



Public R&D in India: Pathways to Increasing its Effectiveness

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■ Introduction

Findings from a recent study¹ indicate there is scope to remould public R&D in India and increase its impact on the wider economy. In recent years, the Union budget announcements have seen new initiatives being announced that are a welcome move towards transforming public research in India. The budget of FY2022 saw the announcement regarding the setting up of a National Research Foundation (Ministry of Finance, Government of India, Press Information Bureau, 2021), the budget of FY2023 saw the announcement that 25 percent of the defence R&D budget would be reserved for the private sector including startups (Ministry of Defence, Government of India, Press Information Bureau, 2022), and the latest FY2024 budget announced the opening up of select ICMR laboratories to both public and private sector institutions as well as industry (Ministry of Finance, Government of India, Press Information Bureau, 2023). These along with other policy measures if implemented well and scaled across the key scientific agencies would have the potential to (i) create a rich scientific talent pool in the country through greater linkages between public research laboratories and higher education institutions (HEIs) (ii) achieve greater returns on the available public research funding by making it competitive and through continuous evaluation to align it with national goals and priorities, (iii) support the R&D objectives of industry and startups by opening up their research facilities and providing R&D related services which will also diversify the sources of funding for public R&D laboratories.

Several other countries such as Australia, France and China have seen their public funded research institutions transform over time to cater to their national priorities. Building on the recent budget announcements in India, and drawing on lessons from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia, French National Centre for Scientific Research (CNRS) and Chinese Academy of Sciences (CAS), this essay suggests pathways to transform public R&D in India to make it more impactful.

1 Evaluation of Innovation Excellence Indicators, Report on Public Funded R&D Organisations (2022)

■ Structure of Public R&D in India

Table 1 National Expenditure On Research And Development By Sector of Performance (2020-21)

Sector	Amount (₹, Million)	Amount (US\$, Million)	Share in total (%)
Government	665043	8959	54
Business Enterprises/Industry	478742	6449	39
Higher Education	86091	1160	7
Total National R&D Expenditure	1229876	16568	100

Source: Notes on Demand for Grants (various Ministries), Union Budget 2022-2023, available at <https://www.indiabudget.gov.in/>; Standing Committee on Defence, Demands for Grants, Ministry of Defence, available at http://164.100.47.193/lssccommittee/Defence/17_Defence_29.pdf; State Budget Accounts (2022-2023) (for all Indian States); Annual Reports (2020-21) of Indian companies; Prowess, data downloaded on 16 October 2022 from the platform; ACE Equity, data downloaded on 16 October 2022 from the platform; Ahmedabad University; Centre for Technology, Innovation and Economic Research (CTIER)

Note: (i) Government = Central Government Ministries/Department + State Governments
(ii) Business Enterprise/ Industry Investment in R&D= 53 Public sector firms + 1504 Private sector firms
(iii) Higher Education spending is estimated as 7 percent of National R&D Expenditure
(iv) Figures in rupees were converted to dollars using the USD-INR exchange rate of 74.23 calculated as an average for the fiscal year 2020-21 based on data from Federal Reserve Bank of St Louis

