FAST
INDIA

A MANIFESTO ON

INDIA'S JOURNEY TOWARDS A TOP 3 SCIENCE & TECHNOLOGY NATION

FAST INDIA

We believe that to be a global leader, India needs to be at the forefront of research: the creation of new science and technology knowledge and its translation to economic and social goods. This would ensure sustained economic growth that is not primarily and overly dependent on the service sector. We believe that this is the right time for India to revive its science and technology agenda.

The Foundation for Advancing Science and Technology (FAST India) is a non-profit institution of excellence dedicated to building capacity and advancing policy solutions that foster scientific enquiry and research, and facilitate the creation, dissemination, and translation of new scientific knowledge. The foundation will work with a variety of stakeholders to develop and strengthen the science ecosystem in India to advance scientific research and its translation into economic value and social good.

FAST India will has four key verticals:

- Government
- Institutions
- Institutions
- Industry

OUR MISSION is to catalyse India's ascent to become a top three science and technology (S&T) nation. S&T is a unique area: a considerable proportion of S&T globally is funded by the government[1], the markets for S&T often have to be formed by the government, and a significant proportion of S&T is executed in public institutions[2]. Yet policymaking in this area is often confused since the role of different actors is not properly understood.

This document summarises FAST's conception of the S&T policy needed for India. It explains why the Indian government must focus on S&T, identifies what it would mean for India to be a top S&T nation, and summarises a set of reforms that would radically enhance India's S&T system.

I. WHY SHOULD INDIA FOCUS ON S&T?

India is a country of many competing priorities. From a broad perspective, economic growth, social development, and national security are top of the list. The good news is that some of the foundational needs in these areas have already been reasonably addressed. India is the fastest growing economy in the world, mass digitization and large-scale access to basic amenities such as electricity/water have happened, and India is one of the few nuclear powers and possesses formidable defence strength. Policy reforms to improve India's performance in these areas will need to continue, but most of the fundamentals are now in place. The same cannot be said of S&T.

Advances in Indian S&T can bring great efficiencies and large gains to all the above areas. An industry that works closely with academia to produce technologically intensive products would keep our economy globally differentiated and competitive, help the transition from services to products, and increase exports. Greater use of S&T would likewise make our social programs more effective – e.g. by lowering the cost of machinery and equipment for healthcare, by producing higher crop yields, or by using AI for fairer benefit disbursal. Furthermore, India's defence force, which largely depends on imports, needs much greater self-reliance and local innovation. Enhancing the ability of defence to work with the university system and industry can solve this challenge. Seizing these opportunities should be seen as a low-hanging fruit and almost a 'free-lunch' from an economic standpoint.

[1] Industry also funds quite a bit of research. However, the bulk of open-ended long-term research is funded by the government, which is the critical foundational impetus to progress of S&T. For instance, see Naushad Forbes. 2022. "The Struggle and the Promise: Restoring India's Potential", HarperCollins Publishers.

[2] Notable exceptions include private universities in US such as MIT and Stanford.

[3] Small countries/economies are unable to reap benefits of S&T progress due to lack of critical mass, industry specialization and markets.

Moreover, given the size of our economy, markets, and demographic strength, we are in an ideal position to reap the benefits of S&T at scale. That is why a focus on S&T is a no-brainer for India. For India to keep up its stupendous economic growth, it needs to be a frontrunner in science-led and technology-led economic disruptions. It is a necessary condition. India has sub-optimally partaken from earlier disruptions including the industrial, internet, mobile and AI revolutions. As we move ahead, economic dominance, industrial competitiveness, and national security prowess will depend more and more on strength in S&T, and our capacity to exploit scientific and technological disruptions.

The challenge is that success in S&T requires a depth of capability that takes years to build. To establish and then retain global leadership, Indian policymakers must look 20 years ahead. In addition, policymakers need to nurture a S&T system that is comprehensive in scope. This means excellence in S&T, a critical mass of high-quality personnel, and the ability to translate S&T into socio-economic goods. Only in this way can India hope to leapfrog other nations and underpin its rise as a global scientific power. Establishing a world-leading S&T capability in this way will be vital if India is be 'atmanirbhar' and a 'Vishwaguru' once again.

