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In need of a Big Bang: Toward a Merit Based System for Government-Sponsored Research in India

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Abstract

Government investment into research is vital to drive innovation. Developing countries have to balance their spending between meeting the immediate needs of their population and funding innovation-driving research projects. The current system of government sponsorship in India could do with much improvement. Unlike other advanced countries, the private sector in India is neither the main spender on research nor the primary recipient of government research expenditure. Moreover, most of state research spending goes to government laboratories, which are far less efficient than private sector or higher education centres. It is in the best interests of India to transition from a government laboratory focussed research system to one in which private research institutes and higher education centres compete in an apolitical, merit-based system for government funding. However, this is likely to encounter resistance from government laboratories, who benefit from the status quo. Nativist beliefs treating Western - and specifically American - practices with suspicion are also likely obstacles. The former issue can be handled by incentivising private sector and higher education research such that researchers of government laboratories have new employment opportunities. Resistance to foreign ideas in certain sectors can be overcome by presenting those ideas as indigenous efforts, and of course government enthusiasm for the same. India has a lot of potential for high-end innovation driven research, but it can only be realized by adopting a merit-based system of Government Sponsorship.

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Stanford Law School: The Rule of Law Program

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I. Introduction

"The time for incremental change is long over. The current age is one that requires transformational change that comes only with drastic policy reform."

– Prime Minister Narendra Modi, Remarks at NITI-Aayog on Indian innovation policy, July 27, 2016

Innovation offers tremendous promise. It has the potential to drive economic growth by attracting investment, creating new jobs, and generally growing the pie for everyone. It can also be directed to solve otherwise intractable problems that a society faces. Innovation can make a society self-sufficient across a variety of domains, including food, energy, and water. It can reduce the costs of the provision of basic services like health, education, and security while simultaneously expanding private sector goods and services. Indeed, innovation can even bring a society together. Not only can it strengthen and democratize communication, but it can foster national pride through high-status pursuits like 'cancer moonshots' and space exploration.

Yet even though innovation might have the potential to unleash advancement across a whole spectrum of developmental projects, a government's innovation policy, on the other hand, must be determined through careful prioritization. After all, a state with limited resources cannot pursue expensive innovation projects in all possible areas. These limitations are particularly acute in a developing country like India, where the state must balance its ambition for funding typically high-risk innovation projects with the more immediate needs of its populous. Such pressing needs often change the calculus of innovation funding, as the opportunity cost for any research project must also taken into account. Government spending for an ambitious mission to Mars or for decoding the human genome or for any other innovation policy comes at the expense of literacy, immunizations, and decent infrastructure. Therefore government-sponsored innovation projects in developing countries need to offer great potential along with a minimal risk of failure.[1]

Against this backdrop, there seems to be widespread agreement that India's strategy for innovation requires drastic reform. During his tenure, Prime Minister Narendra Modi has repeatedly underscored the need to modernize innovation policy in the country; political leaders from the Congress Party and other regional parties have also made similar declarations. Nearly every *Economic Survey of India* over the past two decades has devoted a chapter to reforming innovation policy. Over the same time period, several high-level government panels have been convened to modernize Indian innovation policy. These political and policy moves tend to focus on choosing priority areas for research. Consider, for instance, the *2017-18 Economic Survey of India,* which calls for research and development across six national

1 This is not to say that governments in developing countries should not pursue innovation. Such an argument holds little weight, particularly when the promise of innovation is so great. Instead, it is critical that a government in a developing country ensures that its spending on innovation is maximized for its intended impact. Wasted resources not only undermine the promise of innovation, but they also impede the prospects of development in other resource-poor domains.

missions in areas ranging from agriculture to genomics to dark matter.[2] It is unclear why or how these six national missions were chosen, but it is probably safe to assume that the adoption of these priority areas were set by political officials and not by scientists. In 2019, the Prime Minister convened a new panel on science and technology innovation, this time with some of the country's most eminent bureaucrat-scientists. The panel announced nine other national missions that would explore natural language translation, quantum mechanics, artificial intelligence, biodiversity, electric vehicles, bioscience for human health, how waste can be converted to wealth, and deep ocean exploration, as well as a national mission to commercialize innovative solutions.[3] Yet despite the high publicity that came with the announcement, it is unclear what steps the government would actually take to pursue these national missions.

For government-funded innovation projects to realize their promise, Indian leaders need to get away from the cycle of announcing pet project national missions. Deeper reforms are required. Instead of recommending priority areas, it is worth recognizing that innovation policy is—and should be—a source of constant discussion. In nearly every major country, government officials (usually politicians) and the scientific community struggle to set innovation priorities. Government officials cannot decide these priorities alone as they rarely understand the steps and stages of scientific advancement. At the same time, the scientific community is poorly positioned to answer normative concerns over what is most important to a society. These normative concerns cannot be ignored. Every society needs to decide whether innovation policy should focus on maximizing economic returns exclusively or whether the government should also pursue innovations that might increase societal well being more generally, perhaps by reducing the cost of a vaccine or by landing a person on the moon to inspire the nation. Research priorities should be decided in a systematic and institutionalized manner, ideally with as little national attention as possible, which has the potential to create more flash than substance.

Apart from identifying priority areas, the machinery that is tasked with executing innovation policy needs to be overhauled. Excluding spending for higher education, the Indian Department of Science and Technology estimates that the central government, the state governments, and public sector enterprises spent a combined total of 60,821 crore INR (~$8.5

2 See Chief Economic Advisor to the Government of India, 2018, "Chapter 8: Transforming Science and Technology in India," *Economic Survey of India.* The six national missions include dark matter, genomics, energy storage, mathematics, cyber physical systems, and agriculture.

3 http://psa.gov.in/prime-ministers-science-technology-and-innovation-advisory-council-pm-stiac

billion USD) on research and development in 2017-18.[4] In nearly every other country in the world, government funds for innovation are usually disbursed to the private sector or to academic research laboratories. In India, on the other hand, government research laboratories spent nearly all of this money on in-house research and development. Unfortunately, these government laboratories suffer from hierarchical and inefficient management structures that offer few incentives for the production of research. This model is disturbingly inefficient and the track record of India's government research laboratories is woeful compared to its potential.

To address these structural flaws, in this chapter I argue that India's government research laboratories need to be consolidated and converted into research funding agencies along the lines of the National Science Foundation in the United States or the European Research Council. In government institutions like these, research prioritizations are set through deliberations between government officials and researchers, while funds are allocated through competitive, merit-based peer review processes to external organizations, mostly in the private sector and in academia.

