Innovation: Trending Up but needs thrust, especially from the Private Sector

08
CHAPTER

எய்தற் கரியது இயைந்தக்கால் அந்நிலையே
செய்தற் கரிய செயல்.

"If a rare opportunity occurs, while it lasts, let a man do that which is rarely to be accomplished (but for such an opportunity)".

— Thirukural, Chapter 49, verse 489.

India entered the top 50 innovating countries for the first time in 2020 since the inception of the Global Innovation Index (GII) in 2007, by improving its rank from 81 in 2015 to 48 in 2020. To herald this significant achievement while setting out the path for further progress, the Survey examines India's innovation performance on various dimensions.

India ranks first in Central and South Asia, and third amongst lower middle-income group economies. Among the seven pillars of the GII, India ranks 27th in knowledge and technology outputs (KTO); 31st in market sophistication; 55th in business sophistication; 60th in human capital and research (HCR); 61st in institutions; 64th in creative output; and 75th in infrastructure. Among sub-pillars, India ranks tenth in knowledge diffusion and 15th in trade, commerce and market scale. Among parameters, India ranks first in ICT services exports; third in domestic market scale (PPP); ninth in government's online services; ninth in growth rate of productivity; 12th in science and engineering graduates; 13th in ease of protecting minority investors; 15th in e-participation; 16th in average expenditure of top three global R&D companies; and 19th in market capitalisation.

India's ranking on innovation outputs improved from 69 in 2015 to 45 in 2020. Its ranking on KTO almost halved from 49 in 2015 to 27 in 2020 while ranking on creative outputs improved from 95 in 2015 to 64 in 2020. India's innovation input sub-index ranking improved from 100 in 2015 to 57 in 2020. This improvement was led by business sophistication, where ranking improved from 116 in 2015 to 55 in 2020. India's ranking on Institutions improved from 104 in 2015 to 61 in 2020. Its ranking on HCR improved from 103 in 2015 to 60 in 2020. Its ranking on market sophistication improved from 72 in 2015 to 31 in 2020. India's ranking on infrastructure improved from 87 in 2015 to 75 in 2020.

The GII also highlights areas with scope for improvement. India ranks 107th on education sub-pillar, mainly on account of ranking 118th on pupil-teacher ratio in secondary education; 115th on new business per thousand population in ages 15-64; 108th on tertiary

inbound mobility; 108th on ICT access as well as ICT use; 105th on ease of starting a business; and 101st on females employed with advanced degrees. Also, as the 5th largest economy, India's aspiration must be to compete on innovation with the top ten economies.

The business sector in India contributes much less to gross expenditure on R&D (about 37 per cent) when compared to businesses in each of the top ten economies (68 per cent on average). This is despite the fact the tax incentives for R&D were more liberal in India when compared to those in the top ten economies. The Government does a disproportionate amount of heavy-lifting on R&D by contributing 56 per cent of the gross expenditure on R&D, which is three times the average contributed by governments in the top ten economies. Yet, India's gross expenditure on R&D at 0.65 per cent of GDP is much lower than that of the top 10 economies (1.5-3 per cent of GDP) primarily because of the disproportionately lower contribution from the business sector. Indian government sector contributes the highest share of total R&D personnel (36 per cent) and researchers (23 per cent) amongst the top ten economies (nine per cent on average). Indian business sector's contribution to the total R&D personnel (30 per cent) and researchers (34 per cent) in the country is the second lowest amongst the top ten economies (over 50 per cent on average). Indian residents contribute only 36 per cent of patents filed in India as compared to 62 per cent on average in the top ten economies. Indian firms also perform below expectation on innovation for their level of access to equity finance, which is the most crucial for innovation.

India must significantly ramp up investment in R&D if it is to achieve its aspiration to emerge as the third largest economy in terms of GDP current US$. Mere reliance on "Jugaad innovation" risks missing the crucial opportunity to innovate our way into the future. This requires a major thrust on R&D by the business sector. India's resident firms must increase their share in total patents to a level commensurate to our status as the fifth largest economy in current US$. India must also focus on strengthening institutions and business sophistication to improve its performance on innovation outputs.

As Economic Survey 2019-20 discussed in the chapter "Entrepreneurship and Wealth Creation at the Grassroots", the Startup India campaign of the Government of India recognises entrepreneurship as an increasingly important strategy to fuel productivity growth and wealth creation in India. This assumes greater importance in the context of enhancing private participation in innovation in India - in terms of contribution to gross expenditure on R&D, R&D personnel and researchers, and share in patents filed in the country. The lessons drawn therein on the crucial role of literacy, education, physical infrastructure and policies enabling ease of doing business, as drivers of new firm creation and entrepreneurship, remain relevant in this analysis.

WHY INNOVATION MATTERS

8.1 A vast body of literature in economics extols the role of innovation and technological progress in growth and development. Box 1 presents a selective review of literature highlighting the importance of innovation.

Box 1: Literature on Innovation, R&D and Growth

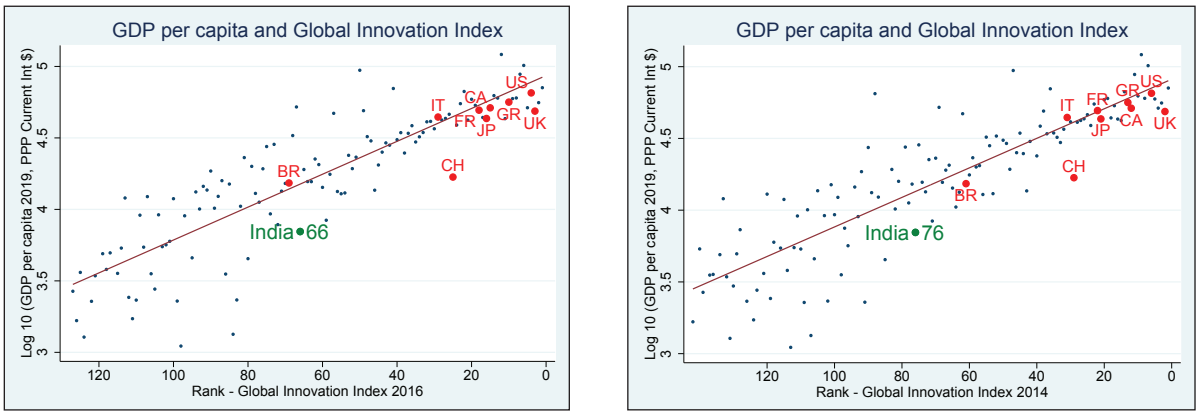
The importance of technological progress in economic growth began with the Solow model (Solow 1956), which highlighted that output per worker mainly depends on savings, population growth and technological progress. This model was empirically extended by Barro (1991); Barro and Sala-i-Martin (1991, 1992), and Mankiw, Romer and Weil (1992), identifying technological progress as the key determinant of long-term economic growth.

While the Solow model treats technological progress as exogenous, the new growth theory endogenises technological progress and suggests several determinants of the same. These include human capital (Lucas, 1988); search for new ideas by profit-oriented researchers (Romer, 1990); infrastructure (Aschauer 1989); and improving quality of existing products (Grossman and Helpman 1991; Aghion and Howitt 1992). Endogenous growth has also been explained using the Shumpeterian model of creative destruction, where innovative products brought to the market by entrants lead to replacement/ destruction of the old ones produced by the incumbents (Aghion, Akcigit, & Howitt, 2013).

The relation between innovation and research sector received attention with endogenous growth models (Romer, 1990 and Aghion & Howitt, 1992). Some postulated that R&D activities could make long run growth possible (Jones, 1995) and R&D effects on aggregate production functions were tested (Sveikauskas, 2007). Research showed that small enterprise R&D activities brought large returns to the national economy through new technologies (Comin, 2004). More recently, studies have focused on patenting and economic growth (Westmore, 2013; Acharya and Subramanian, 2009, Acharya et al. 2013). Studies have also established a relationship between entrepreneurship innovation and economic growth (Galindo & Méndez, 2014). An increase of 10 per cent in R&D investment has been associated with productivity gains ranging from 1.1 per cent to 1.4 per cent (Donselaar and Koopmans, 2016).

Figure 1: Positive Correlation between GDP per capita (2019) and Past Innovation

A) Innovation (2016) **B) Innovation (2014)**



Source: The World Bank and Global Innovation Index database
Note: Highest possible rank is 1. Figure shows India's innovation rank. US = USA, CH = China, JP = Japan, GR = Germany, UK = United Kingdom, FR = France, IT = Italy, BR = Brazil and CA = Canada.

8.2 The positive correlation between past innovation performance and current GDP per capita can be examined empirically. Figure 1 shows the positive correlation between past innovation performance (three-years ago in 2016 and five years ago in 2014) with GDP per capita in PPP

terms (2019) across countries. It may be seen that India has performed below expectation for its past innovation performance in terms of recent GDP per capita.