II. WHAT SHOULD BE INDIA'S S&T MISSION

Even among those who agree that India needs a radically enhanced S&T capability, there is little consistency of opinion as to how India should go about this. This is unfortunate. Debates about whether Indian policy should focus on excellence or massification, on mission-driven or open-ended research, on basic or applied research, or whether it should prioritise India's problems or global problems have proved enormously distracting and impeded S&T policy development. It is time to take stock of India's current situation and to move forward in a deliberate way along each of these dimensions, recognising that to take any particular decision now does not preclude future adjustments.

First, consider the question of whether India should focus on excellence or massification. Research excellence can be measured by the number of world-changing inventions or discoveries made by a country's scientists. This is generally estimated in terms of the number of highly cited papers or researchers, papers in the top 1% of journals, and the number of globally significant prizes such as Nobel Prizes and Field medals[4].

[3] Small countries/economies are unable to reap benefits of S&T progress due to lack of critical mass, industry specialization and markets.
[4] Shanghai Ranking is a good metric of research excellence. For details, please refer here: https://www.shanghairanking.com/

Massification, by contrast, is a pure scale concept, which can be measured by counting how many researchers or the number of papers a country publishes. India already does well on the latter count since it publishes the 3rd highest number of papers in the world. However, these are mostly of low quality since Indian-authored papers are ranked only 7th-9th position by their research impact. On excellence, in other words, we are pretty much nowhere, a reality that is reflected in our lack of consequential discoveries. There are less than 5, if we are generous, world-changing inventions or discoveries that have come from India, since independence[5].

Massification has already happened. India has a scale of effort but we don't have a critical mass of high-quality researchers and institutions. We must now build in world-leading excellence. This might mean building 30 of our universities into world-class institutions – i.e., in the top 200 global research rankings. That would imply 30,000 high-quality researchers in the country (~1000 per institution). The ensuing critical mass would make the ecosystem efficient (by economies of scale), have a multiplicative effect through reputational advantage, and open up opportunities for large-scale translation. This is essential if we are to pave the way to excellence: out of a critical mass of institutions and researchers, a small fraction of them will break the glass ceiling to do excellent research[6].

A second common point of dissension is whether India should do more mission-driven or more open-ended research. Mission-driven research is usually large-scale, outcome-focused, and milestone-driven. Examples would be sending a human to the moon, sequencing the full human genome, or being able to build indigenous defence systems. Applied research often works like mini-missions – it is downstream research to solve a particular problem important for industry or society, made broadly feasible by foundational progress in basic research. Examples of this would include developing COVID vaccines, programming driverless vehicles, or developing genetically modified high-yield crops. By contrast, open-ended research is research undertaken by individual scientists or groups, driven by their passion for the pursuit of knowledge. This sort of research tends to yield more fundamental, universal knowledge. Examples of this sort of work would be the early work in coining the field of AI, the work that led to the discovery of antibiotics, the work that produced CRISPR, and nearly all the work that led to physicists' fundamental understanding of matter and of the stars.

[5] In terms of highly cited papers, India is 1/7th of the USA. It is useful to calculate how much of this is a function of the investment of India into R&D vs. efficiency issues. In terms of investment in PPP terms, India is 1/9th of USA. This may indicate that India's problem is not efficiency, and it is rather the quantum of investment. However, if you look at research rankings, USA has 35-40 in top 100. By our ratios above, India should have 3-10 universities in top 100. But we have none (even in top 200). India's problem is of excellence, the distribution is cut off on the right and policy must address this. The other problem is of translation and social and economic impact, which we have called out as a low-hanging opportunity for India.

[6] Alternatively, one may argue that we must uplift the standard of research across all universities. There are two problems with this approach. First, the bulk of Indian universities are in a state of decay, even on account of teaching, lest considering research. Second, it is observed globally, that great research clusters both geographically and institutionally.

For policymakers, the utility of mission-driven research can be obvious while open-ended research may seem indulgent. Yet, the discovery of new knowledge is non-linear. We simply do not know which path will give us the answers we need. Consequently, multiple formulations and approaches should be pursued simultaneously. This is the strategy that has been so effectively adopted in the US, which is the world in both open-ended and mission-driven activities. The answer for India, then, is not either one or the other. We need both mission-driven and open-ended research. Ultimately, the two approaches are interdependent. Mission-driven research utilises the progress from open-ended discoveries, while mission-driven activities unlock opportunities (whether via discovery or the invention of new technologies) that facilitate further open-ended research7.