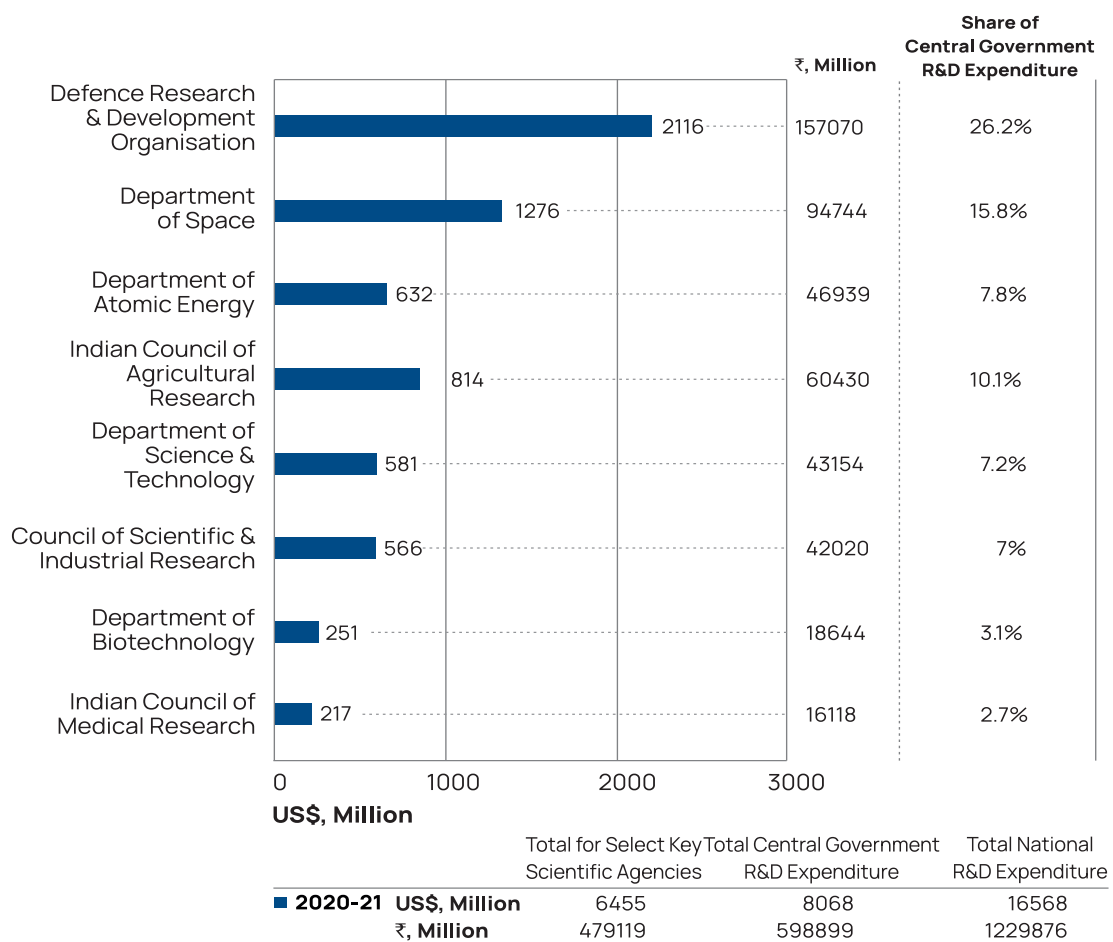
India's R&D spending in 2020-21 was USD 16.6 billion, accounting for around 0.62 percent of its Gross Domestic Product (GDP), a share that is lower than several advanced and emerging economies, and has remained so for several decades. The government performs a lion's share of total national R&D at 54 percent², whereas the industry and higher education sectors perform 39 percent and 7 percent respectively (Table 1). A practice that is unique to India is that the sector that funds R&D also largely performs the R&D, which means that bulk of the national R&D funded by the central government sector is performed through autonomous research institutions functioning under the auspices of various central government ministries and departments. These departments include the Defence Research & Development Organisation (DRDO), Department of Space (DoS), Department of Atomic Energy (DAE), Indian Council of Agricultural Research (ICAR), Department of Science & Technology (DST), Council of Scientific & Industrial Research

² Of the 54 percent, about 10 percent is through state governments and the balance 44 percent is through the central government

(CSIR), Department of Biotechnology (DBT), Indian Council of Medical Research (ICMR) among others.

These select key scientific agencies have around 290 R&D establishments³ and laboratories under them, spanning across the entire country and accounting for 80 percent of the total central government spending on R&D. The combined spending by DRDO, DoS and DAE is around 50 percent of total central government spending (Figure 1).

Figure 1 R&D Expenditure by Select Key Scientific Agencies under Government of India (2020-21)



Source: Notes on Demand for Grants (various Ministries), Union Budget 2022-2023, available at <https://www.indiabudget.gov.in/>; Standing Committee on Defence, Demands for Grants, Ministry of Defence, available at http://164.100.47.193/Isscommittee/Defence/17_Defence_29.pdf; State Budget Accounts (2022-2023) (for all Indian States); Annual Reports (2020-21) of Indian companies; Prowess, data downloaded on 16 October 2022 from the platform; ACE Equity, data downloaded on 16 October 2022 from the platform; Ahmedabad University; Centre for Technology, Innovation and Economic Research (CTIER)