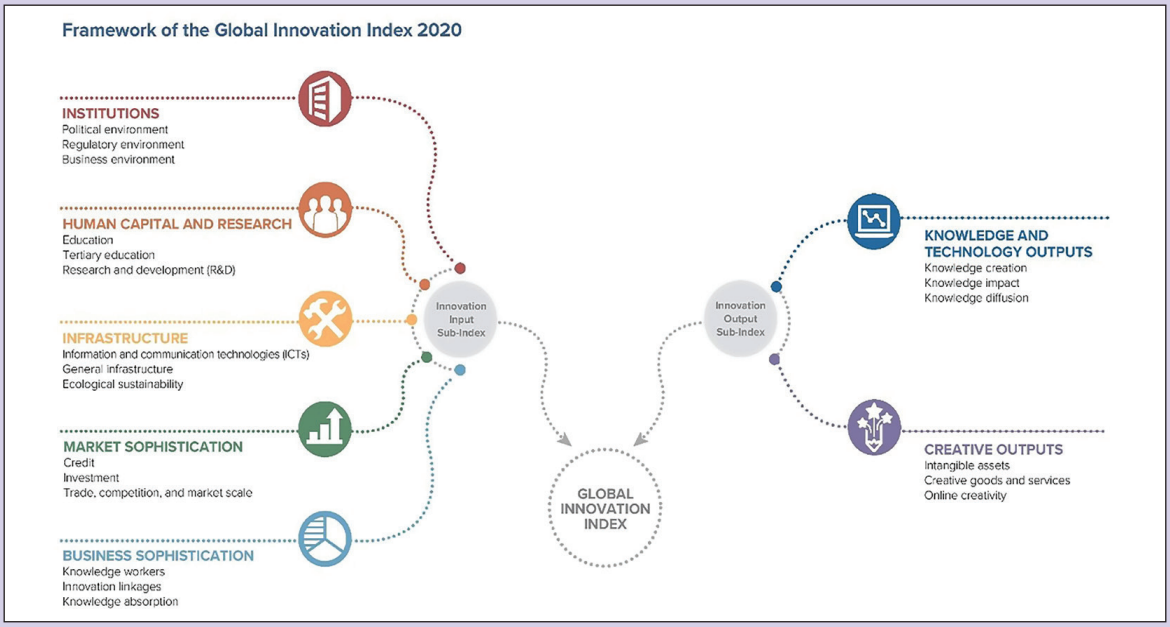
HOW DOES INDIA PERFORM ON INNOVATION?

8.3 India ranks 48th amongst 131 countries in terms of its innovation performance as measured using the Global Innovation Index (GII) 2020. See Box 2 for a description of the GII, which is further sub-divided into the innovation output sub-index and innovation input sub-index. India ranks 45th and 57th on the output and input sub-indices respectively. India entered the top 50 innovating countries for the first time since the inception of the index in 2007. Along with three other economies – Vietnam, Republic of Moldova and Kenya, India has the rare distinction of being an innovation achiever for ten consecutive years.

Box 2: The Global Innovation Index (GII)

The GII is co-published by Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO), a specialized agency of the United Nations. It seeks to assist economies in evaluating their innovation performance.

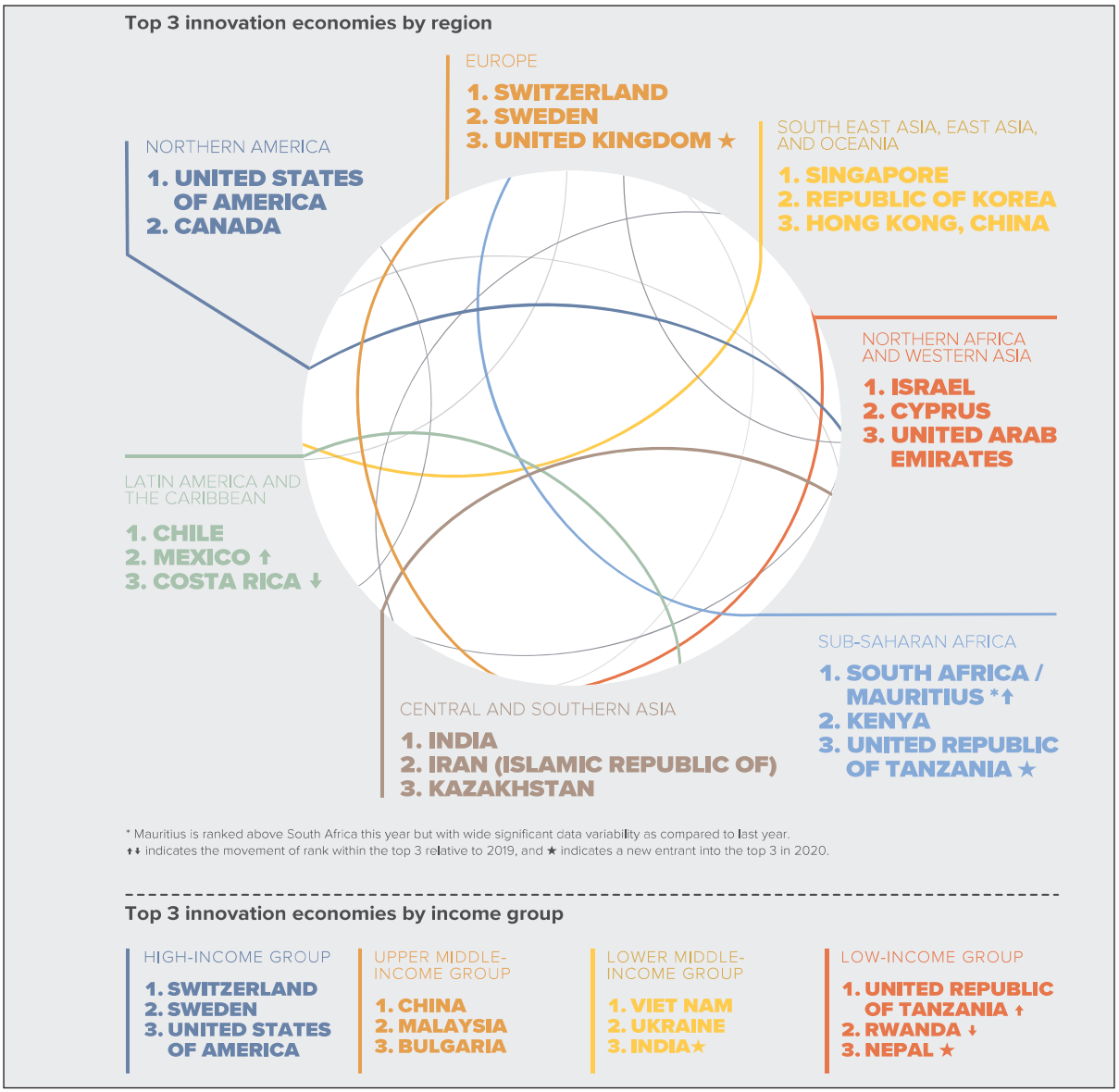
GII has two sub-indices: the Innovation Input Sub-Index and the Innovation Output Sub-Index, and seven pillars, each consisting of three sub-pillars, further divided into a total of 80 indicators. The Innovation Input sub-index and the Innovation Output Sub-Index have equal weight in calculating the overall GII. The Innovation Input sub-index has five pillars: (i) Institutions; (ii) Human Capital and Research; (iii) Infrastructure; (iv) Market Sophistication; and (v) Business Sophistication. The Innovation Output Sub-Index has two pillars (i) Knowledge and Technological outputs and (ii) Creative outputs. GII was first conceptualised in 2007.



Source: GII

GII 2020 includes 131 countries/economies, which represent 93.5 per cent of the world's population and 97.4 per cent of the world's GDP in purchasing power parity current international dollars.

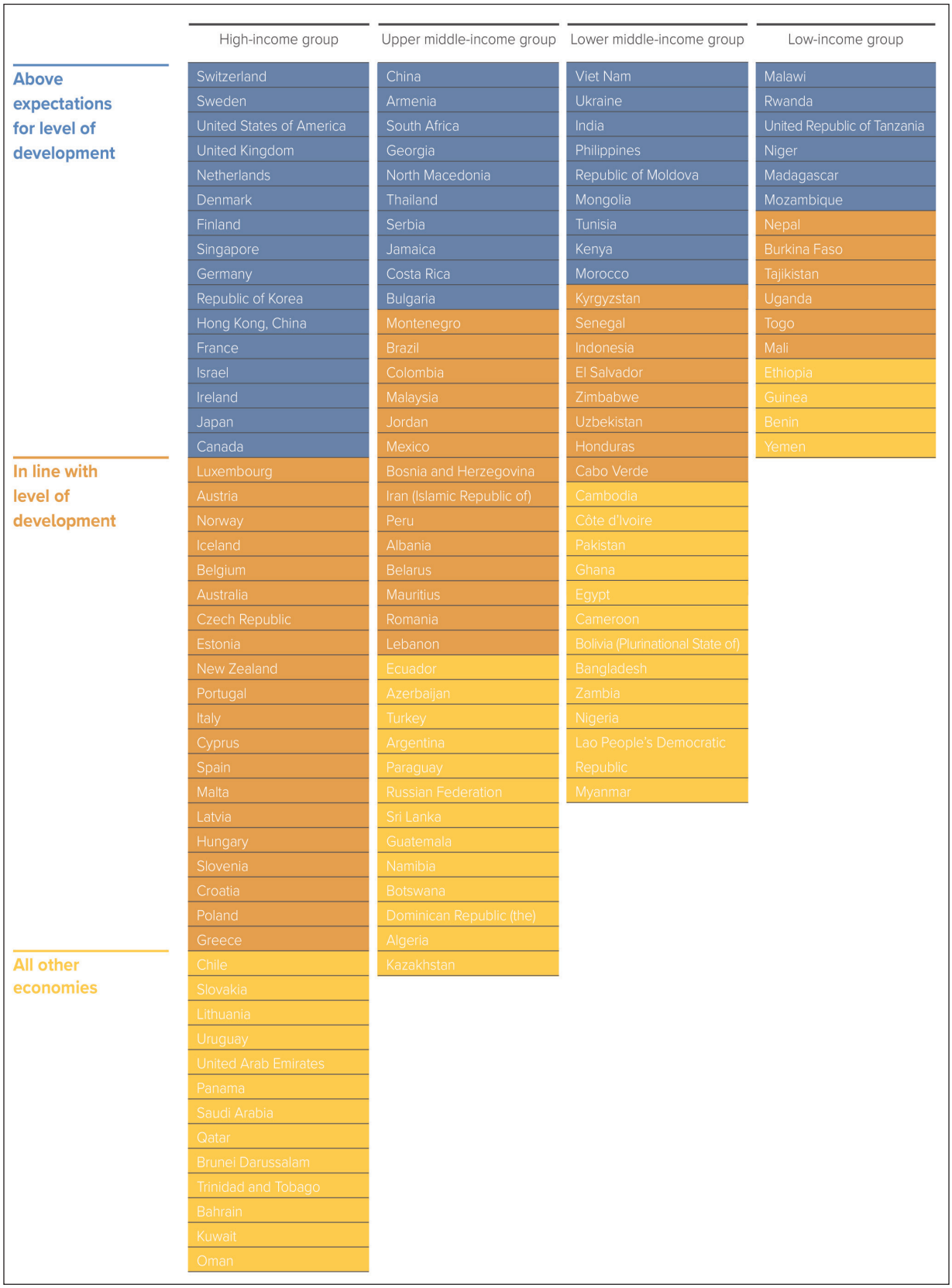
Figure 2: Global Leaders in Innovation in 2020