The third dichotomy relates strongly to the second. That's because the debate about basic and applied research is analogous to the debate about mission-driven and open-ended research. There is a notion that India can let the developed countries do the expensive basic research and just pick up the downstream translation pieces. This may have been a good strategy when India was a much less developed nation than it is today, but it doesn't work for an aspiring world-leading power. Disruptions through basic research move the wheel of innovation. For any country to participate in a new cycle of innovation, it needs a critical mass of researchers working in basic research, because they provide the ready knowledge base from which a society can quickly position itself to develop, exploit and translate new disruptive findings.

India has learnt this lesson the hard way, from its own bitter experience. The lack of a critical mass of fundamental AI researchers in India led us to be at least 10 years late in participating properly in the AI economy. Even today, despite its renowned IT services sector, India's capability in AI is still nowhere comparable to that of the US or China.8 Our position is that India's long-term strategy cannot be focused on downstream research alone, which will always put it in the place of a distant follower. We certainly cannot be a top 3 leader with this strategy. As with the balancing of mission-driven and open-ended research, India needs to celebrate both basic and applied research, with proper resource balancing in each area. Our current lack of basic research investment must be remedied. Mission-driven research, on the other hand, is underleveraged and a low-hanging opportunity, which we must catalyse for stitching the ecosystem together and quick pay-offs.

[7] We prefer the terminology: open-ended research vs. mission-driven research rather than basic and applied research, which we see as a continuum and intrinsically tied together. Please refer to the books, "Cycles of Invention and Discovery" and "The Genesis of Technoscientific Revolutions" by Venkatesh Murthy, et.al.

[8] The deep learning disruption started in 2012, primarily from University of Toronto, Canada.

Lastly, there is the question of whether our researchers ought to focus on Indian problems or global problems. This issue again is closely related to the others. Open-ended research is generally global in nature with implications for the whole of humanity; it is downstream, applied research which takes local colour. [9]

We need a mix in our National research portfolio. On the one hand, we need research that solves Indian-focussed problems and builds our technological capability leading to reduction in imports and social outcomes for the public. On the other hand, we also need research that targets global problems and leads to globally differentiated products and boost high-tech exports. A focus on problems with a global colour will help our industry to be sustainably competitive, and boost long-term economic growth. To do this, our scientists will need to ask original questions with a view to generating universal knowledge with global implications. The difficult reality is that India needs both approaches.

The following table summarises these perspectives, matching our conclusions with various metrics that could be monitored to understand how India is tracking along the various dimensions discussed. More metrics are provided in areas of weakness than in areas of strength – e.g. we propose using fewer indicators of massification than of excellence, while nevertheless still collecting indicators of both.

[9] Something similar can be said of excellence. For excellence to be globally recognised, a researcher usually has to address global challenges. Nobel Prizes are awarded for profound discoveries, for the identification of universal truths, not for the solutions to local problems. By contrast, applied research that is focused on local Indian problems is more likely aligned with a massification agenda – i.e. with expanding the science base rather than lifting its quality.

PERSPECTIVE	METRICS
1. Indian research has achieved massification. We now need to build in excellence and a stronger portfolio of open-ended research for long-term leadership.	a. India's share of global research publications and citations
	b. India's share of the world's R&D workforce
	c. Number of universities in top 200 research ranking
	d. India's share of the world's top 1% of highly cited papers
	e. India's share of the world's mostly highly cited researchers
	f. Proportion of public R&D funds allocated via competitive processes
	g. Proportion of public R&D funds allocated for investigator-driven research in India
	h. India's share of Nature and Science publications
	i. India's share of prestigious global research prizes
2. India needs to focus on research translation, which will deliver huge upside in solving India's current problems.	j. Number of moon-shot-type missions led by India within India-centric areas of education, healthcare, etc.
	k. Contribution to open-source tools for industry efficiency and development sector
	l. India's share of global technology patents
	m. Industry R&D as a share of GDP
	n. Number of government portfolios with an R&D budget over 1% of their annual turnover
	o. Number of Indian companies spending over 2% of annual sales on R&D
	p. Percentage of Indian university and government agency R&D financed by industry
	q. Number of Indian companies with a market capitalisation >$1bn that stemmed from a university R&D discovery
3. India's S&T power needs to address global questions.	r. India's per capita GDP
	s. India's share of global exports
	t. India's share of global high-technology exports
	u. India's share of global venture capital funding
	v. India's share of global industry spending on R&D
	w. India's rank in technology competitiveness in various areas
	x. India's position in global innovation rankings
	y. Proportion of India's research publications with an international co-author

III. ACTORS, ROLES AND INTERVENTIONS

If India is to take its place in the world as a leading economy, a leading power, and one of the world's most vibrant societies, it will need to strengthen its capabilities in S&T . Having outlined in broad terms what is currently missing, we turn now to specific policy changes that might be implemented across government, universities, and the private sector if India is to develop a top three standing in S&T .

