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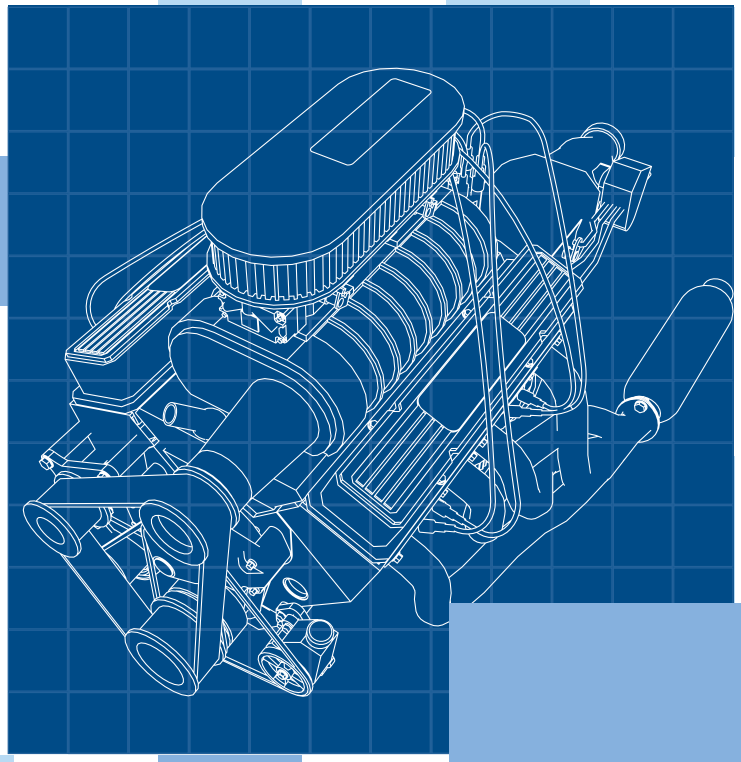

Strengthening India's Innovation System

Janak Nabar

CTIER Research
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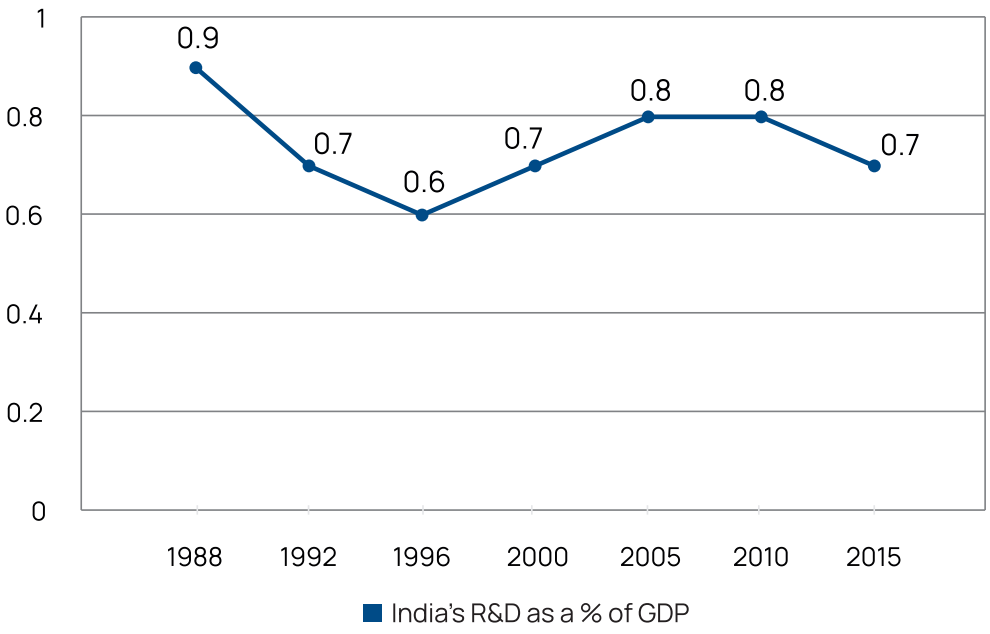
Background – Shortfall in India's R&D spending

India has had a target of '2 percent of GDP' for its expenditure on R&D[1] for some time now. The latest official figures for 2014-15 according to the Department of Science & Technology put India's R&D expenditure at 0.69 percent of GDP. In fact, India's expenditure on R&D as a percent of GDP has been stuck in the 0.6 to 0.9 percent range for nearly three decades.