Source: GII 2020 Report

8.4 India performed particularly well regionally and in its income category, ranking first in the GII rankings in Central and South Asia, and third amongst lower middle-income group economies (see Figure 2). India performed above expectation for its level of development in terms of innovation (see Figure 3).

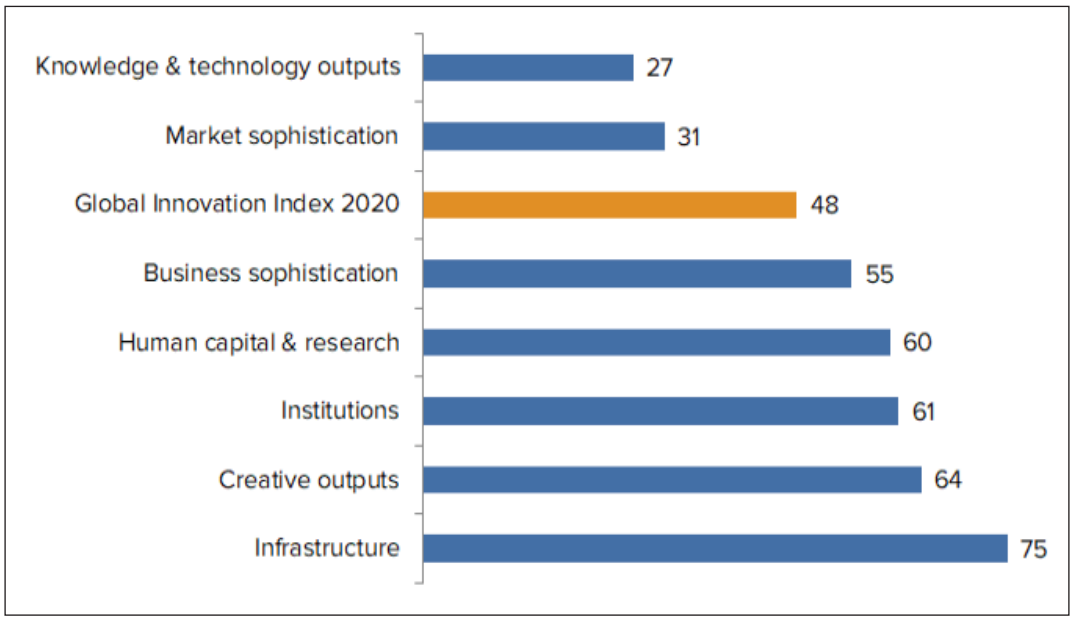
Figure 3: Innovation Performance by Income-level in 2020



Source: GII 2020 Report

8.5 Figure 4 shows India's performance on the GII 2020 (rank) across the seven pillars. India performed best on the knowledge & technology outputs (KTO) pillar (rank 27) followed by Market Sophistication pillar (rank 31). India performed lowest on the Infrastructure pillar (rank 75).

Figure 4: India's performance on pillars of the Global Innovation Index 2020 (rank)



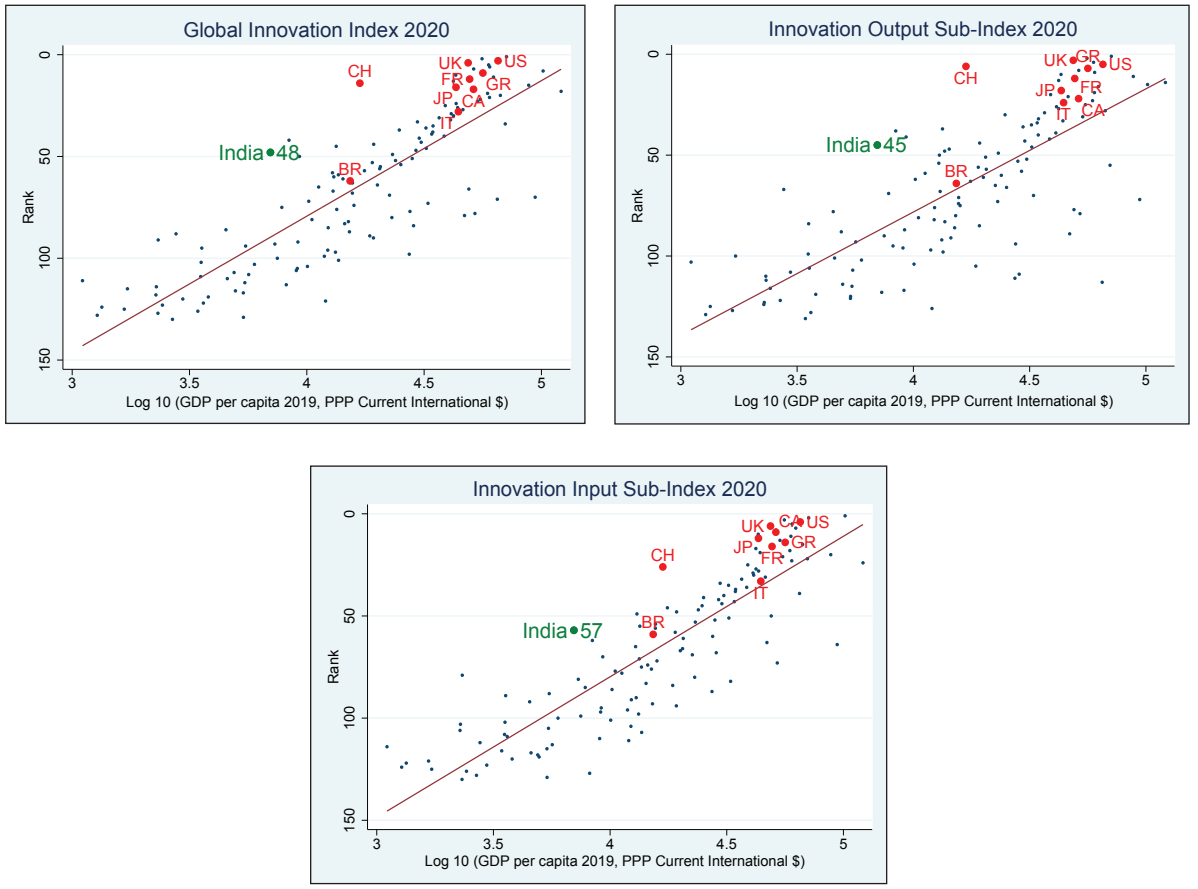
Source: GII 2020 Report

8.6 India's performance in innovation outputs is driven by its competencies. India ranks tenth in the Knowledge Diffusion sub-pillar of the KTO pillar. India's first rank in the Information and Communications Technology (ICT) services exports as per cent of total trade shows its leadership in the global ICT services industry. India ranks ninth in terms of productivity growth (growth rate of GDP PPP per worker). It is ranked 21st for citable documents as well as cultural and creative services exports. India has the distinction of ranking 31st in global brand value by producing many more valuable brands than expected for its income level.

8.7 India has performed impressively in innovation inputs such as domestic market scale (rank three) facilitating its overall rank of 15 in the Trade, Competition and Market Scale sub-pillar. Other leading innovation inputs for India include government's online service (rank nine), graduates in science and engineering (rank 12), ease of protecting minority investors (rank 13), e-participation (rank 15), average exports of top three global R&D companies (rank 16) and average score of top 3 universities in the QS university rankings (rank 22).

8.8 Figure 5 takes a closer look at India's performance on the GII and its sub-indices vis-à-vis the top 10 economies in terms GDP (Current US$). India performs above expectation for its level of development (per capita GDP) on the GII as well as the Innovation Output and Innovation Input sub-indices.

Figure 5: Innovation and Level of Development



Source: The World Bank and GII database
Note: Highest possible rank is 1. Figure shows India's innovation rank. US = USA, CH = China, JP = Japan, GR = Germany, UK = United Kingdom, FR = France, IT = Italy, BR = Brazil and CA = Canada.

Is India a positive outlier only because of its population?

