Assoc. Professor and Asst. Professor at the universities to promote good quality research in the academic environment.
10. Many scientists in universities and research labs have ideas that can be translated into innovative products/ technologies. The GoI has put in place a Faculty-Entrepreneurship Policy, but scientists are unaware of it. In other cases, universities are reluctant to grant leave to scientists to become entrepreneurs because of the limited teaching staff. This situation requires the immediate attention of MoE.
11. Inter-University Accelerator Centre (IUAC) should come up with the idea to bridge the gaps in the university-level research programmes aiming towards the same product. Moreover, an interface needs to be created wherein academia and industry people meet and join hands to address societal issues requiring R&D interventions and work on industry problems needing the intellect of academia.
12. After the retirement of scientists, the process of technology commercialisation of their developed technologies gets stopped. A special assistance scheme should be introduced for taking up such halted technologies and introducing R&D grants for retired scientists. Hand-over of technologies should be made mandatory and technology development should not cease when a scientist leaves the organisation.
13. It has been observed that institutes that hire experienced and superannuated scientists display better R&D outcomes and tend to secure more funds from the agencies. It is suggested that universities be encouraged to employ such scientists as Adjunct Faculty.
14. One of the industry's concerns has been that a scientist of the academic sector is not sensitive to the timelines of the industry. If the scientists desire to work on an industry-academia research project, they need to deliver the product on time as per the agreement.
15. A scientist can prepare/ create/ design a lab-scale prototype. But the industries are inclined to commercial prototypes, which require further research and inputs from the industry. Sadly, there are not ample schemes catering to this aspect of 'Translational Research'. The Department of Biotechnology (DBT) under the Ministry of Science and Technology, GoI, has constituted a Section 8 Company, Biotechnology Industry Research Assistance Council (BIRAC). BIRAC supports technology development through idea generation to prototype development and commercialisation hence, catering to each stage of technology development. In addition, BIRAC has set up various STI based diplomatic channels to facilitate research and innovations. Some of the key diplomatic channels formed in the field of biotechnology are: Indo-Australian Biotechnology Fund; Bill & Melinda Gates Foundation signed a Memorandum of Understanding with BIRAC to attract global funders for serving grand challenges of India; RAPID USAID-TB Diagnostic programme; BIRAC-UK Trade and Investment programme, etc. It is propounded that govt. funding agencies introduce dedicated funding schemes for lab-scale prototypes to commercial prototypes.
16. BIRAC is highly successful in promoting public-private R&D partnerships. It also assists in the TRL evaluation of medical/ pharma technologies. The R&D investment share of public and private sectors in the BIRAC sponsored projects is nearly 50-50. Many patents/ technologies/ startups have been generated in a short span. It is advocated that each funding agency should look into the BIRAC model and re-orient their funding schemes accordingly.
17. Generally, funding agencies introduce schemes in a mission mode approach; in other words, funds are

allocated for a limited/ fixed time. This approach has not delivered the desired results as commercialised technologies generally have a long gestation period. They also need to be updated occasionally to survive the market competition. Hence, long-term funding schemes (spanning 10-15 years) catering to different sectors are imperative.

18. Industries should also transform their mindset of funding short-term (one to three years) research projects to long-term investments by establishing Centres of Excellence (CoE), cooperative labs, etc. Such CoEs should also have highly skilled technical staff.
19. Although Corporate Social Responsibility (CSR) funds of industries can be used to carry out R&D work in the universities/ research labs, industries are not free to utilise these funds. The Centre influences decisions regarding CSR money expenditure. This issue needs the redressal of the policymakers.
20. Many technologies rely on the availability of components from the market. Hence, an institute/ R&D lab must have a strong network with the vendors. This aspect is essential for technology commercialisation. It is recommended that each institution may enlist its alumni who have set up industrial units. Such units naturally bond with their alma mater and render their services happily, even at a lower price.
21. Sometimes, an industry buys the technology but does not use it as imported items fetch more value. Policy intervention is needed in this matter. Moreover, the academic/ research institutes that sell the technology to the industry should be closely associated with the drive for technology use and maintenance. The government should provide a support system to nurture this.
22. Too much time is taken up to grant a patent in India. This process needs to be speeded up. In addition, the protection of utility patents for small inventions can be introduced in India.
23. The market-to-mind approach is far better than the mind-to-market approach, particularly in translational research. Hence, scientists should engage with industries and work on industry-generated R&D problems. This approach has more chance of success and reduces the time to generate industry-ready prototypes.
24. In developed nations, the industry provides necessary funds for R&D projects in universities and R&D labs. The Centre incentivises industries by providing loans, grants and tax benefits for their R&D investments in the academic sector. In developing countries, it is the Government that contributes towards R&D funds. The Centre may look into this aspect seriously. It can reduce its share of R&D expenditure by granting more incentives (tangible and intangible) to the industries.
25. Some Indian funding agencies like DST, DBT, Ministry of Electronics and Information Technology (MeitY), etc., have set up several Technology Business Incubators (TBIs) across India for converting innovative ideas into prototypes. But, the next phase (i.e. accelerated phase) of taking the prototype to the market is very critical. Most of the entrepreneurs fail here. This phase, also called the 'Valley of Death' phase, needs a strong hand holding by the government. The GoI has responded by setting a few domain-specific accelerators. But, the need of the hour is to establish many more accelerators, especially in the domain of 'Clinical Testings' for Phase two and Phase three studies.
26. In the present innovation era, only those industries will survive that have their R&D set-up tied up with academia (universities and R&D labs). In India, many industries situated in the State of Orissa, India, are collaborating with academic institutes and the results are encouraging. It is suggested that all industries tie up with universities and R&D labs, preferably the ones closely located. The Industrial Policy-2019 highlights this very point.
27. 'Robust Technology Commercialisation Policy' should be put in place at the national, state and institutional levels.
28. National Research Organisations, for example, CSIR, are meant for assisting industries and not for financial benefits. Hence, the technologies should be priced moderately to encourage the industries to buy them.

