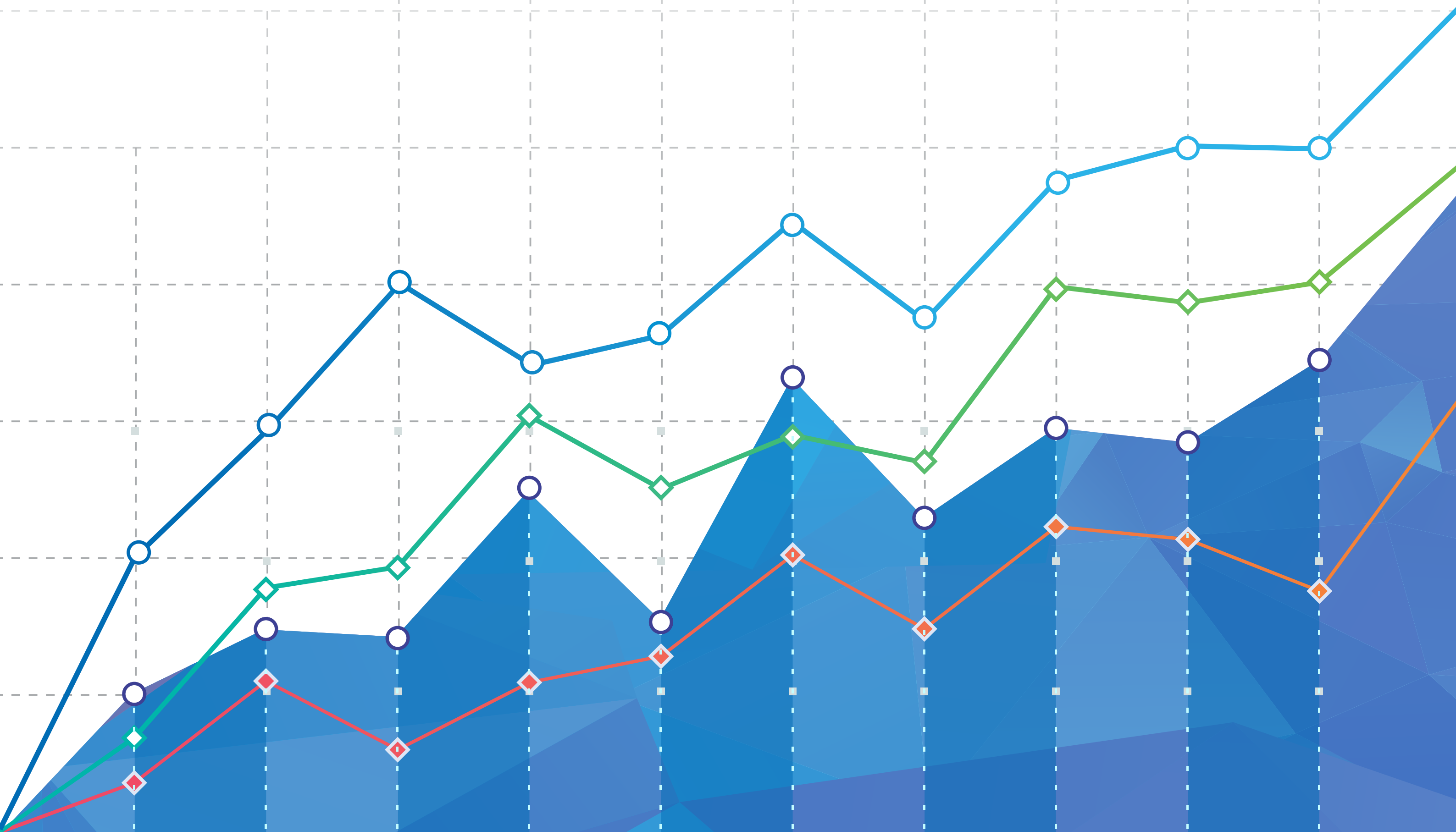
CTIER Handbook:
Technology and Innovation in India
2019



CTIER
CENTRE FOR
TECHNOLOGY, INNOVATION
AND ECONOMIC RESEARCH

An independent think tank established to influence public thinking on the crucial role of technical capability in economic development

"The CTIER Handbook is very useful and relevant as India progresses in increasing its innovation intensity. Technology innovation will be key to India's development and this Handbook is an important addition to catalyse this process."

Nandan Nilekani
Co-founder and Chairman of Infosys and Founding Chairman UIDAI (Aadhaar)

"The CTIER Handbook provides many unique indicators on India's innovation landscape. At Bajaj Auto, we export about 40 percent of our output to over 70 countries. Our success derives from developing products that consumers love worldwide, so innovation is at the heart of what we do. The CTIER Handbook will enable us to benchmark ourselves against global leaders, and will serve as a useful companion in our journey."

Rajiv Bajaj
Managing Director, Bajaj Auto

"Data-driven innovation is the key to India's economic future. By compiling data on R&D related inputs and outcomes in India into an extensive list of indicators, this Handbook provides a good overview of India's technology and innovation sector, appropriately placed in a global context. This is a timely and valuable resource that will be of great use to both government and business leadership as we forge a new path for India in the Fourth Industrial Revolution."

N. Chandrasekaran
Chairman, Tata Sons

"The CTIER Handbook is a brilliant compendium of contemporary, comprehensive, and comparative data based evidence of the state of technological innovation in India. It also draws sharp insights into issues that link firm and sector level innovation driven outcomes to macroeconomic outcomes. It is the most definitive reader for all those who wish to understand how innovation and related government policies are tied to economic growth and well being of the people of India."

Pankaj Chandra
Vice Chancellor, Ahmedabad University

"The CTIER handbook is an impressive review of the level, range and types of innovation ongoing in the Indian economy. Previously analyzing this required scouring almost a dozen different data-sources, so bringing this together into one document with insightful analysis is a huge step forward – anyone interested in modelling and predicting the growth of the Indian economy should read this."

Nicholas A Bloom
William Eberle Professor of Economics at Stanford University,
Co-Director of the Productivity, Innovation and Entrepreneurship program at the National Bureau of Economic Research.

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Suggested citation: Centre for Technology, Innovation and Economic Research (2019); CTIER Handbook: Technology and Innovation in India

Cover: Sameer Karmarkar

Typesetting and design: Satisfice Designs Pvt. Ltd., Pune

Printing: Akruti Printers Pvt. Ltd., Pune

PREFACE

The importance of innovation, or technical change, in economic growth is well-recognised. From the very first growth-accounting exercises of the 1950s for the US economy, through analyses of Japan, South Korea and Taiwan in their catch-up stories, to China today, technical change is estimated to account for over half of all economic growth. As a result, countries around the world have placed great emphasis on Innovation Policy, drawing on an increasingly rich understanding of what has worked, where, and why. This rich understanding needs to be a part of all discourse on economic policy. CTIER was established to do just this for India.

R&D is the most studied component of Innovation, but it is good to always keep in mind that Innovation – defined as something new for commercial advantage – is a much broader concept and applies to all firms in all sectors. Innovation matters as much to a garment firm introducing a new design or a startup launching a local-transport App (activities which rarely involve R&D but are still highly innovative) as to a pharmaceutical firm developing a better cure for a disease involving years of research. R&D is, however, the most directly connected with the study of Innovation.

Innovation largely happens in firms. But the broader National Innovation System matters. The innovative capacity of firms will be affected by both what they do themselves, and the institutions around them. The education system provides skilled labour, engineers and researchers. Where publicly funded research is done affects how it connects with industry. Public policy can provide incentives for investing in R&D, either directly or through patents. The trade regime can foster local production and/or an outward mindset. The culture of entrepreneurship affects investment in different kinds of capabilities. And broader cultural factors can influence how entrepreneurs define “good”.

Consider a key policy objective in India of raising the share of manufacturing from 15% to 25% of GDP. In spite of various initiatives - such as the Make in India programme - crossing two governments, the share of manufacturing in GDP has not budged and has remained stuck at around 15%. My own perspective, using invaluable data from CTIER, is that unless we see dramatic change in both how much firms invest in in-house R&D (the share needs to rise five-fold from 0.3% of GDP to the global average of 1.5%) and how much publicly-funded research is done within the higher education system (the share needs to rise ten-fold from the current 0.04% of GDP to the global average of 0.4%), we will continue to make a lot of noise about manufacturing without actually showing any result - as has been the case for the last ten years across UPA and NDA governments.

Such critical policy questions can only be addressed by drawing on current and comparative data on innovation, and combining it with the rich understanding that exists globally on innovation systems.

This Handbook brings together the most up-to-date and comprehensive data on innovation and technology in India. Though we have tried to present the data as clearly and simply as possible, an apparently simple table often took considerable effort to construct. For example, as apparently straight-forward a task as listing the top 100 R&D spenders in India required much work, blending together various data-bases and then doing a comprehensive individual check on each firm’s accounts.

Janak Nabar and his dedicated young team at CTIER have done us a huge service by making accessible this wealth of interesting data on Innovation.

We hope to make this Handbook at least a biennial publication. Your feedback would be most welcome on how we can make this publication even more useful in future editions.

Naushad Forbes
Chairman CTIER, Co-Chairman Forbes Marshall,
Past President CII

Acknowledgements

We would like to thank Pankaj Chandra, Sunil Mani, Rakesh Basant and Anjan Das for the unstinting support and guidance that they have provided the Centre since its inception in 2015. The idea for a book of this nature was first suggested by Sunil Mani in October 2015.

Our past Research Analysts and Associates contributed in putting together data for numerous presentations and round table discussions that concerned R&D and Innovation in India. Many of them had also been part of earlier attempts at putting a structure together for this Handbook. In particular we would like to thank Geet Chawla, Chitra Balasubramanian, Ashwin Shankar, Mehak Malhotra, and Amrita Brahmo. The newest member of the CTIER team, Vaishnavi Dande, has provided excellent research assistance.

We are grateful to Forbes Marshall for providing the Centre with generous funding support, the space that currently houses the Centre, and the expert help of many of its members. Digvijay Bhandari, Chhaya Gogate and Belinda Gaikwad have provided invaluable support and inputs towards the production of this Handbook. The CTIER team has also greatly benefited from the support and guidance of Bobby Kuriakose, Pratik Ghosh, Shirley Ignatius, Vicky Sareen, Shailesh Shah, Dharmesh Thaker and his team, Nitin Kunjir, Prakash Kinage, Hemant Zende, Pradeep Shelar and Pravin Shinde. Mangesh Nikam supported the team with his smiles and much needed copious cups of tea.

Sameer Karmarkar and Kartiki Jagtap at Satisfice Designs, Pune, through their patient understanding of our requirements, their professionalism, their prompt responses and suggestions have greatly enhanced the layout and design of the Handbook. Girish Rao and his team at Akruti for their printing support.

This being the first edition of this Handbook, the attempt to perfect the content has often meant the team has spent precious hours away from their families. We would like to thank their families for their understanding and encouragement.

Janak Nabar, Swati Joshi, Divya Sebastian, Mihir Baxi and Kathik TL

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Chapter 1

Strengthening India's Innovation System

Chapter 01

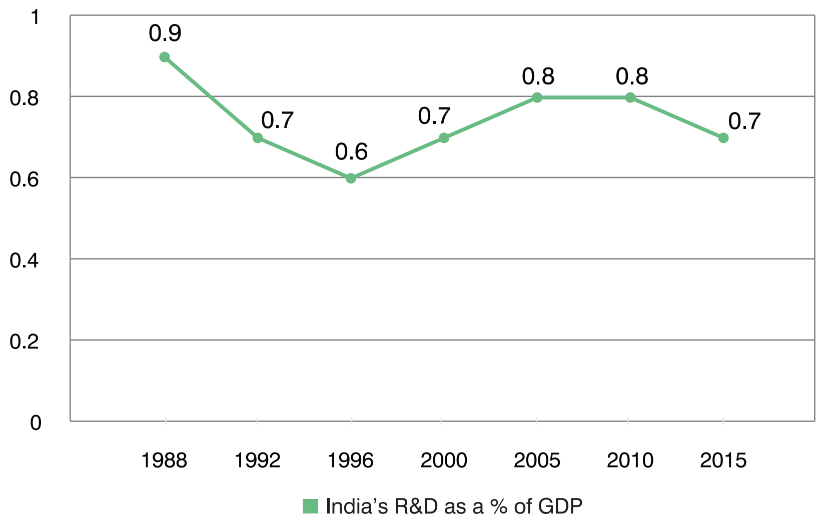
Strengthening India's Innovation System

Janak Nabar

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. 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

Figure 1.1 | 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)

also help propel the share of manufacturing output in GDP closer to 25 percent by 2022.[2] 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.

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

[2] Ministry of Commerce and Industry (2011), Government of India, "National Manufacturing Policy", *Press Information Bureau*

The comments on this chapter by Naushad Forbes, the CTIER Team, Malhar Nabar, Vikram Nabar and Jyotsna Ravishankar are much appreciated.

Table 1.1 | 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 Factor Cost, constant prices, base year 2004-05

Figure 1.2 | 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 1.2, which has been lacking in recent years.

Table 1.2 | 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)

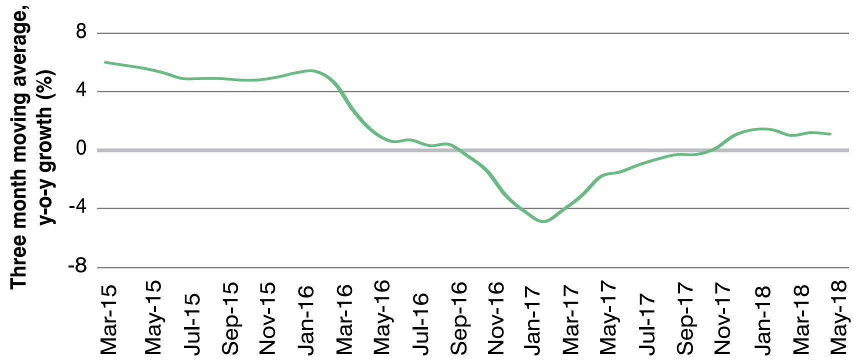
In thinking about increasing the spending on R&D and innovation in India, it would behoove policy makers and industry leaders to think more broadly in terms of strengthening India's innovation system. Adequate attention would need to be given to financing innovation in small and medium enterprises against 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. 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 1.3 | 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 1.3 | 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.[3,4,5] 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. [6], 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"[7] 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 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

[3] Task Force on Innovation, Report on Global Innovation Index: An Indian Perspective

[4] Borgohain, A. (2018), "To soon launch programme to fund R&D in SMEs: NITI Aayog's Rajiv Kumar", The Economic Times

[5] 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.

[6] Lerner, J. (1999), "The Government as Venture Capitalist: The Long-Run Effects of the SBIR Program", The Journal of Business

[7] Meeting of the OECD Council at Ministerial Level, Paris, 7-8 June 2017

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'[8]– and to understand whether any resulting savings for the government were re-allocated towards other productivity enhancing activities.[9] 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,[10] 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[11] 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)[12], 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 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.[13] 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.

'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?

[8] Ministry of Science and Technology, Government of India, "Dehradun Declaration for CSIR Labs", *Press Information Bureau*

[9] 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)

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

[11] 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).

[12] Ding, J. (2018), "Deciphering China's AI Dream" Future of Humanity Institute, University of Oxford

[13] Ghosh, K (2018), "These three young techies gave wings to Maharashtra's start-up policy", *Hindustan Times*

Table 1.4 | 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

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.[14] 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.[15] 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[16] 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')[17] to be higher than that of firms in the UK, Germany and Japan, while another study by Capgemini[18] 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).

[14] Cirera, X. and Maloney, W. (2017), "Managerial Practices as Key Firm Capabilities for Innovation", Chapter 4, *The Innovation Paradox,* The World Bank

[15] Forbes, N. and Wield, D. (2002), "Managing R&D in Technology Followers",Chapter 6, *From Followers to Leaders: Managing Technology and Innovation in Newly Industrializing Countries*

[16] Enterprise Surveys, India (2014), World Bank Group

[17] Küpper, D. et. al (2018), "AI in the Factory of the Future", Boston Consulting Group

[18] Stancombe, C. et. al (2017), "Turning AI into concrete value: the successful implementers' toolkit", Capgemini

India is home to a large number of MNCs and MNC R&D centres[19] 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[20], 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 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.[21] 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

[19] See Indicator 5.6, Chapter 5

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

[21] See Indicator 5.6, Chapter 5

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 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.

Table 1.5 | 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)

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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Section 2

Technology and Innovation in India : Indicators

Chapter 2
About the Handbook

Chapter 02

About the Handbook

The CTIER Handbook: Technology and Innovation in India is a unique compilation of key indicators in India's R&D and innovation ecosystem that provides insights on India and the global economy, regional innovation systems and industry in India. The Handbook is intended for use by policymakers and industry leaders. It is a welcome sign that the Economic Survey 2017-18 had a chapter on Transforming Science and Technology in India. However, much more needs to be done. While words such as artificial intelligence and machine learning, industry 4.0, and other technological innovations have begun to find their way into strategy and policy documents in India[22] – questions remain as to whether the Indian ecosystem is truly prepared for the sweeping changes underway, and the onslaught of technologies that we are yet to see. The data captured in the Handbook builds on the work our Centre has showcased at various fora in recent years and more recently highlighted in Forbes (2017), 'India's National Innovation System: Transformed or Half-formed?' in Rakesh Mohan (ed.) 'India Transformed: 25 Years of Economic Reforms'. By having these indicators in one place, it is hoped the Handbook will enable the reader to raise questions, draw her own conclusions about India's innovation ecosystem, and contribute to raising the level of debate on the role of technical capability in India's economic development, and how it could best be fostered. The next section discusses the Structure of the Handbook followed by the Data and Methodology section, while the last section details what the reader can expect in future editions.

Structure of the Handbook

The Handbook comprises three chapters: the first (Chapter 3) looks at 'India and the global economy', which includes a deep dive into some India specific data; the second chapter (Chapter 4) comprises data on 'Regional Innovation Systems'; and the third chapter (Chapter 5) covers data on 'Industry in India'. We have organized the data to showcase 'input' and 'output' indicators with respect to R&D and innovation in India. Examples of what constitute our classification of input and output indicators can be found in Table 2.1 and 2.2.

Table 2.1 | Examples of Input Indicators

Input Indicators	
• R&D expenditure as percent of GDP	• Manpower employed in R&D
• Charges for the use of intellectual property (payments)	• Policies introduced by state governments
• Foreign Direct Investment	• Pupil teacher ratio and gross enrolment ratio in higher education
• Venture Capital Investment	• Number of incubation centres
• Researchers per million	• MNC R&D presence in India etc

22 Industrial Policy – 2017, A Discussion Paper, DIPP; Budget 2018-2019, Speech of Arun Jaitley, Minister of Finance, February 1, 2018

Table 2.2 | Examples of Output Indicators

Output Indicators
• Publications by country, including share of industry-academia collaborations
• Patents, trademarks, copyrights filed domestically and abroad
• Patents granted
• Share of high technology products in manufactured exports
• Number of startups by state etc.

In Chapter 3, 'India and the global economy', we found that industry's share of total R&D expenditure had risen to 44 percent in 2014-15 from 34 percent in 2009-10, while the share of total R&D expenditure being performed by the higher education sector remained stagnant around 4 percent. India has become one of the top three destinations for global venture capital funding, after the US and China. The patents granted to residents in India by the United States Patent and Trademark Office (USPTO) have continued to rise – however we find that more than 70 percent of the patents in 2015 were granted to multinational corporations based in India.

Chapter 3 also covers input indicators such as R&D expenditure in India compared with select economies[23] and a country-wise comparison of R&D by sector of performance – the private sector, government and the higher education sector. We have delved deeper into data that pertains to India, for example we have compared R&D expenditure by key government agencies across time. We have looked at the structure of global industrial R&D and compared the number of Indian firms with the number of firms from select economies that figure in the top global R&D sectors. We have further compared the structure of industrial R&D in India with the structure of global industrial R&D by sector. Other input indicators include foreign direct investment (FDI) into India across sectors, a country-wise comparison of venture capital investment, a comparison of the number of researchers per million in India and in the select economies, and a country-wise comparison of the number of science & engineering PhDs in India and the select economies. Looking at India specific data, we have considered the number of degrees awarded (undergraduate as well as graduate degrees) in the field of science & engineering, as well as number of students enrolled in science & engineering degree programmes.

With respect to output indicators, we have looked at data on country-wise comparisons for patents granted by the USPTO, as well as country-wise comparisons of patents filed and granted by respective country patent offices. We have also captured country-wise comparisons for publications (including industry-academia collaborations) in top sectors and a comparison between India and select economies for the share of high technology products in manufactured exports.

Chapter 4, 'Regional Innovation Systems', is intended to provide an overview of the innovation systems of India's states. The success of the national innovation system will increasingly depend on the successful development of the regional and state innovation systems. The work on regional innovation systems has become increasingly prominent, and focuses on the innovative capacity of firms and the institutions around them. The chapter begins with an overview of policies that have been announced or being worked on by various state governments.

[23] Select economies include advanced economies such as US, UK, Germany and Japan and emerging/Asian economies such as Brazil, China, Israel and South Korea

At first glance, certain states do appear to stand out in terms of their innovation systems. What the indicators do not however capture is the willingness that we have witnessed amongst state government officials (across a number of states), to learn and implement successful programmes adopted by other states and other countries. While Maharashtra leads with respect to the number of high and medium high and henceforth higher technology[24] R&D centres present in a state, the number of startups that have been established, and the venture capital funding that has been received by a state, Tamil Nadu has a very good showing with respect to a number of higher education indicators.

As input indicators, we have mapped out the location of higher technology R&D centres in different states for 218 firms.[25] We have also considered FDI by state as well as funding[26] received by startups across states. Another input indicator involving startups is the number of incubation centres across states. The higher education data that we have considered as inputs into innovation include the pupil teacher ratio (PTR) and the gross enrolment ratio (GER) in higher education by states, and the number of institutes in a state that appear in the top 100 list of higher education institutes according to the National Institute Ranking Framework (NIRF). The output indicators we have considered in this chapter include number of startups by states as well as patent applications by states.

Chapter 5, 'Industry in India', features some unique data for India, never available before, such as the list of the top 100 R&D spenders in India. As noted in Chapter 3, the industrial sector contributes 44% of R&D in the country. Industrial R&D in India is heavily concentrated in a few firms, with the top 100 firms accounting for around 85 percent of total industrial R&D. The top 25 global industrial R&D spenders have expenditure amounts greater than that of all of Indian industry, with Volkswagen, the top spender, spending nearly 3.5 times that of all Indian industry on R&D.

Based on the top Indian industrial R&D sectors by spending, we have compared the R&D intensity (R&D expenditure as a percent of sales) of top Indian firms with the global average in each of the relevant sectors. There is a notable gap between the R&D intensity of Indian firms in the software and computer services sector compared to the global average – most global firms in this sector tend to have a focus on products rather than services which only partly explains the difference.

We have captured forex spending on intellectual property or 'disembodied technology' by industry, as well as expenditure on 'embodied technology' by industry based on the import of capital goods by firms. The weakness in 'embodied technology' expenditure captured by the data is symptomatic of the overall weakness in private sector investment that had been observed in India in recent years. The analysis of R&D centres of multinational corporations (MNCs) in India continues to evolve - in Indicator 5.6 we present a table to highlight a back of the envelope calculation for our estimate of MNC R&D expenditure in India. In this chapter we also present data on funding received by top Indian technology startups by sector. In a bid to capture industry-academia

[24] The OECD definition for High and medium high technology (HMT) manufacturing is defined in ISIC Rev.4 as Chemicals and chemical products (Division 20), Pharmaceutical products (21), Computer, electronic and optical products (26), Electrical equipment (27), Machinery and equipment n.e.c. (28), Motor vehicles (29) and Other transport equipment (30) Knowledge-intensive "market" services refer to ISIC Rev.4 Section J: Information and communication (Divisions 58-63); K: Finance and insurance (64-66); and M: Professional, scientific and technical activities (69-75).

[25] An explanation of the sample of 218 firms is provided for in the text accompanying the indicator(s) where this sample has been used. These 218 firms account for around 90 percent of industrial R&D in India.

[26] Funding received by startups include PE, VC, Angel and debt investments.

collaborations by focusing on publications by industry, we look at a comparison of publications by firms in India's top industrial R&D sectors and compare it to publications by global firms in the same sector. For other output by industry, we consider the top patentees with both the Indian Patent Office as well as the USPTO.

Data and Methodology[27]

The data in the Handbook has largely been collated from secondary sources.

For global indicators, we have used publicly available databases from the the World Bank, the World Intellectual Property Office, the United States Patent and Trademark Office and the EU Investment R&D Scoreboard.

Data pertaining to India were compiled from various reports, publications, websites and databases of Government of India departments and ministries such as the Department of Science and Technology (DST), Department of Scientific and Industrial Research (DSIR), Department of Industrial Policy and Promotion (DIPP), the Reserve Bank of India (RBI), the University Grants Commission (UGC), Ministry of Human Resource Development (MHRD), StartUp India, Invest India, state government department websites and various annual reports published by firms. We have also used third party subscription databases such as Prowess, Web of Science and Tracxn where required.

The presentation of the data in Chapters 3, 4 and 5 through charts, tables and maps, along with the accompanying text are meant as observations about India's R&D and innovation ecosystem. They are intended for the reader to reach her own conclusion with respect to an indicator. The Handbook also contains certain indicators that have been developed by CTIER – such as the top industrial R&D sectors in India, the number of higher technology R&D centres in different states and technology payments by sector (forex spending on intellectual property). Where an indicator has been developed by CTIER, an explanatory note on the methodology used to construct the indicator can be found in the text accompanying the indicator.

Future editions of the Handbook

We intend this Handbook to be a biennial publication. It is hoped that some of the issues with the data that we have identified are addressed and all appropriate changes are reflected in future editions of the Handbook. We welcome comments from both industry as well as academics, to help strengthen the understanding and interpretation of the data presented. Box 2.1 provides an example of how the indicators presented may raise questions that could be commented on.

[27] There are indicators which may have alternative sources. In such cases, data from the alternative source is provided in Appendix A. For example, while we have chosen to showcase the data on FDI into India for FY2016 and FY2017 using the DIPP Quarterly Factsheet as of December 2017, the data provided in Appendix (Table A.2) on FDI into India is from the RBI website. Similarly, for the number of science & engineering PhDs awarded in India, we have used data from various reports of the All India Survey of Higher Education (AISHE) prepared by MHRD, while the data provided by the UGC on the number of science & engineering PhDs awarded can be found in Appendix 1 (Table A.5).

For the purpose of classifying Indian firms by industry sector, we have used the CTIER industrial classification, to map the Ministry of Statistics and Programme Implementation's National Industrial Classification (NIC 2008) to the Financial Times Stock Exchange's Industry Classification Benchmark (ICB). The ICB classification is used by the EU Industrial R&D Investment Scoreboard, from where we have obtained data on firm level R&D expenditure and other financial information for the top 2500 global R&D spenders.

For data that required converting values in Indian Rupees into US dollars, the exchange rate for USD/INR as applicable to the indicator has been provided.

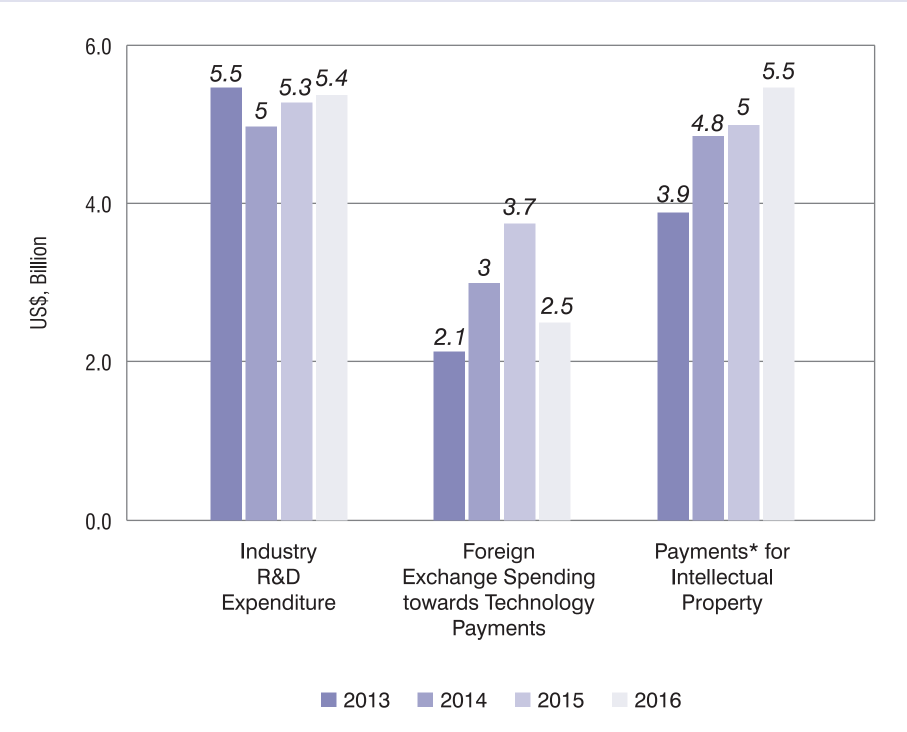
In future editions, the reader can also expect the set of indicators to expand as other relevant indicators become available. We shall invite written contributions from industry leaders, academics and policy makers on topics that will help create systemic change and help strengthen our National Innovation System.

Box 2.1: Technology Payments in India

The indicators in this Handbook raise interesting questions for the reader about the Indian innovation system and also about the quality of the data currently available. For example, if one considers RBI data on payments for intellectual property (Indicator 3.5.1), one can see that India's technology payments[28] have been increasing over the years. Taken as an input into the production of goods and services, rising technology payments may be viewed as being positive for firm level innovation in India, given the potential for technology diffusion both at the firm level as well as at a sector level. However, at present, it is unclear as to how much of the technology payments in the RBI data account for royalty payments towards patented technologies by higher technology firms, and how much of it accounts for payments towards copyrights and trademarks, for instance, by the entertainment industry. A sector wise break up of technology payments by industry and by intellectual property (i.e. patents, copyrights etc.) may help discern the true impact of technology payments on product innovation for the higher technology sectors.

As can be seen in the chart below, both industrial R&D expenditure and foreign exchange spending on technology payments for India as reported by firms have broadly been increasing[29]. An old question about technology payments that remains unanswered is whether technology payments are complements to in-house industrial R&D or substitutes for in-house R&D?[30]

Figure 2.1 | Are Technology Payments Complements to In-house Industrial R&D or Substitutes for In-house R&D?



Source: Prowess, data downloaded on 22 February 2018 from the platform, Reserve Bank of India (RBI) Balance of Payment (various years) available at https://rbi.org.in/scripts/SDDS_ViewDetails.aspx?Id=5&IndexTitle=Balance+of+; Centre for Technology, Innovation and Economic Research (CTIER)
* Payments according to RBI data

Note: Figures in rupees are converted to dollars using the USD-INR exchange rate of 47.85 calculated as an average for the fiscal year 2011-12, the USD-INR exchange rate of 54.35 calculated as an average for the fiscal year 2012-13, the USD-INR exchange rate of 60.42 calculated as an average for the fiscal year 2013-14, the USD-INR exchange rate of 61.13 calculated as an average for the fiscal year 2014-15, the USD-INR exchange rate of 65.42 calculated as an average for the fiscal year 2015-16 according to Federal Reserve Bank of St Louis

[28] Payment of fees towards use of intellectual property such as patents, trademarks, copyrights etc.

[29] It is unclear here whether the dip in technology payments in 2015-16 was due to unavailability of firm level data or whether there was indeed a slowdown in industrial technology payments. Moreover, the overall increase in payments for intellectual property as per the RBI data also raises the question whether payments towards copyrights and trademarks were the main driver for this increase.

[30] This question was posed by Rakesh Basant at CTIER conference on R&D in India hosted in Delhi in June 2016 that included R&D heads of firms that were among India's largest spenders on R&D and innovation – we were unable to elicit a satisfactory response from the participants to this question.