The vast majority of the research personnel who currently work in Indian government laboratories can either opt for the private sector or be transferred to technical or medical universities, where they can create smaller and more nimble laboratories for engaging in research. Such a transfer of talent would simultaneously alleviate the tremendous faculty shortage that the Indian higher education system is currently experiencing. Because of recent expansions to the higher education system, 35 percent of the faculty slots at the Indian Institutes of Technology were vacant as of 2017; India's regional technical colleges, known as the National Institutes of Technology, had 47 percent of their slots to fill.[5] This faculty shortage also afflicts state and central universities throughout India's higher education sector.

Reform efforts must also consider ideological factors as well. Even though the Indian innovation space has been built on previous Western practices—and even though Indian politicians seem more willing than before to incorporate Western practices for innovation—

4 Government of India, *Department of Science and Technology Annual Report* 2017-18. Available online: http://dst.gov.in/about-us/annual-reports (accessed Feb 10, 2019). 1 crore INR equals 10,000,000 INR. The exchange rate as of Feb. 10, 2019 is 71.47 INR for 1 USD. Military spending only accounts for about 14,819 crore INR (~$2 billion USD). See Ministry of Defence (India). (n.d.). "Value of revenue and capital expenditure on defense research and development the by Indian government from FY 2015 to FY 2018 (in billion Indian rupees)." In *Statista - The Statistics Portal*. The government has substantially grown the exchequer's revenue base since 2017-18, and expenditures in the upcoming 2019-20 budget are projected to be about 30 percent higher, although it is unclear whether research and development expenditures will grow correspondingly.

5 See Manash Pratim Gosain, August 20, 2017, "35% of Faculty Posts Vacant in IITs, 53% in Central Universities," *Times of India*. Available online: https://timesofindia.indiatimes.com/india/35-of-faculty-posts-vacant-in-iits-53-in-central-universities/articleshow/60138942.cms (Last accessed May 13, 2019).

many reforms in this space have been and can be derailed by becoming pejoratively associated with foreign influence. A reform effort that brings meritocratic practices to India's innovation space must consider the political realities of material and ideological resistance; superior policy alone will not win out.

This chapter is laid out in the following manner. In the next section, I compare research and development spending in India with other countries in East Asia. As a proportion of overall research and development spending, the Indian government bears a far more substantial burden than counterpart countries in Asia. Just as concerning, most of the money that the Indian government spends is not sent to the private sector or into academia. Instead, government research laboratories spend this money conducting research themselves. In Section III, I discuss the merit-based, peer-reviewed funding system that was developed in the United States and is used in many other countries. Compared to India's current system for funding innovation, this system seems like it would support more nimble and effective research as incentives would be aligned with performance. Also, there could be some positive externalities if government research laboratories were smaller. With some exceptions, Indian government research laboratories measure their success primarily by patents and publications. The private sector and academia not only have the potential to match research laboratory performance in these two metrics, but can also offer other benefits in the forms of more commercializable research (in the case of the private sector) and student training (in the case of academia). In Section IV, I consider possible political resistance to reforming the system, paying special attention to *material resistance* from those who currently gain from the status quo as well as *ideological resistance* from those who might reject the introduction of foreign practices in innovation. I conclude in Section V.

II. Comparisons in Innovation Spending: India versus the Rest

In this section, I consider how Indian innovation spending compares to other innovation-driven economies in Asia. The purpose of this section is to identify how Indian spending patterns diverge from other economies, framing the subsequent policy recommendations advanced in Sections III and IV.

Indian innovation spending stands out in at least three important respects compared to the leading innovation-driven Asian economies. First, India public and private spending for innovation trails other leading Asian economies (see Figure 1). Although India's current level of spending is in line with its level of economic development, this level of spending has stagnated over the past four decades relative to GDP.[6] Since 1980, India has generally spent between 0.6 and 0.8 percent of its GDP on research and development, which trails the Asian Tigers as well as the United States (see Table 1).[7] Interestingly, Indian spending as a percentage of GDP was comparable with South Korea until 1980, and was even ahead of China until 2000. But unlike these other countries where expenditures on research and development has grown over time relative to GDP, India has experienced no such increase. This suggests that while economic growth will increase absolute levels of research and development spending over time, policy changes are required to increase the expenditures on research and development relative to GDP.

This brings up a second difference between India and its comparator countries. Indian private sector firms are not spending enough on research and development. Indeed, Indian policymakers routinely call for research and development spending to increase to 2 percent of GDP, but they usually expect this increase to come from the private sector. Private sector research and development is sorely depressed in India: as a whole, it only contributes 30 percent to the country's research and development expenditures, compared to a global average of 71 percent.[8] Private sector firms in China, Japan, South Korea, and the United States are each responsible for more than 70 percent of gross expenditures for research and development in their countries.[9]

This lack of private sector innovation spending is somewhat puzzling, especially when one considers that Indian industry boasts many private firms that are in globally competitive industries that require constant research and development. These industries include software exports, pharmaceuticals, and the automotive industry, which are all innovation-intensive industries. These industries include many large, globally competitive firms that are export-oriented, which are essentially corporations that should be driving innovation spending. Also, because of earlier investments in medical education and technical higher education, India has a surfeit of talented scientists and engineers. Since 1995, hundreds of thousands of Indians have migrated to the United States; these migrants are known as the IT Generation.[10] Seeking to

6 See *Economic Survey of India*, 2018, Chapter 8, Figure 2: R&D Expenditure as a Percentage of GDP (Development Time).

7 No Indian government agency collects information on contract research and development work done in the country by foreign firms. There are estimates that the total of such expenditures by foreign firms could be as much as 0.5% of GDP. See See Naushad Forbes, 2016, "India's National Innovation System: Transformed or Half-Formed?" *Centre for Technology Innovation and Economic Research Working Paper* No. WP/16/01.

8 5 percent of research and development spending is conducted by state-owned enterprises. See Forbes, 2016.

9 Singapore's businesses are responsible for 61 percent of gross expenditures on research and development.

10 Sanjoy Chakravorty, Devesh Kapur, and Nirvikar Singh, 2017, *The Other One Percent: Indians in America*. New York: Oxford University Press.

leverage the talent available in India, foreign firms have recently set up innovation hubs as well as research and development centers across the country.