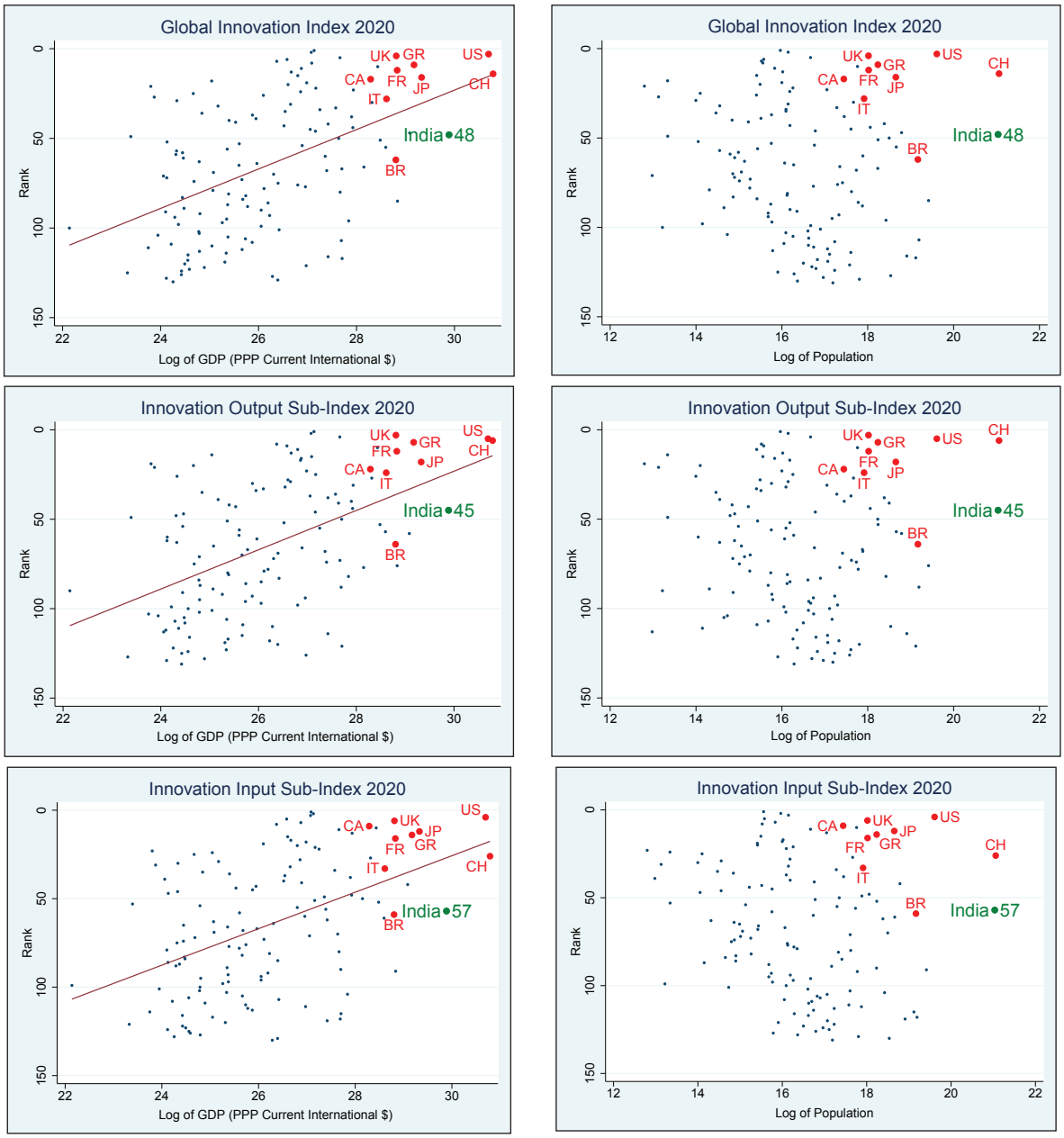
8.9 India is an innovation outlier in terms of its level of development (per capita GDP in PPP terms). India is the third largest economy globally in PPP terms and the second largest in terms of population. Since per capita income is a function of the population, we examine whether India is a positive outlier because of high population.

8.10 Figure 6 sheds light on this issue. It plots GII rank, Innovation Outputs rank and Innovation Inputs rank against log GDP PPP and log population. The top 10 economies (GDP current US$) are highlighted on the graphs. It may be seen that population does not seem to be correlated to GII, Innovation Outputs and Innovation Inputs. However, GDP seems to be positively correlated with innovation performance. Figure 6 suggests that India's status as an innovation outlier w.r.t. its level of development cannot be attributed to its population as we observe no clear pattern of correlation between innovation performance and population.

8.11 Figure 6 also suggests that India is a negative outlier in terms of its GDP, i.e. India seems to be underperforming in innovation w.r.t. the size of its GDP. This divergent performance for India in terms of the size of its economy and its level of development is a significant finding and warns against being complacent.

Figure 6: Performance on GII w.r.t GDP and Population

A) GDP **B) Population**



Source: The World Bank and GII database

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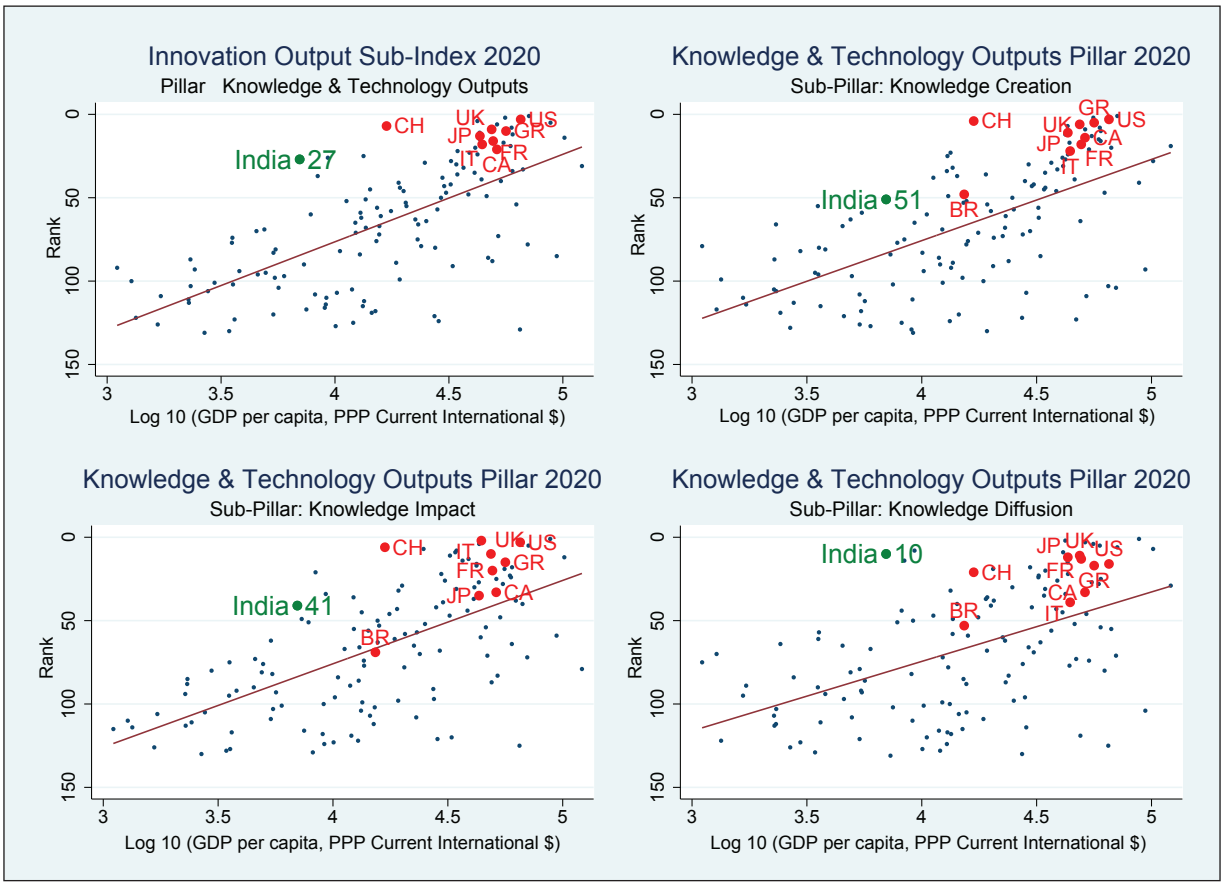
India's performance on sub-components of the Global Innovation Index 2020

8.12 Figures 7-13 examine India's innovation performance (rank) vis-à-vis its level of development (per capita GDP) for the seven pillars and 21 sub-pillars of the GII. India is a positive outlier on most pillars and sub-pillars of the GII w.r.t. its level of development.

8.13 Figure 7 depicts India's performance in its best performing pillar - KTO pillar and its three sub-pillars – knowledge creation, knowledge impact and knowledge diffusion vis-à-vis its level

of development. In 2020, India performed above expectation for its level of development in all three sub-pillars of the KTO pillar. It performed particularly well in knowledge diffusion sub-pillar (rank ten), which can be mainly attributed to its performance in the parameter ICT services exports as per cent of total trade, in which India ranked first globally. In the knowledge impact sub-pillar (rank 41), India's performance was led by the parameter growth rate of GDP PPP$ per worker (rank nine).