Note: (i) Figures in rupees were converted to dollars using the USD-INR exchange rate of 74.23 calculated as an average for the fiscal year 2020-21 based on data from Federal Reserve Bank of St Louis
(ii) The total Central Government R&D Expenditure is estimated

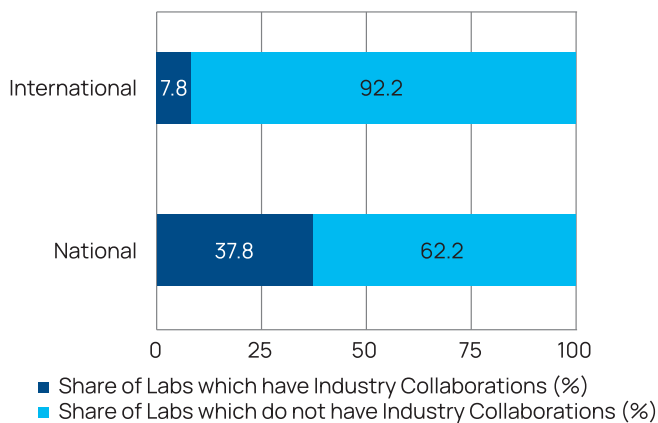
The amount of R&D performed by the government as a share of GDP at 0.3 percent is comparable to several other advanced and emerging economies - the question then is to ask whether the existing structure and practice of public R&D in India needs to change to better serve the country's R&D ambitions going forward?

■ **The Need to Reinvigorate Public Research in India**

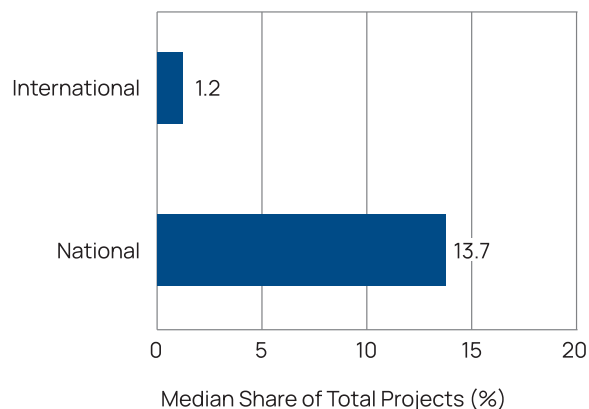
A recently published study conducted jointly by the Office of the Principal Scientific Adviser to the Prime Minister's Office (O/o PSA), Confederation of Indian Industry (CII) and Centre for Technology, Innovation and Economic Research (CTIER) evaluated the innovation and excellence indicators of these public funded R&D organisations. The study saw participation from 193 research laboratories under various central government ministries and departments including all key scientific agencies except DRDO, DoS and DAE. The 193 laboratories were from select key scientific agencies such as CSIR, DST, ICAR, ICMR, DBT and other departments and ministries such as Ministry of Electronics and Information Technology (MeitY), Ministry of Earth Sciences (MoES) and Ministry of Environment, Forest and Climate Change (MoEFCC), Department for Promotion of Industry and Internal Trade (DPIIT), Ministry of Textiles, Ministry of Heavy Industries and Public Enterprises and represented around 45 percent of the total R&D spending by these ministries and departments. The average budget over three years (2017-18, 2018-19 and 2019-20) for these 193 laboratories was around USD 1,890 million (INR 129.1 billion), accounting for approximately 11 percent of the total national expenditure on R&D. The findings from the study suggest there is scope to restructure and transform the work of the public funded research laboratories in India to make the R&D spending more efficient and effective. When looking at academic project collaborations of these laboratories, the median share in total projects for national collaborations was only around 14 percent in 2019-20 and 1 percent for international collaborations. The total publication output of these 193 laboratories was 16,202 in 2019-20, which is estimated to be around 15 percent of the national publication output during that period. The patent filings by these 193 laboratories accounted for around 2 percent of the total patents filed within India and outside India by Indian residents while the patents granted account for around 8 percent of the total patents