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Chapter 3

India and the global economy

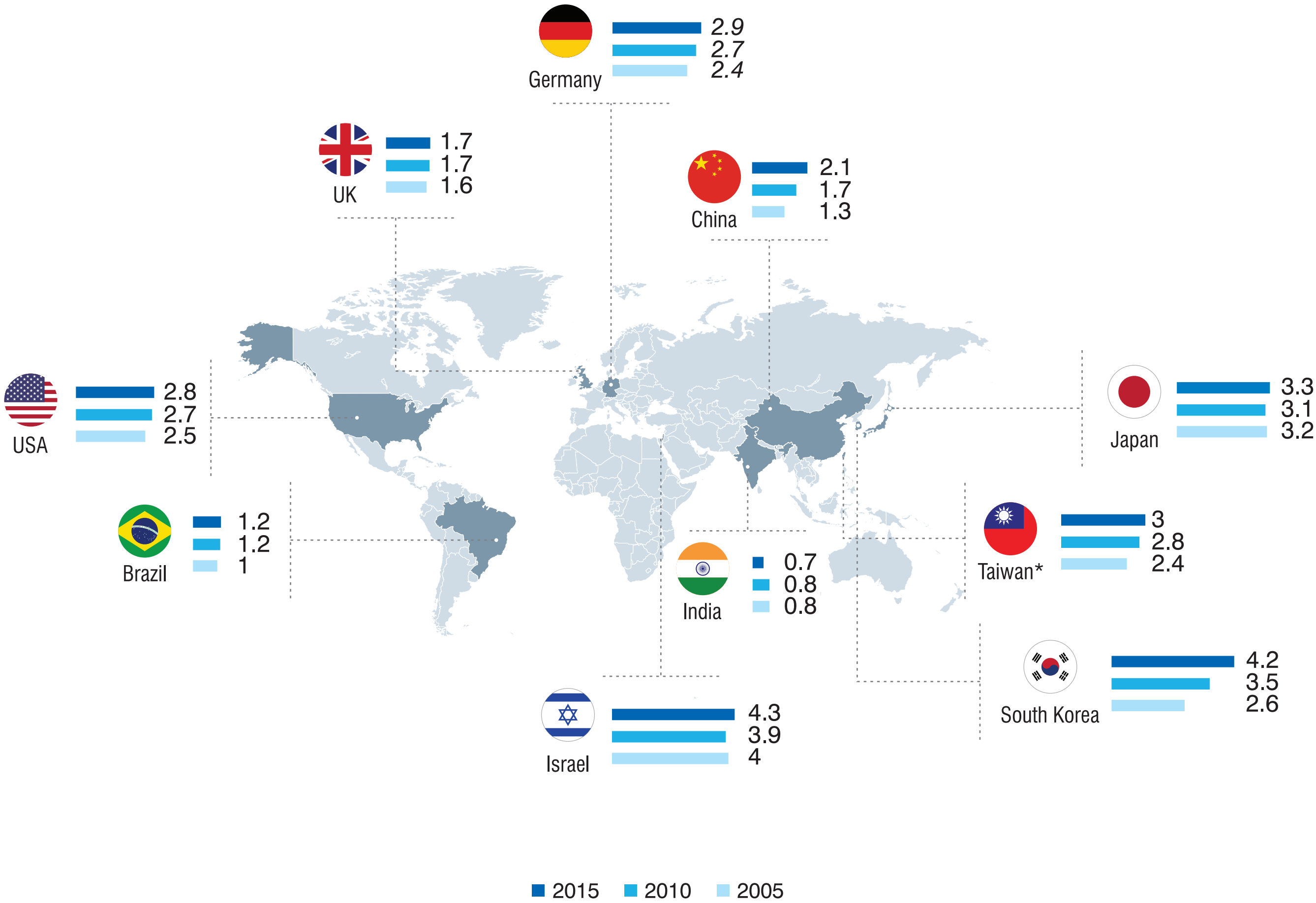
This chapter looks at the comparison of India with select countries on input and output indicators with respect to R&D and innovation outlined below. The select countries are a combination of advanced economies and emerging economies to allow the reader to view India's position relative to both. Where possible, we have also delved deeper into data that pertains to India.

Number	Indicator
3.1	R&D Expenditure as a Percent of Gross Domestic Product across Select Countries
3.2	Country-wise Comparisons of Share of R&D in National R&D Expenditure by Sector of Performance in 2015 (%)
3.2.1	Share of India's R&D Expenditure by Sector of Performance
3.3	R&D Expenditure by Select Key Scientific Agencies under Government of India
3.4	Sector-wise Global Industrial R&D Expenditure and Country-wise Number of Firms (2016)
3.4.1	Comparison of the Structure of Global and Indian Industrial R&D (Sector Share of Total Industrial R&D Spending)
3.5	Payments and Receipts for Intellectual Property (2016)
3.5.1	India's Technology Trade Balance (2012-2016)
3.6	Annual Foreign Direct Investment (FDI) Equity Inflows into India (2012-2016)
3.6.1	Foreign Direct Investment into India by Sector (2015-16 and 2016-17)
3.7	Venture Capital Investment in Select Countries
3.7.1	Funding for New Startups in India (2012 - 2016)
3.7.2	Number of Startups Created in India (2012 - 2016)
3.8	Country-wise Comparisons for Full Time Researchers per million (2015)
3.9	Country-wise Comparisons of Global Science and Engineering (S&E) PhDs
3.9.1	Degrees Awarded in S&E Degree Programmes in India (2015)
3.9.2	Enrolment in S&E Degree Programmes in India (2015)
3.10	Persons employed (full time equivalent) as Researchers by R&D establishments in India
3.11	Country-wise Comparisons by Share of Publications, Impact and Share of Industry-Academia Collaborations in Total Publications (2012-16)
3.12	Country-wise Comparison by Share of Publications, Impact and Share of Industry-Academia Collaborations by Top Sectors of Publication (2012-16)
3.12.1	India's Top Areas of Cumulative Publications (2012-16) - Impact and Industry-Academia Collaborations and their Respective Comparisons with Global Averages
3.13	Ranking of Institutions in India by Number of Publications (2012-16)
3.14	Country-wise Comparisons for Patent Applications Filed Abroad
3.15	Country-wise Comparisons for Patent Applications with Respective Domestic Patent Offices (2016)
3.16	Applications for Patents, Industrial Design and Trademarks from India (2012-16)
3.17	Patent Applications with Indian Patent Office by Residents and Non-Residents (2012-16)
3.18	Patent Applications with Indian Patent Office by Sector (2016)
3.19	Patents Granted by the United States Patent and Trademark Office (USPTO) to Select Countries
3.20	Country-wise Comparisons for Patents Granted by Respective Domestic Patent Offices (2016)
3.21	Patents Granted by the Indian Patent Office to Residents and Non-Residents (2012-16)
3.22	High Technology Exports as Share of Manufactured Exports for Select Countries

Chapter 03

India and the global economy

3.1 | R&D Expenditure as a Percent of Gross Domestic Product across Select Countries



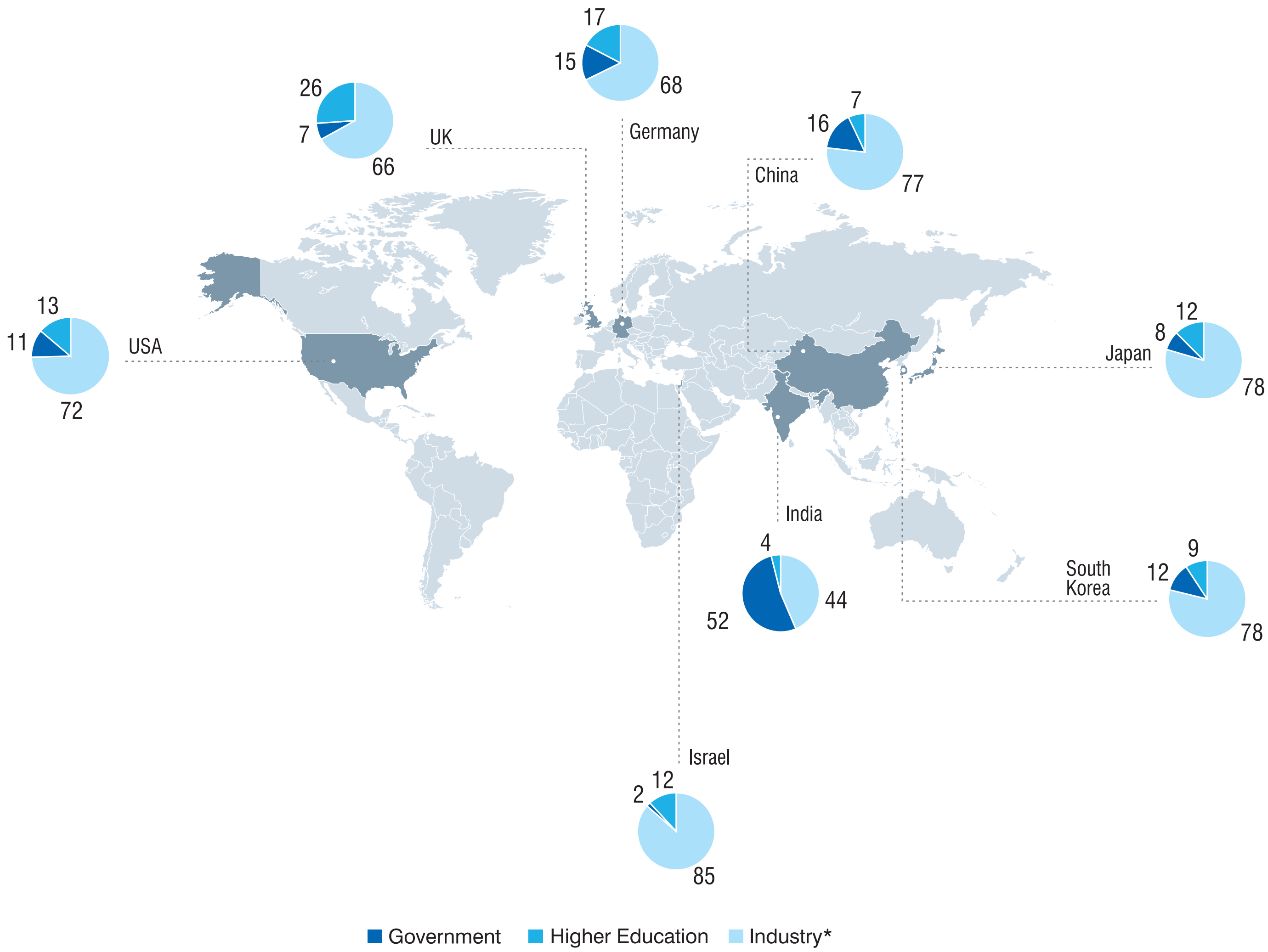
Source: World Development Indicators (various years), Indicators, available at http://data.worldbank.org/ for data on China, Germany, Japan, South Korea, UK and USA; Department of Science and Technology (DST), Government of India, Research and Development Statistics at a Glance 2017-18 available at http://www.nstmis-dst.org/Statistics-Glance-2017-18.pdf for data on India; UNESCO Institute of Statistics (2015), UIS.stat, available at http://data.uis.unesco.org/ for Brazil; Taiwan Statistical Data Book (2016) for data on Taiwan; Centre for Technology, Innovation and Economic Research (CTIER)

Note: Taiwan data is for 2014

R&D expenditure as a percent of Gross Domestic Product (GDP) for India has been in the range of 0.6 to 0.9 percent for the past 30 years31 and declined from 0.8 percent in 2005 to 0.7 percent in 2015. Select advanced economies such as USA, UK, Germany and Japan have shown a marginal increase in their R&D expenditure as a share of GDP between the years 2005-15. During the same time period, South Korea increased from 2.6 percent to 4.2 percent, Taiwan increased from 2.4 percent to 3.0 percent while China increased from 1.3 percent to 2.1 percent.

[31] India's National Innovation System: Transformed or Half-formed? Forbes N (2016)

3.2 | Country-wise Comparisons of Share of R&D in National R&D Expenditure by Sector of Performance in 2015 (%)

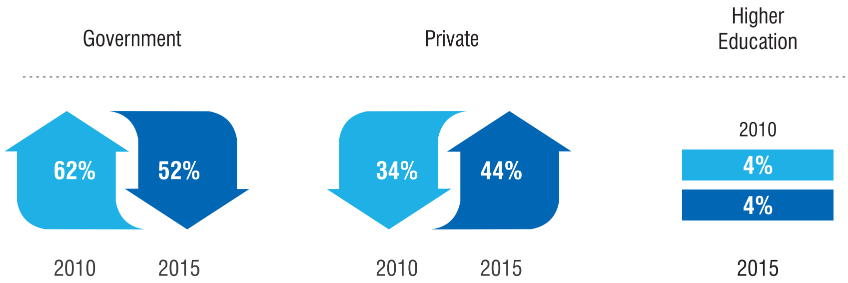


Source: UNESCO Institute of Statistics (2015), UIS.stat, available at: http://data.uis.unesco.org/; Centre for Technology, Innovation and Economic Research (CTIER)
*UNESCO uses the term business enterprises

Note: Data not available for Brazil

India's R&D spending is dominated by the government sector that accounted for 52 percent of total R&D spending in 2015. R&D expenditure by industry (includes private sector and public sector business enterprises) accounted for 44 percent of total R&D expenditure, while the higher education sector accounted for 4 percent. For the other select countries in our sample, R&D spending is dominated by industry - with the UK seeing industry's share at 66 percent and Israel seeing industry's share at 85 percent. In our sample, the share of R&D spending in the higher education sector varies between 8 percent to 15 percent.

3.2.1 | Share of India's R&D Expenditure by Sector of Performance

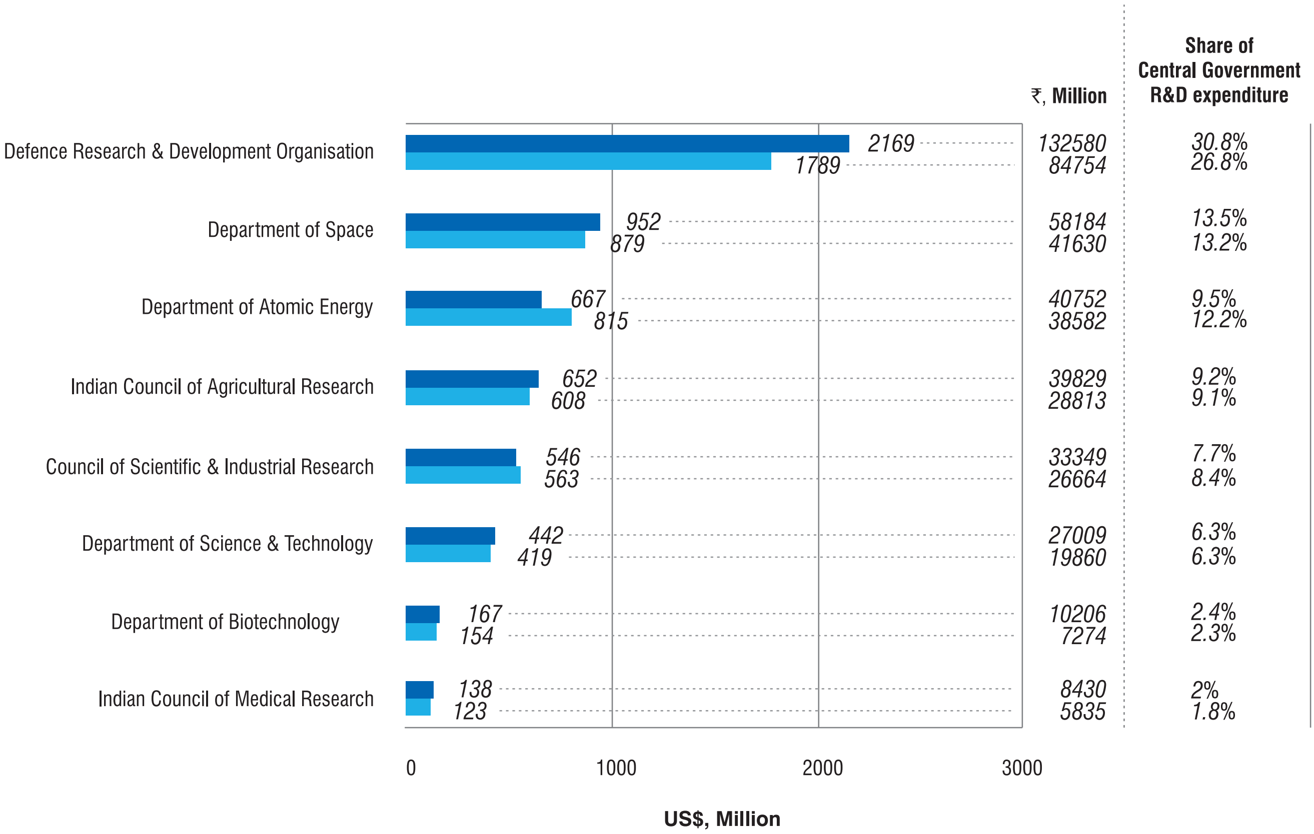


Source: Department of Science and Technology (DST), *Research and Development Statistics at a Glance 2017-18* available at http://www.nstmis-dst.org/Statistics-Glance-2017-18.pdf, *Research and Development Statistics at a Glance 2011-12* available at http://www.nstmis-dst.org/pdf/finalrndstatisticsataglance2011121.pdf; 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 industries

The share of R&D spending by industry has increased from 35 percent in 2010 to 44 percent in 2015. According to data from the Department of Science & Technology (DST), the increase in industry has largely been driven by increased spending by private sector enterprises. The share of R&D spending in higher education in India has remained at 4 percent over the same period.

3.3 | R&D Expenditure by Select Key Scientific Agencies under Government of India



		Total for Select Key Scientific Agencies	Total Central Government R&D expenditure	Total National R&D expenditure
2014-15	**US$, Million**	5731	7053	13965
	₹, Million	35033.8	430949	853261
2009-10	**US$ Million**	5350	6682	11190
	₹, Million	25341.2	316705	530412

Source: Department of Science and Technology (DST), Government of India, Research and Development Statistics 2017-18, December 2017 available at http://dst.gov.in/research-and-development-statistics-2017-18-december-2017; Centre for Technology, Innovation and Economic Research (CTIER)

Note: Figures in rupees were converted to dollars using the USD-INR exchange rate of 47.4 calculated as an average for the fiscal year 2009-10 and the USD-INR exchange rate of 61.1 calculated as an average for the fiscal year 2014-15 based on data from Federal Reserve Bank of St Louis.

Box 3.1 | Health Expenditure on R&D

India's health expenditure on R&D as share of central government R&D expenditure is around 4.4 percent. For India's health expenditure on R&D, we have considered expenditure on R&D by the Department of Biotechnology and the Indian Council of Medical Research. This is significantly lower than the amount of health R&D expenditure in countries like the US and the UK where health expenditure on R&D as a share of their government budgets is 24 percent and 22 percent respectively.

R&D expenditure by major scientific agencies has seen an increase in the past 5 years across all agencies, with the largest increase being seen by the Defence Research & Development Organisation. Strategic R&D investments by the Defence Research & Development Organisation, the Department of Space and the Department of Atomic Energy accounted for 54 percent of total central government expenditure on R&D and 27 percent of national R&D expenditure in 2015. The key scientific agencies listed above accounted for 81 percent of total central government R&D expenditure and 41 percent of national R&D expenditure in 2015.

3.4 | Sector-wise Global Industrial R&D Expenditure and Country-wise Number of Firms (2016)

Sector	R&D expenditure (US$, Millions)	Total Number of Firms	Number of Firms									
			Select Advanced Economies				Select Emerging/Asian Economies					
			USA	UK	Germany	Japan	Brazil	China	India	Israel	South Korea	Taiwan
Pharmaceuticals & Biotechnology	144264	369	195	19	10	29	0	28	10	1	10	1
Technology Hardware & Equipment	121044	298	125	6	5	26	0	39	0	4	7	56
Automobiles & Parts	117536	156	23	6	16	42	0	31	6	0	11	4
Software & Computer Services	86440	278	155	18	6	9	1	34	4	6	5	2
Electronic & Electrical equipment	57067	228	46	11	9	43	0	42	0	2	9	32
Industrial Engineering	30022	199	39	7	23	36	1	33	1	0	2	0
Chemicals	25071	125	35	3	9	38	1	11	0	1	6	1
Aerospace	22977	53	19	7	1	1	1	5	0	2	0	0
General Industrials	21414	86	20	3	6	17	0	15	0	1	6	4
Health Care Equipment & Services	16183	98	57	3	8	9	0	4	0	1	0	0
Top 3 Sectors	382844	823	343	31	31	97	0	98	16	5	28	61
Top 10 Sectors	642018	1890	714	83	93	250	4	242	21	18	56	100
Total (2500)	758600	2500	837	133	132	356	9	326	25	20	74	111

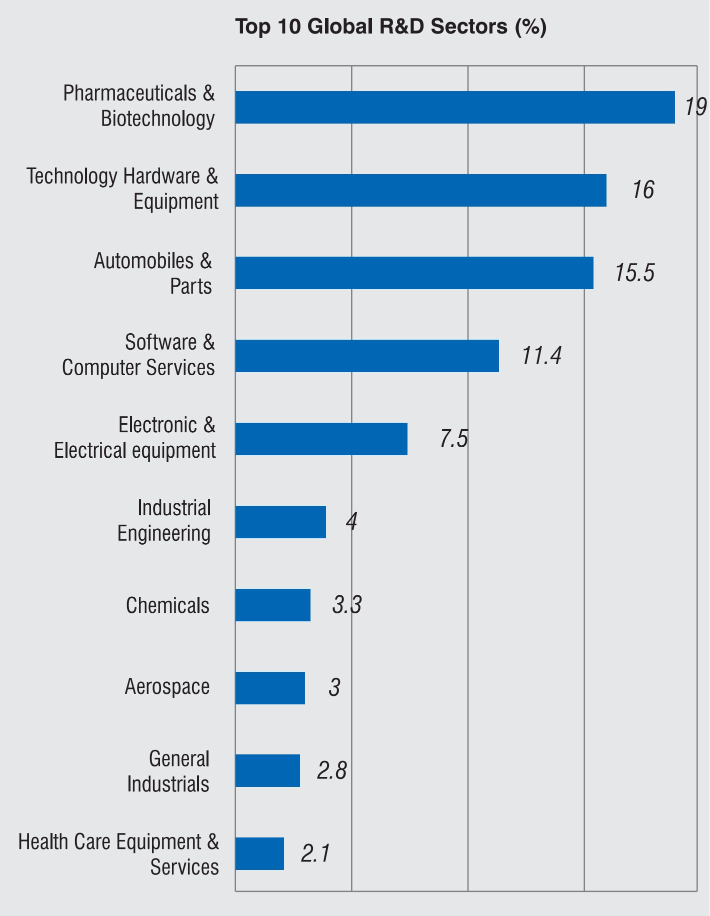
Source: EU Industrial R&D Investment Scoreboard (2016); Centre for Technology, Innovation and Economic Research (CTIER)

Note: Figures in euros were converted to dollars using the EUR-USD exchange rate of 1.09 as at 31 December 2015 and as mentioned in the EU Industrial R&D Investment Scoreboard

The table above captures the top 10 global industrial R&D sectors by expenditure, based on the top 2,500 global firms by R&D expenditure as captured in the EU Industrial R&D Scoreboard 2016. India has 25 firms in the list of the top 2,500 global R&D spenders, with 21 firms in the top 10 sectors. There are 10 firms in the pharmaceutical & biotechnology sector, 6 firms in the automobiles & parts sector, 4 in software & computer services sector, and 1 in industrial engineering.

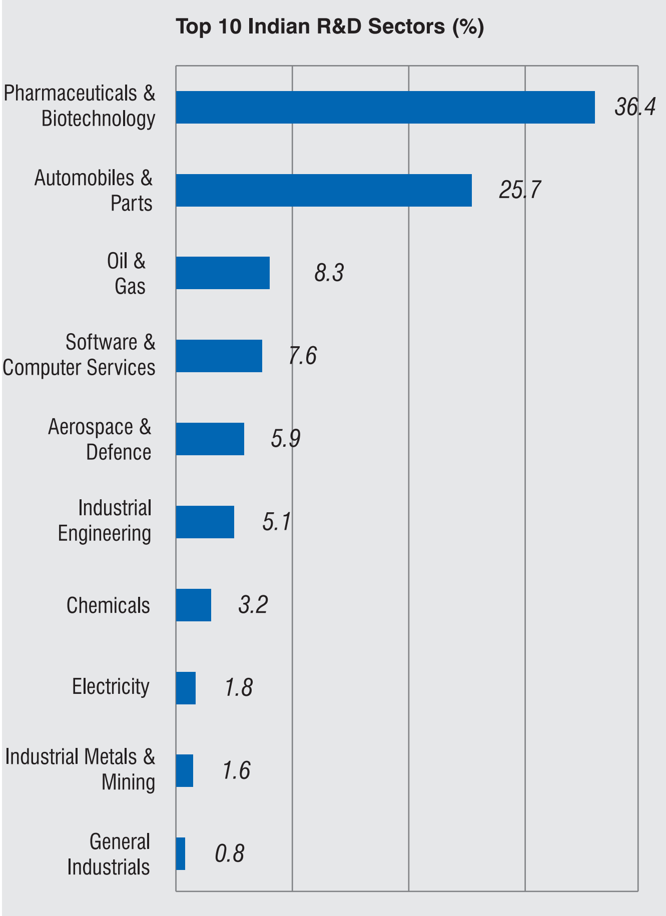
Indian firms are absent in 5 out of the top 10 global industrial R&D sectors. Countries like USA, China and Germany have a presence in each of these top 10 global sectors.

3.4.1 | Comparison of the Structure of Global and Indian Industrial R&D (Sector Share of Total Industrial R&D Spending)



Source: EU Industrial R&D Investment Scoreboard (2016); Centre for Technology, Innovation and Economic Research (CTIER)

Note: (i) Total for the top 2500 firms according to EU Industrial R&D Investment Scoreboard (2016) for the year was USD 759 billion
(ii) Figures in euros were converted to dollars using the EUR USD exchange rate of 1.09 as at 31 December 2015 and as mentioned in the EU Industrial R&D Investment Scoreboard



Source: Prowess, data downloaded on 7 February 2018 from the platform; Annual Reports (2015-16) of Indian Companies; Centre for Technology, Innovation and Economic Research (CTIER)

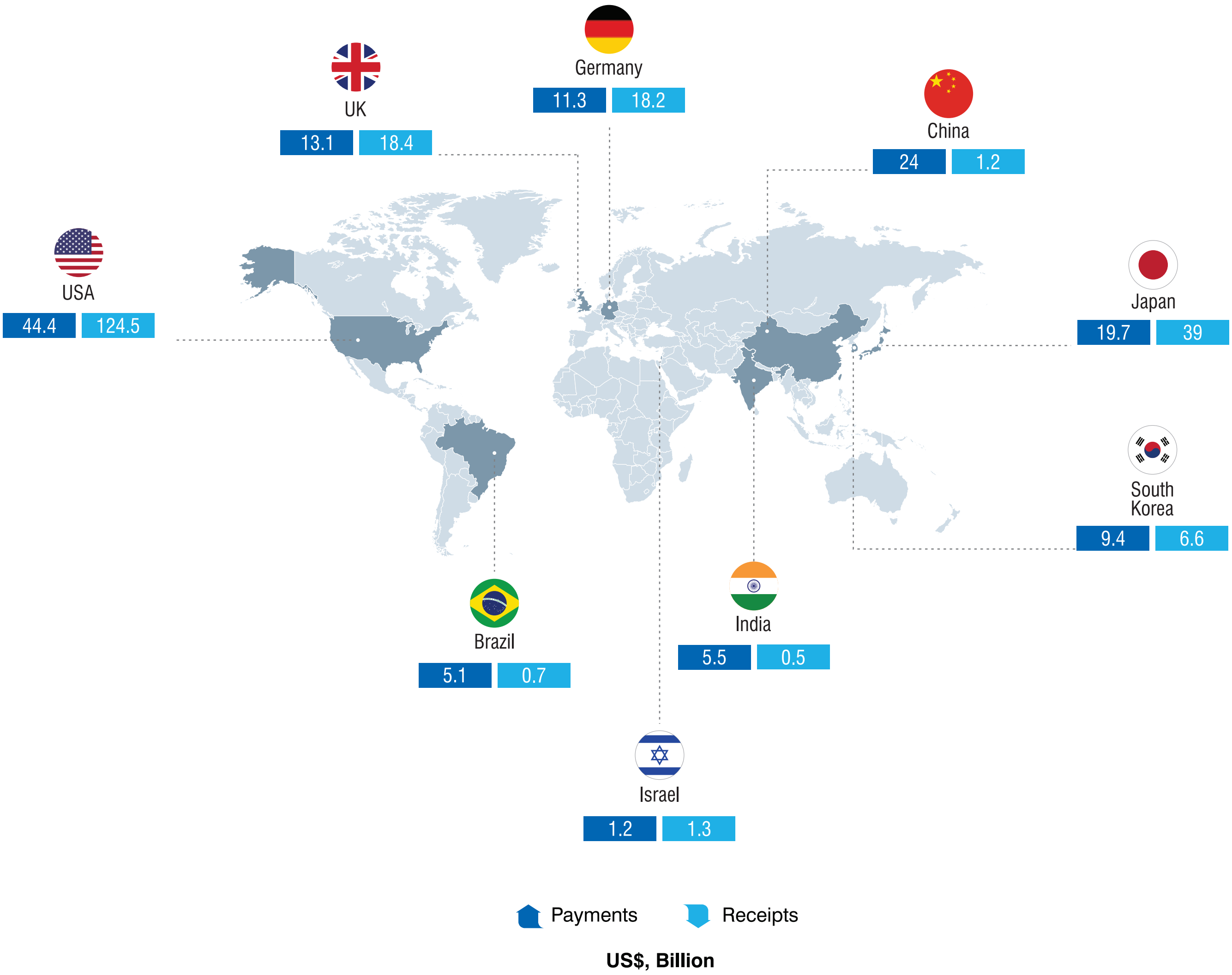
Note: (i) Total for the sample selected for the year was USD 4889 million (INR 320 billion). This sample of top 218 R&D spending firms represented 90% of total industrial R&D spending in 2015-16
(ii) Figures in rupees were converted to dollars using the USD-INR exchange rate of 65.42 calculated as an average for the fiscal year 2015-16 based on data from Federal Reserve Bank of St Louis

India's sectoral structure of industrial R&D by expenditure is dominated by pharmaceutical & biotechnology, and automobiles & parts. While oil & gas and software & computer services are some of the major R&D sectors, they account for less than 10 percent of total industrial R&D expenditure respectively.

The sectoral structure of global industrial R&D has 4 major sectors that includes pharmaceutical & biotechnology, technology hardware & equipment, automobiles & parts and software & computer services.

India has 7 industrial R&D sectors in common with the global industrial R&D structure. Sectors such as technology hardware & equipment, electronic & electrical equipment and healthcare equipment & services are absent from the top industrial R&D sectors for India.

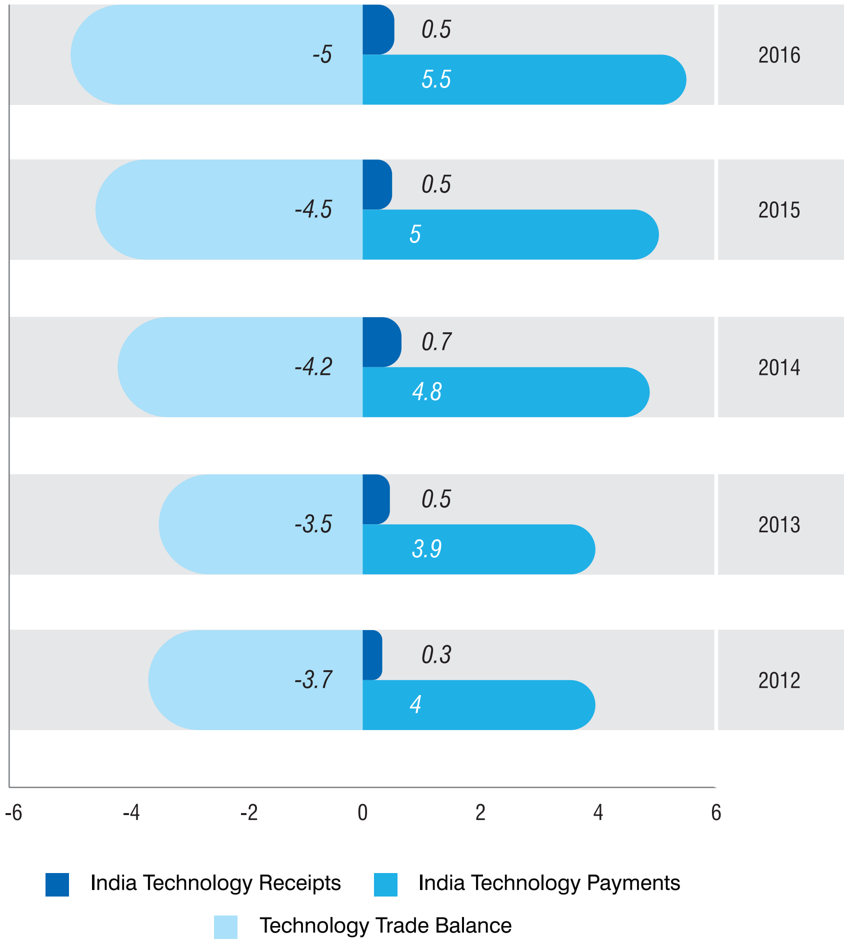
3.5 | Payments and Receipts for Intellectual Property (2016)



Source: Reserve Bank of India (RBI), Balance of Payment (various years) available at https://rbi.org.in/scripts/SDDS_ViewDetails.aspx?Id=5&IndexTitle=Balance+of+ for data on India; World Development Indicators (2016), Indicators, available at http://data.worldbank.org/ for data on Brazil, China, Germany, Japan, South Korea, UK and USA; Centre for Technology, Innovation and Economic Research (CTIER)

In our sample of select economies, India and other emerging/Asian economies had a negative technology trade balance in 2016, with payments for intellectual property outstripping the receipts for intellectual property. China had the largest technology trade deficit at USD 23 billion followed by India that recorded a deficit of USD 5 billion. Data for 2012 for these economies can be found in the appendix (Table A.1). The technology receipts for USA in 2016 are around levels seen in 2012, while Japan has seen a marginal drop in its technology payments data for 2016 compared to 2012.