The role of businesses in innovation spending cannot be overstated. For comparative purposes, India and South Korea had roughly identical research and development spending patterns until around 1980, when South Korean businesses dramatically increased their research and development spending. As of 2014, Korean industry is responsible for 78 percent of the country's research and development spending. The Chinese growth in research and development spending since 2000 has also been due to the role of private industry.[11]

Relative to other innovation-driven economies, the government contributes a much higher percentage of research and development spending versus the private sector. This brings us to the third and perhaps most important difference between India and other innovation-driven economies. India not only differs in terms of its share of government spending, but it also stands out for how those resources are spent. The Indian government is not just the main contributor to research and development spending, but is also the main user of this funding. In other countries, government spending for research and development is either channeled to the private sector or the higher education sector, usually through competitive, peer-reviewed merit-based research grants. In India, on the other hand, most government spending is sent to government research laboratories. In 2014-15 alone, the eight principal science government agencies received more than $5 billion USD in government outlays (35,034 crore INR).[12] Most of this money is spent internally; India's government research laboratories only support a small amount of external research.

What are the innovation returns on this spending? For starters, it is worth recognizing that India's biggest projects are oftentimes derivative of discoveries already made in other countries. Among the most notable of these, India sent a rover to Mars in 2014, following the Soviets, the Americans, and the European Space Agency.[13] In his Independence Day speech in 2018, Prime Minister Narendra Modi announced that he is directing the government to land a man on the Moon by 2022, an initiative that has already been achieved by several other

11 Forbes, 2016.

12 Economic Survey of India, 2018.

13 For a thoughtful review of recent developments in Indian space policy, see Kate Greene March 17, 2017, "Why India is Investing in Space," *Slate Magazine*. Available online: http://www.slate.com/articles/technology/future_tense/2017/03/why_india_is_investing_in_space.html (Last accessed May 13, 2019).

countries.[14] India also seems to avoid international research collaborations. Despite its interest in exploring space, India does not support the International Space Station nor does it support other cross-national space research agendas. Indian research laboratories also completed their own sequencing of the human genome in 2009, six years after the United States announced that it had completed human genome sequencing, in partnership with research centers in the United Kingdom, France, Germany, Japan, and China.[15] Again, India did not join the international effort and instead preferred replication. If India seeks to pursue cutting-edge innovation, the government should consider working with other countries in pursuit of big innovation projects like these.

Apart from the derivative nature of these initiatives, it is also worth considering how well these research laboratories perform according to their own metrics. Consider the Council of Scientific and Industrial Research (CSIR), which in 2013-2014 received approximately 3,099 crore INR (~$500m USD) in government budgetary support, as well as another 705 crore INR (~$100m USD) from other sources.[16] This money supported more than 12,000 researchers across a network of national laboratories. The *CSIR Annual Report* suggests that its main metrics of performance are publications and patents, although CSIR provides some other services as well. During this time period, CSIR researchers published 5,086 journal papers over the course of the year. CSIR researchers also filed for 612 domestic and foreign patents, with many of these patents being double-counted.[17] Of the patents that would have gained approval, historically about 14 percent are ultimately licensed, usually to state-owned enterprises.

For the sake of comparison, the Indian government spent about 400 crore INR (~$57 million USD) on the Indian Institute of Technology-Bombay (IIT-Bombay) in 2016-17, approximately one-eleventh the amount spent on CSIR.[18] The university also brought in about 550 INR crore ($80 million USD) in research and development receipts, to say nothing of the tuition and donations it received. Over the course of the year, IIT-Bombay published 1,377

14 See Rajeswari Pillai Rajagopalan, August 24, 2018, "What's Next for India's New Space Ambitions?" *The Diplomat*. Available online: https://thediplomat.com/2018/08/whats-next-for-indias-new-space-ambitions/ (Last accessed May 13, 2019).

15 See NIH, 2016, "An Overview of the Human Genome Project." Available online: https://www.genome.gov/12011238/an-overview-of-the-human-genome-project/ (Last accessed May 13, 2019).

16 *CSIR Annual Report, 2013-14.* Available online: https://www.csir.res.in/about-us/annual-reports (Last accessed May 13, 2019).

17 These patents are actually counted multiple times, so for instance, the same patent received recognition from the European Patent Office, Germany, France, the United Kingdom, Ireland, the Netherlands and Turkey, for a total of seven foreign patents. See the CSIR Annual Report, 2013-14.

18 See the *IIT-Bombay Strategic Plan, 2017-2022.* Available online*:* http://www.iitb.ac.in/sites/default/files/Strategic%20Plan%20%282017-22%29_1.pdf (Last accessed May 13, 2019).

journal articles and filed 106 patents, approximately equal to one-fifth of the research production of CSIR. Relative to the amount that the government spent, CSIR filed slightly more patents, while IIT-Bombay brought in more non-governmental research and development funding and published more journal papers (see Table 2). Crucially, IIT-Bombay also graduated 2,515 students and educated more than 10,000 students over the course of the academic year.

How did the 550 faculty at IIT-Bombay outperform the 12,000 researchers at CSIR? The superior performance of IIT-Bombay is not necessarily surprising. As I will discuss in the next section, universities offer advantages for pursuing innovation that simply cannot be found in typical government research laboratories. Specifically, universities generally encourage flatter hierarchies. Such decentralized organizational structures are thought to be more advantageous for innovation. Also, apart from patents and publications, universities produce skilled graduates who can further advance innovation. These advantages have been recognized by other countries, which have mostly shifted away from pursuing innovation through government research laboratories in favor of funding research and development in the private sector and in universities.

III. Reforming the Research Laboratories

Government research laboratories are the main beneficiaries of government spending in India. But do government research laboratories actually provide the best environments for pursuing innovation? Despite being a prevalent model historically, nearly every other innovation-driven economy has moved away from government research laboratories in favor of funding research in higher education or in the private sector. The decision that other countries have taken to transfer scientific research out of the halls of government has been made for good reasons. So then why does India cling to this model and what will it take for the country to change?

In order to understand why India's research laboratories have survived, it is first necessary to frame how these research laboratories originally came about. For much of the country's early history, India focused on achieving social objectives where economic growth was an incidental concern.[19] Nevertheless, funding for research and innovation has always been a hallmark of Indian government spending allocations. Following what was a globally standard

[19] Dani Rodrik and Arvind Subramanian, 2005, "From 'Hindu Growth to Productivity Surge: The Mystery of the Indian Growth Transition." *IMF Staff Papers* 52(2): pp. 193-228.

practice at that time (from the 1940s to the 1960s), the Indian government established and funded large research laboratories to develop these technologies. Resources for innovation were channeled to what India's first prime minister famously termed the *temples of modern India*: newly created public sector undertakings like government research laboratories, state-led infrastructural projects, and state-owned enterprises.[20] However, this research was not meant to directly translate to economic growth. Government resources for innovation were mostly allocated to hard-to-commercialize sectors like basic science, atomic energy, and space exploration.