Figure 1 India's R&D as Percent of GDP has been in the Range of 0.6 to 0.9 Percent



Source: Forbes (2017); World Development Indicators (various years), Indicators, available at http://data.worldbank.org/; Department of Science and Technology (DST), Research and Development Statistics at a Glance 2017-18 available at http://www.nstmis-dst.org/Statistics-Glance-2017-18.pdf; Centre for Technology, Innovation and Economic Research (CTIER)

The contribution from industry spending on R&D, in particular, has been low. If India must move closer to the 2 percent target, the contribution from industry would need to increase significantly from its current level of around 0.3 percent of GDP.

A focused increase in spending on R&D and innovation by industry will also help propel the share of manufacturing output in GDP closer to

1 A goal that India's Science, Technology and Innovation Policy 2013 acknowledged as having already been in existence for some time

25 percent by 2022. In the National Manufacturing Competitive Council report 'Competitiveness of Indian Manufacturing: Findings of the Third National Manufacturing Survey', released in 2009, Pankaj Chandra wrote of the need for manufacturing to account for 25 percent of GDP to achieve a growth rate that would help eradicate poverty over the next few decades. Nearly a decade later that 25 percent share of GDP target is something that Indian manufacturing continues to aspire to. The current share of manufacturing in GDP at around 18 percent and is only marginally higher from two decades ago. Increased spending on R&D and innovation will also be critical to increasing India's share of high technology exports as a percent of total manufactured exports which is currently around 7 percent compared to over 20 percent for China.

Table 1 Share of Manufacturing in India's GDP is Only Marginally Higher than Two Decades Ago

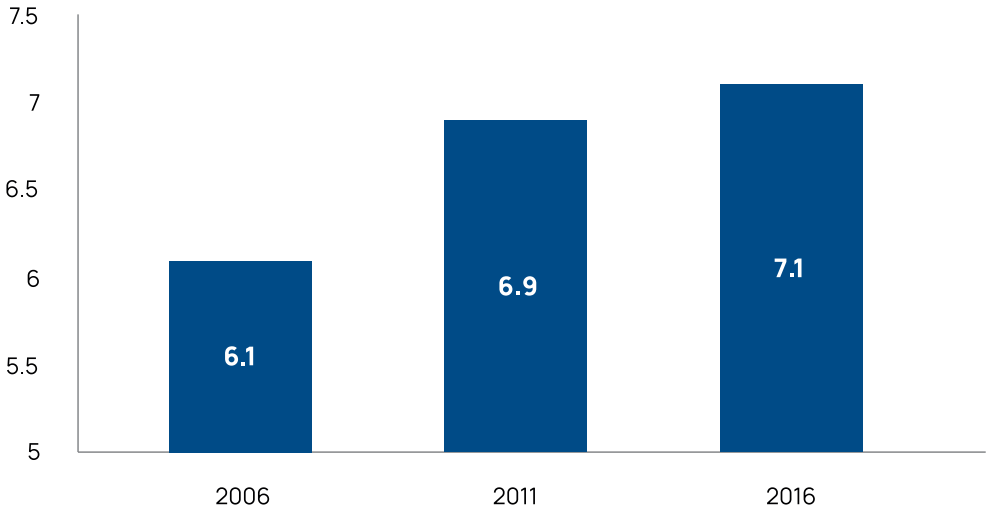
Year	Manufacturing, value added (% of GDP)
1997-98	16
2002-03	15
2007-08	16
2012-13	17
2017-18	18

Source: Reserve Bank of India, Database on Indian Economy, National Income available at https://dbie.rbi.org.in/DBIE/dbie.rbi?site=statistics; Centre for Technology, Innovation and Economic Research (CTIER)

Note: (i) Shares for years 2012-13 and 2017-18 calculated based on Components of Gross Value at Basic Price, constant prices, base year 2011-12

(ii) Shares for years 1992-93 to 2007-08 calculated based on Components of GDP at Facto Cost, constant prices, base year 2004-05

Figure 2 Spending on Innovation will Boost High Technology Exports as Share of Manufactured Exports (%)



Source: World Development Indicators (various years), Indicators available at http://data.worldbank.org/; Centre for Technology, Innovation and Economic Research (CTIER)

Moreover, if the Indian economy has to achieve and maintain growth rates of 8 to 10 percent on an annual basis for the foreseeable future, policy makers and industry leaders would need to push for investments needed to boost private sector productivity. The strong GDP growth rates seen during the period 2004 to 2008 were accompanied by significant contributions from private sector investment as seen in Table 2, which has been lacking in recent years.