Figure 2 Select Findings from the Study of 193 Public Funded R&D Organisations

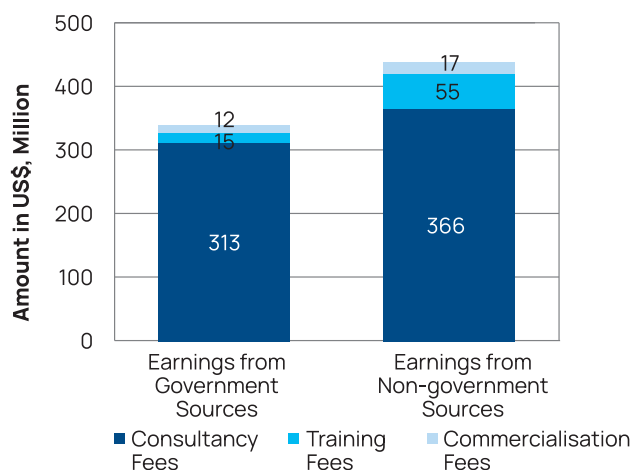
**Project Collaborations with Industry:
International and National in FY2020 (% of Labs)**



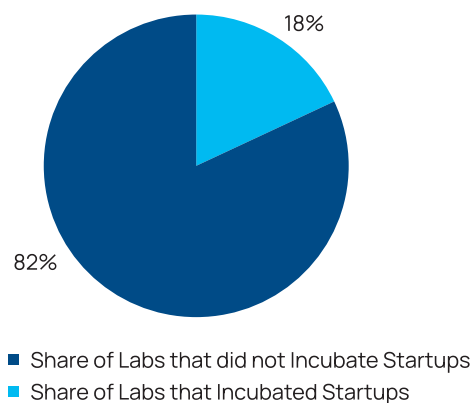
**Project Collaborations with Academia:
International and National in FY2020 (% of Projects)**



**Earnings from Government and Non-government Sources
(FY2018 - FY2020)**



Incubation of Startups in FY2020 (% of Labs)



Source: Evaluation of Innovation Excellence Indicators, Report on Public Funded R&D Organisations (2022) available at <https://www.psa.gov.in/innerPage/psa-initiatives-covid/report-evaluation-innovation-excellence-indicators-public-funded-rd/3635>; Centre for Technology, Innovation and Economic Research (CTIER)

Note: For earnings from government and non-government sources, figures in rupees were converted to dollars using the average exchange rates of USD-INR 64.46, USD-INR 69.92, USD-INR 70.9 for the fiscal years 2017-18, 2018-19 and 2019-20 respectively and based on data from Federal Reserve Bank of St Louis

granted within India and outside India to Indian residents in 2019-20. With respect to the earnings of these laboratories, the study showed that the laboratories earned over USD 780 million (INR 53 billion) over the three years, 2017-18, 2018-19, 2019-20, and most of their earnings both from government and non-government sources were through consultancy

fees while earnings from commercialisation formed a meagre portion of their earnings. The earnings here were majorly driven by a small number of laboratories that are engaged in providing services to specific sectors. The extramural funding received by these laboratories over the three years was around USD 1,450 million (INR 100 billion) and over 90 percent of the funding came from other government sources while the rest came from non-government sources. The study also showed that these laboratories were not collaborating enough with industry as only 38 percent of laboratories had at least one project collaboration with industry in India. Only 18 percent of the 193 laboratories were providing incubation support to startups.

The following sections suggest pathways that could help make public sector research funding more effective in order to achieve the scientific goals of the country and also highlight examples from other countries that have transformed their public R&D ecosystem over the years.

■ **Enriching the Pool of Young Scientific Talent in the Country**

A country's potential talent resides in its higher education institutions (HEIs). Enriching the talent pool of the country is one of the most important factors that can help achieve the objective of sustainable economic growth. A large share of the student population in India is enrolled in central or state government institutions, majority of which have limited access to research facilities or funding and little or no connection to the autonomous public research institutions. The findings above showed that there is very little collaboration between public laboratories and academic institutions in terms of projects. For a start, scientists at the public research laboratories could be incentivised to teach at universities in India through short stints, dual appointments and sabbaticals, without losing their position or seniority. More opportunities should be created for students and young researchers (PhDs, JRFs, post-docs) to work directly with scientists at these laboratories with the aim of enhancing the skills and experience of young students and researchers and making them familiar with real-life applications of research. A formal process could also be set into place to establish a close affiliation of each of these laboratories with HEIs on the basis of parameters such as common subject areas that these institutes are

working on or distance between two institutions. This would enable researchers to spend some of their time teaching students alongside their research and allow students and young researchers to access research facilities and get direct supervision from researchers at these laboratories. Students spending time at these research institutions could also be introduced as a part of the degree curriculum. Eventually, for some of the public research institutions, the greater linkages with HEIs could happen by way of co-location, and for others the public laboratories could get absorbed into the higher education system based on the overlap between the research being undertaken by them. Some examples of the structures adopted by different countries are highlighted below.