Figure 7: India's performance in Knowledge & Technology Pillar in GII 2020



Source: The World Bank and GII database
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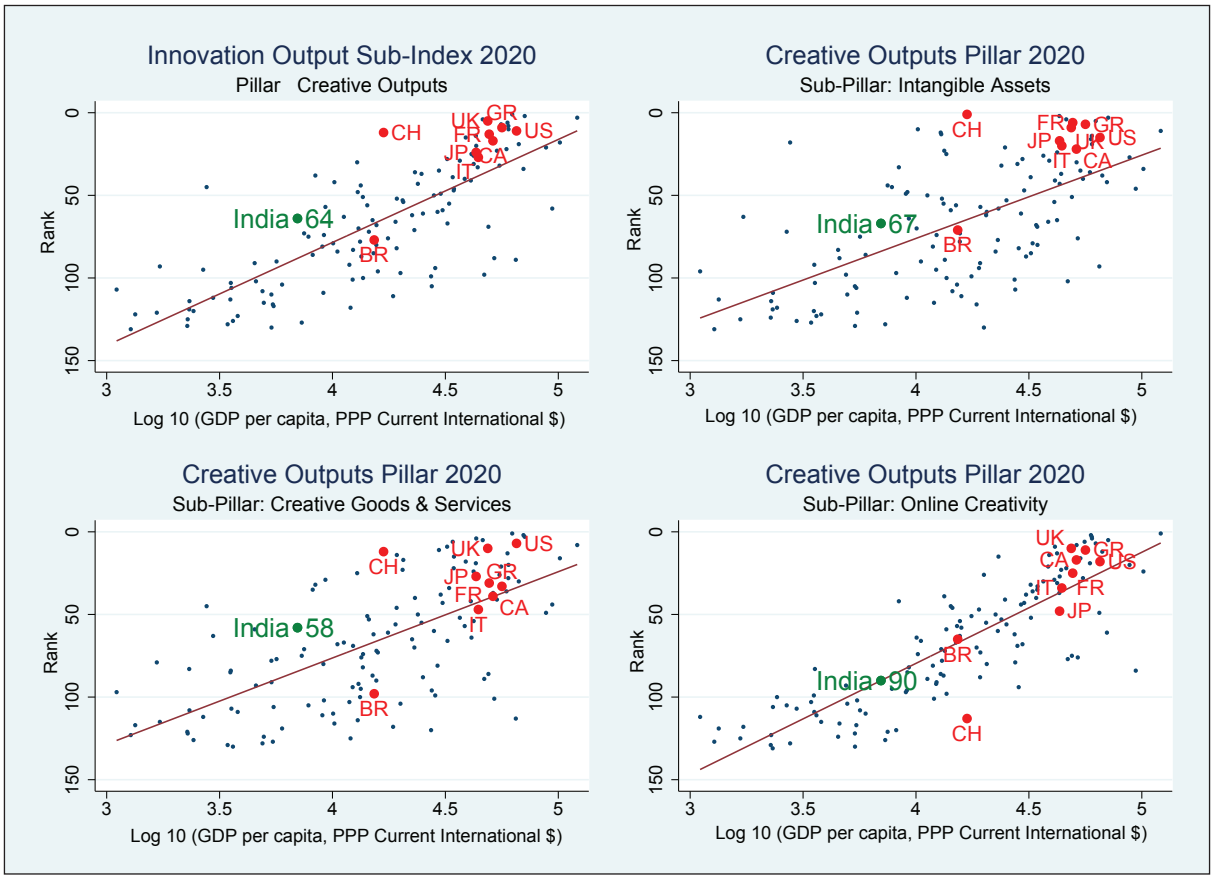
8.14 Figure 8 shows India's performance in the creative outputs pillar and its three sub-pillars – intangible assets, creative goods & services and online creativity vis-à-vis its level of development. In 2020, India performed above expectation for its level of development in two sub-pillars of the creative outputs pillar. It performed better in creative goods & services (rank 58) and intangible assets (rank 67) pillar than online creativity (rank 90). Performance in creative goods & services sub-pillar was led by the parameters cultural & creative services exports as per cent of total trade (rank 21) and creative goods exports as per cent of total trade (rank 23). Performance in intangible assets sub-pillar was led by the parameter global brand value, top 5000 as per cent of GDP (rank 31).

Figure 8: India's performance in Creative Outputs Pillar in GII 2020



Source: The World Bank and GII database

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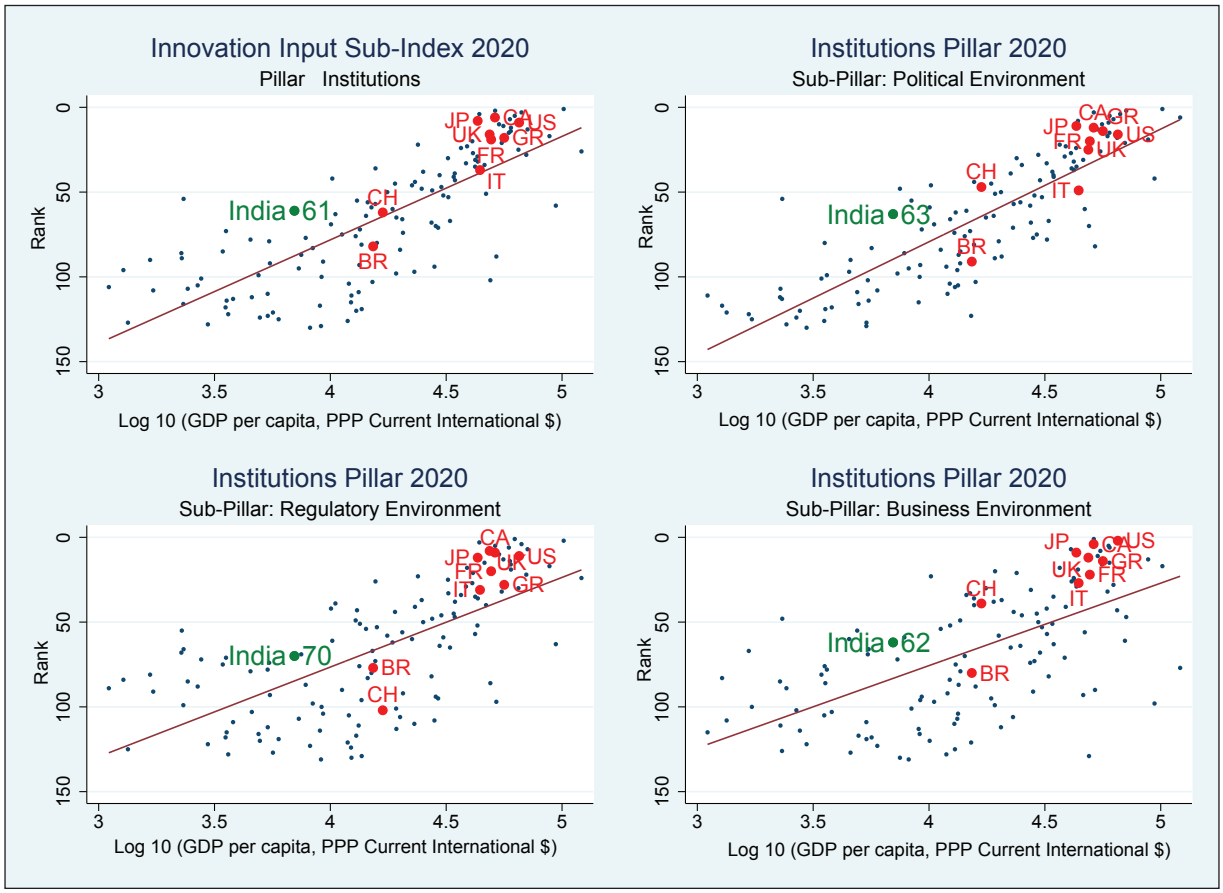
8.15 Figure 9 shows India's performance in the institutions pillar and its three sub-pillars – political environment, regulatory environment and business environment vis-à-vis its level of development. India performed above expectation for its level of development in all three sub-pillars of the institutions pillar in 2020. It performed better in business environment (rank 62) and political environment (rank 63) than in regulatory environment (rank 70), taking its overall institutions ranking to 61.