These public sector undertakings reflected the best practices for innovation policy from this era: large teams of researchers working in strict, vertical hierarchies would carry out scientific and industrial research and development. As with other segments of the bureaucracy, employees would enjoy fixed salaries primarily based on their length of tenure and would maintain long-term job security within their organizations. There was minimal circulation of researchers between government labs and higher educational institutions, and even less circulation between researchers in the public and private sectors. When government researchers discovered marketable opportunities, they would form hierarchical, state-owned enterprises where all equity was controlled by the state. In line with other "license raj" policies, the government did not incentivize private sector research and development and frequently stymied private sector innovation efforts that might challenge any of these public sector undertakings.

But beginning in the 1950s, other countries started to transition from funding vertically organized public sector undertakings in favor of supporting research and development in the private sector and in higher education. This transition started in the United States. During World War II, the U.S. relied on vertical bureaucracies to pursue research. The Manhattan Project, for instance, was a classic example where a few leaders at the top made most decisions and research was 'siloed' into a few critical areas to minimize the likelihood of leaking secrets. After successfully using vertical research organizations during World War II, several reformers spoke out against the model in the post-War years. Vannevar Bush, arguably the most important administrator in American science history, ultimately proposed a model that became the National Science Foundation (NSF). Bush famously laid out five fundamentals behind the creation of the NSF:

[20] Nehru coined the term "temples of modern India" during an October 1954 speech at the groundbreaking for the Bhakra-Nangal Dam. The term came to be associated with Nehruvian political economy, which broadly involved state-led industrial projects. For further reading on this period, see Sunil Khilnani, 1999, "Chapter 2: Temples of the Future," in *The Idea of India*. New York: Farrar, Strauss, and Giroux.

> "First, whatever the extent of [government] support may be, there must be stability of funds over a period of years so that long-range programs may be undertaken. Second, the agency to administer such funds should be composed of citizens selected only on the basis of their interest in and capacity to promote the work of the agency. They should be persons of broad interest in and understanding of the peculiarities of scientific research and education. Third, the agency should promote research through contracts or grants to organizations outside the Federal Government. It should not operate any laboratories of its own. Fourth, support of basic research in the public and private colleges, universities, and research institutes must leave the internal control of policy, personnel, and the method and scope of the research to the institutions themselves. This is of the utmost importance. Fifth, while assuring complete independence and freedom for the nature, scope, and methodology of research carried on in the institutions receiving public funds, and while retaining discretion in the allocation of funds among such institutions, the Foundation proposed herein must be responsible to the President and the Congress. Only through such responsibility can we maintain the proper relationship between science and other aspects of a democratic system."[21]

The NSF was designed in accordance with these principles.[22] Every year, the NSF submits a budget request to Congress based upon expected costs for various research initiatives, usually following discussions with leading researchers in each field and administrators. Congress then allocates this money with few earmarks: Congress does not determine the geographic locations of where NSF should fund research and has minimal say on research priorities for the NSF.[23] In Fiscal Year 2017, the NSF received $7.472 billion USD. More than $6 billion USD was directed into the NSF's Research and Related Activities Account; the remaining money was used to fund major research equipment, education, and operations.[24] The Research and Related Activities Account supports already-approved research as well as other proposals across various disciplines of scientific inquiry. Proposals are submitted by a certain deadline. University research laboratories can submit these proposals, as can researchers in the

21 See Vannevar Bush, 1945, :Science – The Endless Frontier." *A Report to the President of the United States of America.* Available online: https://www.nsf.gov/about/history/vbush1945.htm (Last accessed May 13, 2019).

22 The NSF was created after World War II. Many in government recognized the need to fund science and technology for the country's advancement; at the same time, there was concern that science could become politicized. Ultimately, the NSF model was the compromise. For a brief history of its creation, see Daniel Kevles, 1977, "The National Science Foundation and the Debate over Postwar Research Policy, 1942-1945: A Political Interpretation of Science—The Endless Frontier." *ISIS* 68(1): pp. 4-26.

23 The NSF administration is supposed to take geographical distribution into account, but they are left to determine the best distributions (Kevles 1977).

24 NSF, May 8, 2017. "President Signs Omnibus Appropriations Bill into Law; federal Agencies Funded through September 30." *NSF and Congress.* Available online: https://www.nsf.gov/about/congress/115/highlights/cu17_0508.jsp (Last accessed May 13, 2019).

private sector as can other government scientists. To determine which proposals should get approved, the NSF relies on a scholarly peer review process. Teams of scholars within each discipline identify the strongest proposals, usually basing their decisions on which proposals are practical, which have the most intellectual merit, and on whether the research will have a broad impact that extends beyond academic debate. These scholars who review these proposals are brought from outside of the NSF, although some NSF officials also serve on the decision-making panels. Through this competitive and relatively apolitical process, only the most promising research gets funded.

There are slight variations to this basic model of merit-based grants. Sometimes instead of tendering open proposals, a government agency might specify a project or a predefined problem and solicit outside proposals. The National Aeronautics and Space Administration (NASA), for instance, will oftentimes express interest in the development of a certain technology, perhaps a new design for a spacesuit or a new material for a spaceship. The agency will specify the problem or what kind of research is needed and will open a competitive proposal process. Outside bidders will then submit proposals and conduct the required research. Although some research and engineering is handled in-house at NASA, a large portion of its budget is also earmarked for merit-based grants. The Defense Advanced Research Projects Agency has also sponsored "Grand Challenges" to spur the development of autonomous vehicles, which again relies on merit-based competition.[25]

Whether the research problem is specified by the granting agency or not, peer-reviewed merit-based grant processes offer an exciting opportunity for improving research and development outcomes in India. There are at least three clear benefits for switching away from the state-focused model of innovation in favor of merit-based grants. First, the private sector and universities tend to pursue innovation through decentralized organizational structures. Scholars and policymakers widely agree that flat organizations enable researchers the flexibility to adopt the most optimal paths for research. After all, the researchers who are pursuing the innovation—rather than some senior administrator—are the ones who are best positioned to make decisions about the next steps. This is perhaps why we see greater research productivity per capita from IIT-Bombay than we observe from CSIR.