3.5.1 | India's Technology Trade Balance (2012-2016)



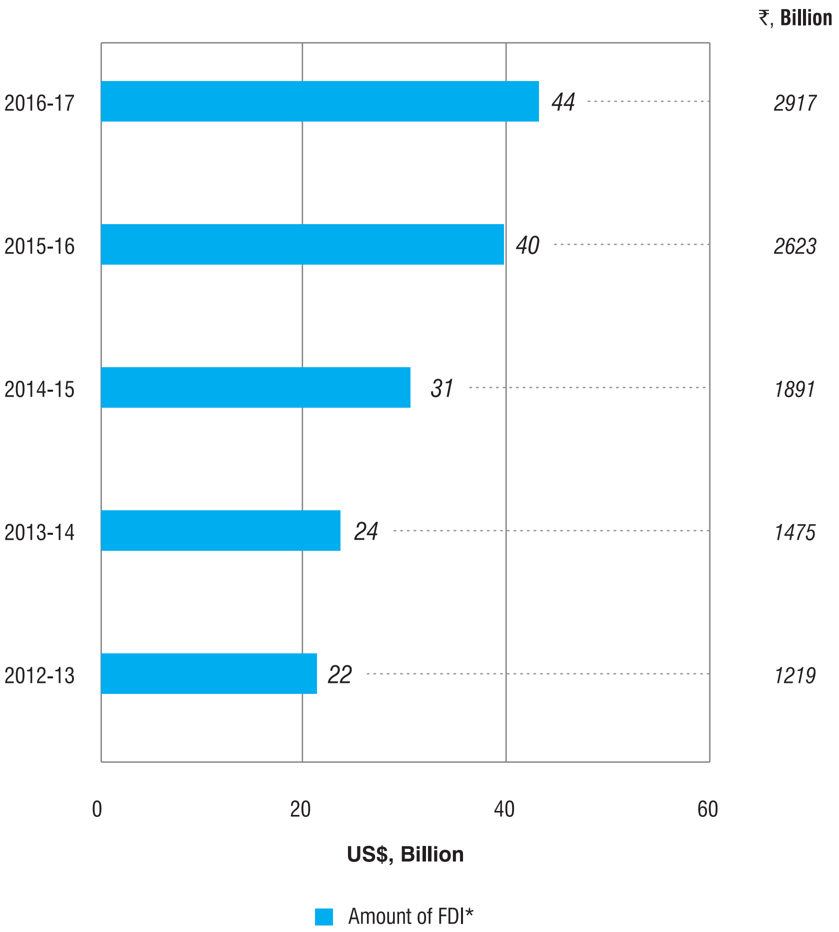
US$, Million

Source: Reserve Bank of India (RBI) Balance of Payment (various years) available at https://rbi.org.in/scripts/SDDS_ViewDetails.aspx?Id=5&IndexTitle=Balance+of+; Centre for Technology, Innovation and Economic Research (CTIER)

Note: Figures reported above are calculated for calendar years. The Reserve Bank of India (RBI), Balance of Payment, captures fiscal year data on Charges for the Use of Intellectual Property (CIP). CIP for the fiscal year 2015-16 was USD 4891 million and for the fiscal year 2016-17 was USD 5729 million.

India's payments and receipts for the use of intellectual property have both steadily increased since 2012. Technology payments for India have been growing at a faster pace than receipts, which has also seen the technology trade deficit for India widen since 2012.

3.6 | Annual Foreign Direct Investment (FDI) Equity Inflows into India (2012-2016)



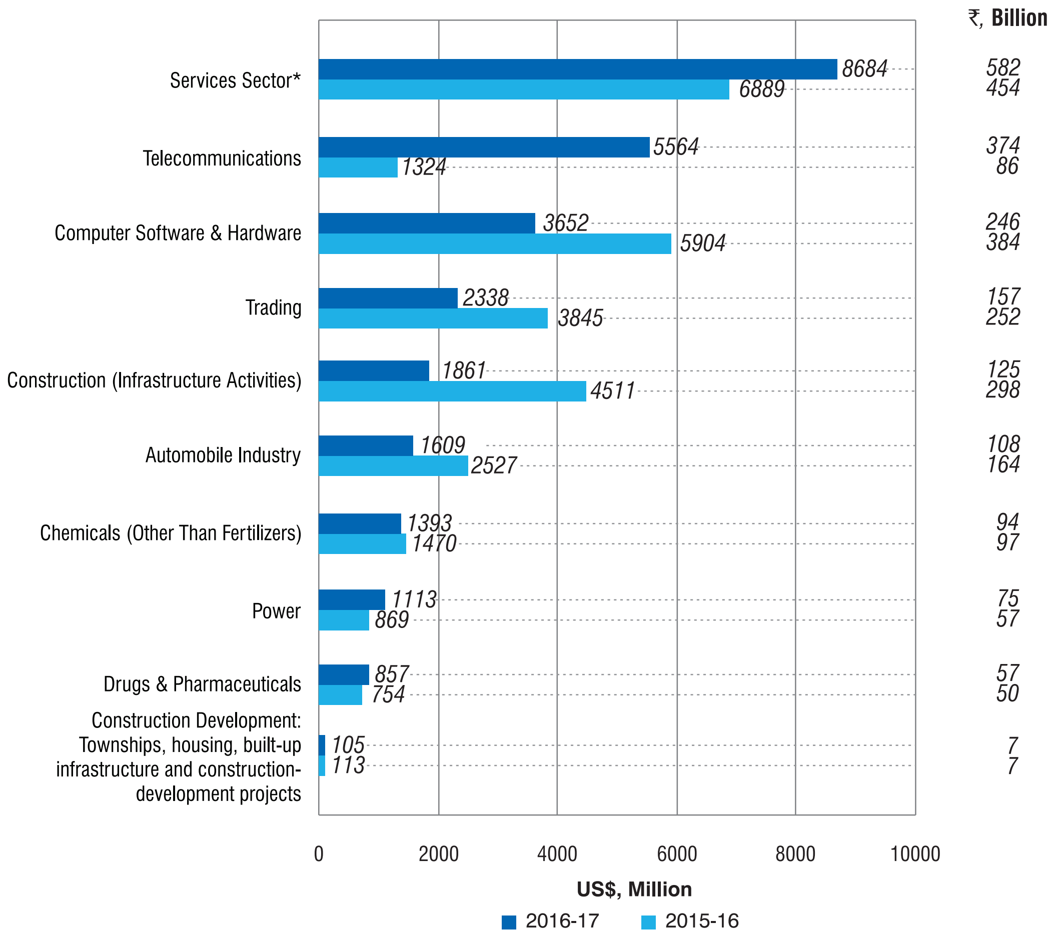
Source: Department of Industrial Policy and Promotion (DIPP), Government of India, *Quarterly FDI factsheet, December 2017;* Centre for Technology, Innovation, and Economic Research (CTIER)
*Does not include reinvested earnings and other capital

According to the Department of Industrial Policy and Promotion (DIPP), Foreign Direct Investment (FDI) equity inflows through the automatic/acquisition route for the year 2016-17 was USD 44 billion. The amount received as FDI through reinvested earnings, equity capital of unincorporated bodies and other capital amounted to USD 17 billion.

FDI excluding reinvested earnings etc. has been increasing over the period under consideration and in 2016-17 was almost double the amount seen in 2012-13 according to DIPP data.

The corresponding data on FDI as reported by the RBI can be found in the appendix (Table A.2). RBI reported direct investment into India as amounting to USD 45 billion in 2016-17, while the investments through reinvested earnings and debt instruments amounted to USD 15 billion.

3.6.1 | Foreign Direct Investment into India by Sector (2015-16 and 2016-17)



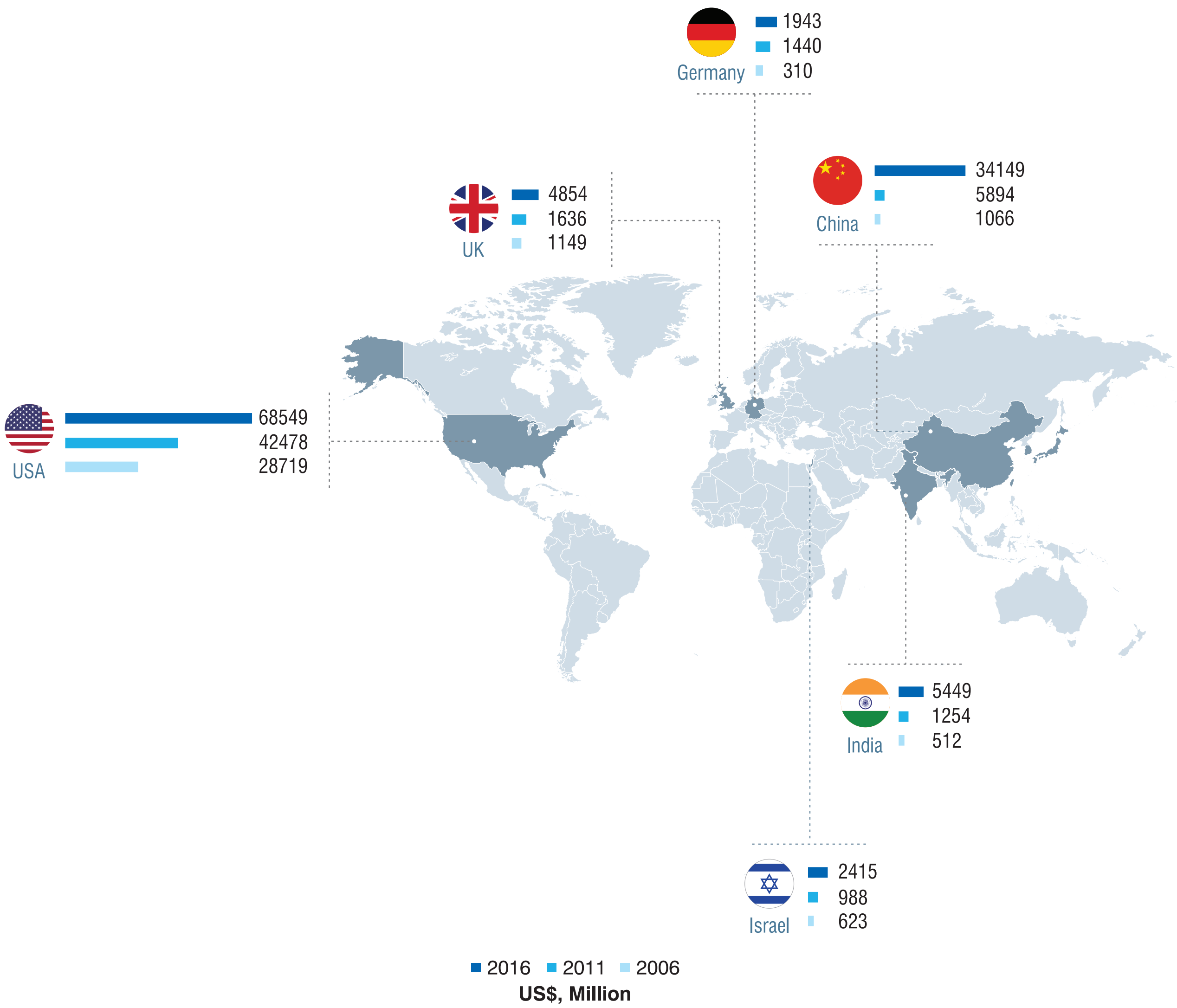
		2016-17		2015-16
Total for Top 10 Sectors	US$, Million	27176	US$, Million	28206
	₹, Billion	1826	₹, Billion	1850
Grand Total	US$, Million	43478	US$, Million	40001
	₹, Billion	2917	₹, Billion	2623

Source: Department of Industrial Policy and Promotion (DIPP), Government of India, *Quarterly FDI factsheet (December 2017);* Center for Technology, Innovation, and Economic Research (CTIER)
*Services sector includes Financial, Banking, Insurance, Non-Financial / Business, Outsourcing, R&D, Courier, Tech. Testing Analysis

FDI equity inflows excluding reinvested earnings etc. came in at USD 44 billion in 2016-17. Of these, the top ten sectors shown above accounted for 62 percent of the FDI equity inflows in 2016-17. The services sector[32] was the highest recipient of FDI inflows at USD 8.6 billion, followed by telecommunications at USD 5.5 billion, and computer software & hardware at USD 3.6 billion. The services sector was also the highest recipient of FDI in the previous year.

[32] The services sector includes financial, banking, insurance, insurance, non-financial/business, outsourcing, R&D,courier, tech. Testing analysis (DIPP)

3.7 | Venture Capital Investment in Select Countries

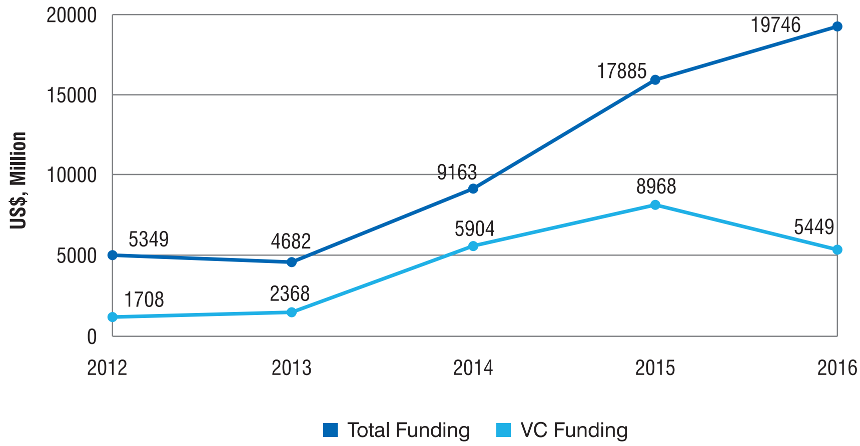


Source: National Science Foundation (NSF), Science & Engineering Indicators 2018, *Invention, Knowledge Transfer and Innovation - Global Venture Capital Investment, by financing stage, selected region, country or economy: 2008-16* for data on China, Germany, Israel, UK and USA; Tracxn data for India for the year 2016, data downloaded on 25 April 2018 from the platform.

Venture Capital (VC) funding into India has grown consistently in the decade between 2006 and 2016. India is now one of the top destinations for VC funding after the USA and China. In 2016, India recorded VC funding totalling around USD 5.4 billion, exceeding that of other economies such as Germany and Israel.

For the purpose of global comparison, the data for India has been obtained from National Science Foundation (NSF) for 2006 and 2011, and from Tracxn for 2016. The NSF data on India for 2016 recorded VC funding at USD 3.5 billion. We have used NSF data for the other countries in our sample.

3.7.1 | Funding for New Startups in India (2012 - 2016)

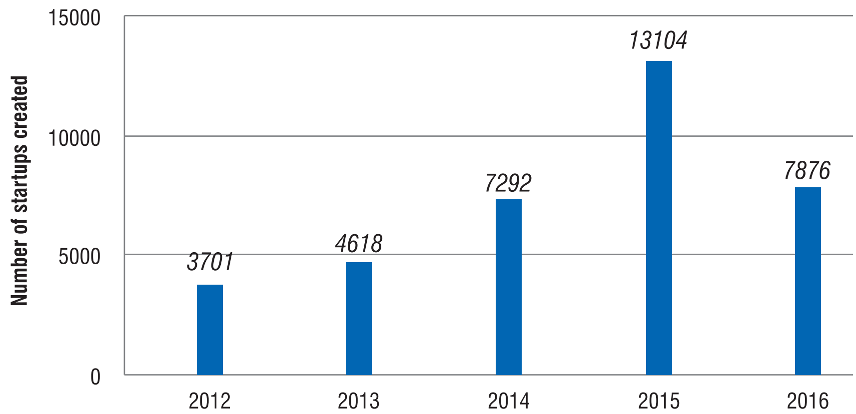


Source: Tracxn (various years), data downloaded on 25 April 2018 from the platform

Note: Total funding includes Venture Capital, Private Equity, Angel, Debt

Total funding for startups (and new companies) in India has increased more than threefold, from around USD 5 billion to more than USD 18 billion between 2012 and 2016. A lot of this growth has been driven by conventional debt financing, amounting to more than 50 percent of total funding in 2016. The details of the breakup of funding into categories like seed funding, various series rounds, etc. can be found in the appendix (Table A.3). VC funding for India in 2016 saw a drop to USD 5.4 billion after having seen a steady increase between 2012 and 2015. The share of VC funding in total funding dropped in 2016 and is closer to the levels seen in 2012. The data on VC funding presented above is provided by Tracxn and includes funding for technology and offline startups (and new companies). The trend captured here is similar to that observed in data from NSF, and the comparison of the two data sources can be found in the appendix (Table A.4).

3.7.2 | Number of Startups Created in India (2012 - 2016)

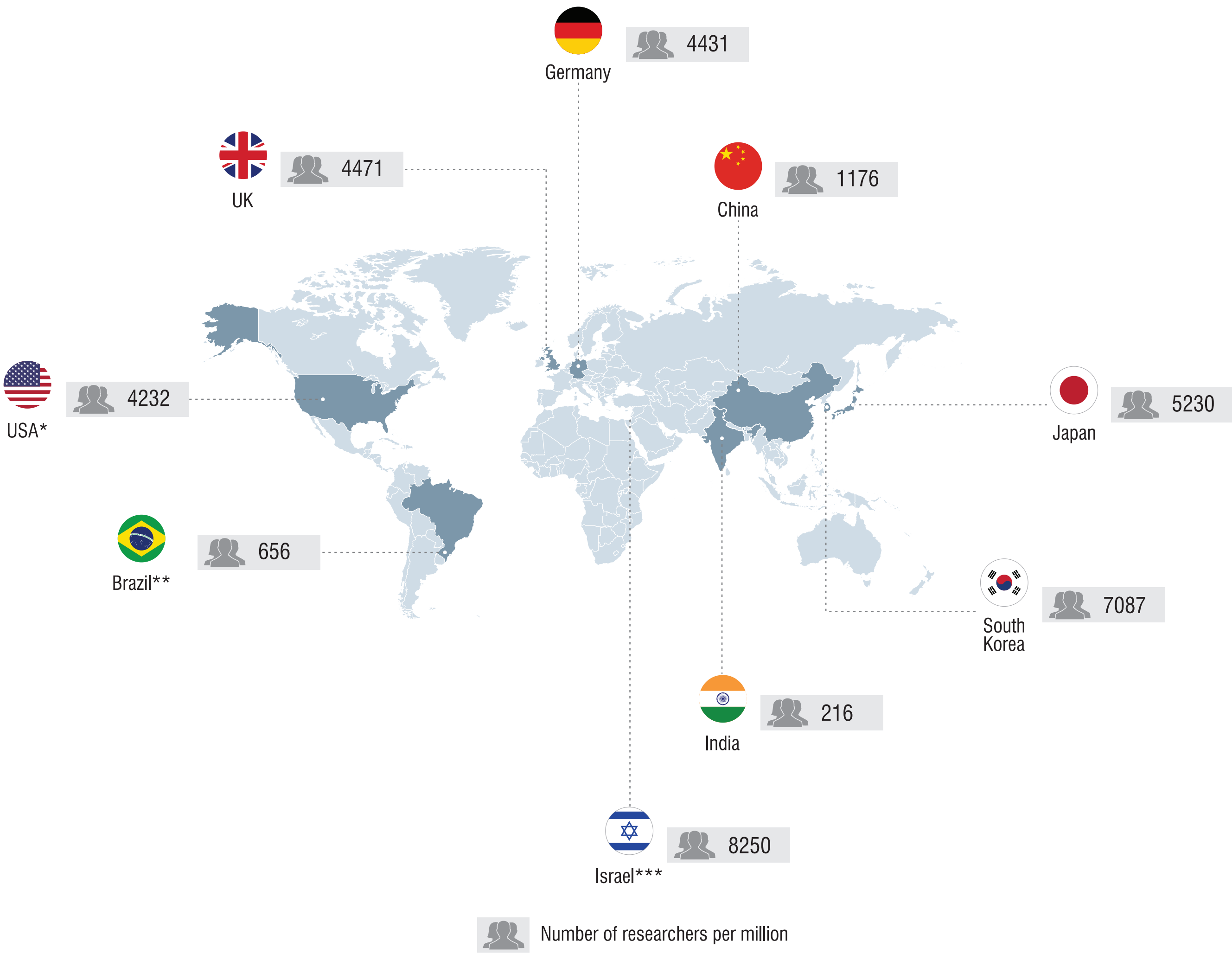


Source: Tracxn (various years), data downloaded on 23 February 2018 from the platform

The number of Indian startups (and new companies) including offline startups in 2016 was 7,876, following a spike in 2015. There has been a steady increase in the number of startups since 2012. The reported startup data (as of February 2018) is subject to change based on when new startups founded in a particular year are identified. The numbers may also vary depending on the source of the data on startups. Details of new companies that conform to the definition of a startup and have registered with Startup India[33] can be found on the website.

[33] See Glossary (B.22)

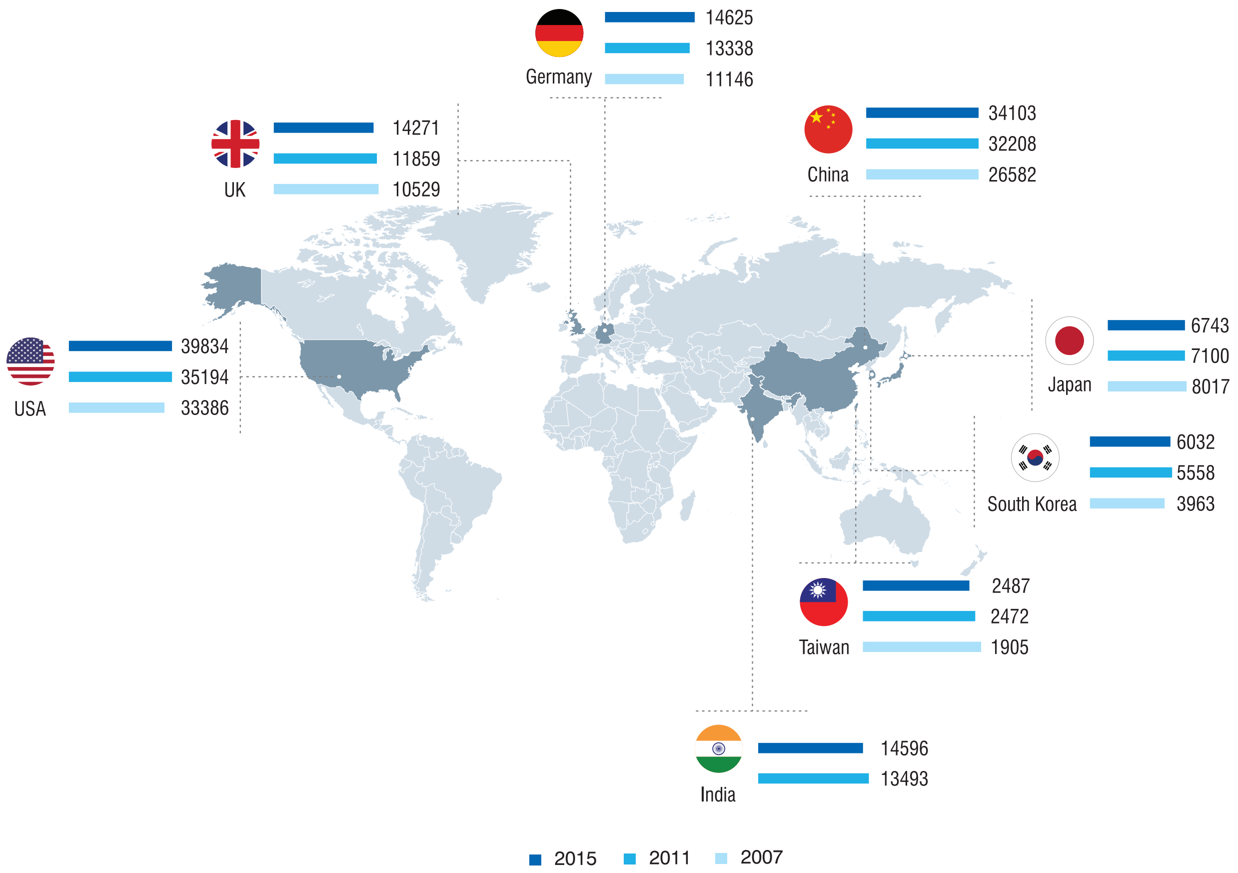
3.8 | Country-wise Comparisons for Full Time Researchers per million (2015)



Source: UNESCO Institute of Statistics (2015), UIS.stat, available at: http://data.uis.unesco.org/ for data on Brazil, China, Germany, India, Japan, South Korea, UK and USA; World Development Indicators (various years), *Indicators,* available at http://data.worldbank.org/ for data on Israel; Centre for Technology, Innovation and Economic Research (CTIER)
*Latest data available for US was for 2014
**Latest data available for Brazil was for 2009
***Latest data available for Israel was for 2012

The number of researchers per million in India was 216 in 2015, significantly below the number of researchers per million in many of the select economies. South Korea has the highest number of researchers per million at 7,087. China has over 5 times the number of researchers per million compared to India.

3.9 | Country-wise Comparisons of Global Science and Engineering (S&E) PhDs



Source: National Science Foundation (NSF), Science & Engineering Indicators 2018, *Higher Education in Science and Engineering - S&E doctoral degrees, by selected Asian country or economy and field: 2000–14; S&E doctoral degrees in the United States and selected European countries or economies, by field: 2000–14,* available at https://www.nsf.gov/statistics/2018/nsb20181/data/appendix; Ministry of Human Resource Development, Department of Higher Education, *All India Survey on Higher Development (AISHE) Report (various years)*

Note: (i) Data for 2007 for India not available
(ii) NSF data for Brazil and Israel not available
(iii) Data reported as 2015 for China, Germany, Japan, South Korea, Taiwan, UK and USA is based on 2014 NSF data

In terms of absolute numbers, the US had 39,834 S&E PhDs, while China had 34,103 S&E PhDs in 2015. India's S&E PhDs at 14,596 in 2015 is comparable to that of Germany that had 14,625. While most countries have seen an increasing trend in the number of S&E PhDs, Japan has seen a decline. India's share of S&E PhDs in total PhDs in 2015 was 60 percent, similar to that observed in most of the other countries under consideration except Japan, South Korea and Germany. For the other countries, the data is based on the numbers reported in the Science & Engineering Indicators, 2018 produced by NSF. The S&E PhDs include the following categories - physical and biological sciences and mathematics and statistics, computer sciences, agricultural sciences, engineering, and social and behavioural sciences.

The data for India is based on the PhD numbers reported in the annual reports of the All India Survey of Higher Education (AISHE). We have considered the following categories reported by AISHE - natural sciences, agricultural sciences, engineering & technology and social science.[34] Data on S&E PhDs for India can also be computed using data from the annual reports of the University Grants Commission (UGC), provided in the appendix (Table A.5). Using UGC data, that includes categories such as science, computer science, engineering/ technology, agriculture, veterinary science, the share of S&E PhDs in total PhDs for India is 53 percent.

[34] Social science includes - History, Sociology, Political Science, Economics, Geography, Psychology, Public Administration, Philosophy, Anthropology, Mathematics, Population Studies, Statistics, Other Social Sciences.

3.9.1 | Degrees Awarded in S&E Degree Programmes in India (2015)

Field	Degrees Awarded in S&E				
	PhD	Postgraduate	Undergraduate	M.Phil	Total
Natural Science	6607	172220	876092	6711	1061630
Agricultural Science	1956	9104	32522	19	43601
Engineering & Technology	2785	114038	849491	95	966409
Medical Science	1226	42012	181735	65	225038
Social Science	3248	229559	139855	3409	376071
Others	8349	838063	4252304	12825	5111541
Grand Total	24171	1404996	6331999	23124	7784290

Source: Ministry of Human Resource Development, Department of Higher Education, *All India Survey on Higher Development (AISHE) Report 2015-16*

For data on Indian S&E PhDs the following categories reported by AISHE have been considered - natural science, agricultural science, engineering & technology and social science. Following from the previous indicator and using the NSF definition of S&E, the number of S&E PhDs awarded stood at 14,596 and accounted for 60 percent of total PhDs awarded in 2015. The S&E PhDs awarded were largely dominated by natural sciences at 6,607. This was followed by social science at 3,248 and engineering & technology at 2,785.

The NSF does not include PhD degrees awarded in medicine when computing the number of S&E PhDs in a country (see Table A.6). We have provided data on PhDs in medicine according to AISHE in the table above and according to UGC in the appendix (Table A.5), although we have also excluded it from the computation of the number of S&E PhDs.

S&E postgraduate[35] degrees awarded accounted for 37 percent of the total number of postgraduate degrees awarded. For postgraduate degrees, social science dominated at 2,29,559 followed by natural science at 1,72,220 and engineering & technology at 1,14,038.

The S&E undergraduate degrees accounted for around 33 percent of the total number of undergraduate degrees awarded in 2015. For undergraduates, natural science dominated at 8,76,092 followed by engineering & technology at 8,49,491 and social science 1,39,855.

[35] Programme after Graduation and generally having the duration of 2/3 years in General/Professional courses (AISHE)

3.9.2 | Enrolment in S&E Degree Programmes in India (2015)

Field	Enrolment in S&E Degree Programmes				
	PhD	Postgraduate	Undergraduate	M.Phil	Total
Natural Science	33197	507320	4377566	10790	4928873
Agricultural Science	4849	22132	183827	63	210871
Engineering & Technology	30587	261065	4250183	62	4541897
Medical Science	5237	130088	899764	175	1035264
Social Science	15885	683907	775781	8222	1483795
Others	36696	2312644	16933329	23211	19305880
Grand Total	126451	3917156	27420450	42523	31506580

Source: Ministry of Human Resource Development, Department of Higher Education, *All India Survey on Higher Development (AISHE) Report 2015-16*

Note: All India Council for Technical Education is an alternate source for approved degree and diploma level intakes for the year 2015-16. Data available at https://www.aicte-india.org/downloads/annual%20report%202015-16.pdf#toolbar=0

The number of S&E PhDs enrolled stood at 84,518 and accounted for 67 percent of total PhDs enrolled in 2015. The S&E PhDs enrolments are largely dominated by natural sciences at 33,197. This is followed by engineering & technology at 30,587 and social sciences at 15,885.

S&E postgraduate degree enrolments accounted for 37 percent of the total number of enrolments. Here, social sciences dominates with 6,83,907 enrolments followed by natural sciences at 5,07,320 and engineering & technology 2,61,065.

S&E undergraduate enrolments account for 35 percent of the total number of enrolments. For undergraduates, natural sciences dominates at 43,77,566 followed by engineering & technology at 42,50,183 and social sciences at 7,75,781.

3.10 | Persons employed (full time equivalent) as Researchers by R&D establishments in India

Name of Establishment	2005			2010			2015		
	R&D Activities	Total	R&D share of total (%)	R&D Activities	Total	R&D share of total (%)	R&D Activities	Total	R&D share of total (%)
A. Institutional Sector									
Major scientific agencies	47587	151658	31.4	57331	138179	41.5	54331	135179	40.2
Central government ministries/ departments	8645	44720	19.3	10030	50070	20	10030	50070	20
State governments	19135	85422	22.4	20544	80949	25.4	21450	78172	27.4
Total institutional sector (A)	75367	281800	26.7	87905	269198	32.7	85811	263421	32.6
B. Higher Education Sector (B)*	22100	22100	-	22100**	22100	-	113074	113074	-
C. Industrial Sector									
Public sector including joint sector	9281	14644	63.4	10701	16180	66.1	10400	15879	65.5
Private sector	42096	55990	75.2	63971	110984	57.6	64446	111459	57.8
SIRO* **	5983	16615	36	8142	22664	35.9	9263	24386	38
Private + SIRO	48079	72605	66.2	72113	133648	54	73709	135845	54.3
Total industrial sector (C)	57360	87249	65.7	82814	149828	55.3	84109	151724	55.4
Total (A+B+C)	154827	391149	39.6	192819	441126	43.7	282994	528219	53.6

Source: Department of Science and Technology (DST), Government of India, *Research and Development Statistics 2017-18*, available at http://dst.gov.in/research-and-development-statistics-2017-18-december-2017, *Research and Development Statistics 2011-12*, available at http://www.nstmis-dst.org/snt-indicators2011-12.aspx; *Higher Education in India - a Data Compendium*, Indicus Foundation (for 2005 data), available at http://www.indicus.org/Higher-Education/Higher-Education-in-India-A-Data-Compendium.pdf
* Data on manpower engaged in auxiliary and administrative activities is unavailable for the higher education sector
** estimated figures
*** Scientific and Industrial Research Organization

The table above considers manpower at R&D establishments in India. It includes manpower engaged in R&D, auxiliary and administrative activities as reported by the Department of Science & Technology (DST). The number of employees engaged in R&D activities as a share of total manpower has grown from 43 percent in 2010 to 53 percent in 2015. This appears to have been driven by an increase in the number of employees engaged in R&D activities in the higher education sector (which saw a four fold jump between 2010 and 2015) and employees engaged in R&D activities in Scientific and Industrial Research Organisations (SIRO).