Looking at CSIRO in Australia, CNRS in France and CAS in China, there were reforms and initiatives introduced to enable these institutions to move towards establishing greater linkages with HEIs as a part of their efforts to make research more effective and beneficial to the economy. With the aim to increase collaboration with universities, CSIRO has started co-locating its sites with universities in Australia (CSIRO, 2015) and till date, CSIRO has 11 of its sites co-located at universities (CSIRO, Annual Report 2020-21). Additionally, CSIRO also encourages their scientists to supervise graduate and post-graduate students.

By way of reforms in the mid-1960s, the CNRS research institutions started converging with the university system in order to address the gaps in the country's university research, which led to the formation of joint research units (UMRs) (Mustar and Larédo, 2002). CNRS committees were formed to conduct periodic evaluation of universities following which the universities were then granted a status of UMRs. The UMR status provided universities access to funds and human resources available at CNRS and allowed the CNRS scientists to work inside the university system and divide their time between teaching and research (Thèves et al., 2007). This became increasingly popular over the decades and now more than 90 percent of CNRS laboratories are joint research units. CAS, on the other hand, has three universities in China affiliated to them namely, the University of Science and Technology of China (USTC), University of the Chinese Academy of Sciences (UCAS) and ShanghaiTech University. The UCAS has been set up with the goal of bridging the gap between research institutes and educational institutions, where teaching and supervising students would be a

part of the duties of the CAS researchers and the students and young researchers at universities would get access to CAS research facilities (Poo and Wang, 2014). Approximately 40 percent of researchers at CAS are research professors or associate professors.

■ **Establishing a Funding and Evaluation Process for Public Research Laboratories**

Almost 54 percent of the total R&D in the country is performed inside the government sector and only 7 percent is performed in the higher education sector in India. Despite the low level of spending on R&D, the higher education sector contributes to around 80 percent of the national publication output, which is significantly higher than the publication output of public research laboratories focusing on basic and applied research. India's top areas of publications include subject areas like electrical & electronic engineering, multidisciplinary material science, telecommunications, applied physics, artificial intelligence, multidisciplinary chemistry, physical chemistry, and environmental sciences. These top research areas, where bulk of the output is being produced in the higher education sector, are of critical importance for India and have significant implications for technologies of the future. The lack of public spending on R&D in the higher education sector is worrisome from the perspective of long-term skill and talent development in the economy. The finance minister, in her budget speech for FY2022, had announced an outlay of USD 6,730 million (INR 500 billion) over a span of five years for the National Research Foundation (NRF). One of the objectives of NRF is to encourage research in the higher education system and provide competitive peer reviewed research funding to universities, colleges, research organisations and national R&D laboratories (DST, 2023). However, it was only recently, after two years of the initial announcement, that a working plan for NRF was presented and USD 270 million (INR 20 billion) was allocated towards NRF (this amount is only 4 percent of what had been announced in the FY2022 budget). More public funding needs to be injected into the higher education sector. Going forward, the funds provided to public research laboratories need to be made increasingly competitive. While laboratories undertaking basic research may still fall under the

domain of government funding, besides the core funding allocated to these laboratories, all additional funding for basic research should be made competitive between public laboratories and HEIs. Laboratories undertaking applied research on the other hand should be encouraged to reduce the dependency on core funding by seeking a major share of their funding through collaborations with industry as well as providing services to industry. A regular evaluation should be undertaken for all these laboratories to gauge the impact that these laboratories are creating.