In thinking about increasing the spending on R&D and innovation in India, it would behoove policy makers and industry leaders to think more broadly in terms of strengthening India's innovation system. Adequate attention would need to be given to financing innovation in small and medium enterprises against the backdrop of rising non-performing assets (NPAs) in the domestic banking sector. India would need to create policy makers and managers who understand the full potential of technology, are able to identify where the technology frontier is, and are able to help the country move closer to that frontier. Strong technology leadership and understanding, both in government as well as in industry, would also be needed to develop absorptive capacities for the future across different levels of government and across different industrial sectors. The diffusion of capabilities through greater integration of MNC R&D activity in India would help contribute towards building a competitive global workforce while also benefiting policy makers and local firms.

Table 2 Contribution from Private Sector Investment to GDP Growth

Fiscal Year	GDP (y-o-y, %)	Percentage point contribution of private sector investment	Fiscal Year	GDP (y-o-y, %)	Percentage point contribution of private sector investment
1993-94 Constant Prices			2004-05 Constant Prices		
2000-01	4.1	-0.8	2009-10	8.6	1.1
2001-02	5.4	0.3	2010-11	8.9	2.9
2002-03	3.9	-0.7	2016-17	7.1	1.8
2003-04	8.0	0.6	2011-12 Constant Prices		
2004-05 Constant Prices			2011-12	6.7	-0.4
2004-05	7.1	4.7	2012-13	5.4	1.9
2005-06	9.5	4.3	2013-14	6.1	1.2
2006-07	9.6	2.3	2014-15	7.2	-0.3
2007-08	9.3	3.9	2015-16	8.1	2.4
2008-09	6.7	-3.6	2016-17	7.1	1.8

Source: Reserve Bank of India, Database on Indian Economy, National Income; Central Statistical Office, National Accounts Statistics (various years) available at http://www.mospi.gov.in/publication/national-accounts-statistics-2017-1; Centre for Technology, Innovation and Economic Research (CTIER)

Ultimately, better design of policies and ongoing evaluation of these policies would also play an important role in strengthening the innovation system.

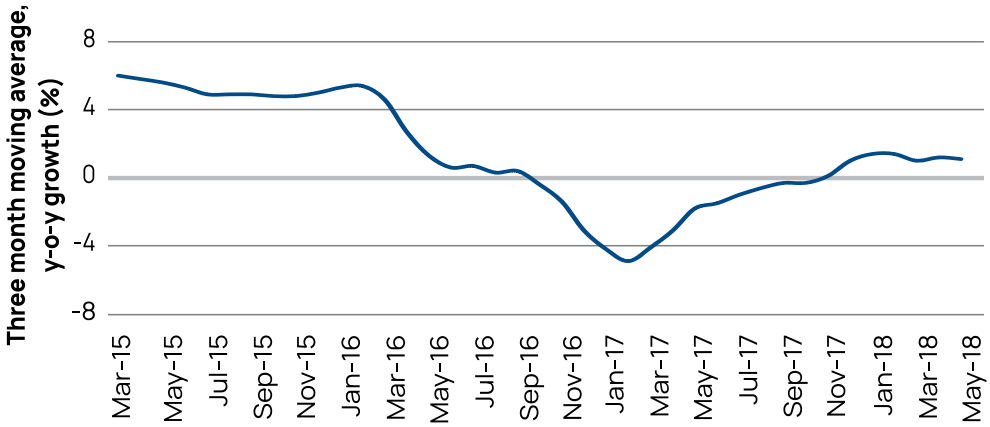
The following sections take up financing innovation, capacity building in government and in industry, and strengthening India's R&D capability through greater integration of multinational corporation (MNC) R&D in India, in turn.