The data on manpower engaged in auxiliary and administrative activities is unavailable for the higher education sector. The number reported for employees engaged in R&D activities in 2010 was reported by DST as an estimate and was the same as that reported in 2005.

3.11 | Country-wise Comparisons by Share of Publications, Impact and Share of Industry-Academia Collaborations in Total Publications (2012-16)

Country		Global Rank	Share in Global Publication Output (%)	Category Normalized Citation Impact	Share of Industry-Academia Collaborations (%)
Select Advanced Economies	USA	1	26.3	1.3	2.8
	UK	3	7.6	1.4	3.1
	Germany	5	6.2	1.4	4.2
	Japan	6	4.7	0.9	2.9
Select Emerging/ Asian Economies	Brazil	15	2.2	0.8	1.2
	China	2	13.9	0.9	1.5
	India	10	3.5	0.8	0.8
	Israel	29	0.8	1.3	2.4
	South Korea	13	2.8	0.9	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)

India ranked tenth globally in terms of publication output, having contributed 4,39,834 publications or 3.5 percent of the cumulative global publication for the years 2012 to 2016.[36] The country's publication output is higher than other emerging economies like Brazil and South Korea.

The Category Normalized Citation Impact (CNCI) devised by the data analytics software 'InCites' has been used to measure the impact of these publications. CNCI gauges the quality of publications by giving a higher weightage to highly cited papers. India has the lowest CNCI score among the select countries.

In terms of Industry-Academia (I-A) Collaborations, India has the lowest percentage at 0.8 percent of total publications among select countries. Germany has the highest share of I-A collaborations at 4.2 percent followed by South Korea at 3.9 percent. The I-A figures are calculated by dividing publications that have at least one industry co-author by total number of publications.

[36] Values are based on cumulative publication output from 2012-16. Five year cumulative values have been considered to account for the lag between the year a paper is published and when it starts being cited.

3.12 | Country-wise Comparison by Share of Publications, Impact and Share of Industry-Academia Collaborations by Top Sectors of Publication (2012-16)

Sector		1. Electrical & Electronic Engineering			2. Multidisciplinary Materials Science			3. Oncology			4. Applied Physics			5. Biochemistry & Molecular Biology		
Output Indicators		Share in Global Publication Output (%)	Category Normalized Citation Impact	Industry-Academia Collaborations (%)	Share in Global Publication Output (%)	Category Normalized Citation Impact	Industry-Academia Collaborations (%)	Share in Global Publication Output (%)	Category Normalized Citation Impact	Industry-Academia Collaborations (%)	Share in Global Publication Output (%)	Category Normalized Citation Impact	Industry-Academia Collaborations (%)	Share in Global Publication Output (%)	Category Normalized Citation Impact	Industry-Academia Collaborations (%)
	Global Average	-	0.95	3.87	-	1.03	2.19	-	1.08	2.59	-	0.95	2.74	-	1.04	1.23
Select Advanced Economies	USA	18.0	1.48	8	14.7	1.52	4.09	35.5	1.6	5.41	19.3	1.32	4.51	35.2	1.34	1.78
	UK	4.3	1.27	4.94	3.7	1.41	3.85	6.9	2.01	8.81	4.6	1.23	3.32	6.9	1.63	3.37
	Germany	4.8	1.28	8.88	5.5	1.38	4.12	7.3	1.68	9.31	7.8	1.3	4.19	7.5	1.42	2.8
	Japan	6.2	0.76	6.73	5.4	1.09	4.35	6.7	1.2	4.2	9.1	0.87	5.48	6.9	0.94	1.51
Select Emerging/Asian Economies	Brazil	1.6	0.75	2.08	1.3	0.7	1.11	1.1	1.44	6.05	1.1	0.69	0.91	2.5	0.72	0.47
	China	21.8	0.79	2.96	37.8	0.9	1.38	14.1	0.92	1.24	22.1	0.99	1.35	14.1	0.89	0.51
	India	7.4	0.6	1.15	5.4	0.9	0.49	1.8	0.69	2.04	5.7	0.69	0.67	3.6	0.78	0.49
	Israel	0.6	1.24	6.23	0.5	1.26	1.76	0.9	1.92	6.87	0.7	1.06	2.7	1.2	1.24	1.6
	South Korea	4.0	0.86	8.28	5.8	1.02	5.92	3.3	1.82	8.7	6.3	0.81	6.72	3.5	0.88	2.16

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)

We have considered the top 10 sectors by cumulative global publication output in the table above for the years 2012 to 2016. India is the third largest contributor to electrical & electronic engineering publications at 7.4 percent of the total output in this sector (after China and USA). Electrical & electronic engineering is the sector with the highest number of global publications. India's cumulative publication output is comparable to advanced economies like Germany and Japan in sectors such as material sciences and multidisciplinary chemistry.

We have noted in Indicator 3.11 that India's share of publications in total global publications is 3.5 percent. In sectors such as applied physics and physical chemistry, India has a higher share of publications in cumulative global publication output compared to sectors such as oncology, neurosciences, surgery and clinical neurology. India's share of output in biochemistry & molecular biology is close to its overall share of publications in total cumulative global publications.

6. Multidisciplinary Chemistry			7. Neurosciences			8. Physical Chemistry			9. Surgery			10. Clinical Neurology		
Share in Global Publication Output (%)	Category Normalized Citation Impact	Industry-Academia Collaborations (%)	Share in Global Publication Output (%)	Category Normalized Citation Impact	Industry-Academia Collaborations (%)	Share in Global Publication Output (%)	Category Normalized Citation Impact	Industry-Academia Collaborations (%)	Share in Global Publication Output (%)	Category Normalized Citation Impact	Industry-Academia Collaborations (%)	Share in Global Publication Output (%)	Category Normalized Citation Impact	Industry-Academia Collaborations (%)
-	1.07	1.45	-	1.09	1.53	-	1.17	1.89	-	0.9	0.45	-	0.98	1.67
26.9	1.24	2.09	36.6	1.4	2.41	20.4	1.54	2.99	34.5	1.2	0.74	32.5	1.26	3.52
4.2	1.53	4.95	9.2	1.58	4.05	4.9	1.32	3.35	9.4	0.97	0.58	9.0	1.6	4.66
5.8	1.47	3.52	9.3	1.44	3.84	7.8	1.2	3.25	6.2	1.05	1.67	7.7	1.48	6.7
5.5	1.15	2.26	5.5	0.81	2.22	6.1	1.02	3.33	6.2	0.8	0.42	4.9	0.78	1.62
1.4	0.48	1.05	2.5	0.84	0.5	1.8	0.72	0.98	2.2	0.71	1.11	1.8	0.92	0.87
23.8	1.39	0.78	7.5	0.92	0.66	25.6	1.47	1.41	5.4	0.73	0.2	4.2	0.82	1.01
5.9	0.68	0.34	1.4	0.78	0.82	5.9	0.9	0.35	2.0	0.55	0.29	1.7	0.67	1.01
0.6	1.4	1.27	1.6	1.02	2.35	0.9	1.24	1.17	0.6	0.96	0.63	1.0	1.06	5.34
5.4	1.09	3.46	2.3	0.84	2.22	4.5	1.55	5.55	3.8	0.68	0.93	3.2	0.75	1.97

Despite having a higher share of publication output in some of the sectors mentioned, India has a lower CNCI score than the global average for all the sectors.

With respect to I-A collaborations, as seen in Indicator 3.11, India's I-A collaborations for its total publication output is 0.8 percent. In sectors such as electrical & electronic engineering and oncology, it has a higher share of I-A collaborations at 1.2 percent and 2 percent respectively. However, as we shall see in Indicator 3.12.1, oncology is not one of the top areas of publication output for India.

3.12.1 | India's Top Areas of Cumulative Publications (2012-16) - Impact and Industry-Academia Collaborations and their Respective Comparisons with Global Averages

Rank	Top areas of Indian publication	Indian publications	Indian Share of World publications (%)	World CNCI	Indian CNCI	World Industry Collaboration (%)	Indian Industry Collaboration (%)
1	Electrical & Electronic Engineering	67581	7.4	0.95	0.6	3.87	1.15
2	Multidisciplinary Materials Science	30881	5.4	1.03	0.9	2.19	0.49
3	Computer Science, Theory & Methods	25440	9.2	1.07	0.83	2.94	1.21
4	Multidisciplinary Chemistry	23491	5.9	1.07	0.68	1.45	0.34
5	Applied Physics	23425	5.7	0.95	0.69	2.74	0.67
6	Telecommunications	21005	9.2	0.96	0.61	4.59	1.19
7	Physical Chemistry	18090	5.9	1.17	0.9	1.89	0.35
8	Computer Science, Artificial Intelligence	16718	7.4	1.16	0.76	2.36	1.04
9	Computer Science, Information Systems	15969	7.1	0.98	0.72	3.33	1.32
10	Biochemistry & Molecular Biology	14768	3.6	1.04	0.78	1.23	0.49

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: Cumulative publication output for India during the period 2012 to 2016 was 439834.

The total cumulative publication output for India during the period 2012-2016 was 4,39,834. Of the top 10 global sectors seen in Indicator 3.12, six global sectors are among the top 10 sectors for India as well. The electrical & electronic engineering sector contributed 15 percent of India's total publication output during the period under consideration, followed by multidisciplinary materials science at 7 percent.

India has a lower CNCI score and I-A share compared to the global average for each of its top 10 sectors by publication output.

Although India's contribution to the publication output in the Electrical & Electronic Engineering sector is one of the largest after China and the US, Indian firms are conspicuous by their absence from this sector for global industrial R&D.[37]

[37] See Indicator 3.4

3.13 | Ranking of Institutions in India by Number of Publications (2012-16)

Rank	Name	Number of Publications	Category Normalized Citation Impact	Industry Collaborations (%)
1	Council of Scientific & Industrial Research (CSIR)	32443	0.92	0.36
2	Anna University	11422	0.69	0.15
3	Indian Institute of Science (IISC) - Bangalore	11009	0.93	2.17
4	Indian Institute of Technology (IIT) - Kharagpur	8903	0.93	0.9
5	Indian Institute of Technology (IIT) - Bombay	8236	1.01	1.68
6	Bhabha Atomic Research Centre	8124	1.08	0.52
7	Indian Institute of Technology (IIT) - Delhi	7456	0.89	1.64
8	Indian Institute of Technology (IIT) - Madras	7163	0.88	1.48
9	University of Delhi	6605	0.83	0.41
10	All India Institute of Medical Sciences	6511	1.07	0.65
11	Jadavpur University	6388	0.84	0.22
12	Banaras Hindu University	6308	0.89	0.21
13	Indian Institute of Technology (IIT) - Roorkee	6019	1.01	0.37
14	Indian Institute of Technology (IIT) - Kanpur	5944	0.93	1.28
15	Defence Research & Development Organisation (DRDO)	5138	0.62	0.14

Highest Rank   Lowest Rank

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)

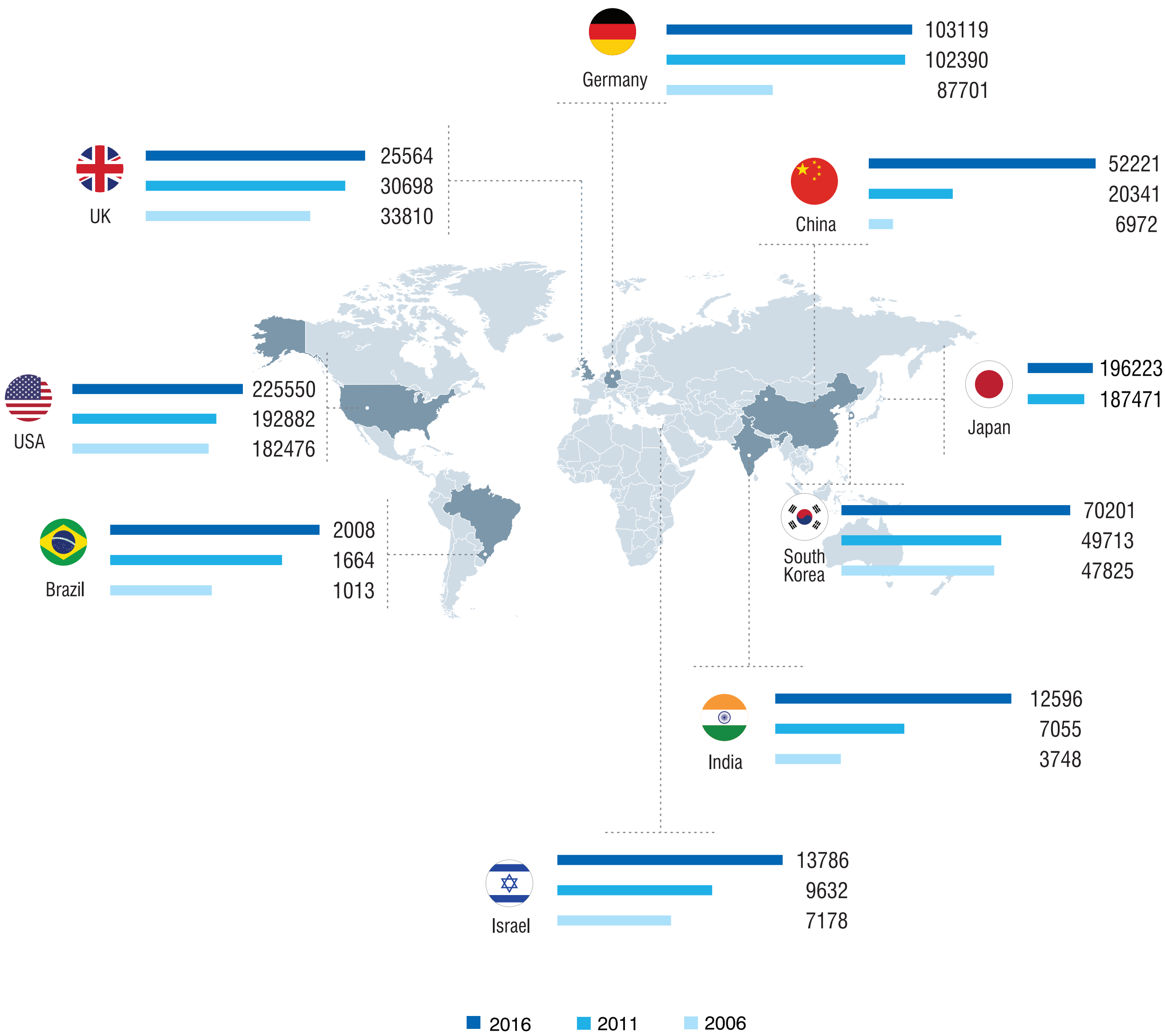
Note: (i) Data is based on cumulative publications by each institution (2012-2016)
(ii) Publications for Anna University include those represented by Anna University Chennai in the Web of Science database

The top 15 Indian institutes have been ranked by cumulative publication output for the years 2012 to 2016. The Council of Scientific & Industrial Research (CSIR) is ranked first in terms of publication output, followed by Anna University. There are six Indian Institutes of Technology (IIT) that feature in the list of the top 15 institutes.

In terms of impact as measured by CNCI, the Bhabha Atomic Research Centre ranks first followed by the All India Institute of Medical Sciences (AIIMS).

With respect to I-A collaborations, the Indian Institute of Science (IISc) Bangalore has the highest share at 2.2 percent, followed by IIT Bombay and IIT Delhi with 1.7 percent and 1.6 percent respectively.

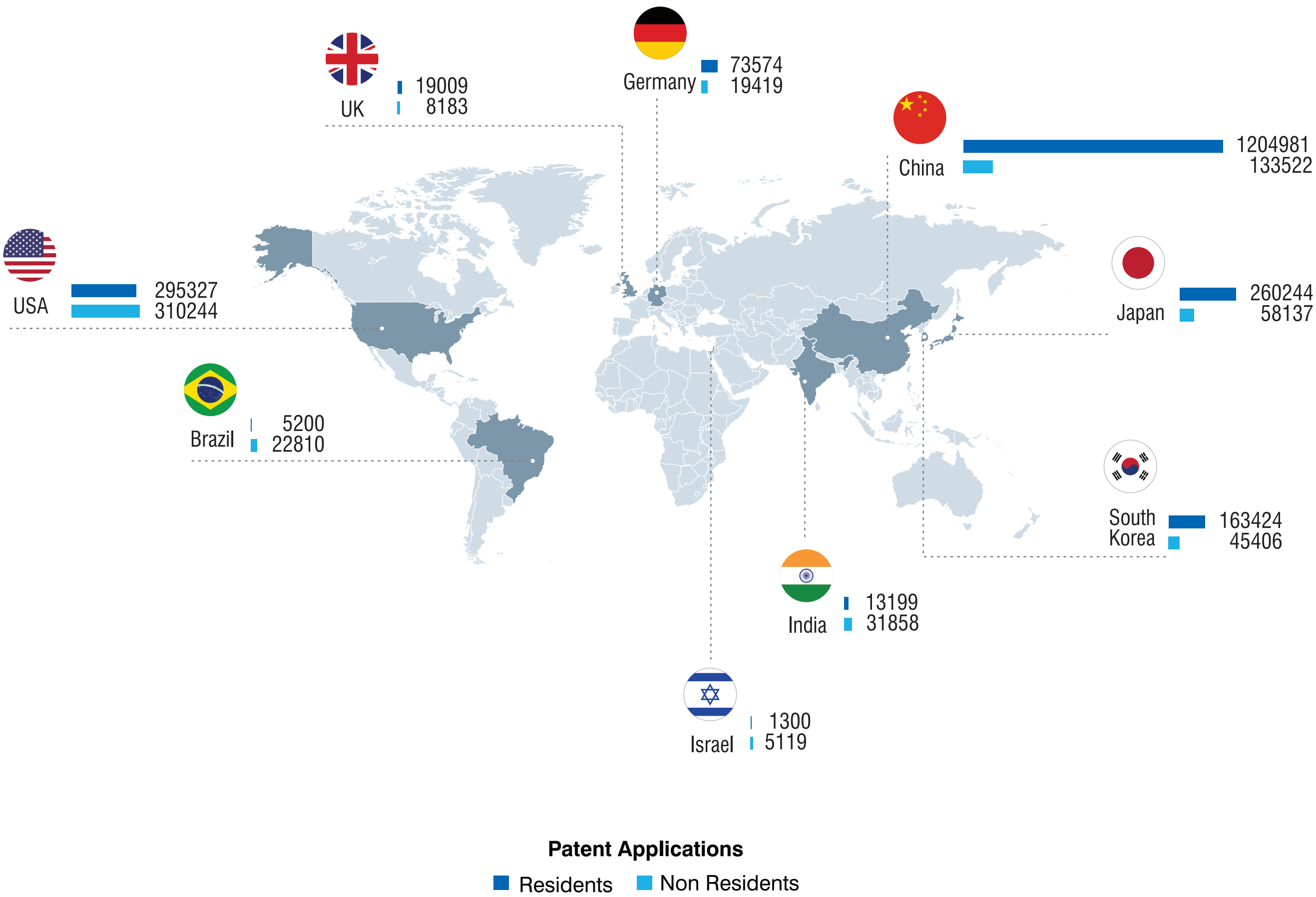
3.14 | Country-wise Comparisons for Patent Applications Filed Abroad



Source: World Intellectual Property Organization (WIPO) Statistical Country Profiles, available at http://www.wipo.int/ipstats/en/statistics/country_profile/

India has seen patent applications filed abroad increase over three fold to 12,596 in 2016 compared to 3,748 in 2006. This follows China's seven fold increase between 2006 and 2016 in the number of patent applications filed abroad. In absolute numbers, USA and Germany continue to dominate the number of patent applications filed. The strong growth rates for patent applications filed abroad that most countries in our sample observed between 2006 and 2011 continued between 2011 and 2016, except for Germany that saw a marginal increase between 2011 and 2016. USA and South Korea have seen a strong pick up in the growth in filings abroad between 2011 and 2016 compared to the previous five year period.

3.15 | Country-wise Comparisons for Patent Applications with Respective Domestic Patent Offices (2016)

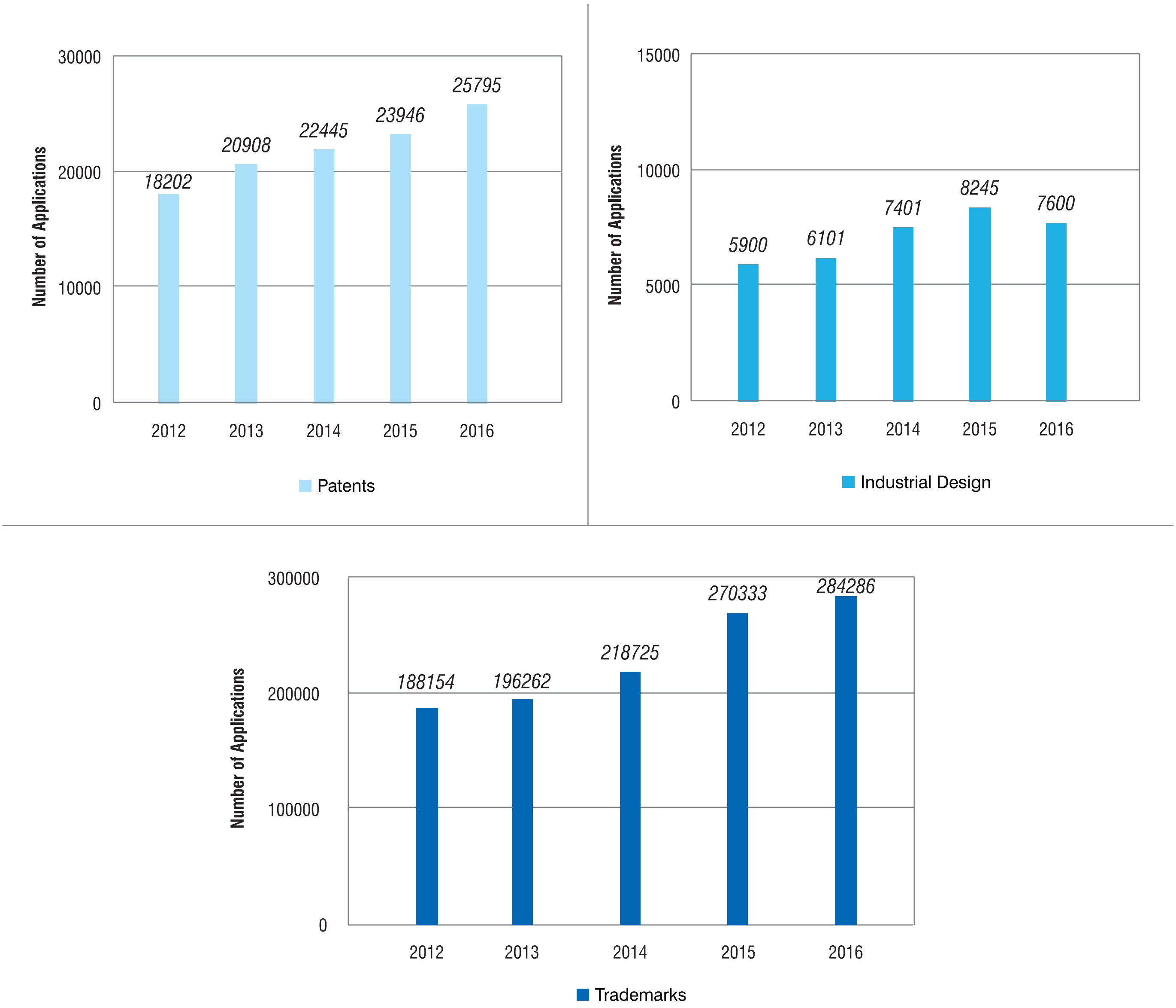


Source: World Intellectual Property Organization (WIPO) Statistical Country Profiles, available at http://www.wipo.int/ipstats/en/statistics/country_profile/

Note: (i) Resident includes domestic filings
(ii) Non-resident includes filings coming in from overseas

Non-resident patent applications with the Indian Patent Office were higher than resident patent applications in 2016. There were around 32,000 non-resident applications and close to 13,000 resident applications. In a majority of the countries in our sample, resident patent applications outnumber non-resident patent applications, most notably in China.

3.16 | Applications for Patents, Industrial Design and Trademarks from India (2012-16)

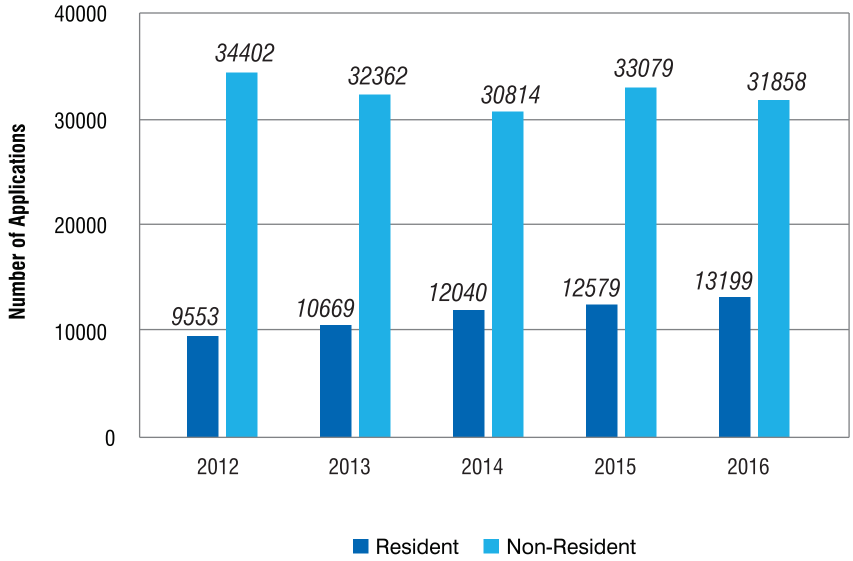


Source: World Intellectual Property Organization (WIPO) Statistical Country Profiles for data on India available at http://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=IN

Note: Intellectual Property filings include resident and abroad

Applications for Patents and Trademarks from India have increased over the five years from 2012 to 2016. The patent applications in the figure above includes filings by residents with the Indian Patent Office as well as filings with patent offices abroad. The applications for industrial designs slowed in 2016 after having seen an increase from 2012 until 2015.

3.17 | Patent Applications with Indian Patent Office by Residents and Non-Residents (2012-16)

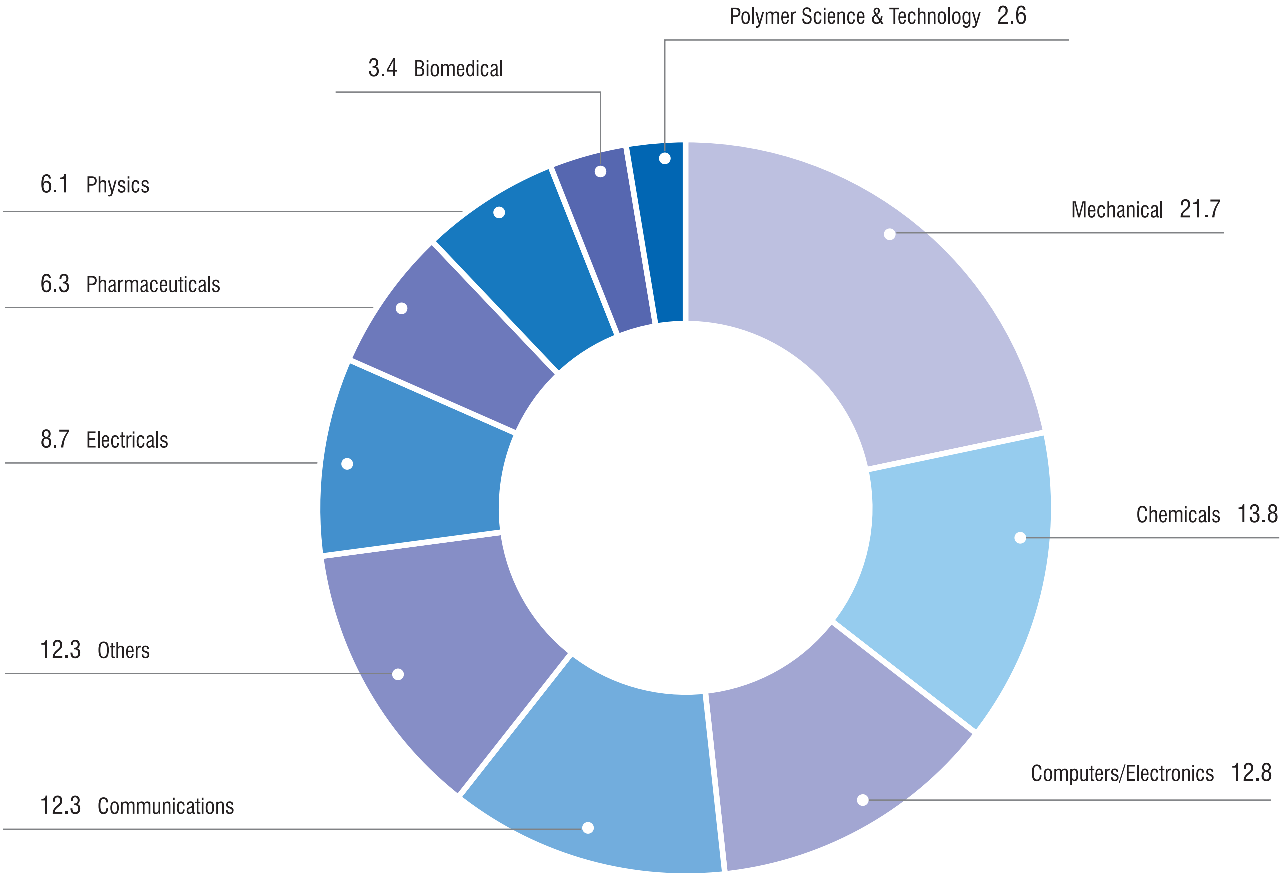


Source: World Intellectual Property Organization (WIPO) Statistical Country Profiles for data on India available at http://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=IN

Note: (i) Resident includes domestic filings
(ii) Non-resident includes filings coming in from overseas

Non-resident patent applications with the Indian Patent Office have consistently been higher than resident patent applications. The number of non-resident patent applications have been in a range between 30,000 to 35,000 over the 5 years between 2012 and 2016, whereas there has been a steady increase in the resident patent applications from 9,553 in 2012 to 13,199 in 2016, resulting in a gradual increase in the share of resident patent applications in total patent application with the Indian Patent Office.

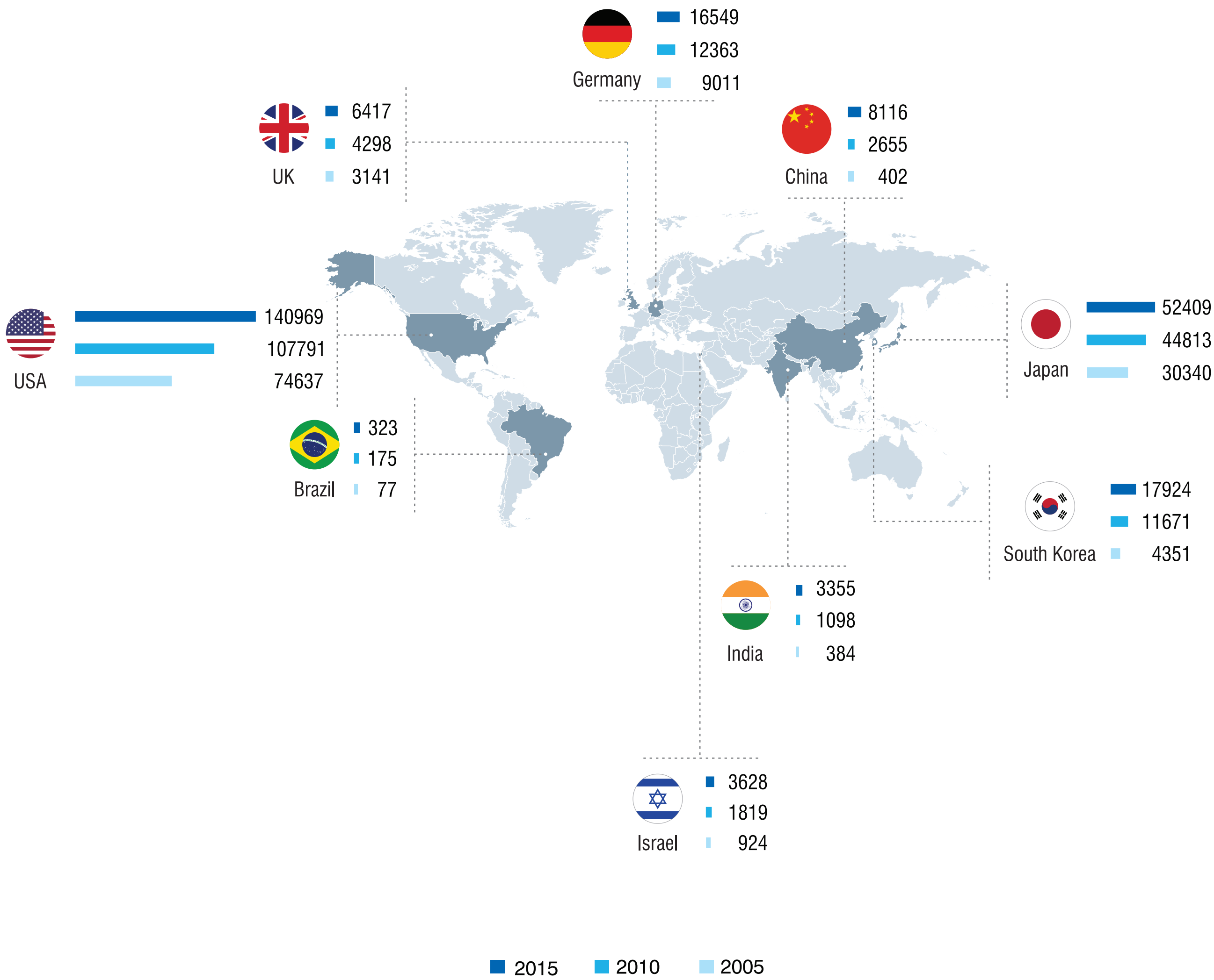
3.18 | Patent Applications with Indian Patent Office by Sector (2016)



Source: The Office of the Controller General of Patents, Designs, Trademarks, and Geographical Indicators, Government of India, *Annual Report 2015-16*

Patent applications by field of technology with the Indian Patent Office are largely concentrated in Mechanical, Chemicals and Electronics sectors.