Competitive research funding is an important reform adopted by the US and China to enable them to efficiently allocate the public funds available for research. The National Science Foundation (NSF) in the US allocates research funding competitively and follows a well established peer-review model for funding and evaluation of projects funded by them. In China, the restructuring of the government funded research institutions started with the announcement of the '1985 Decision on the Reform of the Science and Technology Management System'. The allocated core funding of government research institutions were reduced and they were pushed to obtain funds from external sources such as competitive grants and industry. Institutes that focused on 'public goods' and agricultural research saw minimal reduction in core funding as there was little scope for them to earn through external sources, whereas institutes focusing on industrial technologies saw a complete reduction in their core funding (IDRC, 1997). This was followed by the setting up of National Natural Science Foundation of China (NSFC) in 1986 which distributed central government grants for basic and fundamental applied research on a peer reviewed basis (Gu Shulin, 1995). Separately, in 1998, CAS introduced a 'Knowledge Innovation Programme' (KIP) (Karaulova et al., 2017) which established a robust evaluation process and allocated a portion of KIP funding competitively among the CAS institutes (Suttmeier et al., 2006). The KIP helped contribute to the competitive research environment in the country and enabled an efficient use of resources (Karaulova et al., 2017).

■ **Supporting Industry and Startups to Help them Achieve their R&D Objectives**

The announcement in the Union Budget FY2024 about the opening up of ICMR research facilities to researchers at universities as well as the private sector is a much needed step towards successful transformation of public R&D laboratories in India. The scope of this initiative should be widened to include other departments and ministries. The public laboratories in India should open up their research facilities to industry and academic researchers, both domestic and international, and be a solution provider to industry and startups and support their R&D objectives. As we have seen in the study on the public funded R&D laboratories, the main source of earnings for the laboratories was through consultancy services - however this had been driven by just a few laboratories. Opening up their facilities to industry and startups will also provide an opportunity for many more laboratories to diversify their sources of income. Eventually some of the public funded laboratories could perhaps be transformed into Research Infrastructures (RIs) providing various testing and calibration services as well as access to their facilities for MSMEs, startups and industry. The study on public laboratories had also shown very little engagement between the participating laboratories and the startup ecosystem. Steps to support startups, especially during their early stages, will provide a boost to entrepreneurship and innovation in the country.

This culture of supporting industry and startups, in addition to being closely affiliated with academic institutions as seen earlier, is not uncommon when it comes to the CSIRO, CNRS and CAS. A significant share of the total funding of these organisations comes from sources other than their core government funding which has also helped them achieve financial autonomy to a large extent. The CSIRO in Australia has opened up its facilities to industry, startups and other researchers and closely monitors the use of its facilities through key performance indicators, such as number of hours of use of their centre, the outward loan of its biological collections, revenue from its IP (i.e. royalties, licensing) etc. Other avenues of collaboration with industry adopted by CSIRO include testing and certification, prototyping, data processing and modelling (CSIRO, Annual Report 2020-21). The CAS on the other hand has established over 250 joint research centres with industry and

39 technology transfer centres and incubation centres and works closely with industry for commercialisation of their research. Policy measures that were introduced in China, and captured above, to make the research institutions more market facing, turned some of these public research institutions into enterprises, while other applied research institutions were encouraged to increase engagement with industry and attract funding from external sources.

Both CSIRO and CAS have supported startups and created spin-outs through their research facilities and services. CSIRO has also supported early stage startups in exchange for equity when these startups may have had limited resources. CSIRO manages its equity portfolio through a separate fund (CSIRO Innovation Fund) which focuses mainly on startups and MSMEs (CSIRO, Annual Report 2020-21). CAS holds equity in more than 30 enterprises. Technology hardware & equipment brand, Lenovo (earlier Legend) is a successful example of a spin-out company from the CAS Institute of Computing Technology where CAS is still one of the biggest shareholders in the company (Nature, 2019). The French CNRS too supports startups and has made 48 equity investments in startups along with its partners (CNRS, 2021).

■ **Summing up**

There is a dire need to transform public R&D in India to better serve the country's R&D ambitions going forward. This would need stronger linkages between public funded R&D institutions and higher education institutions, a review of the way public R&D is currently funded and opening up opportunities for industry and the startup ecosystem to access the expertise, facilities and equipment that reside within the public funded R&D laboratories. Several positive announcements have been made in union budget speeches over the last few years that show intent towards a much needed transformation. The announcements need to be capitalised on and expanded in scope as well as scale in the coming years. The pathways suggested in the sections above are only the start of a debate on the kind of transformation that could take place. Ultimately policies and pathways would need to be designed to cover the complete value chain from basic research to applied research to high-tech research and innovation. Getting this right would be key to ensuring that science, technology and innovation propels India onto a sustained high growth trajectory in the coming decades.

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