A. GOVERNMENT[10]

Government has a unique role in the S&T ecosystem in any country. It is the biggest funder of research, especially open-ended research. Given that research leads to public goods (knowledge usually disseminated via publications), it is also the primary 'buyer' of research. This doesn't mean that the government is buying solely for its own use, but that it has to 'buy' such research in order to enable the country's wider goals. This gives governments a special role in allocating to maximise benefit – for example, by funding high-performing scientists over mediocre scientists, by identifying and backing impactful projects, by balancing open-ended and mission-driven research, and by promoting research in areas of national interest.

All of this requires considerably more work from policymakers than is true for economic reforms. In the latter case, markets can often be opened by the government and then relied on to allocate capital efficiently through the price mechanism. There is no equivalent of the price mechanism in S&T policy, so government action is necessarily more interventionist. Here are our recommendations for specific interventions that are needed by the federal government in India to drive national success in S&T:

a. Reform resource allocations for research. India's R&D expenditure as a percentage of GDP is low by international norms[11] and it is heavily skewed in favour of research in government laboratories at the expense of the academic institutions. India spends much more in development ('D' of R&D) within government priority areas (e.g. defence/space) than it does on high-risk, high-impact research discovery projects. There is also an imbalance in Capex and Opex spending and not enough funding for high-performing private institutions.[12] The country needs a new and prudent funding plan for research in India based on global trends, national priorities and understanding the likely return on investment from different spending models.

[10] In the scope of this note, we haven't considered what priorities State Governments may have. We have focussed on the role of Central government and institutions, where the strategic action must happen. The state government's role needs to be studied in detail; however one idea is that they should participate more in the translation ecosystem, using S&T to address local social and industry needs.

[11] Indian government spends around 0.7% of its GDP on research, USA 2.8%, China 2.2%, UK 1.7%, South Korea 4.8% and Israel 5%. It will be useful to make calculations on how percentage spending on R& D varied as function of GDP per capita for different countries to make comparisons with India.

[12] Scientists at private institutions like MIT and Stanford get truckloads of money from government agencies and has led to huge paybacks.

b. Introduce transparent, standardised and competitive processes. The current funding process is highly suspect, with a lack of credible 'buyers' in its marketplace, a lack of digitization/standards, the lack of objectivity in decision-making, and unpredictable delays in funding processes. India's funding structures need to be revamped or created afresh to be highly competitive; they should be run using an NSF or DARPA-like structure with program managers; and they should be reformed to increase transparency, digitisation, and implementation discipline.[13]

c. Create balance and collaboration between mission-driven and open-ended research. The government needs to spur ambitious missions that are built on India's distinct advantages and which have the potential to solve India's big problems and revolutionise India's S&T capability. This can only happen with political will,[14] and if leading government laboratories are enabled to collaborate seriously with universities and industry.[15] The government also needs to spawn specific programs to build critical mass in different emerging areas – these currently fall too short in size and scale.

d. Simplify rules for institutions and scientists. There are some stringent rules for spending money relating to travel, procurement, and the salary determination of scientists, similar to any other government official. These rules are sub-optimal and a big dampener for the pursuit of science: 'ease of spending money' is rated lowest by Indian scientists among 5 enabling parameters by scientists as shown in our Ease of Doing Science Report 2023. The rules need to be simplified, and standards formulated (on the lines of India stack) to allow both efficiency and compliance.

e. Simplify financial models and provide performance-driven funding in higher education. For Indian higher education institutions to be world-class, they need to have a leadership focus on research excellence and to operate with a budget that is 3-6 times larger than at present. This calls for the government to simplify its funding model, and to put the onus of financial management on institutions while clearly calling out the purpose of subsidies (e.g., the undergraduate fee) and providing performance-driven research funding (based on excellence) rather than providing untied grants.

[13] The Anusandhan National Research Foundation (ANRF) bill was passed in August 2023 and is now an Act . The ANRF Act is a great opportunity to fix both resource allocation and funding processes.

[14] Such political will has been shown in projects as Mars/Lunar missions but needs to be many more in scale and more imaginative in purpose. Science has to impact not only 'space' but be 'grounded' as well.