3.19 | Patents Granted by the United States Patent and Trademark Office (USPTO) to Select Countries

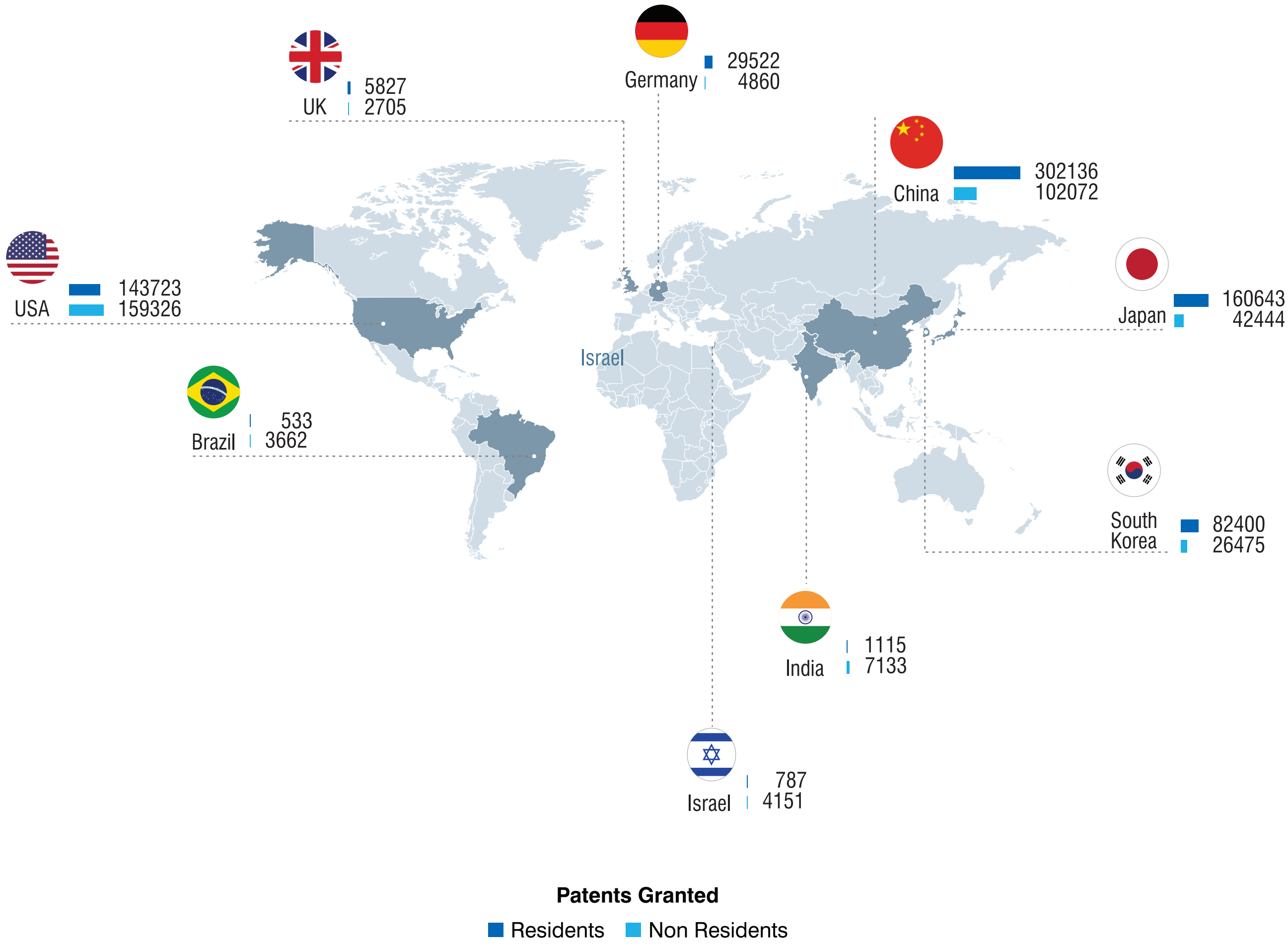


Source: United States Patent and Trademark Office (USPTO), Patent Counts By Country, State, and Year - Utility Patents (December 2015), available at https://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_utl.htm; Centre for Technology, Innovation and Economic Research (CTIER)

Between 2005 and 2015, patents granted by the USPTO to applicants from India increased from 384 to 3,355. For India, a major driver of this has been the multinational corporations (MNCs) that are based in India. In 2015, we found that MNCs accounted for over 70 percent of the total patents that were granted to India.[38] The list of the top 10 MNC patentees present in India can be found in Indicator 5.10. Data for our sample of countries on patents granted abroad can be found in Appendix (Table A.7).

[38] Number of patents granted by USPTO to MNCs based in India was 2,441 in 2015.

3.20 | Country-wise Comparisons for Patents Granted by Respective Domestic Patent Offices (2016)

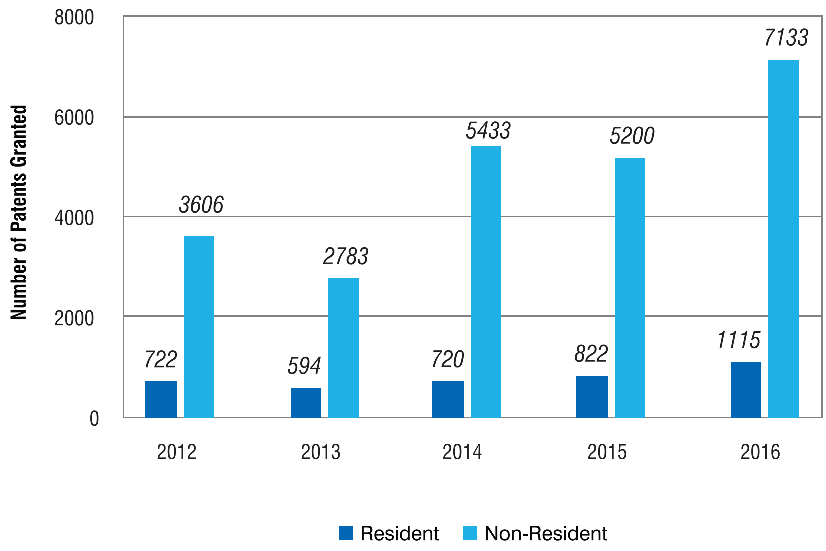


Source: World Intellectual Property Organization (WIPO) Statistical Country Profiles, available at http://www.wipo.int/ipstats/en/statistics/country_profile/

Note: (i) Resident includes domestic filings
(ii) Non-resident includes filings coming in from overseas

There were 1,115 patents granted to resident applicants, and 7,133 patents granted to non-resident applicants by the Indian Patent Office in 2016. Similar to the trend in patent applications, a majority of the countries in our sample had more residents being granted patents compared to non-residents by their respective patent offices. In countries like China and South Korea, the number of residents who were granted patents by their respective patent offices was almost three times the number of non-residents, while in Japan this was nearly four times and in Germany six times.

3.21 | Patents Granted by the Indian Patent Office to Residents and Non-Residents (2012-16)

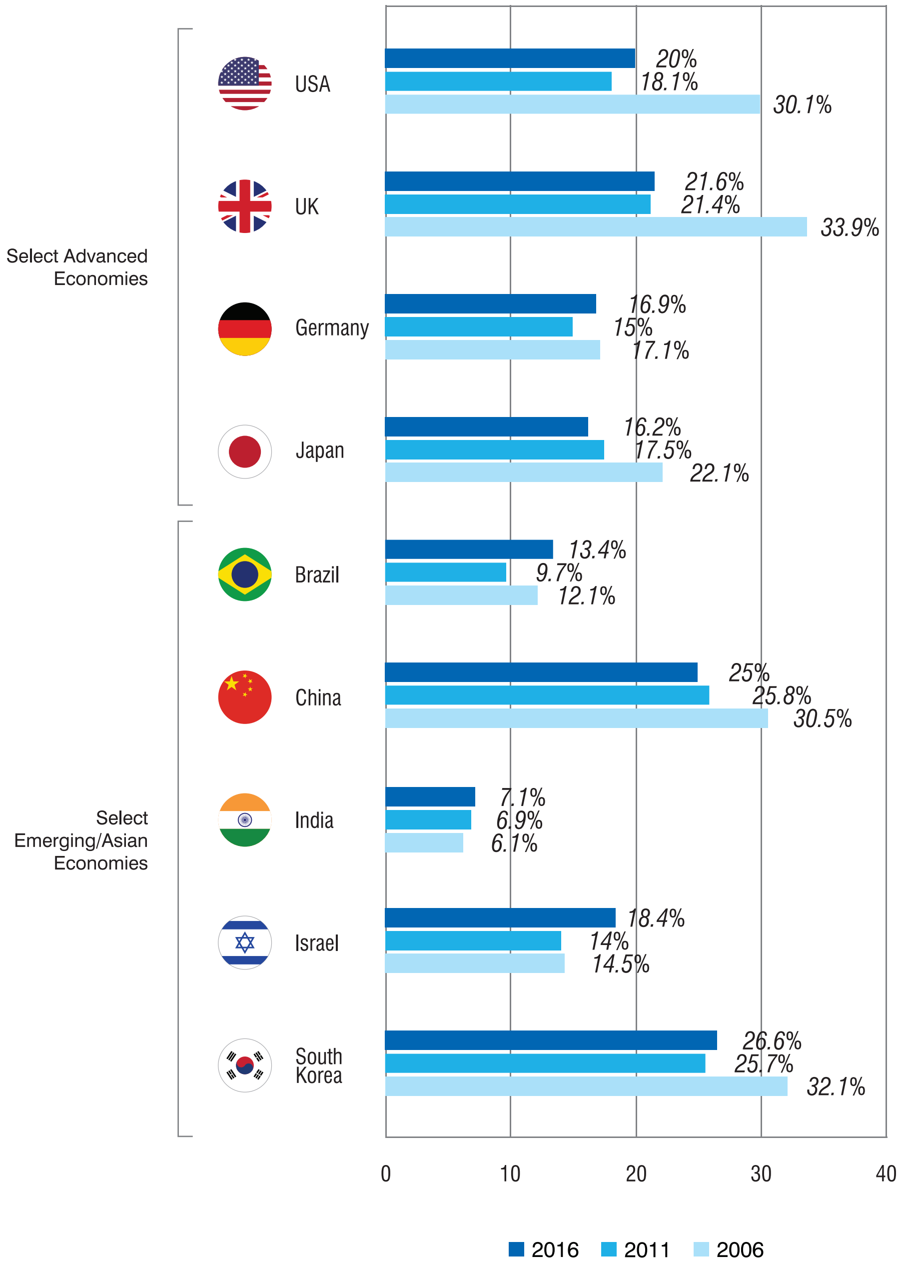


Source: World Intellectual Property Organization (WIPO) Statistical Country Profiles - India available at http://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=IN

Note: (i) Resident includes domestic filings
(ii) Non-resident includes filings coming in from overseas

As with the patent applications data, grants to non-residents by the Indian Patent Office outnumbered the grants to residents. While, the number of patents granted to non-residents and residents respectively were significantly higher in 2016 compared to 2012, the growth in number of patents for non-residents was higher compared to that for residents over the period under consideration.

3.22 | High Technology Exports as Share of Manufactured Exports for Select Countries



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

India's share of high technology exports in manufactured exports increased to 7.1 percent in 2016 compared to 6.1 percent in 2006. Compared to the other select economies, India has the lowest share of high technology exports in manufactured exports. Countries like South Korea, China, UK and USA have shares of high technology exports that are greater than 20 percent.

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Chapter 4

Regional Innovation Systems

This chapter is intended to provide an overview of the innovation systems of India's states. The work on regional innovation systems has become increasingly prominent, and focuses on the innovative capacity of firms and the institutions around them. The reader should be aware that these are however, still newly developing ecosystems and data availability and reliability will evolve over time to allow for better analysis.

Number	Indicator
4.1	Select Policies Introduced by States
4.2	State-wise Distribution of Industrial R&D Centres
4.2.1	State-wise Distribution of Select Higher Technology and Knowledge Intensive R&D Centres
4.3	Foreign Direct Investment into India for Select States (2015-16 and 2016-17)
4.4	Funding for Startups in Top Indian States (2016)
4.4.1	State-wise Distribution of Startups (and New Companies) (2016)
4.5	State-wise Number of Incubation Centres
4.6	State-wise Gross Enrolment Ratio in Higher Education (2015-16)
4.7	State-wise Pupil Teacher Ratio in Higher Education (2015-16)
4.8	State-wise Number of Institutes in Top 100 under the National Institute Rankings Framework (2017)
4.9	State-wise Number of Institutes of National Importance (2017)
4.10	Patent Applications Filed from Select States with Indian Patent Office

Chapter 04

Regional Innovation Systems

4.1 | Select Policies Introduced by States

State	Biotech Policy	Industrial Policy	IT Policy	MSME Policy	Startup Policy
Andhra Pradesh	2015-20	2015-20	2014-20	2015-20	2014-20
Arunachal Pradesh		2008	-	-	-
Assam	2018-22	2014-19	2017	-	2017
Bihar	-	2016	2011	-	2017
Chattisgarh	-	2014-19	2014-19	-	2015
Goa	-	2014	2015	-	2017
Gujarat	2016-21	2015	2016-21	2016	2016-21
Haryana	-	2015	2017	2016	2017
Himachal Pradesh	-	2017	-	-	2016
Jammu and Kashmir	-	2016	-	-	-
Jharkhand	-	2016	2016	-	2016
Karnataka	2017-22	2014-19	2011	-	2015-20
Kerala	2003	2017	2017	-	2014
Madhya Pradesh	2003	2014	2016	-	2016
Maharashtra	2001	2013-18	2015	-	2017
Manipur	-	2017	2015	-	-
Meghalaya	-	2016	-	-	-
Mizoram	-	2012	-	-	-
Nagaland	-	2000	2011	-	-
Odisha	2016	2015	2014	2016	2016
Punjab	-	2017	-	-	-
Rajasthan	2015	2014	2015	2015	2015
Sikkim	-	-	-		-
Tamil Nadu	2014	2014	-	2016-17	-
Telangana	2015-20	2016	2016	-	2016
Tripura	-	2007	2017	-	-
Uttar Pradesh	2014	2017	2017-22	-	2017-22
Uttarakhand	-	2016	2016-25	2015	2017
West Bengal	-	2013	2012	2013-18	2016-21

Source: Startup India Hub, available at https://www.startupindia.gov.in/; Invest India, available at https://www.investindia.gov.in/; Various State Government Websites; News Reports; Centre for Technology, Innovation and Economic Research (CTIER)

Most states have an Industrial policy. A larger number of states have started adopting startup policies while some of the states have a policy for Micro, Small & Medium Enterprises (MSME).

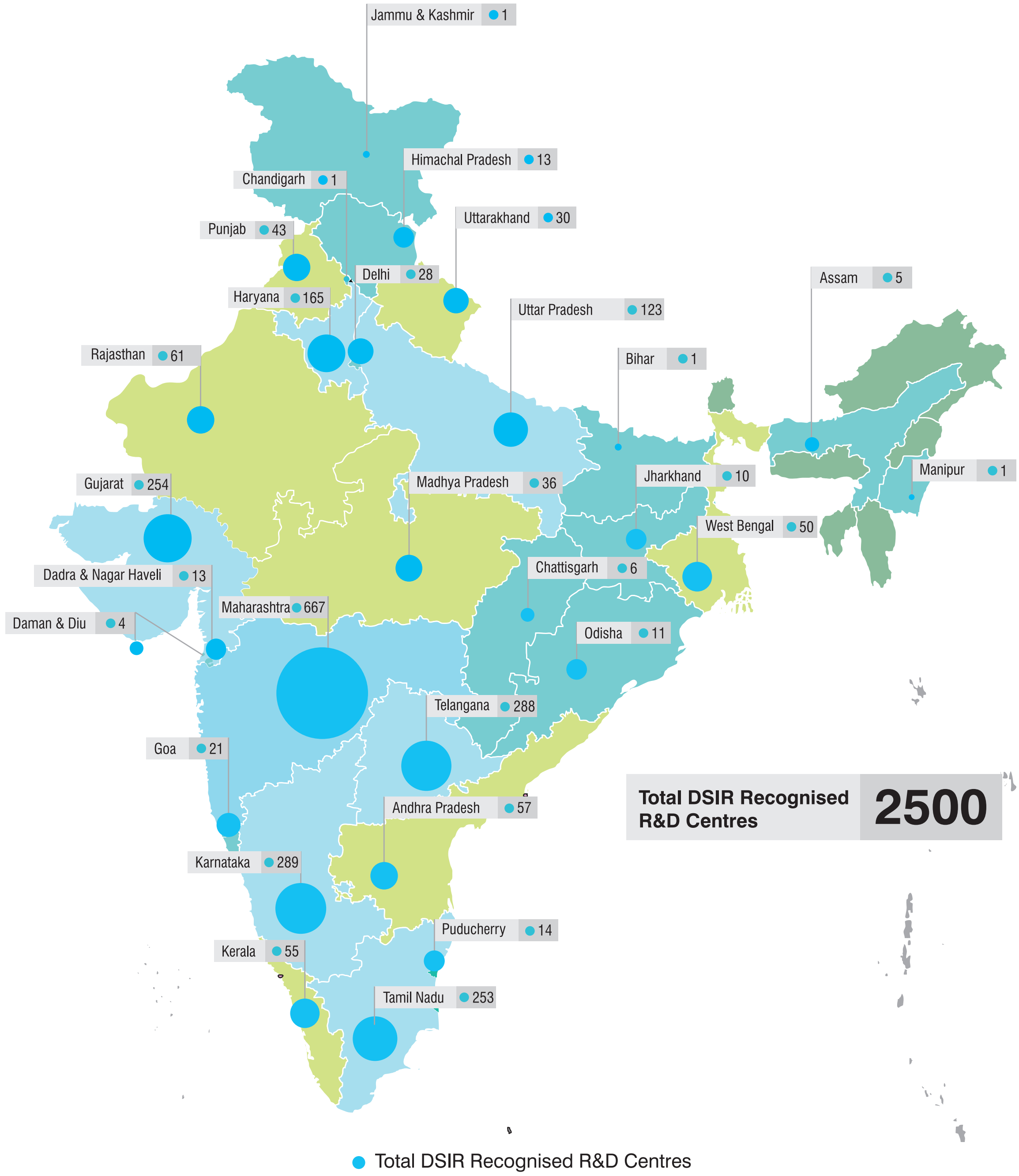
Among the higher technology and knowledge intensive policies, the most common across the states are the Biotechnology and Information Technology (IT) policies respectively. However, a few of the states

Renewable Energy Policy (Particulars)	Automobile & Auto-components	ICT	Aerospace & Defence
Solar (2015), Wind (2015)	2015-20	-	2015-20
-	-	-	-
Solar (2017), small Hydro (2007)	-	-	-
Solar (2012), Wind (2012), Biomass (2011), Hydro (2011)	-	-	-
Solar (2017)	-	-	-
Solar (2017)	-	-	-
Solar (2015), Wind (2016), Hydro (2016), Waste to Energy (2016)	-	-	2016
Solar (2016)	-	-	-
Solar (2016)	-	-	-
Solar (2013), small Hydro (2016), Waste to Energy (2016)	-	-	-
Solar (2015), Hydro (2012), Biomass (2012), Waste to Energy (2012)	2016	-	-
Solar (2014). Wind (2009), Biomass (2009), Hydro (2009)	-	2011	2013-23
Solar (2013), small Hydro (2012)	-	-	-
Solar (2012), Wind (2012), Biomass (2011), small Hydro (2011)	-	-	-
Solar (2015), Waste to Energy (2015), Bagasse (2015), Wind (2015), Biomass (2015)	-	-	2018
Solar (2014)	-	-	-
-	-	-	-
Solar (2017)	-	-	-
-	-	-	-
Solar (2016), Wind (2016), small Hydro (2016), Biomass (2016), Waste to Energy (2016)	-	2014	-
Solar (2012), Hydel (2012), Biomass (2012), Wind (2012), Waste to Energy (2012)	-	-	-
Solar (2014), Wind (2012), Biomass (2010)	-	-	-
-	-	-	-
Solar (2012)	2014	-	-
Solar (2015)	-	2016	-
-	-	-	-
Solar (2017)	-	-	2017
Solar (2013)	-	2016-25	-
Solar (2012), Wind (2012), Biomass (2012), Hydel (2012), Waste to Energy (2012)	-	2012	-

have introduced other higher technology policies like an Aerospace and Defence policy in Andhra Pradesh, Gujarat and Maharashtra, an Aerospace policy in Karnataka and an Automobiles & Auto Components policy in Andhra Pradesh, Jharkhand and Tamil Nadu.

The data on state policies has been collated from individual state government websites, Invest India and the Startup India websites.

4.2 | State-wise Distribution of Industrial R&D Centres

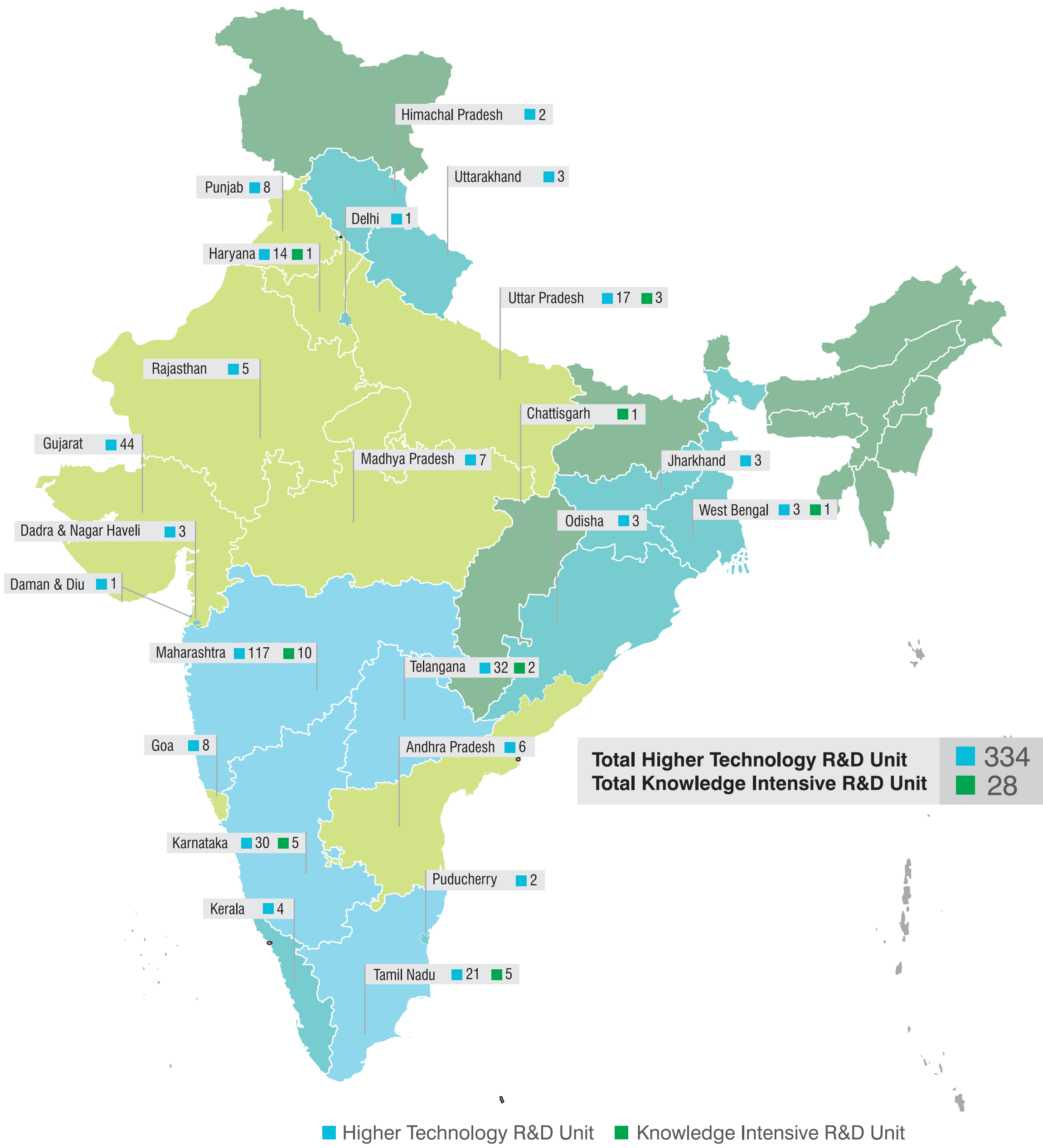


Source: Department of Scientific and Industrial Research (DSIR), Government of India, *Directory of In-house recognized R&D Units (various years);* Centre for Technology, Innovation and Economic Research (CTIER)

Note: Telangana was formed in the year 2014. Prior to 2014, data for Telangana was covered under Andhra Pradesh

The 2016 Directory of Recognized In-house R&D Units published by the Department of Scientific and Industrial Research (DSIR) had around 1,900 firms with one or more registered R&D units. Around 315 firms were found to have multiple R&D units. We identified the locations of 2,500 R&D units across various states as shown in the figure above. Maharashtra has the highest number of these R&D units, accounting for close to 27 percent of the 2,500 recognized R&D units. Karnataka, Telangana, Gujarat and Tamil Nadu are some of the other top locations for the DSIR recognised R&D units.

4.2.1 | State-wise Distribution of Select Higher Technology and Knowledge Intensive R&D Centres



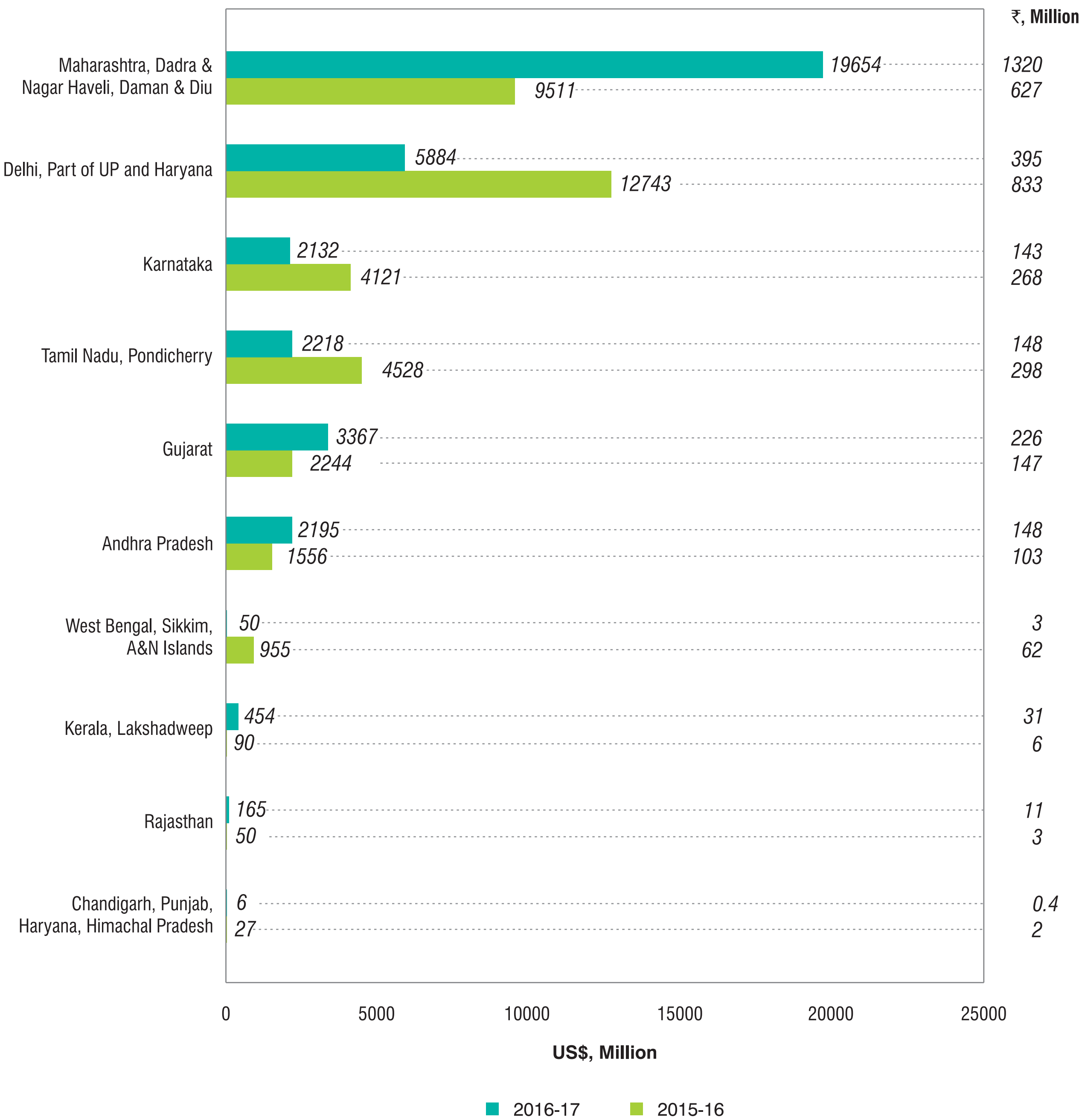
Source: Department of Scientific and Industrial Research (DSIR),Government of India, *Directory of In-house recognized R&D Units (various years);* Centre for Technology, Innovation and Economic Research (CTIER)

Note: (i) The DSIR registered R&D centres of the top 150 R&D spenders were classified into higher technology and knowledge intensive R&D centres. Firms were then added to ensure that total spending of firms captured for each sector represented at least 85 percent of R&D spending for a particular sector. The firms were segregated into higher technology and knowledge intensive on the basis of ISIC Rev 4.
(ii) Telangana was formed in the year 2014. Prior to 2014, data for Telangana was covered under Andhra Pradesh

The R&D units of the firms that were classified as Higher Technology and Knowledge Intensive above are based on the definition according to the International Standard Industrial Classification (ISIC) Rev 4[39], and were from our sample of 218 firms that account for around 90 percent of industrial R&D in India (see Indicator 3.4.1). Maharashtra has the highest number of Higher Technology and Knowledge Intensive R&D units at 117 and 10 respectively.