25 In this model, DARPA announced a grand prize and encouraged teams to compete. Student teams were able to raise money from their universities and through corporate sponsorships. Students and faculty who were involved in the early DARPA Grand Challenges were some of the pioneers in this space. See Joshua Davis, 2006, "Say Hello To Stanley," *Wired Magazine.* Available online: https://www.wired.com/2006/01/stanley/ (Last accessed May 13, 2019).

A second benefit derives from the nature of merit-based competition. When a merit-based process works well, resources are efficiently allocated to the most promising research. This competition for resources—as opposed to automatically sanctioned funding—increases accountability as researchers must not only come up with strong proposals, but must also deliver if they want their peers to approve future proposals. Competition for resources usually spills into other domains as well. When research funding is merit based, researchers will seek stronger collaborators and students; universities and the private sector will compete to attract those who can bring in more research money; typically researchers derive greater autonomy within their organizations when more research money is available. [26]

A third benefit comes from the multiplying effects that are unique to the private sector and to higher education. When the government transfers resources for research and development to the private sector, the private sector is better positioned to commercialize any technologies that are discovered. A small amount of seed money from the government might stimulate other private sector investment, as is regularly the case with many early-stage research discoveries. When the government instead transfers resources to the higher education sector, the multiplying benefits are manifest. In the United States and in Europe, peer-reviewed, competitive merit-based funding—combined with university autonomy—leads to much stronger university outcomes.[27] Research funding that is directed to universities not only increases research output in the immediate term, but also funds students who are simultaneously trained in research. This research training is not to be ignored. An innovation like a new technical protocol to protect sensitive data might have a shelf life of only a few years (or even a few months), while a student who is properly trained in the field of data security can continue to develop solutions for a generation to come. Perhaps not surprisingly, many other research laboratories and funding agencies within the U.S. government use this merit-based grant process; it also is a popular model for funding research and development in Europe and is growing in popularity in East Asia.

We should see better outcomes if the Indian government transitions its research funding away from the typical government laboratory system toward a merit-based system where smaller groups at universities and in the private sector bid for research proposals. Achieving such a transition, however, can be politically fraught, especially when there are so many

26 For the considerable effects of merit-based grant systems on university productivity and autonomy, see Philippe Aghion, Mathias Dewatripont, Caroline Hoxby, Andreu MasColell, Andre Sapir, and Bas Jacobs, 2010, “The Governance and Performance of Universities: Evidence from Europe.” *Economic Policy* 25(61): pp. 7-59.

27 Ibid.

government researchers who are currently in relatively stable positions. If such a transition is to take place, these government researchers need to be convinced that the opportunities from the merit-based system will be greater than the positions that they currently enjoy. In the next section, I consider two forms of political resistance: *material resistance*, which would emerge from actors who currently gain from the status quo, and *ideological resistance*, which refers to indigenous political forces who are unwilling to adopt foreign models for ideological reasons.

IV. Transitioning the System

How might a merit-based grant process be installed in India? In an ideal world, government research laboratories would either be converted or replaced with agencies involved in merit-based research allocation processes, modeled on global best practices. The granting agencies would have to be politically insulated, but they should also empower part-time proposal reviewers and not just full-time administrators.

Achieving this transition can be politically fraught, however. Governments across Asia and in the rest of the world have come to adopt merit-based funding for innovation, and it is worth considering the political resistance that these transitions encountered. These transitions have usually been met with two types of resistance. The first type of resistance is material; it emerges from those who materially benefit from the status quo. When a country transitions to providing merit-based allocation of resources, the government research laboratories who conduct most of their research in-house often stand to lose. Instead of spending their resources directly, they will have to send these resources out. A second type of resistance is ideological. In many countries, there has historically been an intense resistance to Western—and specifically American—scientific practices. India has been no different, with full-throated calls to maintain Indian scientific practices pretty much since the country's Independence in 1947. A reformer who is focused on bringing merit-based practices to India must be prepared to encounter both types of resistance. In this section, I analyze how other countries have mitigated—or altogether sidestepped—these political forces, with special attention to how reform can be achieved in India.

Addressing Material Resistance

In the case of the United States, the transition from vertical government research laboratories to merit-based research funding happened following the end of World War II. Scientists and technocrats had seen firsthand the virtues and limitations of bureaucratized research and decided to transition research and development away from government research laboratories. Even though there were some concerns about whether a merit-based system for allocating research money would work, there was also little material resistance to the reforms. Prior to World War II, government research laboratories were very small. These research agencies of course ballooned during World War II, as American military leaders realized the importance of technology for battles. Because of the general upheaval of World War II, however, few researchers who had joined during the War actually expected to remain with their government research laboratories after the War.[28] Instead, many of these scientists and engineers pursued careers in academia or in the private sector.

More senior administrators who might have wanted to keep the structure in place would have also come up against a very difficult political network led by Vannevar Bush. By the end of the 1940s, Bush had basically acquired celebrity status and enjoyed direct communications with the President as well as key leaders of Congress. His recommendations shaped government policy in favor of merit-based research.

For India, material resistance is likely to be far more substantial. The government spends more than $8 billion USD annually on government research. These resources support tens of thousands of scientists and engineers within the Indian bureaucracy. These research laboratories have long institutional histories, with many of them tracing their lineages back to the 1950s. Equally important politically, the leaders of these government research laboratories hold high-level positions within government and can regularly interact with political leaders. Any reform efforts have to be balanced with efforts to mitigate the losses in resources and power that these actors would face.

In seeking to minimize material resistance, the transitions from East Asian economies might prove particularly instructive. In Singapore, the National Science and Technology Board was founded in 1991 with a specific mission: to increase gross expenditure on research and development (GERD) to at least 2 percent of GDP; to encourage the private sector to account for at least 50 percent of GERD; and to increase the number of research scientists and engineers to a minimum of 40 per 10,000 in the labor force.[29] Notably, Singapore's goals with the National Science and Technology Board did not focus on the number of papers or patents or licensing deals, which are the measures that Indian government research laboratories currently use to gauge their success. As a first step, the Indian government should define and pursue its

28 On a personal note, both of my maternal grandparents joined Oak Ridge National Laboratories during World War II. Like many others, they left for opportunities in the private sector following the conclusion of the War.

29See Lawrence Loh, 1998, "Technology Policy and National Competitiveness," in *Competitiveness of the Singapore Economy: A Strategic Perspective*, Toh Mun Heng and Tan Kong Yam (eds.). Singapore: Singapore University Press.

innovation policies based upon these economic metrics instead of focusing on papers, patents, and licenses.