[15] An announcement was made in the 2022-23 Budget that 25 % of Defence budget will go to universities and private industry to spur the ecosystem. (Please see: PIB announcement here: https://pib.gov.in/PressReleasePage.aspx?PRID=1794415) However, different people in government seem to have different interpretation on the quantum of budget and nothing has moved in practice. Similar efforts are needed in context of ISRO, CSIR Labs, etc. and be actually implemented.

This would enable the institutions to plan their own journey towards excellence, plan budgets, open-up for much larger raises and use of private money. The government must provide institutions much greater autonomy (in theory and practice) so they can flourish.[16]

f. Incentivise industry to invest in research and spur a deep-tech start-up ecosystem. As we will argue in the 'Industry' section, investing in research is not a now-and-here priority for industry. In such a case, the government can incentivise spending in industrial research to catalyse the ecosystem. The incentives will give more bang for the buck if they are outcome-driven, verticalised, and spur collaboration with research institutions. The government and industry must also take shared responsibility for developing technology capability in strategic areas[17] and use 'national missions' as a template to inspire sectoral ecosystems to do the same. The deep-tech ecosystem is still nascent in India with limited funding for cutting-edge ideas. This is an area ripe for the government to provide risk capital and make the market.

This covers the primary role of the government in easing the market, making the market and spurring collaboration. Achieving such reforms, however, would take great political will. While Indian governments have shown a consistent interest in S&T, this interest has not translated into practical reforms. The Indian Government now needs to replicate the zeal it has shown in reforming the economy, helping build the start-up ecosystem and public service delivery in order to nurture a stronger S&T capability. China is a good exemplar, whose 30-year focus on S&T has enabled it today to compete head-to-head with the United States.

[16] There are instances of such attempts being made by the government. For instance, the Institutions of Eminence Scheme of the University Grants Commission was announced in 2017 which intends to empower higher educational institutions to achieve a world-class status through grants and greater autonomy in managing their teaching and research activities. For more details, please refer: https://ioe.ugc.ac.in/

[17] An example of such collaboration was indigenous COVID-19 vaccine development. We need systems to do this as a process and not only at times of crisis.

B. HIGHER EDUCATION INSTITUTIONS

Globally, universities have become the place for open-ended research, whereas government laboratories tend to perform the majority of mission-driven research. As noted above, Indian Government research funding of universities (10% of government funding) pales in comparison to Indian Government funding for its own laboratories. This inevitably skews the kind of research that India is able to undertake. In particular, it has constrained India's success in fundamental and ground-breaking discovery work.

One of the lessons of the past 50 years, is that higher education institutions are essential for producing disruptive discoveries in S&T. Higher education institutions and the scientists working within them need to compete in the market created by the government, to maximize their resources. Thereafter, they need to use these resources to compete with global actors and push the envelope of excellence. Currently, our institutions simply aren't there which is why they do not show up in top research rankings. However, we believe our institutions are 'sleeping giants' and maintain that careful interventions can change the story over the coming decade:

a. Setup mission and strategic goals to become a world-class research institution. Indian institutions need to set ambitious visions, underpinned by clear long-term missions, and precise year-on-year goals. Today, many institutions are still unclear about what their ambition should be, how high they must shoot, and what will be good yardsticks of measurements. They struggle to balance teaching and research, massification and excellence, and undergraduate and graduate programs. Joining the global top 100 research organisations within the next 10 years seems an appropriate vision for our leading universities, but all institutions should be defining their own goals according to their own specific conditions and seeking to create their own niche of excellence. There is a need for precise goals and a doggedness to achieve them.

b. Professionally run strategy and administration and build support offices. Indian institutions need to have a proper strategy office working closely with the leadership and support offices for execution. Today, Indian higher education institutions are mostly run by academicians and lack professional support functions such as research offices, science communications office capabilities, industry liaison offices, recruitment teams, or alumni and development capabilities. As institutions gain autonomy and begin to chase more ambitious goals, they will need to drive 'efficiency'. This will require modern organisational structures along with professional and specialist expertise working alongside and supporting academics. The leadership must still be academic; but professionalisation of research administration will be needed.