Financing Innovation in India

Higher oil prices, the withdrawal of global liquidity, rising trade protectionism, and geopolitical concerns over the Iran nuclear deal are potential headwinds for the Indian economy. Credit to industry in India remains weak, and the domestic banking sector continues to be plagued by rising NPAs. It is the smaller innovative firms in India and their ability to have access to adequate finance that may remain a source of concern

for the economy. Until we see a marked improvement with respect to the NPA situation, growth in credit to industry in India will likely continue to remain weak. Credit growth with respect to industry has been weak since 1H2016, including a brief negative spell between October 2016 and October 2017, only to have recovered closer to 1 percent year on year as of May 2018.

Figure 3 Credit Growth to Industry Remains Subdued



Source: Reserve Bank of India, Database on Indian Economy, Banking - Sectoral Statistics, Deployment of bank credit by major sectors avaliable at https://dbie.rbi.org.in/DBIE/dbie.rbi?site=statistics; Centre for Technology, Innovation and Economic Research (CTIER)

As interest rates edge higher in the U.S. and as global liquidity begins to dry up, firms that were able to tap the global debt market may face external funding constraints. The withdrawal of global liquidity will also have implications for alternative sources of funding such as venture capital, private equity and angel investing.

So how can one overcome this challenge of financing innovative activities especially for small and medium enterprises? As part of its fiscal consolidation efforts, starting April 2017, the government lowered the weighted deduction amount for its tax incentive for R&D from 200 percent to 150 percent – the weighted deduction policy will virtually be done away with starting fiscal year 2021. One way of addressing the financing concerns would be if the government were to consider differential rates for weighted deduction depending on the size of a firm (allowing smaller firms to avail of a higher weighted deduction amount for longer) – which could provide some relief to small and medium enterprises. In a CTIER working paper, 'Weighted deductions for in-house R&D: Does it benefit small and medium firms more?', the authors

found that the weighted deduction policy positively impacted firm level spending on R&D, and particularly for firms whose expenditure on R&D was less than INR 100 million. While a more comprehensive study, using data on the amount of weighted deduction (in INR) that was given to individual firms, should be undertaken by the authorities, the findings suggested that smaller firms were responding to the weighted deduction policy more than the larger firms who would in any case spend on R&D irrespective of the tax incentive.

Table 3 Differential Rates rather than Blanket Rate for Weighted Deduction may be More Effective

Union Budget	Change in R&D Tax incentive	Scope
2009–10	R&D tax incentive extended to all industries in 2009–10	Scope of the provision of weighted deduction of 150% on expenditure incurred on in-house R&D was extended to all manufacturing businesses except for a small negative list.
2010–11	R&D tax incentive increased from 150% to 200% until 2016–17	Weighted deduction on in house R&D expenditure increased from 150% to 200%.
2016–17	R&D tax incentive progressively reduced from 200%	Benefit of weighted deductions for R&D limited to 150% from 1 April 2017 and 100% from 1 April 2020.

Source: Mani and Nabar (2016); Government of India, Union Budget Reports (various years); Centre for Technology, Innovation and Economic Research (CTIER)

Small firms often face constraints when trying to avail of government benefits. For example, with respect to the weighted deduction policy, firms are ineligible for the tax benefit if they do not have a separate R&D unit. And yet there are many small firms engaged in very innovative activities. One has to only move around the industrial belt on the outskirts of Pune to see the very interesting work being done by some of the small and medium enterprises, be it in the automotive industry or even in new materials. The authorities could perhaps simplify the procedures in determining the eligibility criteria of firms for government benefits that are meant to support innovation related activities.
One way to do this would be through the support of the various industry associations present in India. Industry associations like the Confederation of Indian Industry have instituted awards to recognise innovative firms. Perhaps the same mechanism could be used by funding

agencies to provide additional support to firms that have been identified as champion innovators to help them scale up their activities.