[39] See glossary (B.5)

4.3 | Foreign Direct Investment into India for Select States (2015-16 and 2016-17)



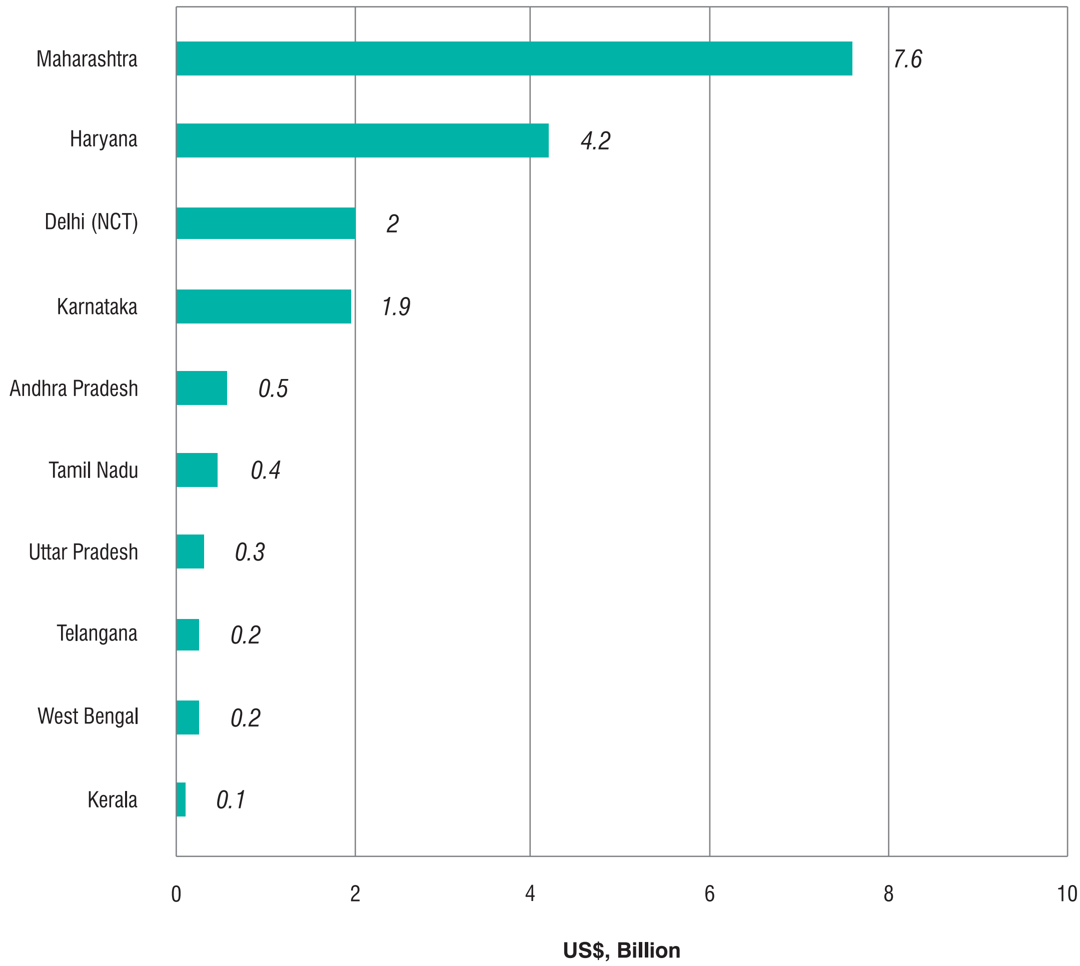
Source: Department of Industrial Policy and Promotion (DIPP), Government of India, *Quarterly FDI factsheet, December 2017*; Centre for Technology, Innovation, and Economic Research (CTIER)

In 2016-17, Maharashtra[40] was the top recipient of FDI inflows totalling USD 19.7 billion, followed by Delhi[41] that received USD 6 billion. Other states among the top recipients of FDI in 2016-17 included Karnataka, Tamil Nadu, Gujarat and Andhra Pradesh.

[40] Includes Dadra & Nagar Haveli and Daman & Diu

[41] Includes part of Uttar Pradesh and Haryana

4.4 | Funding for Startups in Top Indian States (2016)

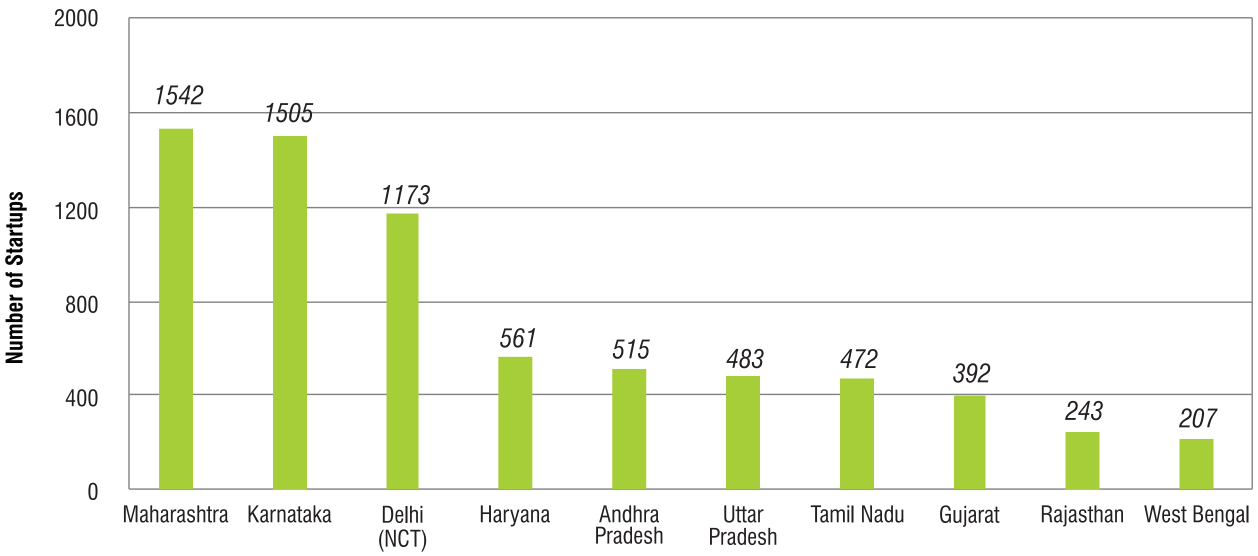


Source: Tracxn, data downloaded on 23 February 2018 from the platform

Note: Total funding includes Venture Capital, Private Equity, Angel, Debt

In 2016, Maharashtra attracted the most funding for startups (and new companies), amounting to USD 7.6 billion. This was followed by the state of Haryana, which includes the commercial hub of Gurugram, that received USD 4.2 billion and Delhi that received USD 2 billion. Karnataka's USD 1.9 billion followed in fourth place. The funding mentioned here includes angel investments, debt, private equity, seed funding, various series rounds, and venture debt as provided by Tracxn. The Tracxn data considered here includes funding for technology and offline startups (and new companies).

4.4.1 | State-wise Distribution of Startups (and New Companies) (2016)

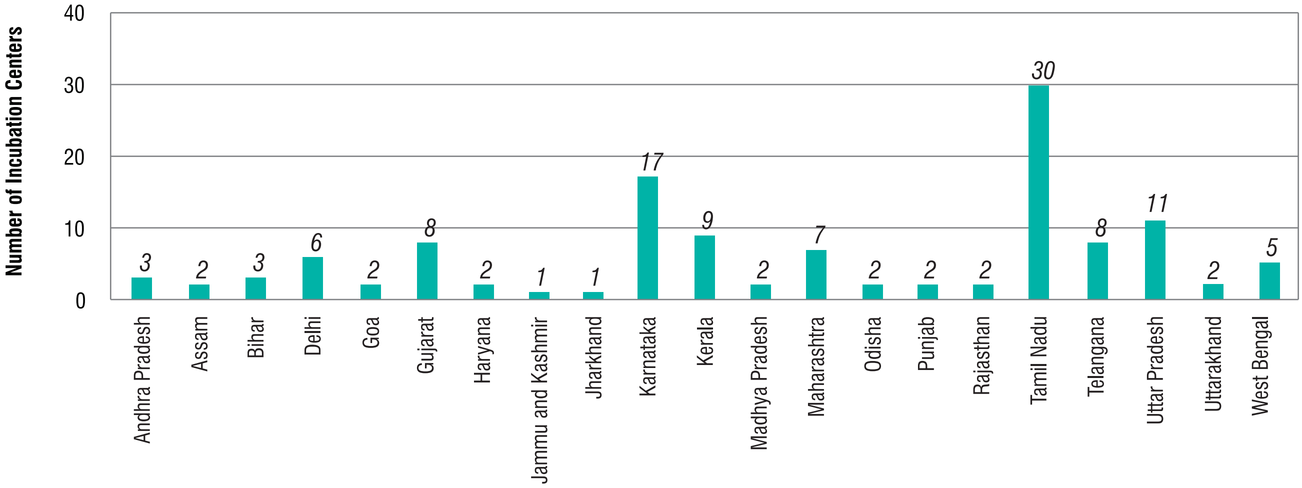


Source: Tracxn, data downloaded on 14 February 2018 from the platform

In 2016, Maharashtra saw 1,542 startups being established[42], followed by Karnataka that saw 1,505 new startups. The National Capital Territory (NCT) came in third with 1,173, while Haryana was fourth with 561 startups. Comparing the two indicators above, it is interesting to note that while the top four states are the same for both indicators, Karnataka and Haryana differ in their rankings for these indicators. We have provided data on state-wise number of new companies registered with the Ministry of Corporate Affairs (MCA) in the appendix (Table A.8).

[42] See comment on Tracxn data as explained in Indicator 3.7.2

4.5 | State-wise Number of Incubation Centres

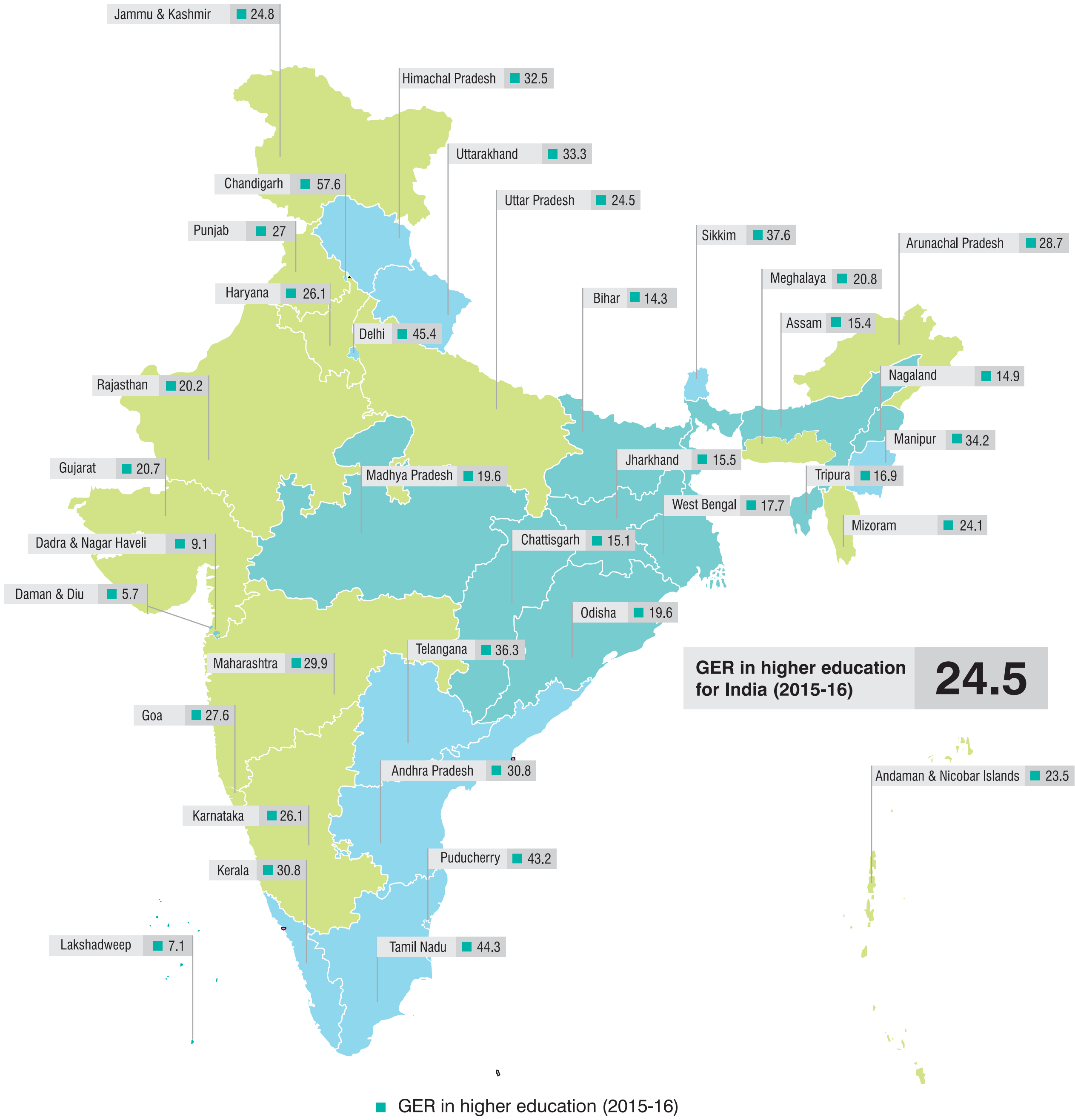


Source: Startup India, available at https://www.startupindia.gov.in/; Centre for Technology, Innovation and Economic Research (CTIER)

India has a total of 125 incubators according to the Startup India website, 30 of which are in Tamil Nadu. The thrust areas of these 30 incubators are wide ranging and include - biotechnology engineering, information and communications technology based systems, information technology enabled services electronics, medical devices, healthcare, agribusiness, waste management and nanotechnology. Karnataka has 17 incubators, the second highest number of incubators with major thrust areas like data analytics, blockchain, artificial intelligence, machine learning, green energy, healthcare, agriculture, information technology and fintech to name a few. Other states with a relatively higher number of incubators are Uttar Pradesh, Kerala and Gujarat.

Some of these incubators are located at academic institutions. The data on incubators at academic institutions can be found in the Appendix (Table A.9). Tamil Nadu leads here as well, with 27 incubators located at academic institutions. Karnataka, with the second highest number of incubators, has only 2 incubators located at academic institutions.

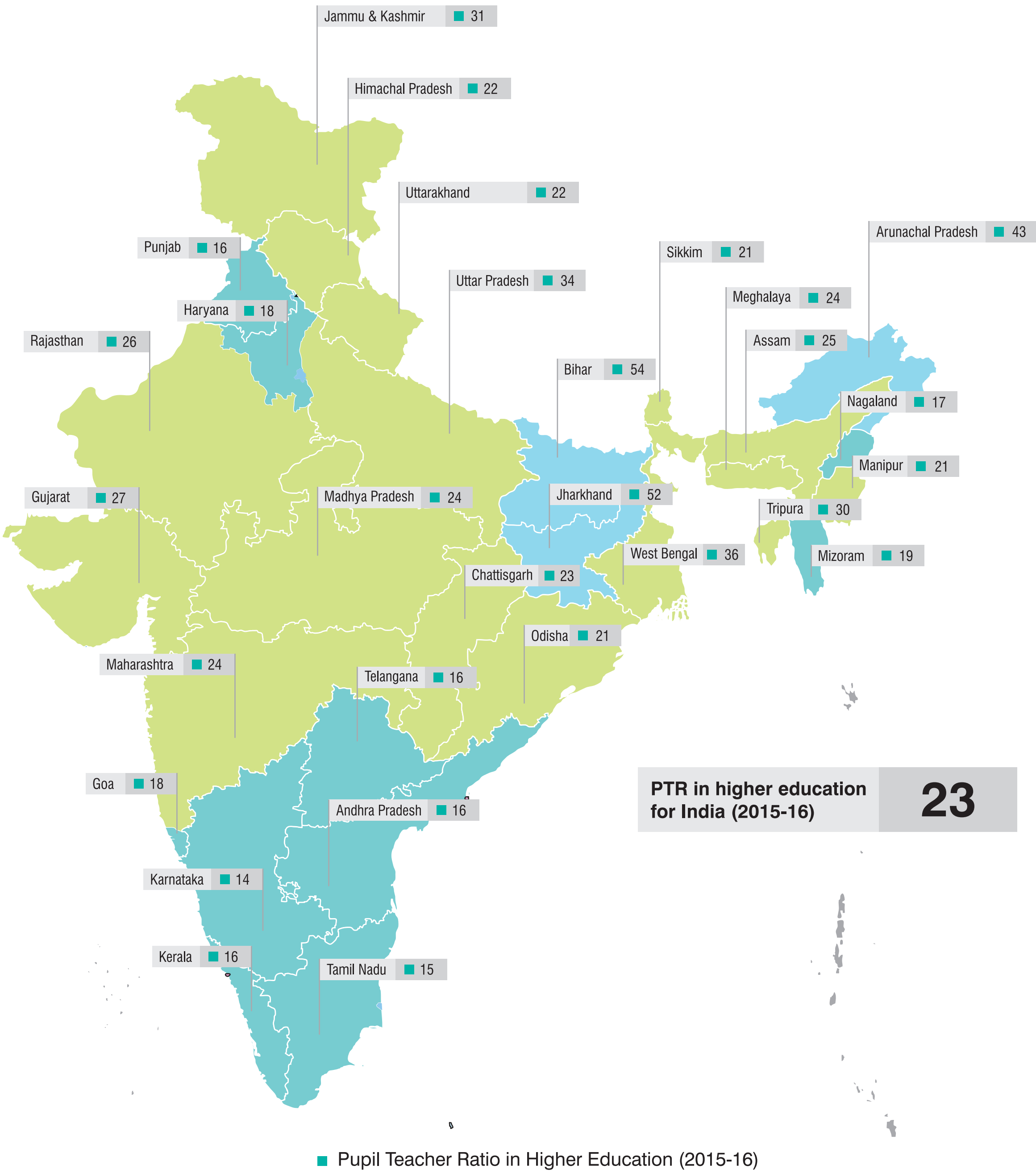
4.6 | State-wise Gross Enrolment Ratio in Higher Education (2015-16)



Source: Ministry of Human Resource Development, Department of Higher Education, *All India Survey on Higher Development (AISHE) Report 2015-16*

The national average Gross Enrollment Ratio (GER) for India was 24.5 percent in 2015-16. The GER varies significantly across States/Union Territories, ranging from 5.7 percent in Daman & Diu to 57.6 in Chandigarh. Other states that have a relatively higher GER include Delhi (45.4 percent) and Tamil Nadu (44.3 percent), while those states with relatively lower GERs include Bihar (14.3 percent), Nagaland (14.9 percent) and Chattisgarh (15.1 percent). GER captures the percentage of people between the ages 18-23 enrolled in universities, colleges or other higher education institutes.

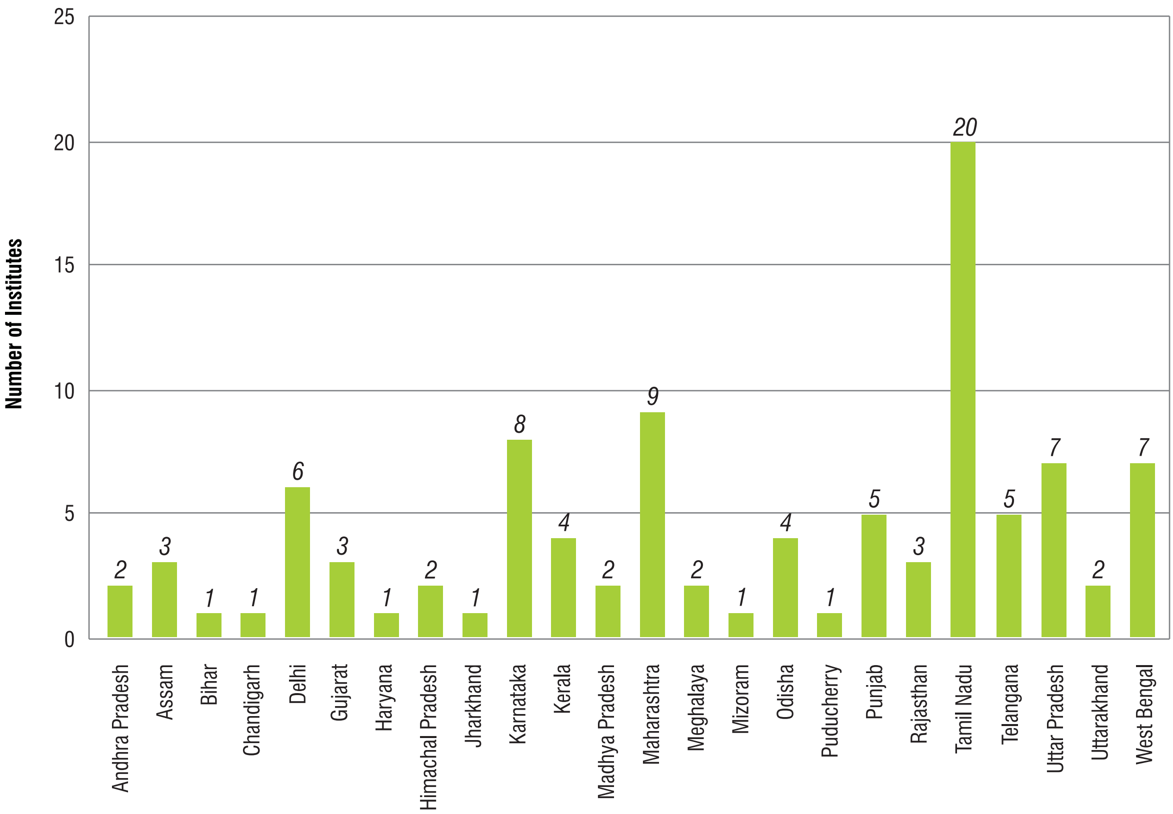
4.7 | State-wise Pupil Teacher Ratio in Higher Education (2015-16)



Source: Ministry of Human Resource Development, Department of Higher Education, *All India Survey on Higher Development (AISHE) Report 2015-16*

The national average Pupil Teacher Ratio (PTR) for India was 23 for the year 2015-16 ranging from 14 in Karnataka to 54 in Bihar. States with very low PTR were Karnataka, Tamil Nadu and Andhra Pradesh while states with a very high PTR were Bihar, Jharkhand and Arunachal Pradesh.

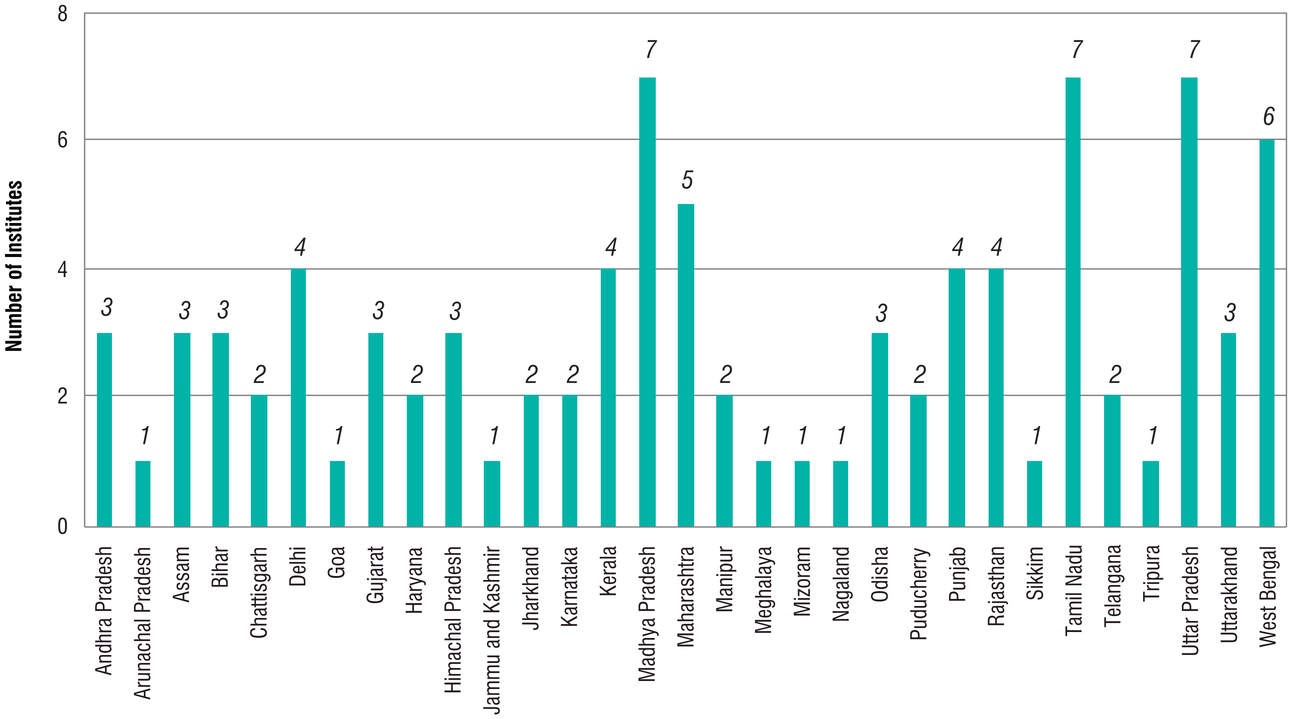
4.8 | State-wise Number of Institutes in Top 100 under the National Institute Rankin Framework (2017)



Source: Ministry of Human Resource Development (MHRD), National Institute Ranking Framework (NIRF) Rankings (2017), available at https://www.nirfindia.org/OverallRanking.html

The figure above considers the top 100 ranked universities and institutes in India according to the National Institute Ranking Framework (NIRF), and their distribution across states. NIRF outlines a methodology to rank institutions across the country on the basis of parameters which broadly cover "Teaching, Learning and Resources," "Research and Professional Practices," "Graduation Outcomes," "Outreach and Inclusivity," and "Perception". Tamil Nadu has the highest number of educational institutes ranked in the top 100 with 20 institutes followed by Maharashtra and Karnataka with 9 and 8 institutes respectively.

4.9 | State-wise Number of Institutes of National Importance (2017)



Source: Ministry of Human Resource Development (MHRD), available at http://mhrd.gov.in/institutions-national-importance, data as of December 2017

Note: Institute of National Importance (INI) is a status that may be conferred to a premier public higher education institution in India by an act of parliament, an institution which “serves as a pivotal player in developing highly skilled personnel within the specified region of the country/state”. INIs receive special recognition and funding. As of 29 December 2017 the Ministry of Human Resource Development has listed 91 institutions under this category.

As of end 2017, there were 91 Institutes of national importance (INI) in the country as published by Ministry of Human Resource Development (MHRD). The institutes of national importance have been established by an Act of Parliament. These include the various Indian Institutes of Technology (IIT)[43], National Institutes of Technology (NIT)[44], Indian Institutes of Information Technology (IIIT)[45], Indian Institutes of Science Education & Research (IISER)[46], All India Institutes of Medical Sciences (AIIMS)[47] and the schools of planning and architecture[48], among others. Madhya Pradesh, Tamil Nadu and Uttar Pradesh each have 7 INIs, the highest number of INIs in a state.

[43] Government of India. “The Institute of Technology Act, 1961”

[44] Government of India. “The National Institutes of Technology Act, 2007”

[45] Government of India. “The Indian Institutes of Information Technology (Public-Private Partnership) Act”

[46] Government of India. “The National Institutes of Technology (Amendment) Act, 2012”

[47] Government of India. “All India Institute of Medical Sciences Act, 1956”

[48] Government of India. “The School of Planning and Architecture Bill, 2014”

4.10 | Patent Applications Filed from Select States with Indian Patent Office

No.	State/UT	Number of Patent Applications Filed				
		2011-12	2012-13	2013-14	2014-15	2015-16
1	Maharashtra	2770	2690	2955	3267	3699
2	Karnataka	893	1208	1670	2134	2020
3	Tamil Nadu	1180	1223	1452	1423	1756
4	Delhi	1066	930	1023	1131	1154
5	Telangana	-	-	-	462	795
6	Uttar Pradesh	390	482	478	665	655
7	Gujarat	381	658	548	585	529
8	West Bengal	444	442	564	406	454
9	Haryana	202	289	288	343	395
10	Kerala	337	259	316	263	280
11	Andhra Pradesh	629	879	892	563	275
12	Punjab	73	109	89	97	192
13	Madhya Pradesh	69	112	96	101	159
14	Rajasthan	62	78	106	149	150
15	Bihar	27	47	35	35	28
	Total for top 15	8356	9406	10512	11624	12541
	Total for all States	8921	9911	10931	12071	13066

Source: The Office of the Controller General of Patents, Designs, Trademarks, and Geographical Indicators, Government of India, *Annual Reports (various years)*; Department of Science and Technology (DST), Government of India, *Research and Development Statistics 2017-18, December 2017, Patents Applications Filed by Different States in India, 2012-13 to 2015-16*; Centre for Technology, Innovation and Economic Research (CTIER)

Note: (i) Telangana was formed in the year 2014. Prior to 2014, data for Telangana was covered under Andhra Pradesh
(ii) Ranking of States done based on 2015-16 filings
(iii) Patents applications filed are the sum of ordinary, convention and national phase applications

The 15 states in the table above account for more than 90 percent of the total number of patent applications filed with the Indian Patent Office in 2015-16. Maharashtra, Karnataka, Tamil Nadu and Delhi have seen an increase in patent applications over the years. For Bihar and West Bengal, the patent applications in 2015-16 are close to levels seen in 2011-12. The state of Telangana was formed in 2014 and has seen an increase in patent applications in 2015-16 compared to the previous year. Prior to 2014, data for Telangana was captured under the data for Andhra Pradesh. Andhra Pradesh has seen a drop in patent applications in 2015-16 compared to the previous year. Kerala on the other hand has seen a decline in patent applications in 2015-16 compared to 2011-12.

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Chapter 5

Industry in India

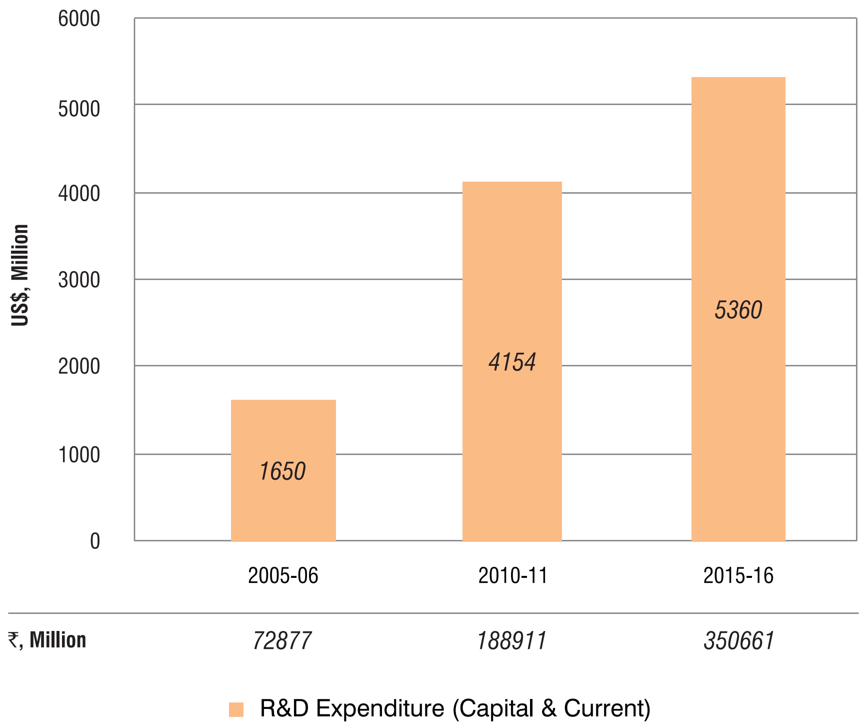
This chapter features some unique data for India, never available before, such as the list of the top 100 R&D spenders in India. We have also included some introductory data on startups and expect to add newer indicators in forthcoming editions.

Number	Indicator
5.1	Total Industrial R&D Expenditure in India
5.2	CTIER's Top 100 Industrial R&D Spenders in India (2015-16)
5.3	Comparison of Select Indian Firms' R&D Intensity with Respective Sector Global Average R&D Intensity
5.4	Total Foreign Exchange Spending on Technology Payments
5.4.1	Technology Payments by Sector (2015-16)
5.5	Import of Capital Goods by Indian Industry
5.5.1	Import of Capital Goods by Sector
5.6	Global MNCs having R&D Presence in India
5.7	Startup Sectors Attracting Funding in India
5.8	Sector-wise Publication and Industry-Academia (I-A) Collaborations Comparisons for Top Indian Sectors and Corresponding Sectors Globally (2012-16)
5.9	Top Patentees with the Indian Patent Office (2015-16)
5.10	Top Patentees with the United States Patent and Trademark Office (USPTO) (2015)

Chapter 05

Industry in India

5.1 | Total Industrial R&D Expenditure in India



Source: Prowess, data downloaded on 7 February 2018 from the platform; Centre for Technology, Innovation and Economic Research (CTIER)

Note: Figures in rupees are converted to dollars using the USD-INR exchange rate of 44.17 calculated as an average for the fiscal year 2005-06, the USD- INR exchange rate of 45.48 calculated as an average for the fiscal year 2010-11 and the USD-INR exchange rate of 65.42 calculated as an average for the fiscal year 2015-16 according to Federal Reserve Bank of St Louis.

Industrial R&D expenditure in India has more than doubled in the decade between 2006 to 2016. The R&D expenditure captured above considers capital and current account expenditure on R&D reported by firms in their annual reports. The current account component of R&D expenditure represents around 75 percent of total industrial R&D spending in India.

In the list of top 2,500 global R&D spenders[49], Qualcomm (ranked 25th) spends[50] slightly more than the entire Indian industry on R&D.