c. Set ourselves up to attract best talent in the world. Any country's research is only as good as its researchers. While the government has instituted a number of schemes for attracting talent, these tend to be tactical and short-term, rather than strategic and sustainable. Similarly, institutional hiring processes continue to be bureaucratic and inefficient. Government and institutions must work together to attract the best talent from across the world (even only if Indians to begin with) to Indian institutions, giving them the confidence that they will thrive personally and professionally. This goes not only for faculty, but also PhD students, who are arguably the most ignored, yet the most important community in the ecosystem. Talent acquisition needs to be made into a strategic priority.[18]

d. Align incentives to build a performance-driven culture. Indian institutions have tended to a culture where 'mediocrity' is the norm. There is no great soft/hard disincentive on non-performance, and no outsized reward for performance. Contrast this with MIT which expects its faculty 'to add to the reputation of the institution' if they are to continue to serve as faculty after the first seven years. Or compare it with the Chinese system, which controversially (though effectively) provides direct monetary rewards for top papers. World class programs are built by accumulating resources around excellence. With excellence as the goal, Indian institutions need to provide big rewards for performance, such as faster promotions, more resources and more sway in decisions making. Many make a cultural argument calling for a change in mindset of mediocrity. While this can be helpful, we believe Indian science will not be galvanized unless there is also an accompanying shift in incentives. As India itself experienced when economic liberalisation solved the problem of the 'Hindu Rate of Growth' things can change very rapidly when the incentives are right.

[18] The elephant is the room is compensation for scientists and science staff. It is hugely below market standards. Even though academia never compares to industrial salaries anywhere in the world, the gap in India is formidable. This needs to be addressed immediately. For further reading, refer to Varun Aggarwal. 2018 "Leading Science and Technology: India Next?". Sage Publishers.

e. Develop hunger for collaborating and impacting the ecosystem. Excellence cannot be pursued entirely independent of broader social and national needs. Institutions cannot think that publishing top papers is the final and only goal. The goal for all research in India should be far more multidimensional: impacting industry, spawning deep-tech start-ups, IP creation, local ecosystem impact, global collaborations, and producing a public that is engaged with and energized about science. While all institutions will not be excellent at each of these activities, each institution needs to find its own niche in this multidimensional space. In the modern age, the impact of the institutions must be visible, they cannot take their continued existence and resource allocation for granted.

C. INDUSTRY AND START-UPS

In modern societies, industry and start-ups are pivotal in the translation of research. While the government funds and regulates the S&T ecosystem, and while research institutions deliver the public knowledge goods into S&T markets, it is the industry that exploits this knowledge and converts it into differentiated products and services, leading to economic and social outcomes.

Indeed, any country that aspires to be a global economic leader must have industry and start-ups that undertake applied research and technology development to improve, update and create their next generation of products and services. The R&D operations of leading companies such as GE, Microsoft, Huawei, Pfizer, and Google – all of which run big labs to do open-ended research for long-term leadership in their markets – are a testament to the importance of in-house S&T focused R&D.

Indian firms ought to be positioning themselves to replicate this model. Yet in terms of research-led products, the contribution of the Indian industry remains fledgling, a fact reinforced by the low high-tech exports in India's economy.[19] Indian industry's contribution to R&D as a percentage of GDP at 0.25% is also low compared with developed economies. While some may claim accounting discrepancies and suspect the accuracy of these numbers, moderately correlated indicators such as the number of patents, industry-supported research papers, the count of industry research labs, and national rankings in innovative company lists all tell the same story.

[19] India's exports of high complexity goods and services such as motor vehicle parts, serums & vaccines are low at 0.82% and 0.23% of the total exports out of India respectively. For details, please refer: https://atlas.cid.harvard.edu/.

Industry is primarily profit-driven and seeks (as it should) to maximize value to shareholders, but S&T are fundamental over the long-run. Moreover, the Indian industry is at the cusp, where further growth – and especially growth involving international expansion – will require continuous long-term spending on research and development. While some players do already understand this and have started interventions[20], there still isn't a widespread realisation of this in India. Here what industry and industrialists must do to change this:

a. Create research goals, and earmark budgets for sustainable global competitiveness. Indian industry has gained critical mass in size and is cash rich and globally competitive. This is an ideal time to invest in research for long-term and sustainable differentiation, value-based products and global competitiveness. Our industry leadership needs to define sharp decadal R&D goals and earmark a consistent part of company outlays to meet these goals. This would mean setting up mission-driven research groups at companies and the establishment of full research labs by the larger players. This will take industry to the next level of maturity.