As Singapore developed its research and development capabilities, the National Science and Technology Board was reorganized in 2001 and renamed the Agency of Science, Technology, and Research (A*STAR) in 2002. In 2006, the Singapore government created the National Research Foundation to coordinate innovation policy across various domains; A*STAR would be placed under the National Research Foundation. The National Research Foundation largely serves as a coordinating and agenda-setting body, although it also allocates merit-based grants. It is also important to recognize that the Foundation faced little material resistance at its creation. The National Research Foundation gives considerable policy leeway to its subsidiary branches in pursuing agendas and it was also developed as the funding pie was growing. Since the National Research Foundation was created, government spending for research and development has tripled. As a result, few government researchers in Singapore lost out when the National Research Foundation came into existence. Barring an economic miracle, it is doubtful that India can triple its own government funding for research and development over the next fifteen years.

South Korea also offers several lessons when it transitioned its system to a merit-based granting process. Initial government funding for research and development focused on military applications, and the government formed the first two government research laboratories, the National Defense Research and Development Institute and the Korea Atomic Energy Research Institute in the 1950s.[30] By the 1960s, Park Chung Hee was championing Western style technological advancement, which would become a core platform for Korean national identity as well as economic development. The government sought to develop a domestic capacity that could absorb and improve upon foreign technologies. Korea began by focusing on light industry like textiles and simple electronics, also relying upon foreign partners to develop turnkey operations. By the 1970s, Korea sought to shift to more capital- and technology-intensive industries. A few large private firms led this shift, with the government playing a supporting role. The government developed a number of research institutes in the fields of heavy machinery, chemicals, and electronics. Government researchers at these institutes usually partnered with researchers in the private sector on very specific projects. Researchers

30 The budgets and expectations for both remained relatively modest as the government would mostly come to rely on military technology from the United States. See Sungchul Chung, Innovation, Competitiveness and Growth: Korean Experiences. Available online: http://siteresources.worldbank.org/EXTABCDE/Resources/7455676-1288210792683/Sungchul-Chung.pdf (Last accessed May 13, 2019).

would also circulate between the government and the private sector; equally important, these institutes also lured back Korean engineers and scientists from abroad.

In the 1980s, foreign technology transfer was no longer as desirable or as accessible, and so large Korean firms ramped up their own spending on research and development. Researchers could find attractive career options outside of the government, in many cases continuing the projects that they had already been pursuing. By the 1990s, Korea boasted one of the strongest industrial platforms of any developing country, but business groups backed more than 80 percent of all patents filed, and as the private sector grew, it took the lead in research and development spending.[31] Much of this spending remains concentrated among a few key business groups. In the 2000s, the Korean government sought to reformulate its priorities in spending, seeking to focus on basic sciences and higher education. They combined two of the leading government research organizations and set up a merit-based model for funding research as well as higher education. The private sector continues to dominate research and development spending.

Learning from Singapore and Korea, the Indian government should formulate a strategy to grow private sector research and development spending. India has already encouraged private sector research and development through generous tax breaks, although the generally idiosyncratic structure of the Indian taxation regime means that large companies often have to jump through way too many hoops to avail themselves of these benefits. This is especially true for foreign research and development outfits. Streamlining these processes would encourage the growth of the private sector research and development sector.

Perhaps more importantly, the government should also consider meaningful partnerships with the private sector research and development outfits that are already in country. In Korea, a network of government researchers and private sector researchers was developed over decades. Researchers could easily transition between the government and the private sector, oftentimes continuing the same projects and maintaining their collaborations regardless of their institutional homes. Singapore rapidly developed a similar network, oftentimes by encouraging top-tier foreign researchers to move in country. Although it is unlikely that India will be able to recruit top-tier foreigners at this stage, the Indian government should encourage its non-military research laboratories to align their research agendas with

31 See Ishtiaq Mahmood and Jasjit Singh, 2003, “Technological Dynamism in Asia,” *Research Policy* 32(6): 1031-54.

industry demand, especially in the private sector.[32] To this end, the government should create systems of lateral entry and exit for its researchers so that they can explore already-existing opportunities in the private sector. Establishing a research network that extends beyond the government is vital for any transition to a merit-based system.

It India has a special advantage compared to Korea and Singapore in making its transition to a merit-based system. India boasts one of the world's largest higher education systems and it is particularly adept at technical higher education. Due to its growth in recent years, however, there is a huge shortfall in faculty positions. Researchers who currently work in government laboratories should be encouraged to transition to careers in academia. These researchers could continue their research, hopefully by competing for merit-based grants, while simultaneously training their students to also conduct research. Researchers would strengthen these universities and the government-sponsored research platform could transition to a merit-based system. But such a movement will only happen if the government sets appropriate incentive structures for such a transition.

Allaying Ideological Resistance

For many developing countries, science and technology policy is shaped by nationalist concerns.[33] India is no different. At its Independence, nationalist leaders struggled to lay out a cohesive science and technology platform. British rule in India had extensively relied upon scientific advancement, or at least the claim of scientific advancement.[34] Some of the nation's founders were keen to continue and expand Western practices for science and technology. Perhaps most prominently, Nehru's vision for the future of India rested squarely on achieving industrialization through Western technological advancement, hence the *temples of modern India*.[35] Indian research laboratories were modeled on British structures. Higher technical education was also affected. The Indian Institutes of Technology were created, where each of

32 Memoranda of Understanding (MOUs) are another popular metric in India, as CSIR, other Indian government research laboratories, and many universities boast of the number of MOUs that they have signed. The MOUs signed by government research laboratories are generally with other governmental bodies or with foreign institutions. It is unclear what precisely is included in each MOU or whether MOUs actually contribute to the growth of research and development in any meaningful sense. As such, MOU counts alone are poor measures for the quality of collaboration. To see the list of MOUs that CSIR has signed, please visit: https://www.csir.res.in/sites/default/files/Agreements%20and%20MoUs%20signed%20by%20CSIR%20with%20Foreign%20Institutions%28Latest%29_0.pdf (Last accessed April 30, 2019).

33 See Gi-Wook Shin, 2006, *Ethnic Nationalism in Korea: Genealogy, Politics, and Legacy*, Stanford, CA: Stanford University Press.

34 See Gyan Prakash, 1999, *Another Reason: Science and the Imagination of Modern India*, Princeton, NJ: Princeton University Press.