Figure 9: India's performance in Institutions Pillar in GII 2020



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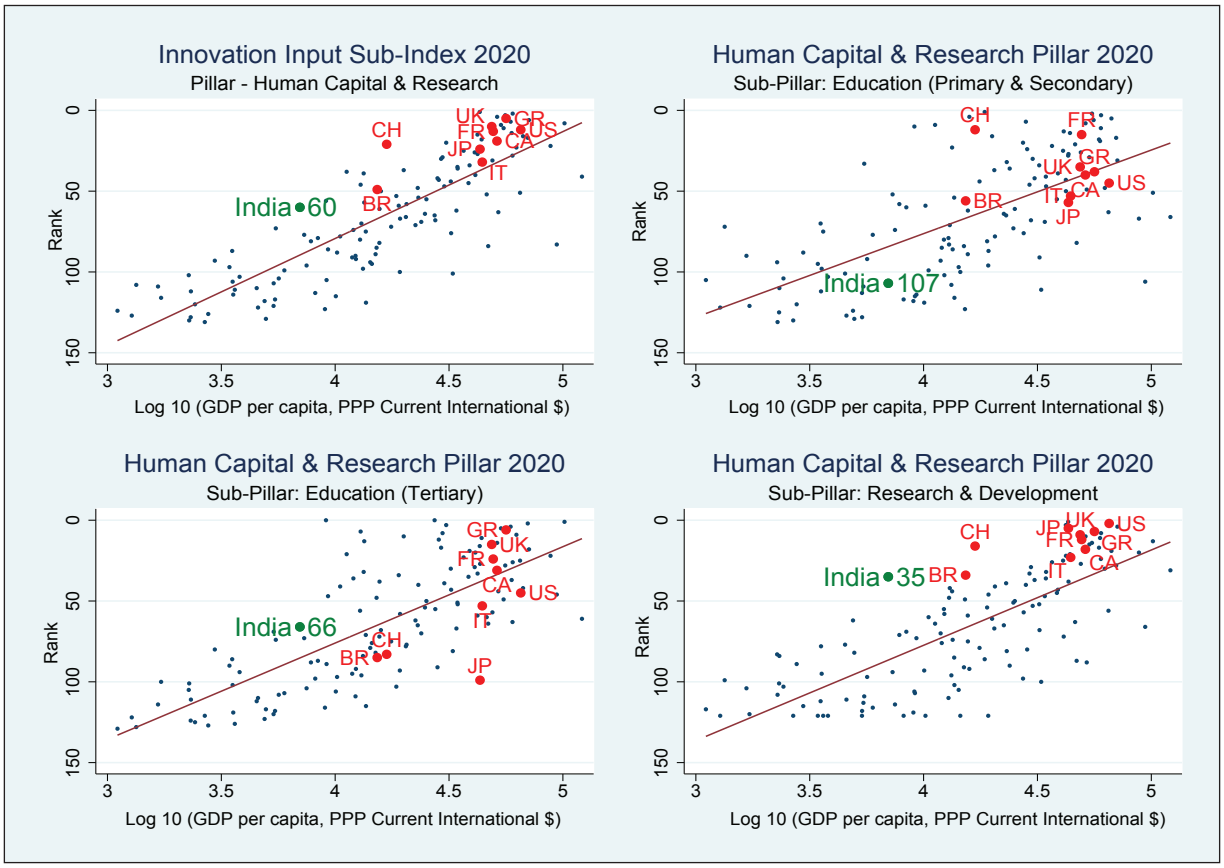
8.16 Figure 10 shows India's performance in the Human Capital & Research (HCR) pillar and its three sub-pillars – primary and secondary education, tertiary education and research & development vis-à-vis its level of development. India performed above expectation for its level of development in two sub-pillars (tertiary education and R&D) of the HCR pillar in 2020, performing particularly well in R&D (rank 35). It performed below expectation for its level of development in the primary & secondary education sub-pillar (rank 107), which is mainly attributed to India's poor performance in pupil-teacher ratio in secondary education (rank 118).

Figure 10: India's performance in Human Capital & Research Pillar in GII 2020



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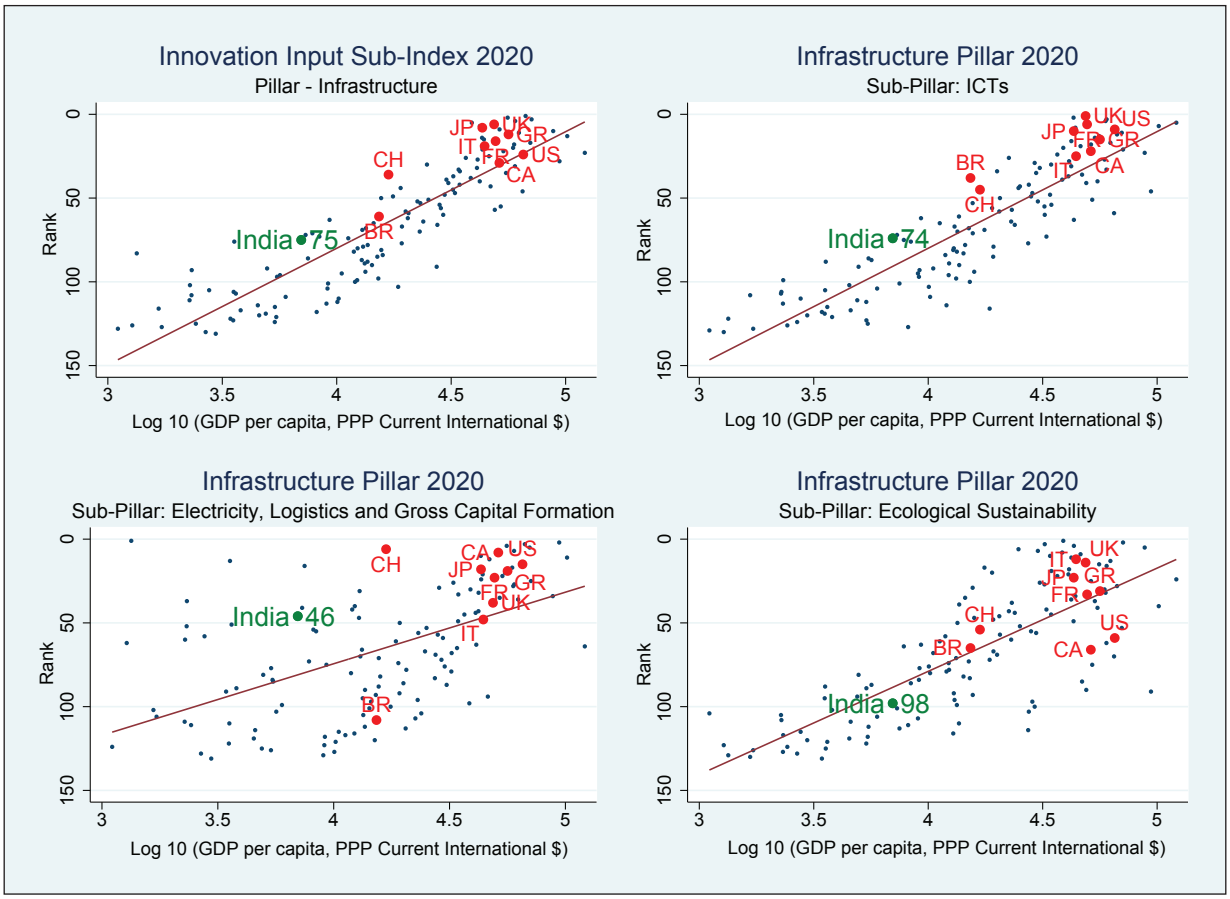
8.17 Figure 11 shows India's performance in the infrastructure pillar and its three sub-pillars – ICT; electricity, logistics and gross capital formation (GCF); and ecological sustainability vis-à-vis its level of development. India performed above expectation for its level of development in two sub-pillars of the infrastructure pillar in 2020, performing well in the electricity, logistics and GCF sub-pillar (rank 46). Its performance in the electricity, logistics and GCF sub-pillar was led by the parameter gross capital formation as per cent of GDP (rank 24). India's performance in the ICT sub-pillar was led by government's online services (rank 9) and e-participation (rank 15) but dragged down by ICT access (rank 108) and ICT use (rank 108). India performed below expectation for its income level in the ecological sustainability sub-pillar (rank 98), which can be mainly attributed to the parameter environmental performance (rank 124).

Figure 11: India's performance in Infrastructure Pillar in GII 2020



Source: The World Bank and GII database

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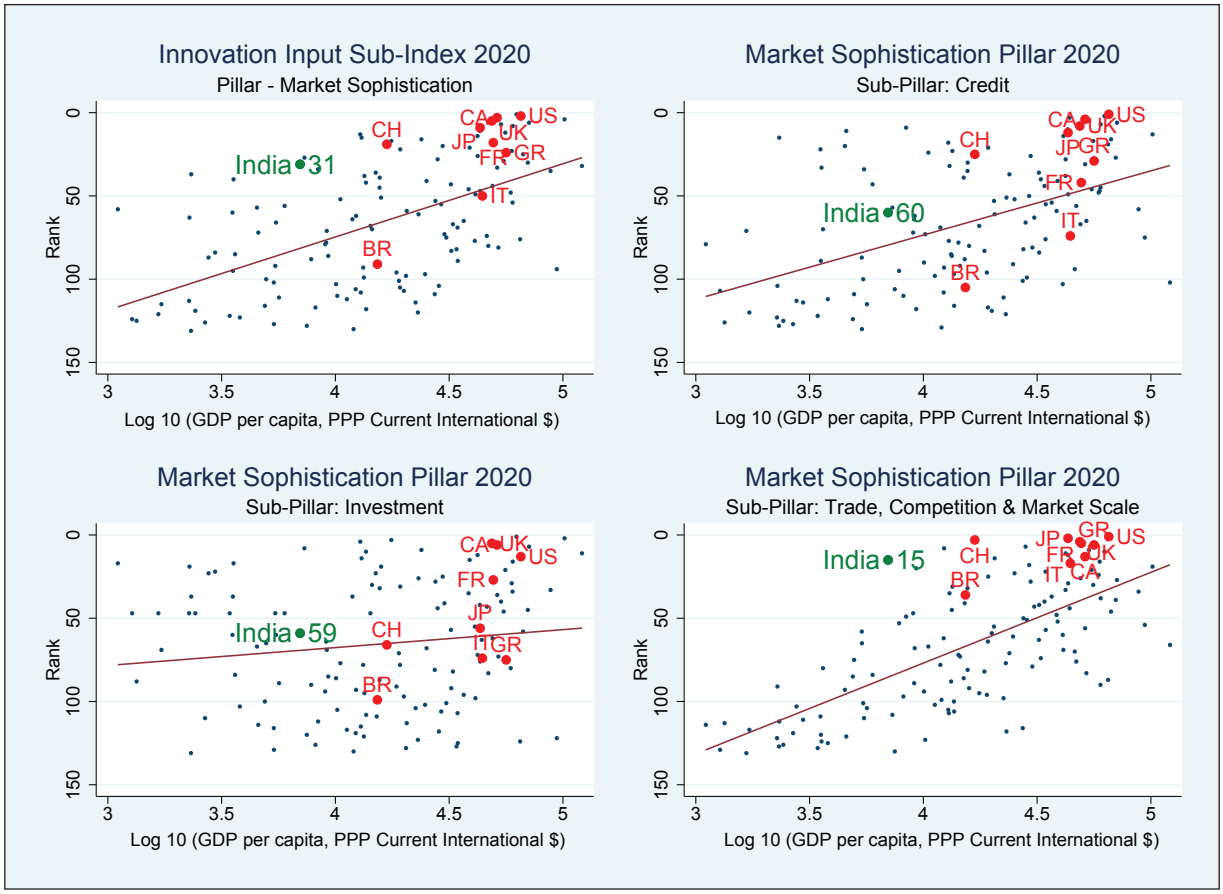
8.18 Figure 12 examines India's performance in the market sophistication pillar and its three sub-pillars – credit, investment and trade, competition and market scale vis-à-vis its level of development. India performed above expectation for its level of development in all three sub-pillars of the market sophistication pillar in 2020, performing particularly well in trade, competition and market scale sub-pillar (rank 15). This was driven by the parameter domestic market scale in which India ranked third globally. India's performance in investment sub-pillar was driven by the parameters ease of protecting minority investors (rank 13) and market capitalisation as per cent of GDP (rank 19). India's performance in credit sub-pillar was driven by the parameters ease of getting credit (rank 23) and microfinance gross loans as per cent of GDP (rank 25).