[49] EU Industrial R&D Investment Scoreboard (2016)

[50] Qualcomm reported USD 5497 million as R&D Expenditure for the year 2015-16 in the EU Industrial R&D Investment Scoreboard (2016)

5.2 | CTIER's Top 100 Industrial R&D Spenders in India (2015-16)

Rank	Company Name	Sector	R&D Spending ₹, Million	R&D Spending US$, Million	Share of in Total Top 100 R&D spending (%)
1	Tata Motors Ltd.	Automobiles & Parts	22171.1	334.8	6.3
2	Mahindra & Mahindra Ltd.	Automobiles & Parts	18858.9	284.7	5.4
3	Lupin Ltd.	Pharmaceuticals & Biotechnology	18145.1	274	5.2
4	Dr. Reddy'S Laboratories Ltd.	Pharmaceuticals & Biotechnology	14143	213.5	4
5	Reliance Industries Ltd.	Oil & Gas	12590	190.1	3.6
6	Hindustan Aeronautics Ltd.	Aerospace & Defence	11822.8	178.5	3.4
7	Hero Motocorp Ltd.	Automobiles & Parts	10358.6	156.4	3
8	Cipla Ltd.	Pharmaceuticals & Biotechnology	10353.4	156.3	3
9	Tata Consultancy Services Ltd.	Software & Computer Services	10125.8	152.9	2.9
10	Sun Pharmaceutical Inds. Ltd.	Pharmaceuticals & Biotechnology	9581.6	144.7	2.7
11	Bharat Heavy Electricals Ltd.	Industrial Engineering	8930.7	134.8	2.5
12	Bharat Electronics Ltd.	Aerospace & Defence	7042.7	106.3	2
13	Cadila Healthcare Ltd.	Pharmaceuticals & Biotechnology	6810	102.8	1.9
14	Wockhardt Ltd.	Pharmaceuticals & Biotechnology	6685.3	100.9	1.9
15	Indian Oil Corpn. Ltd.	Oil & Gas	6058.6	91.5	1.7
16	Maruti Suzuki India Ltd.	Automobiles & Parts	5935	89.6	1.7
17	Mylan Laboratories Ltd.	Pharmaceuticals & Biotechnology	5925	89.5	1.7
18	Glenmark Pharmaceuticals Ltd.	Pharmaceuticals & Biotechnology	4554.9	68.8	1.3
19	Aurobindo Pharma Ltd.	Pharmaceuticals & Biotechnology	4425.6	66.8	1.3
20	Infosys Ltd.	Software & Computer Services	4150	62.7	1.2
21	Oil & Natural Gas Corpn. Ltd.	Oil & Gas	4119.6	62.2	1.2
22	Bajaj Auto Ltd.	Automobiles & Parts	3299.5	49.8	0.9
23	Edgeverve Systems Ltd.	Software & Computer Services	3068.8	46.3	0.9
24	Suzlon Energy Ltd.	Electricity	3043.2	45.9	0.9
25	V E Commercial Vehicles Ltd.	Automobiles & Parts	3001.2	45.3	0.9
26	Intas Pharmaceuticals Ltd.	Pharmaceuticals & Biotechnology	2992.4	45.2	0.9
27	Ashok Leyland Ltd.	Automobiles & Parts	2797	42.2	0.8
28	Steel Authority Of India Ltd.	Industrial Metals & Mining	2770	41.8	0.8
29	Oracle Financial Services Software Ltd.	Software & Computer Services	2746.3	41.5	0.8
30	Wipro	Software & Computer Services	2561	38.7	0.7
31	Alembic Pharmaceuticals Ltd.	Pharmaceuticals & Biotechnology	2550.7	38.5	0.7
32	Sun Pharma Advanced Research Co. Ltd.	Pharmaceuticals & Biotechnology	2358.8	35.6	0.7
33	T V S Motor Co. Ltd.	Automobiles & Parts	2263.8	34.2	0.6
34	Alkem Laboratories Ltd.	Pharmaceuticals & Biotechnology	2124.9	32.1	0.6
35	Torrent Pharmaceuticals Ltd.	Pharmaceuticals & Biotechnology	2656.3	40.1	0.8
36	Larsen & Toubro Ltd.	Construction and Materials	2035.5	30.7	0.6
37	Delphi Automotive Systems Pvt. Ltd.	Automobiles & Parts	1961.8	29.6	0.6
38	Hindustan Petroleum Corpn. Ltd.	Oil & Gas	1803.2	27.2	0.5
39	Bosch Ltd.	Automobiles & Parts	1746	26.4	0.5
40	Apollo Tyres Ltd.	Automobiles & Parts	1712.5	25.9	0.5
41	I T C Ltd.	General Industrials	1553.6	23.5	0.4
42	Biocon Ltd.	Pharmaceuticals & Biotechnology	1515	22.9	0.4
43	Ajanta Pharma Ltd.	Pharmaceuticals & Biotechnology	1493.3	22.5	0.4
44	Emcure Pharmaceuticals Ltd.	Pharmaceuticals & Biotechnology	1461.2	22.1	0.4
45	Fresenius Kabi Oncology Ltd.	Pharmaceuticals & Biotechnology	1391.4	21	0.4
46	Ipca Laboratories Ltd.	Pharmaceuticals & Biotechnology	1376.7	20.8	0.4
47	Strides Shasun Ltd.	Pharmaceuticals & Biotechnology	1315.3	19.9	0.4
48	N T P C Ltd.	Electricity	1296.8	19.6	0.4
49	Tata Steel Ltd.	Industrial Metals & Mining	1293.2	19.5	0.4
50	Intellect Design Arena Ltd.	Software & Computer Services	1220.4	18.4	0.3
	Watson Pharma Pvt. Ltd.	Pharmaceuticals & Biotechnology	1198.8	18.1	0.3

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Source: Annual Reports (2015-16) of Indian companies; Prowess, data downloaded on 7 February 2018 from the platform; Centre for Technology, Innovation and Economic Research (CTIER)

Rank	Company Name	Sector	R&D Spending ₹, Million	R&D Spending US$, Million	Share of in Total Top 100 R&D spending (%)
51	H C L Technologies Ltd.	Software & Computer Services	1026.2	15.5	0.3
52	Tata Power Co. Ltd.	Electricity	1018.4	15.4	0.3
53	Eicher Motors Ltd.	Automobiles & Parts	915.3	13.8	0.3
54	Laurus Labs Ltd.	Pharmaceuticals & Biotechnology	906.6	13.7	0.3
55	Shantha Biotechnics Pvt. Ltd.	Pharmaceuticals & Biotechnology	901.2	13.6	0.3
56	Syngenta India Ltd.	Chemicals	872.8	13.2	0.2
57	Johnson & Johnson Pvt. Ltd.	Pharmaceuticals & Biotechnology	823.2	12.4	0.2
58	P I Industries Ltd.	Chemicals	815.1	12.3	0.2
59	Piramal Enterprises Ltd.	Pharmaceuticals & Biotechnology	806.1	12.2	0.2
60	Escorts Ltd.	Industrial Engineering	802.7	12.1	0.2
61	S R F Ltd.	Chemicals	789	11.9	0.2
62	Force Motors Ltd.	Automobiles & Parts	765.5	11.6	0.2
63	G A I L (India) Ltd.	Oil & Gas	764.9	11.5	0.2
64	Asian Paints Ltd.	Chemicals	751.6	11.3	0.2
65	Indoco Remedies Ltd.	Pharmaceuticals & Biotechnology	751.2	11.3	0.2
66	Renault Nissan Technology & Business Centre India Pvt. Ltd.	Automobiles & Parts	732.9	11.1	0.2
67	General Motors India Pvt. Ltd.	Automobiles & Parts	720.9	10.9	0.2
68	Rolta India Ltd.	Software & Computer Services	719.7	10.9	0.2
69	Serum Institute Of India Pvt. Ltd.	Pharmaceuticals & Biotechnology	715.4	10.8	0.2
70	Natco Pharma Ltd.	Pharmaceuticals & Biotechnology	703	10.6	0.2
71	Suven Life Sciences Ltd.	Pharmaceuticals & Biotechnology	701.8	10.6	0.2
72	Kirloskar Oil Engines Ltd.	Industrial Engineering	688.6	10.4	0.2
73	U P L Ltd.	Chemicals	670	10.1	0.2
74	L G Electronics India Pvt. Ltd.	Household Goods & Home Construction	669	10.1	0.2
75	B E M L Ltd.	Industrial Engineering	666.1	10.1	0.2
76	Ind-Swift Laboratories Ltd.	Pharmaceuticals & Biotechnology	615.9	9.3	0.2
77	Brakes India Pvt. Ltd.	Automobiles & Parts	602.7	9.1	0.2
78	Advinus Therapeutics Ltd.	Pharmaceuticals & Biotechnology	600.9	9.1	0.2
79	Bharat Petroleum Corpn. Ltd.	Oil & Gas	597	9	0.2
80	Gland Pharma Ltd.	Pharmaceuticals & Biotechnology	573.1	8.7	0.2
81	Secure Meters Ltd.	Electronic & Electrical Equipment	566.1	8.5	0.2
82	M R F Ltd.	Automobiles & Parts	548.9	8.3	0.2
83	P A R Formulations Pvt. Ltd.	Pharmaceuticals & Biotechnology	531.5	8	0.2
84	Ceat Ltd.	Automobiles & Parts	522.3	7.9	0.1
85	Minda Industries Ltd.	Automobiles & Parts	511.3	7.7	0.1
86	Blue Star Ltd.	Household Goods & Home Construction	498.2	7.5	0.1
87	C G Power & Indl. Solutions Ltd.	Electronic & Electrical Equipment	487.5	7.4	0.1
88	Hetero Drugs Ltd.	Pharmaceuticals & Biotechnology	483.6	7.3	0.1
89	J K Tyre & Inds. Ltd.	Automobiles & Parts	478.1	7.2	0.1
90	Godrej & Boyce Mfg. Co. Ltd.	Household Goods & Home Construction	477.4	7.2	0.1
91	Unichem Laboratories Ltd.	Pharmaceuticals & Biotechnology	472.4	7.1	0.1
92	3M India Ltd.	General Industrials	469.8	7.1	0.1
93	Oil India Ltd.	Oil & Gas	467.6	7.1	0.1
94	Panacea Biotec Ltd.	Pharmaceuticals & Biotechnology	463	7	0.1
95	Endurance Technologies Ltd.	Automobiles & Parts	456.9	6.9	0.1
96	Bayer Seeds Pvt. Ltd.	Food Producers	441.8	6.7	0.1
97	Britannia Industries Ltd.	Food Producers	438	6.6	0.1
98	Grasim Industries Ltd.	Chemicals	435.6	6.6	0.1
99	Hyundai Motor India Ltd.	Automobiles & Parts	433	6.5	0.1

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Note: Figures in rupees were converted to dollars using the USD-INR exchange rate of 66.23 as at 31 December 2015 and based on exchange rates mentioned in the EU Industrial R&D Investment Scoreboard (2016)

5.3 | Comparison of Select Indian Firms' R&D Intensity with Respective Sector Global Average R&D Intensity

Sector	Company	R&D Intensity	Top 2500 Global Average R&D Intensity
Pharmaceuticals & Biotechnology	Lupin Ltd.	16.1	15.0
	Dr. Reddy'S Laboratories Ltd.	13.7	
	Cipla Ltd.	8.5	
	Sun Pharmaceutical Inds. Ltd.	12.4	
	Cadila Healthcare Ltd.	10.1	
Automobiles and Parts	Tata Motors Ltd.	4.7	4.3
	Mahindra & Mahindra Ltd.	4.3	
	Hero Motocorp Ltd.	3.4	
	Maruti Suzuki India Ltd.	0.9	
	Bajaj Auto Ltd.	1.4	
Oil & Gas	Reliance Industries Ltd.	0.5	0.5
	Indian Oil Corpn. Ltd.	0.2	
	Oil & Natural Gas Corpn. Ltd.	0.5	
	Hindustan Petroleum Corpn. Ltd.	0.1	
	G A I L (India) Ltd.	0.1	
Software & Computer Services	Tata Consultancy Services Ltd.	1.2	10.6
	Infosys Ltd.	0.8	
	Edgeverve Systems Ltd.	20	
	Oracle Financial Services Software Ltd.	7.8	
	Intellect Design Arena Ltd.	14.6	

Source: Annual Reports (2015-16) of Indian companies; Prowess, data downloaded on 7 February 2018 from the platform; Centre for Technology, Innovation and Economic Research (CTIER)

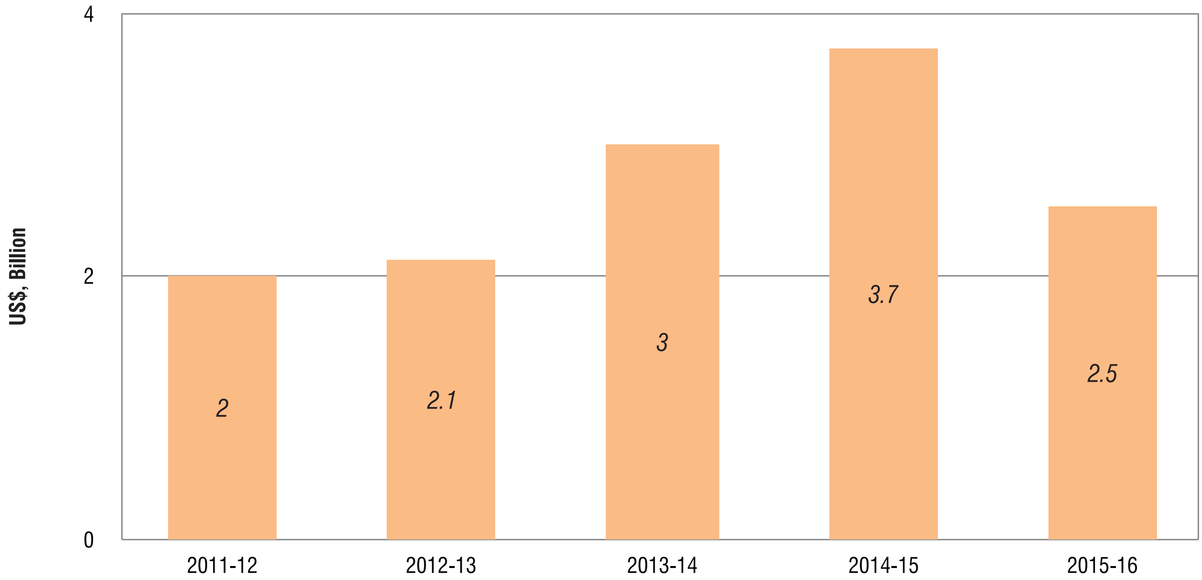
The top 10 industrial R&D sectors in India, as captured in Indicator 3.4.1, have been considered in the table above. The R&D intensities (R&D expenditure as a percent of sales) for top Indian R&D spenders have been listed in each sector, and compared to the global average R&D intensity for the respective sector.

Lupin, Dr Reddy's, Sun Pharmaceuticals, Tata Motors, Mahindra & Mahindra, Reliance Industries and Hindustan Aeronautics Limited (HAL) figure among the top 10 R&D spenders in India, and have R&D intensities that are close to or in some cases even above the global average R&D intensities for their respective sectors.

Sector	Company	R&D Intensity	Top 2500 Global Average R&D Intensity
Aerospace & Defence	Hindustan Aeronautics Ltd.	6.9	4.3
	Bharat Electronics Ltd.	9.2	
Industrial Engineering	Bharat Heavy Electricals Ltd.	3.3	3.2
	Escorts Ltd.	2.6	
	Kirloskar Oil Engines Ltd.	2.3	
	B E M L Ltd.	2	
	C N H Industrial (India) Pvt. Ltd.	1.7	
Chemicals	Syngenta India Ltd.	3.7	2.9
	P I Industries Ltd.	3.7	
	S R F Ltd.	2	
	Asian Paints Ltd.	0.5	
	U P L Ltd.	1.1	
Electricity	Suzlon Energy Ltd.	5.1	0.6
	N T P C Ltd.	0.2	
	Tata Power Co. Ltd.	1.2	
	Nuclear Power Corpn. Of India Ltd.	0.3	
Industrial Metals & Mining	Steel Authority Of India Ltd.	0.6	1
	Tata Steel Ltd.	0.3	
General Industrials	I T C Ltd.	0.3	2.8
	3M India Ltd.	2.1	
	D C M Shriram Ltd.	0.7	

Other top Indian firms, such as Tata Consultancy Services (TCS), Infosys, Bajaj Auto and Tata Steel have R&D intensities below the global average R&D intensity for their respective sectors. The global Software & Computer Services sector tends to be dominated by software product firms Alphabet, Microsoft and Baidu, which have higher R&D intensities compared to software services firms like TCS and Infosys.

5.4 | Total Foreign Exchange Spending on Technology Payments



₹, Million	*96*	*116*	*181*	*228*	*164*

Source: Prowess, data downloaded on 22 February 2018 from the platform; Centre for Technology, Innovation and Economic Research (CTIER)

Note: (i) 1416 firms have reported foreign exchange spending on technology payments at least once in the five years 2011-12 to 2015-16
(ii) Total excludes firms engaged in mining, quarrying or extraction
(iii) Figures in rupees are converted to dollars using the USD-INR exchange rate of 47.85 calculated as an average for the fiscal year 2011-12, the USD-INR exchange rate of 54.35 calculated as an average for the fiscal year 2012-13, the USD-INR exchange rate of 60.42 calculated as an average for the fiscal year 2013-14, the USD-INR exchange rate of 61.13 calculated as an average for the fiscal year 2014-15, the USD-INR exchange rate of 65.42 calculated as an average for the fiscal year 2015-16 according to Federal Reserve Bank of St Louis

While the trend in technology payments (that includes payments on royalty, technical know-how and license fees)[51] as per our calculations broadly mirrors that of the RBI data on technology payments[52] (for the period 2011-12 to 2015-16), we found the amount to be around half of that reported by the RBI.[53] At present, a breakdown of RBI's technology payments data by industry is unavailable. For instance it is difficult to discern how much of the payments are towards patented technologies by higher technology or knowledge intensive firms and how much of it may be as payments for copyrights and trademarks, for instance by the entertainment industry.

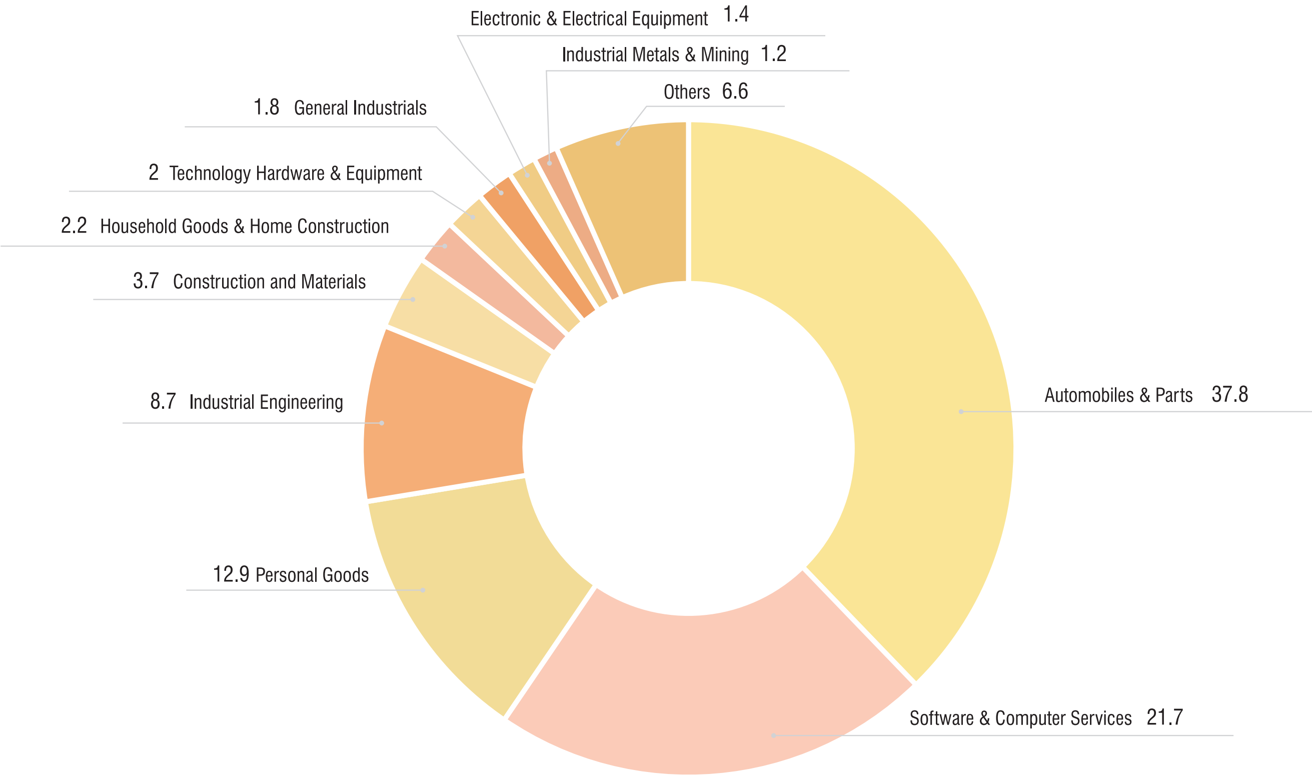
Technology payments as per our calculations saw a dip in 2015-16, while the RBI reported an increase for the corresponding period. It is unclear here whether the difference in the trend in 2015-16 was due to unavailability of firm level data or whether there was indeed a slowdown in industrial technology payments. Moreover, the overall increase in payments for intellectual property as per the RBI data also raises the question whether payments towards copyrights and trademarks were the main driver for this increase.

[51] Also known as 'disembodied technology'.

[52] See Indicator 3.5

[53] RBI reports technology payments as Charges for the Use of Intellectual Property (Payments) in Balance of Payments data. For the year 2015-16 the amount reported was USD 4.9 billion. Forex spending on technology payments as per our calculation was USD 2.5 billion for the same period.

5.4.1 | Technology Payments by Sector (2015-16)



Source: Prowess, data downloaded on 22 February 2018 from the platform; Centre for Technology, Innovation and Economic Research (CTIER)

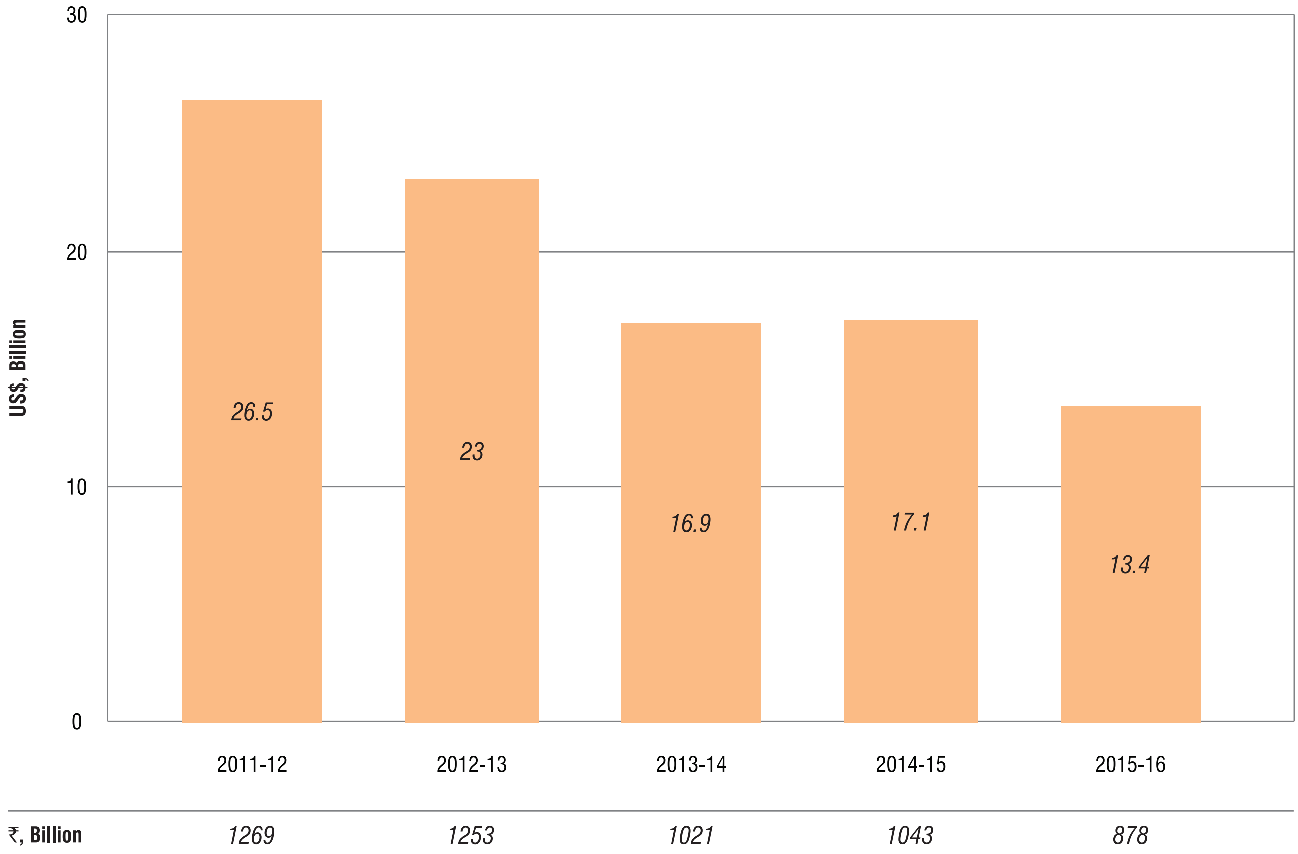
Note: (i) Excludes spending of firms engaged in mining, extraction and quarrying
(ii) Total foreign exchange spending on technology payments for the year 2015-16 was USD 2510 million (INR 164217 million). Our sample covers 154 firms accounting for 90% of the total foreign exchange spending on technology payments. The total for the sample was USD 2228 million (INR 149589 million)
(iii) Figures in rupees are converted to dollars using the USD-INR exchange rate of 65.42 calculated as an average for the fiscal year 2015-16 according to Federal Reserve Bank of St Louis

In providing a break up of technology payments by industry sector, we considered the foreign exchange (forex) expenditure amounts reported by 154 firms as technology payments for the year 2015-16. These firms accounted for more than 90% of the USD 2.5 billion on technology payments by industry as per our calculations.[54]

Expenditure on royalty, technical know-how and license fees by Indian industry is dominated by sectors such as automobiles & parts, software & computer services and industrial engineering. While the technology & hardware and electronic & electrical equipment sectors are absent from the top Industrial R&D sectors in India, they do find a minor presence when it comes to technology payments.

[54] Firms engaged in mining, quarrying and extraction according to the National Industrial Classification (NIC) 2008 have been excluded. NIC (2008) is available on the Ministry of Statistics and Programme Implementation website.

5.5 | Import of Capital Goods by Indian Industry

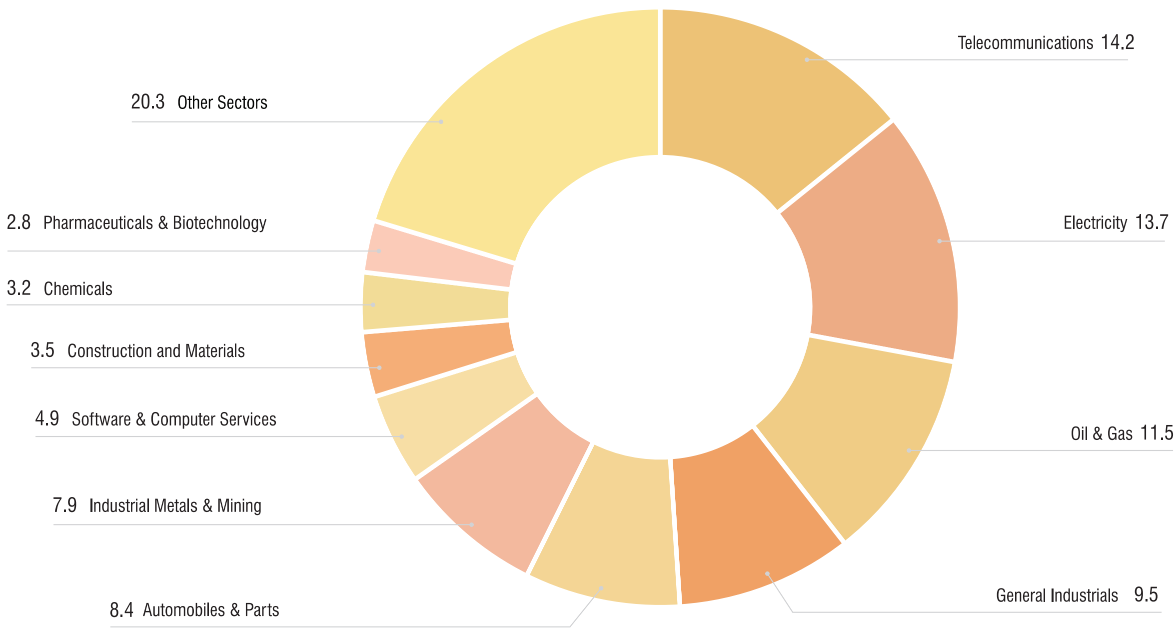


Source: Prowess, data downloaded on 22 February 2018 from the platform; Centre for Technology, Innovation and Economic Research (CTIER)

Note: (i) 5759 firms have reported foreign embodied technology spending atleast once in the five years 2011-12 to 2015-16
(ii) Figures in rupees are converted to dollars using the USD-INR exchange rate of 47.85 calculated as an average for the fiscal year 2011-12, the USD-INR exchange rate of 54.35 calculated as an average for the fiscal year 2012-13, the USD-INR exchange rate of 60.42 calculated as an average for the fiscal year 2013-14, the USD-INR exchange rate of 61.13 calculated as an average for the fiscal year 2014-15 and the USD-INR exchange rate of 65.42 calculated as an average for the fiscal year 2015-16 according to Federal Reserve Bank of St Louis

Total import of capital goods, used as a proxy for embodied technology, has decreased over the five year period from 2011-12 to 2015-16.

5.5.1 | Import of Capital Goods by Sector



Source: Prowess, data downloaded on 22 February 2018 from the platform; Centre for Technology, Innovation and Economic Research (CTIER)

Note: (i) Analysis based on 4669 firms who have reported import of capital at least once in the three years 2013-14 to 2015-16 as reported in Prowess
(ii) Total foreign spending on embodied technology for the years 2013-14 to 2015-16 was USD 46 billion (INR 2942 billion)
(iii) Sector shares based on amount in US$, Million
(iv) Figures in rupees are converted to dollars using the USD-INR exchange rate of 60.42 calculated as an average for the fiscal year 2013-14, the USD-INR exchange rate of 61.13 calculated as an average for the fiscal year 2014-15 and the USD-INR exchange rate of 65.42 calculated as an average for the fiscal year 2015-16 according to Federal Reserve Bank of St Louis

We considered data for the three year period from 2013-14 to 2015-16 to identify the top sectors by the import of capital goods or embodied technology payments over this period. The number of firms that have reported import of capital goods at least once in the three year period from 2013-14 to 2015-16 was 4,669.

Over the three year period from 2013-14 to 2015-16, industry spent around USD 46.3 billion on embodied technology. The top sectors by expenditure were telecommunications, electricity and oil & gas.

Sectors that dominate industrial R&D expenditure as seen in Indicator 3.4.1, namely pharmaceuticals & biotechnology and automobiles & parts, were not among the top three sectors when it comes to embodied technology expenditure.

5.6 | Global MNCs having R&D Presence in India

Firms	Total R&D Expenditure (US$, Billion)	Share in Total of Top 2500(%)
Top 2500 global R&D Spenders	759	100
Top 100 global R&D Spenders	403	53
95 global R&D Spenders (in top 100 with presence in India*)	378	50
61 global R&D Spenders (in top 100 with R&D Centres in India)	280	37

Source: EU Industrial R&D Investment Scoreboard (2016); Ministry of Corporate Affairs (MCA); Various News reports; Company Websites; Centre for Technology, Innovation and Economic Research (CTIER)
*in the form of either an R&D Centre or a subsidiary

Note: Figures in euros were converted to dollars using the EUR-USD exchange rate of 1.09 as at 31 December 2015 and as mentioned in the EU Industrial R&D Investment Scoreboard (2016)

There is no comprehensive data for R&D spending by Multinational Corporation (MNC) R&D centres in India. India has a presence of over 1,000 MNC R&D centres.[55] To arrive at an estimate of the MNC R&D spending in India, we have considered the top 100 global R&D spenders from the list of the top 2,500.[56] The top 100 R&D spenders account for more than 50 percent of R&D expenditure of the top 2,500, amounting to USD 403 billion. Of the top 100 R&D spenders, we were able to verify the presence of 95 MNCs in India, either through a subsidiary or as having a R&D centre in India. Using the Ministry of Corporate Affairs (MCA) database, individual company websites and news reports, we were able to identify the presence in India of 61 of the top 100 global R&D spenders, that had a total expenditure on R&D amounting to USD 280 billion globally in 2016. Assuming that these 61 firms spend around 3 percent of their global R&D expenditure in India, we arrived at a conservative estimate of at least USD 8.4 billion of R&D expenditure by these firms in the country.

Our estimate of USD 8.4 billion for MNC R&D activity in India would be at the lower end of what global MNC R&D centres possibly spend on R&D in India. Nevertheless, even with this conservative estimate, the amount is higher than the R&D expenditure amount that we have reported for Indian industry. Our estimate, if taken into account, effectively more than doubles the amount of R&D performed by industry in India.