35 Before studying law, Nehru earned an honour's degree in natural science from Cambridge in 1910.

the five initial campuses sought to emulate a foreign technical educational structure: the German structure (at IIT-Madras), the Soviet structure (at IIT-Bombay), the British structure (at IIT-Delhi), the American structure (at IIT-Kanpur), and a UNESCO-recommended structure (at IIT-Kharagpur).

At the same time, a separate set of India's founders sought to define Indian nationalism by breaking from British practice. In the realm of the sciences, this meant celebrating and protecting pre-colonial indigenous practices while rejecting foreign (and specifically British) practices. Mohandas Gandhi's own writings are filled with skepticism about Western scientific and technological practices, which he viewed as instruments of subjection with limited potential for improving the wellbeing of the average Indian.[36] Many government officials shared Gandhi's views on science and industry and sought to complicate Nehru's vision. For instance at the IITs, these officials were concerned that simply turning over these Institutes to foreign professors would undermine Indian technical education and so they restricted foreigners from becoming university administrators. The government also placed special provisions for the practice of aryuvedic, yoga, naturopathy, unani, siddha and homeopathic (AYUSH) medicine.[37] In recent years, government support for AYUSH has increased considerably, although the government has been uninterested in subjecting AYUSH to Western-style systematic scientific investigations.

This ideological resistance to Western science in favor of indigenous practice has fluctuated over time and seems to matter in certain domains more than others today. In some scientific fields, the Indian government is resistant to Western scientific practice. This is perhaps most prominent when it comes to AYUSH, where the government—and its research laboratories—continuously produce remedies without subjecting them to systematic scientific studies.[38] The government also supports clinical trials on AYUSH medications, although

36 See Ashis Nandy, 1981, "From Outside the Imperium: Gandhi's Cultural Critique of the West," *Alternatives VII*, 171-194.

37 Support for AYUSH has been consistent throughout independent India's history, although in recent years the ruling Bharatiya Janata Party has further promoted these practices, forming an independent ministry to oversee AYUSH and tying AYUSH with other major health programs. From 2018-2020, the government is sponsoring the National AYUSH Mission to the tune of 2,400 crore INR (~340 million USD). This money is meant to promote AYUSH. It is doubtful that any of this money will be used to conduct rigorous scientific research on AYUSH.

38 The experience of Indian research into indigenous medical practice stands in contrast to China. In 1995, a CSIR laboratory released an antimalarial drug entitled Ayush 64, which does not seem to have a medical impact. In contrast to studies in traditional Chinese medicine, however, Indian research organizations refuse to subject AYUSH to systematic scientific research. In China, on the other hand, government-supported systematic scientific research of traditional Chinese medicine aided in the development of artemisinin, which has become a mainstream anti-malarial today. Government scientists have also claimed that another herbal remedy (Ayush 82) can get diabetes patients off of insulin in six months, despite no scientific evidence of its efficacy, and have commercially released a product called "Memory Plus," which is also dubious. See Bhushan Patwardhan, 2016, "Aryuvedic

Western outlets have mostly rejected the validity of these trials. In other fields, however, India seems all too willing to leverage foreign technological advancements and adopt global best practices. In areas like steel production, pharmaceutical manufacturing, and information technology, for instance, Indians leverage Western practices and are consequently at the forefront of technological development. The success of entrepreneurs in these spaces has become a source of great national pride.

Because of the important role that science and innovation holds in the context of Indian national sentiment, it is critical to recognize that ideological concerns could potentially derail attempts to Westernize government-sponsored innovation policies. Therefore reformers must think carefully about how to introduce such reforms in the face of such ideological challenges. Broadly conceptualized, there are two possible ways to ideologically brand a shift toward a system of merit-based resource allocation for innovation in India.

The first way to brand such reforms would be based on a 'universalistic' appeal.[39] According to this logic, if India is to take its rightful place as a global leader in innovation, it must understand and modernize its system by adopting global best practices. Here it deserves mentioning that many of India's innovation institutions are already modeled on Western and British structures, albeit from the 1930s and 1940s. Additionally, many of India's researchers have trained abroad and have sought to bring Western practices of innovation to India. Some commentators have also observed that there is a growing celebration in the transformative power of Western-style technology and innovation in India, and these changes could overcome any particularistic ideological resistance.[40]

Alternatively, merit-based reforms could be branded as 'particularistic,' meaning that they could be portrayed as indigenous to India. Recent efforts to introduce cultural change—such as the Swachh Bharat Mission to promote the usage of toilets or the campaign to make compulsory education a fundamental right—have been championed by the government in large part because they have been delinked from foreign influence and are framed as Indian-led projects.[41] Although both of these projects have suffered from conceptualization and

Drugs in Case: Claims, Evidence, Regulations, and Ethics," *Journal of Aryuveda and Integrative Medicine*, 7(3): 135-137.

39 This framing of universalistic versus particularistic appeal is drawn from Shin (2006).

40 See Lilly Irani, 2019, *Chasing Innovation: Making Entrepreneurial Citizens in Modern India*, Princeton NJ: Princeton University Press.

41 Both Swachh Bharat and the Right to Compulsory Education Movement were heavily encouraged and supported by international actors; in both areas, international organizations had repeatedly tried and failed to realize large-scale cultural change. Both Swachh Bharat and the Compulsory Education Movement have been criticized for various implementation shortcomings, but both have received considerable government buy-in,

implementation issues, previous efforts to improve sanitation or increase mass education were frequently derailed much earlier due to ideological resistance from government officials. Swacch Bharat and the Right to Compulsory Education have also received foreign funding and foreign technical support as their predecessor attempts, but the big difference is that these have also received government buy-in as well.

Reformers must carefully consider which ideological framing would be more effective at bringing merit-based practices to India's government research laboratories. Indeed, the sources of anti-Western bias are not well understood in India. As with anti-Western views in other parts of the world, these views in India seem to stem from several sources ranging from nationalist sentiment to anti-capitalism/anti-modernity to fear of traditional ways of life and culture being usurped.[42] For a reform effort to be successful, reformers must identify and address specific sources of ideological resistance to Westernizing Indian research and development.

Summary

The Indian government's anachronistic system of research and development needs to change. In an era where innovation is pursued by small teams who are competing against one another, the Indian government continues to allocate money to highly bureaucratized government research laboratories that do not have the correct incentive structures in place. These research laboratories need to be disassembled: the researchers need to be encouraged to move to academia or into the private sector. The considerable amount of money that the government currently allocates to these research laboratories should instead be distributed to these smaller teams through peer-reviewed, merit-based mechanisms. Other countries in the West and in Asia have already adopted these mechanisms and the Indian government can leverage other countries' experiences as it designs its own system.