Figure 12: India's performance in Market Sophistication Pillar in GII 2020



Source: The World Bank and GII database
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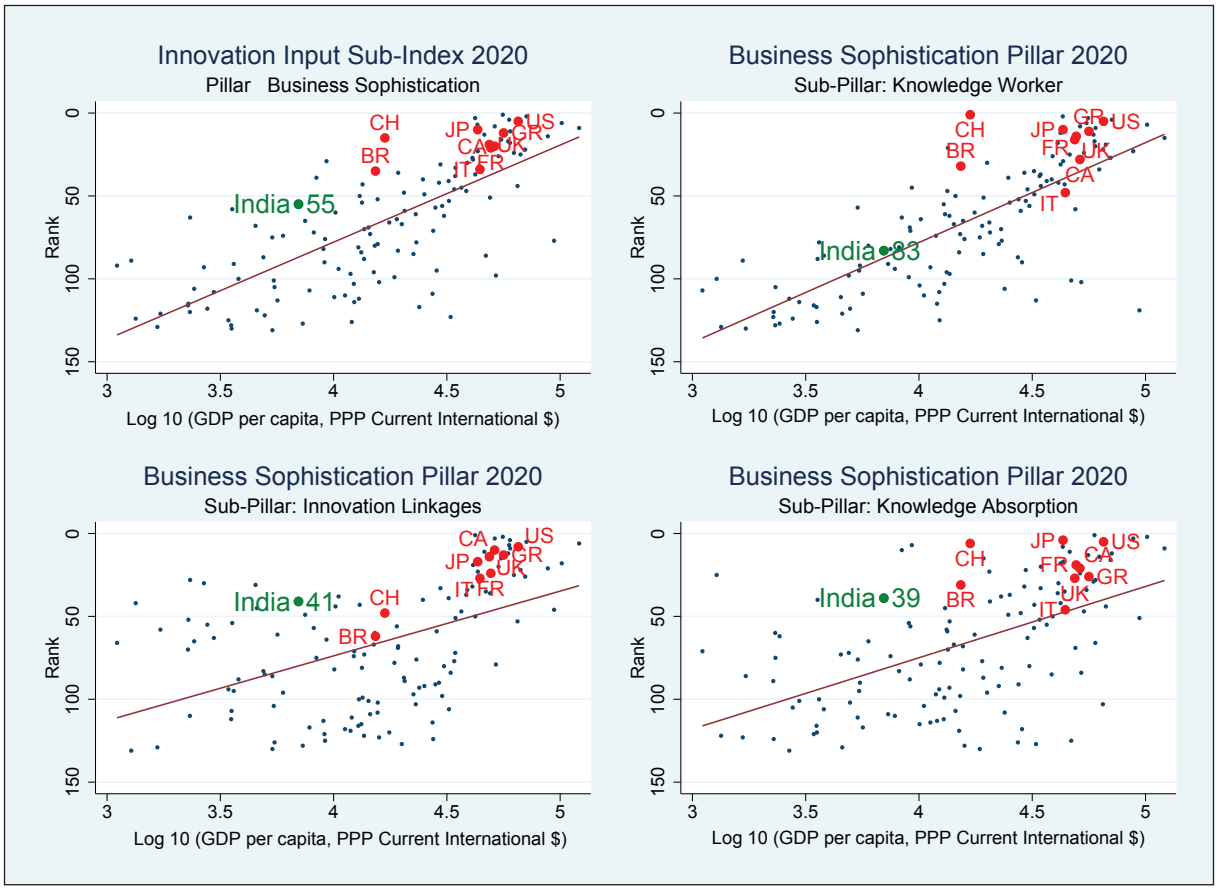
8.19 Figure 13 examines India's performance in the business sophistication pillar and its three sub-pillars – knowledge worker, innovation linkages and knowledge absorption vis-à-vis its level of development. India performed above expectation for its level of development in two sub-pillars of the business sophistication pillar in 2020 – knowledge absorption (rank 39) and innovation linkages (rank 41). Its performance in knowledge absorption sub-pillar was led by the parameters intellectual property payments as per cent of total trade (rank 27) and high-tech imports as per cent of total trade (rank 29). India's relatively poor performance in knowledge workers sub-pillar can be mainly attributed to its low performance in the parameter females employed with advanced degrees (rank 101), followed by the parameter knowledge-intensive employment (rank 90).

Figure 13: India's performance in Business Sophistication Pillar in GII 2020



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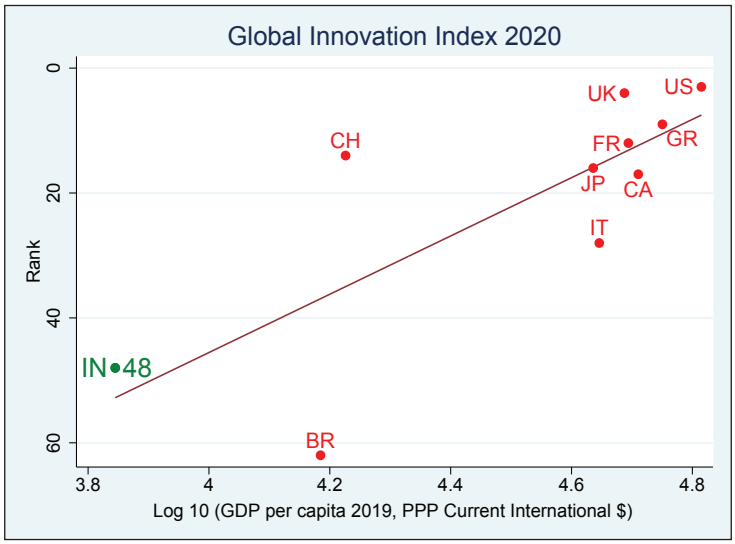
INDIA'S INNOVATION PERFORMANCE VIS-À-VIS TOP TEN ECONOMIES

8.20 India is currently the fifth largest economy in terms of GDP current US$ while it is the third largest in terms of GDP PPP current international $. Although India has performed above expectation on innovation w.r.t. its level of development, India lags behind most other large economies (top ten in terms of GDP current US$) on most indicators of innovation.

8.21 Figure 14 shows GII performance of the ten largest economies (GDP current US$). Although India performs in line with its level of development, India ranks second lowest, after Brazil, on the overall GII. Countries such as China and the UK rank much higher than expected for their level of development.

Figure 14: Performance of Top 10 Economies on GII



Source: The World Bank and GII database
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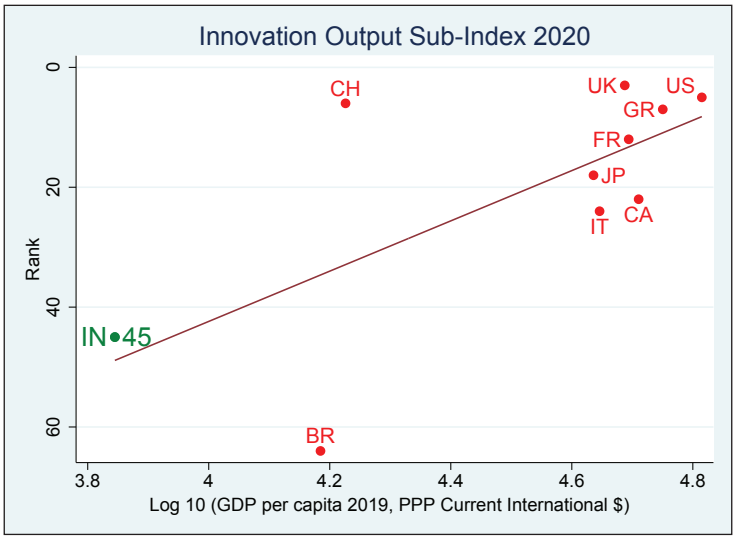
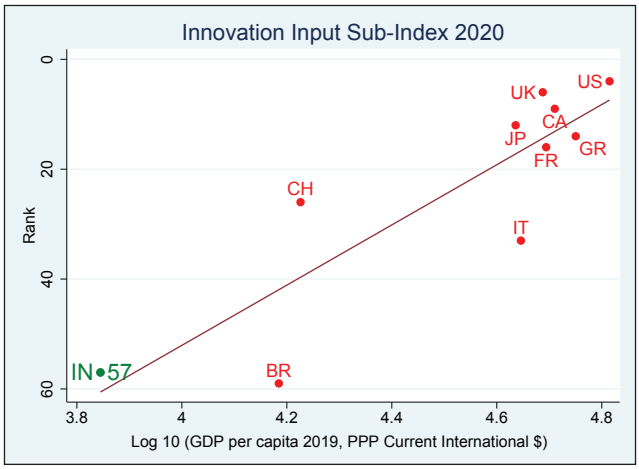
Figure 15: Performance of Top 10 Economies on Innovation Output Sub-Index



Source: The World Bank and GII database
Note: Highest possible rank is 1. Figure shows India's innovation rank. US = USA, CH = China, JP = Japan, GR = Germany, IN=INDIA, UK = United Kingdom, FR = France, IT = Italy, BR = Brazil and CA = Canada.