The government has recognised the need to support small businesses in undertaking research and development. The programme being considered is along the lines of the 'Small Business Innovation and Research Programme (SBIR)' in the U.S. that encourages small businesses to partake in government led R&D initiatives[2] (CIPAM, 2017; Borgohain, 2018). The introduction of any new financing scheme, however, should be evaluated on an ongoing basis and modified accordingly to ensure its success. For instance, in a study on the SBIR programme in the U.S. (Lerner, 1999), Lerner found that firms that received support through SBIR performed better in terms of sales as well as employment compared to firms that did not receive the grant. However, the impact of the SBIR programme was largely felt in geographies with significant venture capital activity and with existing industrial activity. If one were to learn from this and try and apply it to the Indian context, India's policy makers would need to design the programme to ensure that the benefits are also felt by SMEs that lie outside of the current venture capital hubs of Bengaluru, Delhi, Gurgaon, Hyderabad and Mumbai.

Financing mechanisms to support innovation in small and medium enterprises (SMEs) will need to be a key ingredient in India's innovation strategy going forward to boost overall output as well as increase the export competitiveness of firms.

Capacity building within the government

The OECD in "Going Digital: Making the Transformation Work for Growth and Well-Being" talks about the need to bridge the gap between "Technology 4.0" and "Policy 1.0". While the OECD mentioned this in the context of adopting digital technologies globally, it clearly also applies in the context of India's broader innovation system. Policy makers

2 In India, the Department of Biotechnology introduced a public-private partnership initiative for SMEs called the 'Small Business Innovation Research Initiative' in 2005. According to Aggarwal (2014), most SMEs interviewed in the study were required to obtain 50 percent funding from alternate sources. This differs from SBIR in the US that offers block funded grants as opposed to match funded grants.

would need to be equipped with not just an understanding of the latest technologies and how they can boost productivity in the economy, but also with an understanding of the regulatory and policy framework that will govern these technologies. In addition, policy makers would also need to be equipped with the right tools and data to evaluate existing policies being implemented, while identifying opportunities for increased budgetary allocations to support initiatives that could be truly transformational for the economy. For example, it would be good to evaluate the impact of the government's decision to push the Council of Scientific & Industrial Research (CSIR) towards self-reliance and towards greater collaboration with industry under the 'Dehradun Declaration for CSIR Labs'– and to understand whether any resulting savings for the government were re-allocated towards other productivity enhancing activities.[3] Another example could be to evaluate the impact of the government's decision to double the amount for the Digital India programme to approximately USD 480 million (INR 30,730 million) in FY2018-19,[4] and identify how much more expenditure would be required in the coming years for researching and developing digital technologies, as well as improving the infrastructure[5] needed to support the digital transformation underway. With respect to digital technologies, if China has ambitions to dominate the global artificial intelligence (AI) industry by 2030 (with gross industry output exceeding USD 150 billion) (Ding, 2018), and if AI is the 'next space race', then India's policy makers would need to plan for where they see India in that race. The digital transformation in India will also not be complete without India's policy makers being equipped to handle issues of data privacy as well as data security.

Since early 2017, CTIER has been involved in a few capacity building initiatives that have met with moderate success in terms of participation from various Central and State government departments. In many of our interactions we have been encouraged by the eagerness of some of

3 Where should incremental public research funding be allocated? – whether to autonomous R&D laboratories or to higher educational institutions is a separate matter of debate altogether and is addressed in Forbes (2017)

4 Jaitley, A. (2018), Minister of Finance, Government of India, "Budget Speech 2018-2019"

5 The 2018-19 budget allocation towards creating and augmenting telecom infrastructure to increase broadband access across India was USD 1.6 billion (Rs 100 billion).

the top officials in a number of states to embrace and adopt technology to address societal challenges, or even work on policies to address shortcomings in their respective state innovation systems. Many officials have also recognised the lack of resources or capabilities in the government machinery needed to engineer a complete overhaul of India's innovation ecosystem. States like Maharashtra and Telangana, to name a few, have adopted innovative solutions to fill the capability void – by hiring talent from the private sector, or instituting fellowships to draw in young talent keen to work with the government. The Chief Minister's (CM) Fellowship programme in Maharashtra is worthy of praise and the contribution from some of the young CM Fellows to the Maharashtra Startup policy did not go unnoticed by the media (Ghosh, 2018). Similarly, other CM Fellows in Maharashtra have been providing support to the bureaucracy in a number of other projects and programmes. Successful as they may be, programmes such as the CM Fellowship are commendable, but at best short-term solutions. The structure of the Fellowship programme is such that the Fellows leave the system after having spent a year or two with the government. Long-term capacity building within the bureaucracy across India will need to take centre stage.