Reformers who seek to promote such a profound institutional change should expect two forms of political resistance. First, there are many who benefit from the current status quo and are a source of material resistance. In order to mitigate potential material resistance, the experiences of other countries suggest several steps. The Indian government should consider adopting different measures of success for its government research laboratories. The

especially compared to their predecessor missions. On compulsory education see Myron Weiner, 1991, *The Child and the State in India*, Princeton, NJ: Princeton University Press.

42 On anti-American views in the Korean experience, see Gi-Wook Shin, 1996, "South Korean Anti-Americanism: A Comparative Perspective," *Asian Survey* 36(8): pp. 787-803.

government should particularly encourage its researchers to collaborate with private industry and academia. Such collaboration would not only make the quality of the research stronger, but creating a stronger network of researchers that cuts across government, academia, and the private sector would also generate alternative career opportunities for government researchers. The government should also encourage lateral entry and exit for its researchers, ideally with more exit than entrance.

A second form of political resistance can potentially arise from ideology. If merit-based peer review systems for pursuing innovation are to be adopted, then reformers need to determine whether to advertise these reforms as Western or indigenous. There are pros and cons for both approaches—and deeper study is required to fully understand the political circumstances of the ideological resistance—but the wrong decision could derail reforms before they even start.

Crafting a plan for reforming government-supported innovation—and designing a political strategy for such reform—is particularly vital for India. There is a widespread expectance that innovation will drive economic growth and social development, but there is also widespread recognition that the current system is not delivering the results that it should, as the quotation by Prime Minister Narendra Modi at the beginning of this chapter highlights. Reforms to date have focused on announcing national missions without addressing the underlying weaknesses in the ways that innovation areas are identified and pursued.[43] Without a big bang change, India is unlikely to live up to its developmental potential.

Table 1: R&D Expenditure as a Percentage of GDP over time

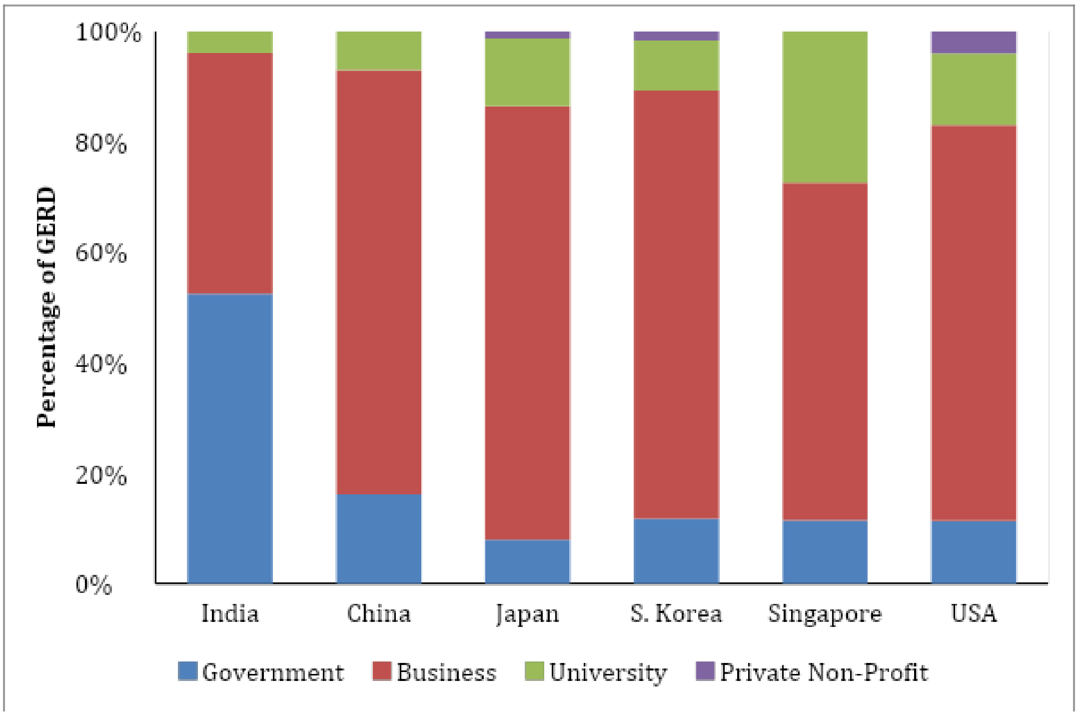
	1980	**1984**	**1988**	**1992**	**1996**	**2000**	**2004**	**2008**	**2012**	**2016**
India	0.56	0.78	0.86	0.73	0.65	0.77	0.77	0.87	0.6	0.7
China	…	…	0.67	0.64	0.56	0.89	1.21	1.44	1.91	2.11
Japan	2.19	2.63	2.80	…	2.69	2.91	3.03	3.34	3.21	3.15

43 One area of promise is the Atal Innovation Mission, through which the government financially supports innovation training through transparent and competitive processes.

S. Korea	0.57	1.19	…	2.10	2.26	2.18	2.53	3.12	4.03	4.24
Singapore	0.30 (1981)	0.53	0.87	0.94 (1990)	1.32	1.82	2.10	2.62	2.00	…
USA	2.32	2.87	2.84	2.74	2.44	2.62	2.49	2.77	2.69	2.74

Source: Data from 1980-1996 is as a percentage of GNP (rather than GDP) and comes from UNESCO Statistical Yearbook (1999). Data from 2000-2016 is from UNESCO Institute of Statistics (various years) available at: http://data.uis.unesco.org/. Estimates for India 2012 and India 2016 are from the *Economic Survey of India 2017-18*, Chapter 8.

Figure 1: Gross Domestic Expenditures on Research and Development, by Performer Share in 2015



Source: UNESCO Institute of Statistics. Singapore data is from 2014.

Table 2: CSIR versus IIT-Bombay

	Year	Gov. Spend-ing	Non-Gov R&D Funding	Journal Public-ations	Patents Filed	Gov. Funding/ Journal Pubs	Gov. Funding/ Patents Filed	Total Stud-ents
CSIR	2013-14	3,099	705	5,086	612	~6m	~51m	0
IIT-Bombay	2016-17	705	550	1,377	106	~5m	~65m	10,169

Notes: Government Spending and Non-Government R&D Funding in crore INR. Gov. Funding / Journal Publications and Government Funding / Patents Filed in millions INR.