29. A national policy needs to be in place to purchase homegrown technologies/ products. CSIO, in collaboration with three agencies, developed 6MeV Medical Linear Accelerator (LINAC) in the 1990s. All were working efficiently at hospitals and prices of foreign accelerators came down heavily in India. But the Government stopped funding for making more accelerators.
30. Auditing the universities, R&D labs, and funding agencies should be a serious business. It should be done annually by competent teams who are fully aware of the ins and outs of the organisations.

Exploring Technology Diplomacy

International diplomacy plays a significant role in addressing the emerging issues and challenges globally, and S&T is playing a central role in this. The science diplomats are actively mobilising technical expertise and scientific knowledge for new, emerging and sustainable technologies. The emerging field of technology diplomacy is also catering to policy decisions related to the entire value chain associated with technology development and commercialisation. It has led to the emergence of innovative and collaborative ways to address the whole life cycle of technology development from the idea to the market. As highlighted in India's upcoming STIP draft, the GoI is substantially working towards strengthening its international engagements through STI diplomacy. The policy has a dedicated section on 'International Engagement for Technology Development and Adaptation'. This section brings out the focus of the Central Government in gaining access to the knowledge base (technical know-how) associated with the importing technologies. It has also actively promoted India's participation in Mega-science projects and developed scientific and technological capabilities for indigenous technology development and commercialisation. The outcomes generated through mega-science projects can be further adapted and commercialised in India in line with national priorities and needs, focusing on domestic demands. This can be one of the approaches to achieve the bigger goal of Atmanirbhar Bharat by aspiring for technological self-reliant India. The initiatives taken in this direction are listed below:

- The Ministry of External Affairs (MEA), GoI, has set up a division New, Emerging and Strategic Technologies (NEST). The division has undertaken efforts to reinvigorate Indian organisation capacities by promoting interplay of trade, technology, security and geopolitics in a larger context. The division focuses on dealing with foreign policy and other international legal aspects along with the standard-setting in the technological fields. The diplomatic channels will focus on exchanging knowledge and views with foreign governments, domestic ministries and various associated departments. The diplomatic channels are working towards strengthening India's positioning in the digital landscape, especially in the era of the next generation of network technology. Technology diplomacy has to cater to the global context of technology export and import. The new and emerging technologies are essential for the country's innovation-backed socio-economic development.
- The GoI has initiated Pravasi Bharatiya Academic and Scientific Sampark - Integrating Indian Diaspora with the Motherland (PRABHASS) as a flagship initiative. The virtual portal has been established to develop a database and a platform to bring the global Indian S&T Community to address the Indian societal challenges. This has led to collaborative arrangements for technology development and technology import from abroad as suited for the Indian landscape.
- Presently, India has bilateral S&T cooperation agreements with 83 countries with active cooperation with 44 countries. During recent years the cooperation has strengthened significantly with Australia, Canada, EU, Israel, Japan, Russia, UK and USA. Cooperation with African countries has also been strengthened through the India-Africa S&T initiative. The soft prowess of S&T has been leveraged to engage with several countries under India's Act East policy and with some neighbouring countries. Three bi-national S&T Centres, IFCPAR/ CEFIPRA, IUSSTF and IGSTC have been established under inter-governmental bilateral agreements.
- The International Cooperation division of DST provides thematic cooperation for generating theme-based technologies. Some of the leading programmes where India is taking the lead are:

- International AIDS Vaccine Initiative (IAVI)
- International Solar Alliance (ISA)
- Mission Innovation (MI)
- Laser Interferometer Gravitational-Wave Observatory (LIGO)

- India is also part of various regional, bilateral and multilateral engagements [regional engagements with ASEAN; EU; BRICS; SAARC; multilateral organisations such as OECD, UNESCO, etc.; Ministerial multilateral platforms (Science and Technology for Society Forum)] to promote and strengthen its STI ecosystem. These initiatives and engagement dialogues have established a technology diplomacy channel in India. This division has also created dedicated funds [India-Israel Innovation & Industrial R&D Fund (I4F); Australia -India Strategic Research Fund (AISRF); Indo-Hungarian Joint Research Fund (IHJRF); India-Portuguese Joint Research Fund (IPJRF); ASEAN-India S&T Development Fund (AISTDF)] to support technology development and its deployment with global support.
- DST has also created Global Innovation and Technology Alliance (GITA), a "not-for-profit" Public-Private Partnership (PPP) between the Technology Development Board (TDB), DST and Confederation of Indian Industry (CII), India's apex industry association. It focuses on: a) Professionally managing Government's industrial innovation funds, b) Providing flexibility to industry for R&D, including with global partners, and c) Delivering commercialised products and services to Indian and global markets. It offers funding, capacity building, deployment and strengthening of the innovation ecosystem. It is one of the diplomatic channels for promoting collaborative technology development and deployment in association with global partners.

Conclusions

In the current COVID-19 pandemic, it has become necessary for countries worldwide to become technologically self-reliant. Governments must push indigenous technology development and deployment by strengthening national policies and action plans and exploring the technological prowess of countries routing diplomatic technology channels. The technical deployment in reaching society and contributing to social-economic development requires a conducive environment for supporting technology commercialisation. The economic value and its reach to the masses are only possible with dedicated steps that cater to the endorsement of technology development and its commercialisation. The Indian STI trajectory faces current challenges in commercialising the technologies at the national level, institute level and individual level. Therefore, necessary mitigative steps need to be undertaken by the GoI to promote and create accessible and reliable institutional mechanisms and policy instruments to support the commercialisation of the technologies developed in academic and research institutes. It also calls for introducing policy-level interventions and programme-level interventions to explore technology diplomacy to gain maximum from imported technologies, global resources, and mega-science projects.

In the author's opinion, the GoI can take critical steps to remove barriers to technology commercialisation. It should introduce policies to develop institutional mechanisms, funding mechanisms, incentivisation mechanisms, and legislative and administrative mechanisms for imbibing the culture of technology commercialisation at all levels. The creation of national policy guidelines and protocols and a rulebook for technology commercialisation should be laid at the institutional level. Necessary support mechanisms in terms of setting up Centres of Excellence, Business management cells, thematic incubators, accelerators, etc., should be widely promoted. The funding models for addressing the up-gradation of technology commercialisation should be put in place. The author opines that if the Government undertakes such initiatives, a culture of technology marketing and its commercialisation can be inculcated as a trait amongst the technology developers, technology facilitators, technology deployment vehicles and technology consumers. Furthermore, India should proactively participate in agenda-setting and standard-setting in various technological domains and utilise global knowledge in developing technologies addressing global and national problems.

References

1. Kirchberger MA, Pohl L (2016) Technology commercialization: a literature review of success factors and antecedents across different contexts. *The Journal of Technology Transfer*, 41(5): 1077–1112. https://doi.org/10.1007/s10961-016-9486-3
2. Rath S, Nathani A, Patel D, Kulkarni P, Gota V (2014) Status of Technology Transfer in India – the much needed Magic Remedy. *Current Science*, 106(8): 1058–1060.
3. Srivastava P, Chandra S (2012) Technology Commercialization: Indian University Perspective. *Journal of Technology Management & Innovation*, 7(4): 121–131.
4. Frattini F, De Massis A, Chiesa V, Cassia L, Campopiano G (2012) Bringing to Market Technological Innovation: What Distinguishes Success from Failure. *International Journal of Engineering Business Management*, 4(15): 1–11. https://doi.org/10.5772/51605
5. D'Este P, Iammarino S, Savona M, Tunzelmann NV (2012) What hampers innovation? Revealed barriers versus deterring barriers. *Research Policy*, 41(2): 482–488. https://doi.org/10.1016/j.respol.2011.09.008