b. Use academic institutions as a vehicle to push the envelope of innovation. While building their own research capability for mission-oriented research, the industry needs to leverage academia for more open-ended and basic research. It is remarkable to note that 20% of MIT's research budget is funded by industry. At a steady state, large companies need to have sizable research programs with Indian universities and ways to engage PhD students at scale. If Indian universities are simultaneously able to improve the excellence of their research offerings, this association will add tremendous value both to industry and academia.

c. Spur philanthropic efforts in research. India will also benefit if private industry and high-net-worth individuals (HNIs) can be inspired to fund large philanthropic initiatives in S&T. Private money provides differentiated advantages relative to the government system in terms of problem statements, the need for efficiency and speed. Private funding can also shift the agenda and help foster reforms to the way governments themselves fund science. There are many significant examples in the West where private funding has proved transformational. Examples include HHMI, OpenAI, the Allen Institute of AI/ Brain Science, the Wellcome Trust, Scripps, the Broad Institute, and many other similar bodies. India needs to build its own differentiated research centres backed by private money and positioned to thrive on India's strengths.

[20] For example, companies in the automobile and pharmaceutical sectors spend the most amount on R&D activities, even though the research intensity i.e. the R&D expenditure as a proportion of the overall sales in comparison with their global counterparts remains low. For more information, refer https://www.businesstoday.in/latest/corporate/story/at-09-of-revenues-rd-spending-by-listed-cos-remains-low-at-rs-36000-cr-in-fy20-276150-2020-10-19.

d. Industry spurring the deep-tech start-up ecosystem will be a win-win. While India's start-up ecosystem has grown dramatically in recent years, the deep-tech ecosystem is still nascent. There is a need here to make the market: funding is bleak for cutting-edge ideas that have longer gestation times or for which the market is unclear at the outset. Industry and investors must work together to build programs that support (by way of knowledge and funding) start-ups looking at riskier or harder problems in their area, and which may become future vendors/acquisition targets. A shared funding model could be a capital efficient way to spur innovation, a win-win for industry and start-ups, and create a sustainable model for innovation in India.

e. Build support structures to catalyse the industry research ecosystem. Research should be a focus area for industry to support growth and profitability in the long term, yet Indian firms have been slow to appreciate this, being focused on immediate markets and near-term profitability. Given this, our domestic industry needs support structures such as advocacy organisations, intermediaries, and knowledge-providers who can offer how-to knowledge and case studies from which emerging players can learn. Other initiatives such as awards, recognition for industry research, standardized contracts for industry-academia collaboration, IP-sharing best practices, and advocacy for representation of top academics on industrial boards and industry representation in university governance all have the potential to help jumpstart the ecosystem. Support of this kind could be easily offered by current industry organisations such as CII, FICCI, and NASSCOM as well as new initiatives.[21]

D. AMBITION AND NARRATIVE

India needs to have a collective ambition to become a top 3 S&T nation. We need to pursue this goal with the same zeal and dedication that we give to economic growth targets, infrastructure development, and scalable social programs. Unfortunately, S&T is poorly understood or not taken seriously among most intellectuals, public policy specialists, and government. While all these actors are interested in the outcomes that long term S&T provides, the linkages aren't so obvious to them.

Thus, there are many misconceptions about S&T in India. Giving to S&T is considered a virtue rather than an investment which will provide big returns to the nation. Innovation is primarily seen from the lens of start-ups and not research.

[21] The industry must support this. Additionally, it needs independent entrepreneurial effort. We will discuss this again in next section, but given its importance to industry, included it here as well.

The linkage between long term open-ended research and national security is poorly understood. Universities' potential in breakthrough research is mostly not appreciated. There is a widespread misconception that university research must lead to immediate tangible products or economic gains to be efficient. Strangest of all, Indian S&T is often considered to be great simply because Indian IT industry is doing well. It is believed that we can outsource basic research, while only working on downstream translational activities.

We need a more compelling narrative explaining why S&T is important for India. This narrative must identify India's ambitions and remove misconceptions about S&T. All stakeholders need to educate and advocate for the cause and join together to build community and political support. There is an important role here, too, for actors beyond the direct stakeholders we have described above. Non-profits, policy institutions, science communication and communication professionals in general, the media, and quasi-government bodies can all play a vital role in building a narrative around S&T being a top National priority. This will be essential if we are to reform India's S&T ecosystem. Until the benefits are recognised at multiple levels of society, the system will lack the will the change.