[55] Sujit John, Shilpa Phadnis. 'For MNCs, India still an R&D hub and it's growing', The Times of India, 2 March 2017

[56] EU Industrial R&D Investment Scoreboard (2016)

5.7 | Startup Sectors Attracting Funding in India

Sector	Total Funding Amount (US$, Million)				
	2012	2013	2014	2015	2016
Consumer	174	152	954	2651	1550
Retail	402	646	3248	2384	855
FinTech	13	31	145	1207	657
Enterprise Applications	120	81	350	786	419
EdTech	24	40	36	107	196
HealthTech	14	52	15	293	131
Enterprise Infrastructure	28	56	44	29	97
Media & Entertainment	9	24	26	80	64
Technology	25	16	42	72	50
AdTech	43	37	17	34	47
Life Sciences	134	94	17	21	43

Source: Tracxn, data downloaded on 7 May 2018 from the platform

Note: Excludes Debt, Grant and post IPO rounds

According to data from Tracxn, the sectors that were among the larger recipients of funding for startups (and new companies) excluding offline companies in 2016, included consumer, retail, fintech, and enterprise applications. Sub-sectors such as online retail that cuts across consumer and retail, as well as mobile payments that is part of fintech appear to dominate the funding landscape in their respective sectors. The data on funding for online retail and mobile payments can be found in the appendix (Table A.10).

5.8 | Sector-wise Publication and Industry-Academia (I-A) Collaborations Comparisons for Top Indian Sectors and Corresponding Sectors Globally (2012-16)

Sector	India Top Sectors			World		
	Total Publications	Total I-A	% I-A	Total Publications	Total I-A	% I-A
Pharmaceuticals & Biotechnology	826	447	54.1	94687	50309	53.1
Automobiles & Parts	158	102	64.6	13787	7697	55.8
Oil & Gas	376	227	60.4	9322	5994	64.3
Software & Computer Services	297	154	51.9	26520	11934	45.0
Aerospace & Defence	83	36	43.4	9575	5100	53.3
Industrial Engineering	91	54	59.3	12438	7793	62.7
Chemicals	106	55	51.9	18158	9103	50.1
Electricity	92	62	67.4	2868	1817	63.4
Industrial Metals & Mining	792	456	57.6	5786	3546	61.3
General Industrials	22	15	68.2	11639	6031	51.8

Source: EU Industrial R&D Investment Scoreboard (2016); Prowess, data downloaded on 14 February 2018 from the platform; InCites (based on data from Web of Science), data downloaded from the platform on 14 February 2018; Centre for Technology, Innovation and Economic Research (CTIER)

We have considered the top 10 industrial R&D sectors in India, and the firms within them. We looked at publications by these firms during the period 2012 to 2016, and the share of industry-academia collaborations with respect to these publications. The same exercise was performed for the global firms that fall into these sectors. These global firms contributed to at least 85 percent of the R&D spending in their respective sectors.

Indian firms were found to have a higher share of academic collaborations for their publications compared to their global sector average in sectors such as automobiles & parts and software & computer services, while the share of academic collaborations in sectors such as pharmaceuticals & biotechnology and chemicals were found comparable to the respective global sector average. Sectors such as oil & gas and industrial metals & mining appear to have a lower share of academic collaborations compared to their respective global sector average.

As shown in Indicator 3.4, there are more Indian firms in the pharmaceutical & biotechnology and automobiles & parts sectors that make it to the global 2,500 list, compared to Indian firms in the Industrial metals & mining sector. However, it is worth noting that the share of publications by Indian firms in the industrial metals & mining sector, in the global publication output for this sector, is higher relative to the contribution by other Indian firms to the global publication output for their respective sectors.

5.9 | Top Patentees with the Indian Patent Office (2015-16)

Top 5 Non Resident Patentees with the Indian Patent Office (2015-16)

No.	Name of Organisation	Patents Granted
1	GM Global Technology Operations	252
2	Qualcomm Inc.	212
3	LG Electroncs Inc.	89
4	Koninklijke Philips Electronics N.V.	68
5	Honda Motor Co. Ltd.	65
Total		686

Source: The Office of the Controller General of Patents, Designs, Trademarks, and Geographical Indicators Government of India, *Annual Report 2015-16*

In 2015-16, the largest non-resident patent holder with the Indian Patent Office (IPO) was GM Global Technology Operations, closely followed by Qualcomm.

Top 5 Indian Resident Patentees with the Indian Patent Office (2015-16)

No.	Name of Organisation	Patents Granted
1	Council of Scientific & Industrial Research	113
2	Samsung R&D Institute - Bangalore	55
3	Bharat Heavy Electricals	45
4	IIT	40
5	Defence R&D Organization	32
Total		285

Source: The Office of the Controller General of Patents, Designs, Trademarks, and Geographical Indicators Government of India, *Annual Report 2015-16*

Resident patent holders are dominated by public sector institutions. The top patent holder was the Council of Scientific and Industrial Research (CSIR) followed by Samsung R&D Institute Pvt Ltd.

5.10 | Top Patentees with the United States Patent and Trademark Office (USPTO) (2015)

Top Multinational Corporation Patentees (Residents in India) with the United States Patent and Trademark Office (USPTO) (2015)

No.	Company/Institution Name	Patents Granted
1	International Business Machines Corporation	332
2	General Electric Company	133
3	Symantec Corporation	127
4	Hewlett-Packard Development Company, L.P.	92
4	Texas Instruments, Incorporated	92
5	Qualcomm, Inc.	88
6	Honeywell International Inc.	77
7	Freescale Semiconductor, Inc.	63
8	Samsung Electronics Co., Ltd.	63
9	STMicroelectronics International N.V.	53

Source: United States Patent and Trademark Office (USPTO), Patenting By Geographic Region (State and Country), Breakout By Organization (2015), available at https://www.uspto.gov/web/offices/ac/ido/oeip/taf/stcasg/inx_stcorg.htm; Centre for Technology, Innovation and Economic Research (CTIER)

The top 10 multinational corporation patentees with the United States Patent and Trademark Office (USPTO) and based in India are from sectors such as technology hardware & equipment, software & computer services, general industrials and electronic & electrical equipment.

Top 10 Indian (Resident in India) Patentees with the United States Patent and Trademark Office (USPTO) (2015)

No.	Company/Institution Name	Patents Granted
1	Council Of Scientific And Industrial Research	99
2	Tata Consultancy Services Ltd.	85
3	Infosys Limited	74
4	Wipro Limited	22
5	Lupin Limited	21
6	Wockhardt Limited	17
7	Cadila Healthcare Limited	15
8	Tejas Networks Limited	14
9	Dr. Reddy's Laboratories Ltd.	12
10	Indian Institute Of Science	11

Source: United States Patent and Trademark Office (USPTO), Patenting By Geographic Region (State and Country), Breakout By Organization (2015), available at https://www.uspto.gov/web/offices/ac/ido/oeip/taf/stcasg/inx_stcorg.htm; Centre for Technology, Innovation and Economic Research (CTIER)

The top 10 Indian patentees with the USPTO comprise of publicly funded autonomous research institutions, higher education institutions, and firms that have a presence in industrial sectors such as software & computer services and pharmaceuticals & biotechnology.

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Section 3

Appendix

Appendix A

Data from Alternate Sources

Table A.1 | Country Comparison of Charges for use of intellectual property (2012)

	Country	Receipts (US$, Billion)	Payments (US$, Billion)
Select Advanced Economies	USA	124.4	38.7
	UK	15.5	9.3
	Germany	10.3	6.4
	Japan	31.9	19.9
Select Emerging/Asian Economies	Brazil	0.3	4.2
	China	1.0	17.7
	India	0.3	4.0
	Israel	1.1	1.1
	South Korea	3.9	8.6

Source: Reserve Bank of India (RBI) Balance of Payment (2012), available at https://rbi.org.in/scripts/SDDS_ViewDetails.aspx?Id=5&IndexTitle=Balance+of+ for data on India, World Development Indicators (2012), Indicators, available at http://data.worldbank.org/ for data on Brazil, China, Germany, Japan, South Korea, UK and USA; Centre for Technology, Innovation and Economic Research (CTIER)

Table A.2 | Annual Foreign Direct Investment Equity Inflows into India

Year	Equity other than reinvestment of earnings (US$, Billion)	Reinvestment of earnings (US$, Billion)	Debt instruments (US$, Billion)	Total FDI (US$, billion)
2012-13	23	10	2	35
2013-14	25	9	2	36
2014-15	32	9	3	44
2015-16	41	10	4	55
2016-17	45	12	3	60

Source: Reserve Bank of India (RBI) Balance of Payment (various years), available at https://rbi.org.in/scripts/SDDS_ViewDetails.aspx?Id=5&IndexTitle=Balance+of+

Note: Does not include repatriation/disinvestment amounting to around USD 18 billion

Table A.3 | Total Funding for Startups (and New Companies) by Type of Financing

Total Round Amount US$, MIlion	2012	2013	2014	2015	2016
Angel	44	27	44	127	162
Conventional Debt	428	324	1051	3684	9503
Debt	1055	103	132	743	1
Equity Crowdfunding	0	0	0	0	0
Grant (prize money)	9	27	3	21	1
PE	1596	965	1165	3320	1953
Post IPO	509	833	862	911	2572
Seed	71	101	139	313	266
Series A	415	454	427	1360	1050
Series B	470	670	772	1550	1054
Series C	383	419	817	1619	874
Series D	336	366	623	1047	1032
Series E	32	360	426	1011	690
Series F	0	0	939	607	260
Series G	0	0	1060	560	0
Series H	0	0	700	150	219
Series I	0	0	0	751	4
Unattributed	0	0	0	0	
Venture Debt		34	1	111	104

Source: Tracxn, data downloaded on 25 April 2018 from the platform

Table A.4 | Venture Capital Funding by Source of Data

VC Funding by Source (US$, Million)	2012	2013	2014	2015	2016
Tracxn	2458.5	2780.8	5174.2	5865.7	3036.4
NSF	1,147	1,453	5,051	8,155	3,473

Source: National Science Foundation (NSF), Science & Engineering Indicators 2018, Invention, Knowledge Transfer and Innovation - Global Venture Capital Investment, by financing stage, selected region, country or economy: 2008-16 for data on China, Germany, Israel, UK and USA; Tracxn data for India for the year 2016, data downloaded on 25 April 2018 from the platform.

Table A.5 |Faculty-wise Number of Doctorate Degrees (Ph.D.) Awarded

Faculty	2007-08	2011-12	2015-16*
Science	4,514	6,334	7,636
Computer Science	--	--	698**
Engineering/Technology	1,427	2,173	4,772
Medicine	277	638	1,021
Agriculture	664	677	1,350
Veterinary Science	123	189	283
Other Fields	402	996	2,091
Grand Total	13,237	19,861	27,671

Source: Ministry of Human Resource Development, Department of Higher Education, University Grants Commission (UGC), Annual Reports (various years), available at: https://www.ugc.ac.in/page/Annual-Report.aspx
* Provisional figures for 2015-16 based on AISHE data and UGC collection of data from universities
**Computer Science numbers were included under Science Ph.D numbers prior to 2015-16

Note: Science Ph.D numbers include Computer Science numbers as well prior to 2015-16

Table A.6 | Science & Engineering Doctoral Degrees in India (as Reported by NSF)

Faculty	2007*	2011	2015**
Physical and biological sciences and mathematics and statistics	5,625	5,442	5,721
Computer sciences	NA	240	321
Agricultural sciences	1,299	1,804	1,545
Social and behavioural sciences	NA	4,215	2,960
Engineering	1,058	2,081	2,597

Source: National Science Foundation (NSF), Science & Engineering Indicators 2018, Higher Education in Science and Engineering - S&E doctoral degrees, by selected Asian country or economy and field: 2000–14 available at https://www.nsf.gov/statistics/2018/nsb20181/data/appendix
*NSF data for 2006
**NSF data for 2014

Table A.7 | Country Comparisons for Patents Granted Abroad

	Country	2006	2011	2016
Select Advanced Economies	USA	69073	93431	133014
	UK	10991	13412	18067
	Germany	42228	51015	70133
Select Emerging/Asian Economies	Brazil	360	567	939
	China	1279	5783	20325
	India	919	2104	5549
	Israel	2257	3518	6108
	South Korea	13566	25444	38035

Source: World Intellectual Property Organization (WIPO) Statistical Country Profiles, available at http://www.wipo.int/ipstats/en/statistics/country_profile/

Table A.8 |New Companies Registered with the Ministry of Corporate Affairs (MCA)

State	2016-17	2015-16
Chandigarh	460	511
Delhi	16,025	14,129
Haryana	4,235	3,387
Himachal Pradesh	340	265
Jammu & Kashmir	274	273
Punjab	1,037	831
Rajasthan	2,693	2,331
Uttar Pradesh	8,685	7,534
Uttarakhand	677	522
Arunachal Pradesh	16	9
Assam	410	262
Bihar	2,709	2,391
Jharkhand	1,031	867
Manipur	51	49
Meghalaya	20	16
Mizoram	12	8
Nagaland	26	20
Sikkim	2	-
Odisha	1,525	1,245
Tripura	36	31
West Bengal	4,751	4,480
Chattisgarh	537	420
Dadra & Nagar Haveli	17	16
Daman and Diu	12	7
Goa	293	228
Gujarat	4,628	3,672
Madhya Pradesh	2,174	1,546
Maharashtra	17,507	15,513
Andaman and Nicobar Islands	50	44
Andhra Pradesh	2,330	2,175
Karnataka	8,902	7,548
Kerala	3,067	2,203
Lakshadweep	-	2
Pondicherry	93	99
Tamil Nadu	6,647	6,083
Telangana	6,568	5,764

Source: Ministry of Corporate Affairs (MCA), Government of India, Annual Reports (various years), available at http://www.mca.gov.in/MinistryV2/annualreports.html

Table A.9 | State-wise Number of Incubation Centres

State	No. of Incubation Centres in State	Incubators in Educational Institutes
Andhra Pradesh	3	0
Assam	2	2
Bihar	3	1
Delhi	6	3
Goa	2	2
Gujarat	8	5
Haryana	2	1
Jammu and Kashmir	1	1
Jharkhand	1	1
Karnataka	17	2
Kerala	9	3
Madhya Pradesh	2	2
Maharashtra	7	4
Odisha	2	1
Punjab	2	1
Rajasthan	2	1
Tamil Nadu	30	27
Telangana	8	5
Uttar Pradesh	11	5
Uttarakhand	2	2
West Bengal	5	4

Source: Startup India, available at https://www.startupindia.gov.in/; Centre for Technology, Innovation and Economic Research (CTIER)

Table A.10 | Funding for Indian Technology Startups for Select Sectors

Total Funding US$, Million	2012	2013	2014	2015	2016
Online Retail	303	626	3089	2075	658
Mobile Payments	10	14	53	890	208
Medical Devices	134	94	17	23	46
HealthTech	14	52	15	293	131
Solar Energy	101	271	319	528	107
Wind Energy	460	84	193	693	169

Source: Tracxn, data downloaded on 7 May 2018 from the platform; Centre for Technology, Innovation and Economic Research (CTIER)

Table A.11 | Exchange Rates

Indicator Name	Indicator Number	Exchange Rate used for converting to USD
R&D Expenditure by Select Key Scientific Agencies under Government of India	3.3	1 USD = 47.365 INR
		1 USD = 61.133 INR
Sector-wise Global Industrial R&D Expenditure and Country-wise Number of Firms (2016)	3.4	1 EUR = 1.09 USD
Total Industrial R&D Expenditure in India	5.1	1 USD = 44.17 INR
		1 USD = 45.48 INR
		1 USD = 65.42 INR
CTIER's Top 100 Industrial R&D spenders in India (2015-16)	5.2	1 USD = 66.23 INR
Total Foreign Exchange Spending on Technology Payments	5.4	1 USD = 47.85 INR
		1 USD = 54.35 INR
		1 USD = 60.42 INR
		1 USD = 61.13 INR
		1 USD = 65.42 INR
Technology Payments by Sector (2015-16)	5.4.1	1 USD = 65.42 INR
Import of Capital Goods by Indian Industry	5.5	1 USD = 47.85 INR
		1 USD = 54.35 INR
		1 USD = 60.42 INR
		1 USD = 61.13 INR
		1 USD = 65.42 INR
Import of Capital Goods by Sector	5.5.1	1 USD = 60.42 INR
		1 USD = 61.13 INR
		1 USD = 65.42 INR
Global MNCs having R&D presence in India	5.6	1 EUR = 1.09 USD

Source: Federal Reserve Bank St.Louis; EU Industrial R&D Investment Scoreboard (2016)

Period	Source
April 1 2009 to March 31 2010	Federal Reserve Bank St.Louis
April 1 2014 to March 31 2015	
31 December 2015	EU Industrial R&D Investment Scoreboard (2016)
April 1 2005 to March 31 2006	Federal Reserve Bank St.Louis
April 1 2010 to March 31 2011	
April 1 2015 to March 31 2016	
31 December 2015	EU Industrial R&D Investment Scoreboard (2016)
April 1 2011 to March 31 2012	Federal Reserve Bank St.Louis
April 1 2012 to March 31 2013	
April 1 2013 to March 31 2014	
April 1 2014 to March 31 2015	
April 1 2015 to March 31 2016	
April 1 2015 to March 31 2016	"Federal Reserve Bank St.Louis "
April 1 2011 to March 31 2012	Federal Reserve Bank St.Louis
April 1 2012 to March 31 2013	
April 1 2013 to March 31 2014	
April 1 2014 to March 31 2015	
April 1 2015 to March 31 2016	
April 1 2013 to March 31 2014	Federal Reserve Bank St.Louis
April 1 2014 to March 31 2015	
April 1 2015 to March 31 2016	
31 December 2015	EU Industrial R&D Investment Scoreboard(2016)

Note: An exchange rate corresponding to a full year period is based on the average for the said period.

Appendix B

Glossary

Serial No.	Term	Definition
B.1	**Category Normalized Citation Impact (CNCI)**	The Category Normalized Citation Impact (CNCI) of a document is calculated by dividing the actual count of citing items by the expected citation rate for documents with the same document type, year of publication and subject area. When a document is assigned to more than one subject area, an average of the ratios of the actual to expected citations is used. The CNCI of a set of documents, for example, the collected works of an individual, institution or country, is the average of the CNCI values for all the documents in the set. For a single paper that is only assigned to one subject area, this can be represented as: NCI = c/e_{ftd}, where: e = the expected citation rate or baseline, c = Times Cited, f = the field or subject area, t = year, d = document type. For a single paper that is assigned to multiple subjects, the CNCI can be represented as the average of the ratios for of actual to expected citations for each subject area. And for a group of papers, the CNCI value is the average of the values for each of the papers. A CNCI value of one represents performance at par with world average, values above one are considered above average and values below one are considered below average. A CNCI value of two is considered twice world average.
B.2	**Charges for the use of intellectual property, Payments**	Charges for the use of intellectual property are payments and receipts between residents and nonresidents for the authorized use of proprietary rights (such as patents, trademarks, copyrights, industrial processes and designs including trade secrets, and franchises) and for the use, through licensing agreements, of produced originals or prototypes (such as copyrights on books and manuscripts, computer software, cinematographic works, and sound recordings) and related rights (such as for live performances and television, cable, or satellite broadcast). Data are in current U.S. dollars.
B.3	**Foreign Direct Investment**	Foreign Investment means any investment made by a person resident outside India on a repatriable basis in capital instruments of an Indian company or to the capital of an Limited Liability Partnership (LLP). Foreign Direct Investment (FDI) is the investment through capital instruments by a person resident outside India (a) in an unlisted Indian company; or (b) in 10 percent or more of the post issue paid-up equity capital on a fully diluted basis of a listed Indian company. There are two routes under which foreign investment can be made: automatic and government. Under the automatic route, foreign Investment is allowed under the automatic route without prior approval of the Government or the Reserve Bank of India, in all activities/ sectors as specified in the Regulation 16 of Foreign Exchange Management Act, 1999 (FEMA) 20 (R). And for the government route, foreign investment in activities not covered under the automatic route requires prior approval of the Government.
B.4	**Gross Enrolment Ratio in Higher Education**	Students enrolled in higher education as a percentage of population between 18-23 years of age.
B.5	**High and Medium High Technology (HMT)(Also referred to as Higher Technology)**	The OECD definition for High and medium high technology (HMT) manufacturing is defined in ISIC Rev.4 as Chemicals and chemical products (Division 20), Pharmaceutical products (21), Computer, electronic and optical products (26), Electrical equipment (27), Machinery and equipment n.e.c. (28), Motor vehicles (29) and Other transport equipment (30)
B.6	**High technology Exports**	High-technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery. The original high-tech products classification is based on SITC Rev. 3 and is taken from Table 4 of Annex 2 of the 1997 working paper of Thomas Hatzichronouglou, OECD.
B.7	**Industry - Academia Collaborations**	An industry collaborative publication is one that lists its organization type as “corporate” for one or more of the co-author’s affiliations. The % of Industry Collaborations is the number of industry collaborative publications for an entity (as described above) divided by the total number of documents for the same entity represented as a percentage.

Source	Link	Indicator Numbers
Clarivate Analytics, InCites Indicators Handbook		3.11, 3.12, 3.12.1, 3.13
World Development Indicators, World Bank	http://databank.worldbank.org/data/metadataglossary/all/series	3.5, 3.5.1, 5.4
Reserve Bank of India	https://www.rbi.org.in/scripts/FAQView.aspx?Id=26#Q10	3.6, 3.6.1, 4.3
Ministry of Human Resource and Development, Department of Higher Education, All India Survey on Higher Education (2015-16)	http://aishe.nic.in/aishe/viewDocument.action?documentId=227	4.6
OECD	https://www.oecd.org/sti/ind/48350231.pdf	4.1, 4.2, 4.2.1
World Development Indicators, World Bank	http://databank.worldbank.org/data/metadataglossary/all/series	3.22
Clarivate Analytics, InCites Indicators Handbook		3.11, 3.12, 3.12.1, 3.13, 5.8

Serial No.	Term	Definition	
B.8	**Industry Classification Benchmark**	Industry Classification Benchmark (ICB) is a globally recognized standard, operated and managed by FTSE Russell for categorizing companies and securities across four levels of classification. Each company is allocated to the subsector that most closely represents the nature of its business, which is determined by its primary source of revenue and other publicly available information.	
B.9	**Knowledge Intensive(KI)**	Knowledge-intensive “market” services refer to ISIC Rev.4 Section J: Information and communication (Divisions 58-63); K: Finance and insurance (64-66); and M: Professional, scientific and technical activities (69-75)	
B.10	**National Industrial Classification**	National Industrial Classification 2008 (NIC-2008) is a revised version of NIC-2004. The 38th session of the UN Statistical Commission recommend that countries should make an effort either to adopt national versions of the ISIC, Revision 4, or to adjust their national classifications in such a way that data can be presented according to the categories of the ISIC, 10 Revision 4. Specifically, countries should be able to report data at the two-digit (division) level of the Classification without a loss of information; that is, national classifications should be fully compatible with this level of the ISIC, or it should be possible to arrange them.	
B.11	**National Institute Rankings Framework**	The National Institutional Ranking Framework (NIRF) was approved by the MHRD and launched by Honourable Minister of Human Resource Development on 29th September 2015. This framework outlines a methodology to rank institutions across the country. The methodology draws from the overall recommendations broad understanding arrived at by a Core Committee set up by MHRD, to identify the broad parameters for ranking various universities and institutions. The parameters broadly cover “Teaching, Learning and Resources,” “Research and Professional Practices,” “Graduation Outcomes,” “Outreach and Inclusivity,” and “Perception”.	
B.12	**Non Resident Patents**	The terms "non-resident" and "abroad" both relate to filings in a foreign office. However, we use the term "non-resident" for statistics by office, while use the term "abroad" for statistics by origin. In other words, when an office receives an application filed by a foreigner, it’s a non-resident filing for that office. By contrast, when an applicant files an application at a foreign office, it’s a filing abroad from the applicant’s origin.	
B.13	**Patents**	A patent is an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem. To get a patent, technical information about the invention must be disclosed to the public in a patent application.	
B.14	**Pupil Teacher Ratio in Higher Education**	The ratio of students in a particular academic institution to the teachers/instructors employed at that institution. Takes into account all institutions - university, colleges and stand-alone institutions in both regular and distant mode.	
B.15	**R&D intensity**	R&D intensity is the ratio between R&D investment and net sales of a given company or group of companies. At the aggregate level, R&D intensity is calculated only by those companies for which data exist for both R&D and net sales in the specified year. The calculation of R&D intensity in the Scoreboard is different from than in official statistics, e.g. BES-R&D, where R&D intensity is based on value added instead of net sales.	

	Source	Link	Indicator Numbers
	FTSE Rusell	http://www.ftserussell.com/financial-data/industry-classification-benchmark-icb	3.4, 3.4.1, 5.3, 5.3, 5.4.1, 5.5.1, 5.8
	OECD	https://www.oecd.org/sti/ind/48350231.pdf	4.1, 4.2, 4.2.1
	Ministry of Statistics and Programme Implementation, Government of India, National Industrial Classification (2008)	http://mospi.nic.in/classification/national-industrial-classification	
	Ministry of Human Resource Development, Government of India, National Institute Ranking Framework (NIRF) Rankings (2017)	https://www.nirfindia.org/OverallRanking.html	4.8
	WIPO	http://www.wipo.int/ipstats/en/help/	3.15, 3.16, 3.17, 3.20, 3.21, 5.9
	WIPO	http://www.wipo.int/patents/en/	3.15, 3.16, 3.17, 3.20, 3.21, 4.10, 5.9, 5.10
	Ministry of Human Resource and Development, Department of Higher Education, All India Survey on Higher Education (2015-16)	http://aishe.nic.in/aishe/viewDocument.action?documentId=227	4.7
	EU Industrial R&D Scoreboard (2016)	http://iri.jrc.ec.europa.eu/scoreboard16.html	5.3

Serial No.	Term	Definition	
B.16	**Research & Development Expenditure**	Research and experimental development (R&D) comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge.	
B.17	**Researchers in R&D**	Researchers are professionals who conduct research and improve or develop concepts, theories, models techniques instrumentation, software of operational methods. R&D covers basic research, applied research, and experimental development	
B.18	**Resident Patents**	The term "resident" is used for filings made by applicants at their home office. The home office can be a national office and/or a regional office. The resident figures by origin may thus correspond to the sum of filings made at a national and a regional office.	
B.19	**Small Business Innovation Research (SBIR)**	The Small Business Innovation Research (SBIR) programme is a highly competitive programme that encourages domestic small businesses to engage in Federal Research/Research and Development (R/R&D) that has the potential for commercialization. Through a competitive awards-based programme, SBIR enables small businesses to explore their technological potential and provides the incentive to profit from its commercialization.	
B.20	**Small Business Innovation Research Initiative (SBIRI)**	The Small Business Innovation Research Initiative (SBIRI) scheme of the Department of Biotechnology, Ministry of Science & Technology was launched in 2005 to boost Public-Private- Partnership (PPP) efforts in the country. SBIRI was the first of its kind, early stage, innovation focused PPP initiative in the area of Biotechnology.	
B.21	**Science & Engineering PhDs**	The Science and Engineering PhDs include Physical and Biological Sciences and Mathematics and Statistics, Computer Sciences, Agricultural Sciences, Engineering, and Social and Behavioural Sciences.	
B.22	**Startup**	Startup is an entity, incorporated or registered in India: a) Upto a period of seven years from the date of incorporation/registration or upto ten years in case of Startups in Biotechnology sector b) As a private limited company or registered as a partnership firm or a limited liability partnership c) With an annual turnover not exceeding Rs. 25 crore for any of the financial years since incorporation/registration d) Working towards innovation, development or improvement of products or processes or services, or if it is a scalable business model with a high potential of employment generation or wealth creation e) Provided that an entity formed by splitting up or reconstruction of an existing business shall not be considered a 'Startup'. An entity shall cease to be a Startup: a) On completion of seven years from the date of its incorporation/registration, ten years in case of Startups in Biotechnology sector, or b) If its turnover for any previous year exceeds Rs. 25 crore	

	Source	Link	Indicator Numbers
	OECD, Frascati Manual 2015	https://www.oecd-ilibrary.org/science-and-technology/frascati-manual-2015_9789264239012-en	3.1, 3.2, 3.2.1, 3.3, 3.4, 3.4.1, 5.1, 5.2, 5.3
	World Development Indicators, World Bank	http://databank.worldbank.org/data/metadataglossary/all/series	3.8
	WIPO	http://www.wipo.int/ipstats/en/help/	3.15, 3.16, 3.17, 3.20, 3.21, 5.9, 5.10
	SBIR US Government website	https://www.sbir.gov/about/about-sbir	
	Department of Biotechnology, BIRAC website	http://www.birac.nic.in/desc_new.php?id=217	
	NSF	https://www.nsf.gov/statistics/2018/nsb20181/assets/561/tables/at02-38.pdf	3.9, 3.9.1, 3.9.2
	Startup India	https://www.startupindia.gov.in/content/sih/en/startup-scheme.html	3.7.1, 3.7.2, 4.4, 4.4.1, 5.7

About CTIER

The Centre for Technology, Innovation and Economic Research (CTIER) is working to raise the level of debate and awareness amongst policy makers, industry and researchers in India about the essential role of technical capability in economic development, and how it is best fostered. The Centre is committed to improving the quality of India's R&D and innovation data, assessing the impact of policy measures introduced to promote R&D and identify ways to create systemic change in India's R&D and innovation system. We aim to influence policy making on the back of high quality empirical economic research, as well as impact higher education in India.

Our Team

Naushad Forbes

Naushad is Co-Chairman of Forbes Marshall, India's leading Steam Engineering and Control Instrumentation firm. He is also the Chairman and Founder of CTIER. Naushad was the President of the Confederation of Indian Industry (CII) in 2016-17. He was also a member of the Task force on Innovation established in 2016 by the Minister of Commerce and Industry, Government of India.

Between 1987 and 2004, Naushad was a part-time Lecturer and Consulting Professor at Stanford University where he developed courses on Innovation and Technology in Newly Industrializing Countries. A recent publication is 'India's National Innovation System: Transformed or Half-formed?' (2017) in Rakesh Mohan (ed) India Transformed: 25 years of Economic Reforms. In 2002, he co-authored (with David Wield) 'From Followers to Leaders: Managing Innovation in Newly Industrialising Countries (Routledge, London).

Naushad is on the Board of several educational institutions and public companies and has chaired CII National Committees on Higher Education, Innovation, Technology and International Business.

He received his Bachelors, Masters and PhD Degrees from Stanford University.

Farhad Forbes

Farhad is Co-Chairman of Forbes Marshall. He has been at Forbes Marshall since 1982. Previously, he was a member of the R&D technical staff of Hewlett-Packard Company in Palo Alto, California. He is presently Chairman and Board member of Family Business Network - International (FBN-I), an association of 3500 family businesses from 65 countries with 16,000 individual members.

He is also currently Chairman of the CII National Committee on Affirmative Action, and is a past Chairman of CII western region and a past Chairman of the CII-FBN India chapter. He is a past member of the Advisory Council of the Graduate School of Business at Stanford University, and a member of the Advisory Board of the MSx Program (formerly known as the Sloan Program) at Stanford University's Graduate School of Business.

He received his B.S. in 1977 and his M.S. in 1979 in Electrical Engineering from Stanford University. He received his M.S. in Management in 1991 from the Sloan Master's Program at the Graduate School of Business at Stanford University.

Janak Nabar

Janak is CEO of CTIER and has been leading CTIER's research efforts. He is a member of the CII National Committee on Technology and has been part of working groups constituted by NITI Aayog to rank national R&D laboratories and develop the India Innovation Index. Janak has previously worked as an Economist and Investment Strategist in the private sector in Singapore. His experience also includes two years with the United Nations High Commissioner for Refugees in Belgrade, Serbia. Besides his research interest in innovation and technology policy, Janak also researches and writes on India's macroeconomic policies.

He holds an MSc in Econometrics and Mathematical Economics from the London School of Economics and Political Science, MA (Mathematics) from Balliol College, University of Oxford (as a Radhakrishnan Scholar), and BA (Mathematics) from the University of Pune (ranked first in the university).

Swati Joshi

Swati is a Senior Research Associate at CTIER. She has extensive experience working with state governments and international agencies such as the UNICEF and the World Bank across different development sectors like education, WASH, public health, social security and participatory planning.

She holds a MSc with Distinction in Industrial Biotechnology from Newcastle University and a BSc with Distinction from the University of Pune.

Divya Sebastian

Divya is a Research Associate at CTIER. Her research interests lie in the areas of international trade and the economics of innovation.

She has an MA in Applied Economics from the Centre for Development Studies (affiliated to the Jawaharlal Nehru University, New Delhi) and a BA (Hons) Economics from St. Stephen's College, University of Delhi.

Mihir Baxi

Mihir worked on this Handbook as a Research Analyst at CTIER. Mihir has a BS in Economics from Ohio State University and is currently pursuing an MSc in Economics at the University of Warwick.

Karthik TL

Karthik worked on this Handbook as a Research Analyst at CTIER. Karthik has a BA in Economics from Sri Aurobindo International Centre of Education and is currently in the Mathematical Methods in Economics and Finance programme at Universite Paris 1 Pantheon Sorbonne.