Table 4 Share of India's R&D Expenditure by Sector of Performance (%)

Sector	2009-10	2014-15
Government Sector	62	52
Industry	34	44
Higher Education	4	4

Source: Department of Science and Technology (DST), Government of India, Research and Development Statistics at a Glance 2017-18 available at http://www.nstmis-dst.org/Statistics-Glance-2017-18.pdf, Research and Development Statistics at a Glance 2011-12 available at http://www.nstmis-dst.org/pdf/finalrndstatisticsataglance2011121.pdf; Centre for Technology, Innovation and Economic Research (CTIER)

Note: (i) Government Sector includes Centre and State expenditure on research and development

(ii) Industry includes private and public sector business enterprises

‘Technology’ managers for the future in industry

The share of industrial R&D in India’s total R&D expenditure has seen an increase to 44 percent in 2014-15 from 34 percent in 2009-10. Government R&D expenditure continues to outstrip industrial R&D expenditure, making India an outlier compared to many of the advanced economies as well as China, where R&D spending is largely dominated by industry. However, will increased spending on R&D by industry alone suffice to get India closer to the technology frontier?

There is a growing body of empirical economic literature that points to the importance of managerial capabilities and organisational practices within firms that is needed to complement R&D and innovation spending, to have meaningful productivity increases (Cirera & Maloney, 2017). Given the pace at which technology is evolving, there is a greater need today for managerial capability in India to also include ‘technology capabilities’. The ‘technology’ manager would need to continually benchmark their R&D and innovation capabilities against their competitors, make R&D an attractive career option for the several talented young engineers India produces every year, and have better linkages with external sources of knowledge, for example through universities or even contract research (Forbes & Wield, 2002). The CII National Committee on Technology is full of examples of excellent R&D managers and Chief Technology Officers operating in India. There is no dearth of talent, and Indian industry would do well to focus on attracting and providing opportunities to create thousands of many more such ‘technology’ managers for the future.

While the low level of spending on R&D by Indian industry is now a well appreciated fact, there are surveys that suggest however that Indian firms are indeed engaging in some form of innovation. Responses to questions on innovation and technology in the 2014 World Bank’s Enterprise Survey on India showed that 38 percent of 2,845 small firms, 43 percent of 4,133 medium firms, and 51 percent of 2,303 large firms had introduced a new product/service. Furthermore, over 70 percent of the small and medium firms respectively and close to 80 percent of the large firms said their products/services were new to their main market. In the said categories – introduction of a new product/service and the product/service being new to the main market – India appeared to fare better than the group ‘All Countries’ for small, medium and large firms.

An encouraging study by the Boston Consulting Group found the share of firms based in India that are early adopters of AI technology (i.e. 'companies that have fully implemented more than one AI use case') to be higher than that of firms in the UK, Germany and Japan, while another study by Capgemini found that close to 60 percent of around 90 firms surveyed in India who were using AI, have adopted it on a wider scale (i.e. beyond the initial pilot and testing stages).
India is home to a large number of MNCs and MNC R&D centres that have access to the latest technologies, which may partly explain some of the above findings. Pranjal Sharma's 'Kranti Nation: India and the Fourth Industrial Revolution', too highlights a number of MNCs in India and Indian firms that have adopted industry 4.0 technologies, cutting across sectors in manufacturing and services.

There is a risk, however, that unless efforts are made by Indian industry more broadly to create 'technology' managers for the future, technology will exacerbate the divide between firms in India in terms of productivity growth as well as hamper their ability to compete with firms globally. Scaling up investments in R&D and complementary factors such managerial capabilities should help result in higher productivity of firms and consequently greater output at the aggregate level.