This brings us, finally, to consider the S&T ecosystem in the broadest possible terms. While all stakeholders may work efficiently in isolation, innovation happens best through the constructive and continuous collaboration across different parts of the system. Furthermore, when we think of the S&T ecosystem, we must include another actor: the public. The public may be seen only as a beneficiary of S&T outcomes, but the members of the public have a decisive role to play in other ways as well: as taxpayers, they are the financiers of government S&T programs. India needs them to lend their support to S&T investment and missions, to respect our S&T institutions, and to encourage the young to pursue S&T careers and demand that we use S&T to solve their problems.[22]

Ultimately, the 'market' for innovation will only operate effectively when the public, together with all other actors, are working in symphony. That means that every party must vigorously communicate, so that all stakeholders are able to understand and respect one another's priorities, and re-align their own efforts as required for constructive outcomes. Given the non-linear and multi-stakeholder nature of innovation, vigorous and continuous communication and collaboration are essential.

[22] Less than 5% students in top 20 NIRF engineering colleges are interested to pursue a MS/PhD in India. Source: Varun Aggarwal. 2018 "Leading Science and Technology: India Next?". Sage Publishers

This calls for intermediaries and independent organizations that can help the stakeholders work together: those that help in easy information exchange, discovery, glue-funding, best practice manuals and others. The form of these institutions includes but are not limited to inter-university centres, science bodies/associations, non-profits, private research funds, science communication organizations, public science bodies, private enterprises, and more.

India is more likely to succeed in attaining its S&T goals if there is a whole-of-society outlook that supports the reforms that we are proposing. This is a good reason for the Indian Government to try to develop a model of reform that is carefully coordinated across all sectors and that is linked to a powerful, unifying message about the value of S&T for India's future.

IV. FAST'S PRIORITIES

Now is the time to reform India's S&T ecosystem. India is in a position where large-scale and efficiently delivered investment in S&T could have a powerful impact on India's future prosperity and vibrancy. FAST believes that India can become one of the world's great S&T powers – a beacon of civilisation, technical advancement, and knowledge for all humanity. We believe that our description of the problems faced by India and our remedies for them would transform the country.

We will continue to advocate for all the reforms laid out in this manifesto. However, we recognise that success in advocacy requires focus just as much as success in research does.

FAST's strategy to catalyse this change has three prongs. First, FAST will produce "how-to" policy briefs on fixing the many issues mentioned above, based on global practices and understanding of the Indian context. Second, FAST will identify high-leverage intervention points and provide programmatic support to reforms. Third, FAST will periodically bring out foundational State-of-Sector Reports. The latter reports will be data-based, track objective outcomes and also the efficiency of processes/methods.

These will look at four key areas:

• **EASE OF DOING SCIENCE:** The report tracks how easy is it for scientists to do various activities in the process of doing their research.

• **INSTITUTIONAL RANKING AND PROCESS EFFICIENCY:** The report tracks how top Indian universities rank on various facets of research excellence and scale and efficiency of processes in universities to facilitate research.

• **INDUSTRY RESEARCH STATE OF SECTOR:** The report tracks the level of investment and R&D outcomes of top Indian companies across sectors.

• **SCIENCE PUBLIC PERCEPTION AND INTEREST:** The report tracks the level of interest, and awareness the general public, with a focus on young adults, have about S&T.

These reports will provide an objective understanding of the current issues in the ecosystem and shine light on the issues that need most attention. They will also become a way to track progress and measure if various interventions are improving the S&T ecosystem in India.

In all of our work, including our how-to policy briefs, our programmatic work, and our state-of-sector reports, FAST will emphasise the following core dimensions:

Reforms to government funding processes to make them transparent and competitive, and to increase research support for higher education institutions relative to government research agencies, and to simplify the rules for institutions and scientists.

Initiatives and incentives that will attract talent, and nurture a performance-oriented culture of excellence in higher education organizations.

Efforts to encourage industry to invest more actively and deliberately in its own R&D, and to connect with emerging excellence in Indian universities, while also encouraging support for deep-tech start-ups.

Programs for science communication, efficient information exchange between stakeholders and large-scale public engagement.

As steps are taken to address the diverse issues identified in this paper, we will continue to push for a powerful and compelling narrative about the value of S&T across Indian society. Our message will evolve over time, but each step we take will be directed at the same overriding – and attainable – goal. We are determined to inspire India to become a top three S&T nation.

This paper includes ideas of the
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Cite as, Aggarwal, et.al., "India's Journey towards a Top 3 Science and Technology Nation," FAST, India, 2023.

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