Greater integration of MNC R&D activity in India

In order to tap into the potential that the MNC R&D centres have to offer the Indian innovation system, policies should be designed to facilitate better linkages between MNC R&D centres and the local universities, think tanks and state governments. Local firms too should increasingly invest in building capabilities that would allow them to create better linkages with MNCs and become part of global value chains. In discussions with a number of MNCs engaged in R&D activity in India[6], we found that India is increasingly favoured as a destination by these R&D centres not only for the low cost of operations, but also because of the opportunity to cater to the domestic market and markets similar to India. This differs from a previous study by Basant and Mani (2012) that

6 CII Round table discussions on MNC R&D Activity in India in Ahmedabad, Pune, Bengaluru, Hyderabad, December 2016

found that MNC R&D centres preferred to develop new technologies for different markets rather than develop new technologies or adapt existing technologies for the domestic market. This suggests that a gradual shift in priorities for the MNC R&D centres in India may be underway that needs to be capitalized upon by local industry and policymakers.

We have estimated MNC R&D expenditure in India to be USD 7.8 billion. Of the top 100 global R&D firms by expenditure that account for around USD 350 billion in spending (or just over 50 percent of global industrial R&D), 95 of these firms have a presence in India either through a subsidiary or an MNC R&D centre. In terms of output as measured by patents, MNCs contributed to over 2,400 patents of the 3,355 patents that were granted to India by the USPTO in 2015. The top 10 MNC firms that were granted patents by the USPTO contributed nearly a third of the total patents granted to India and were from sectors that included electronic & electrical equipment and technology hardware & equipment - two sectors among the top R&D sectors globally in which Indian firms are not present.

Besides helping to diversify India's industrial base and promote technology deepening, introducing policies that promote greater integration of MNC R&D research may also help firm up many of the larger commitments that were made by MNCs, particularly in these two sectors, following the announcement of the "Make in India" campaign in September 2014.

Access to a wide talent pool is often cited as one of the reasons for MNC R&D operations being located in India. Creating stronger and sustained linkages with the university system, especially on the research front, would go a long way in building a competitive global workforce in India. Barriers to successful industry-academia collaborations need to be understood and addressed – sometimes these barriers are simply a lack of awareness of schemes that promote collaborative research between industry and academic institutions, or may be related to the ownership of intellectual property. Going back to the above example of the electronic & electrical equipment sector, we find that industry-academia collaborations as a share of total publication output in the field of electronic & electrical engineering is 1.2 percent for India compared to 3.9 percent globally. The electronic & electrical engineering sector is the top sector in terms of global publication output, and India's contribution to global publication output in this field at just over 7 percent is one of the largest after China and the US. Pushing for greater industry-academia research collaboration between the MNC R&D centres and the

Table 5 Country Comparisons by Share of Publications, Impact and Industry-Academia Collaborations for Electronic and Electrical Engineering Sector

Countries		Share of Countries in Global Publication Output (%)	Category Normalized Citation Impact	% Industry Collaborations
Select Advanced Economies	USA	18	1.5	8
	UK	4.3	1.3	4.9
	Germany	4.8	1.3	8.9
	Japan	6.2	0.8	6.7
Select Emerging/ Asian Economies	Brazil	1.6	0.8	2.1
	China	21.8	0.8	3
	India	7.4	0.6	1.2
	Israel	0.6	1.2	6.2
	South Korea	4	0.9	8.3
	Global Average		1	3.9

Source: InCites (based on data from Web of Science), data downloaded from the platform on 18 February 2018; Centre for Technology, Innovation and Economic Research (CTIER)

Note: Data is based on cumulative publications by each country (2012-2016)

local universities would not only benefit the research being undertaken by the local universities but also the teaching that would be promoted at these universities towards producing better trained graduates. Greater integration of MNC R&D activity will also result in the diffusion of capabilities that will help strengthen India's innovation system, benefiting policy makers and local firms too.

If the Indian economy is to grow consistently at 8 to 10 percent for some time to come, increased investment by industry especially on R&D and innovation will be critical for maintaining these growth rates. These investments will also be important for boosting the share of manufacturing output from 18 percent to 25 percent of GDP by 2022 as well as increasing India's share of high technology exports as a percent of total manufactured exports. India's policy makers and industry leaders would need to strengthen the innovation system by focusing on avenues for financing innovation in India, bridging the gap between 'technology 4.0' and 'policy 1.0', creating 'technology' managers for the future, and ensuring greater linkages between MNC R&D activity in India and other key stakeholders in India's innovation system.

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