8.22 This trend continues in innovation outputs and innovation inputs. Performance on innovation outputs of the ten largest economies (GDP current US$) may be seen in Figure 15. Although India performs as per expectations for its level of development, India is ranked second lowest, after Brazil, on innovation outputs. Figure 16 shows performance on innovation inputs of the ten largest economies (GDP current US$). India performs in line with its level of development but ranks second lowest, after Brazil, on innovation inputs amongst the top ten economies.

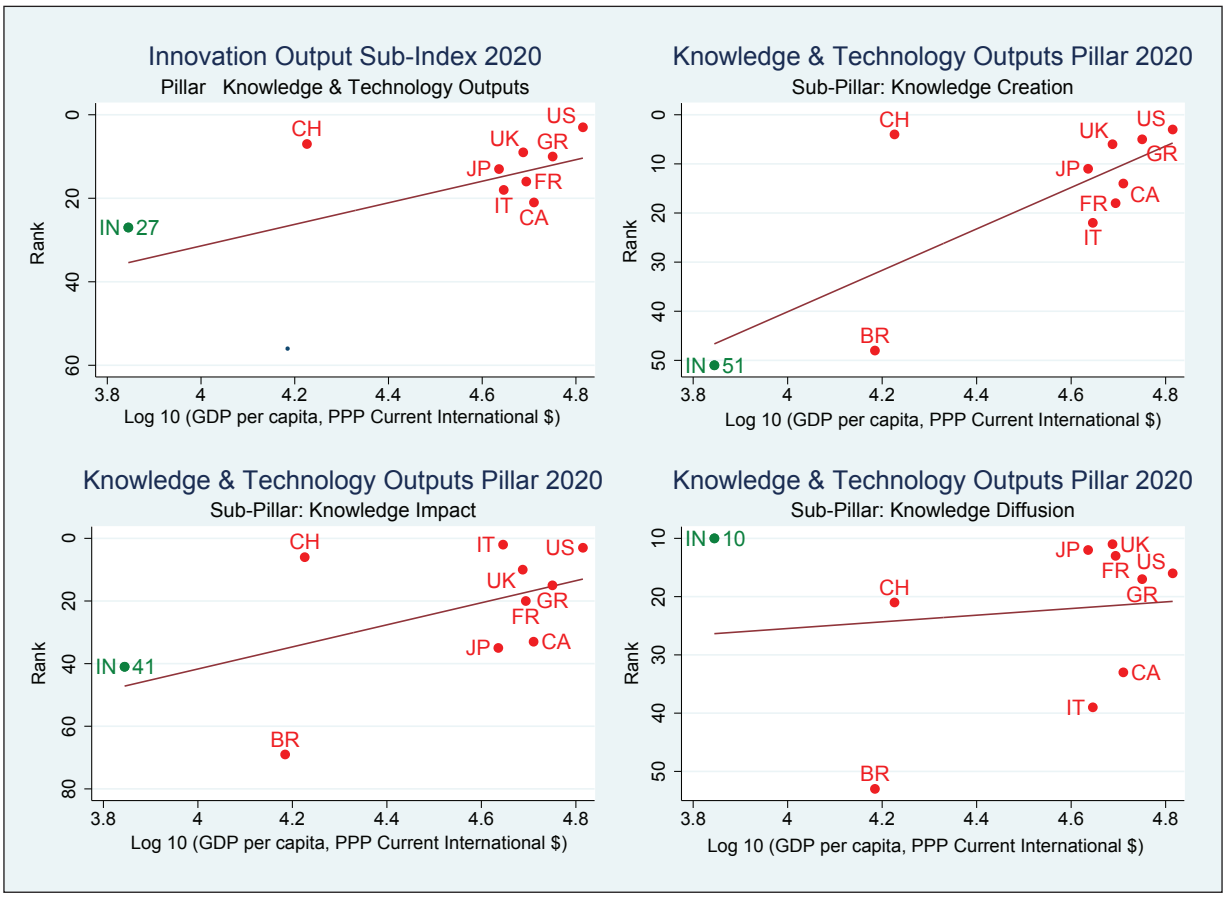
Figure 16: Performance of Top 10 Economies on Innovation Input Sub-Index



Source: The World Bank and GII database

Note: Highest possible rank is 1. Figure shows India's innovation rank. US = USA, CH = China, JP = Japan, GR = Germany, IN=INDIA, UK = United Kingdom, FR = France, IT = Italy, BR = Brazil and CA = Canada.

Figure 17: Performance of Top 10 Economies on KTO Pillar



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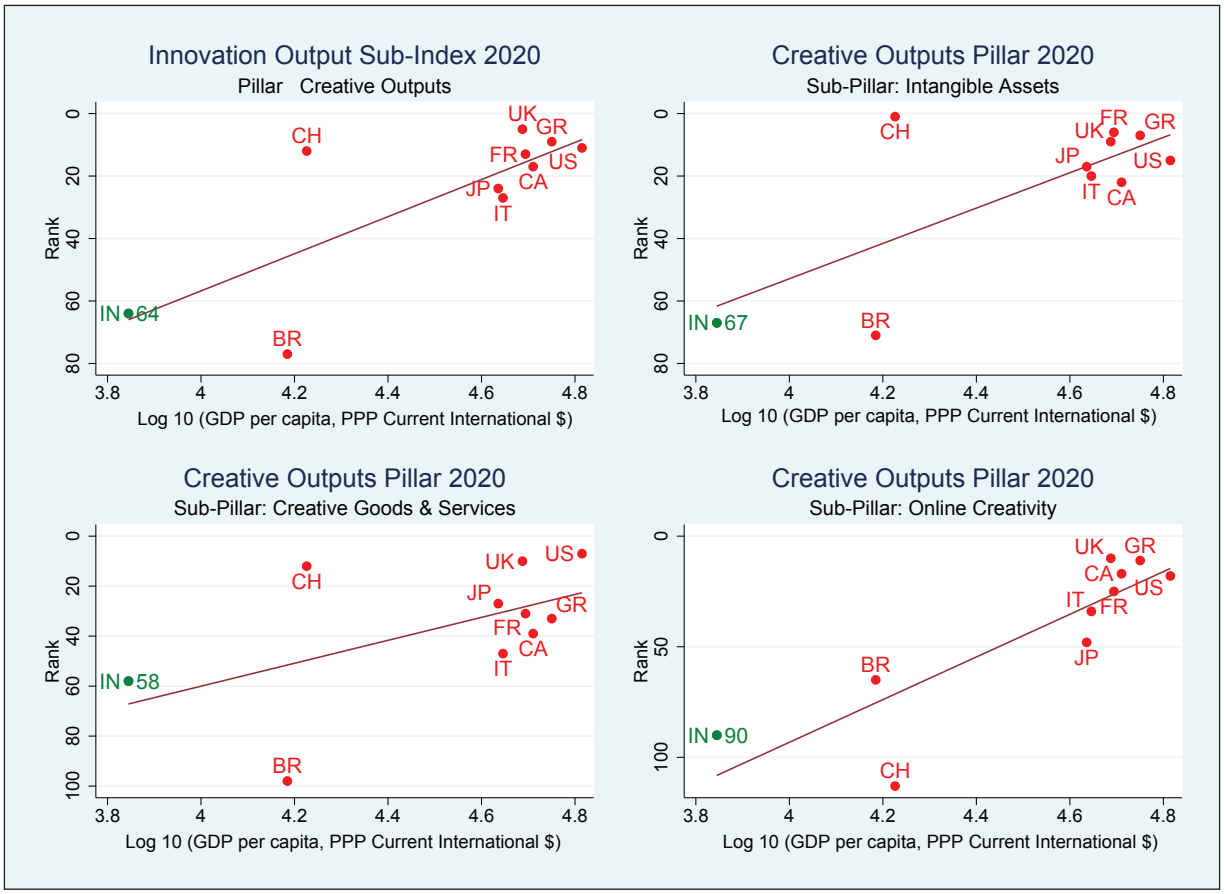
8.23 Figure 17 compares India's performance in its top ranked pillar – KTO w.r.t. the other largest economies. India performs above expectation for its level of development on KTO pillar, performing particularly well on the knowledge diffusion sub-pillar. India ranks highest amongst the top ten economies (GDP current US$) on the knowledge diffusion sub-pillar while it ranks lowest on the knowledge creation sub-pillar. In comparison, China performs much above expectation for its level of development on the KTO pillar as well as knowledge creation and knowledge impact sub-pillars.

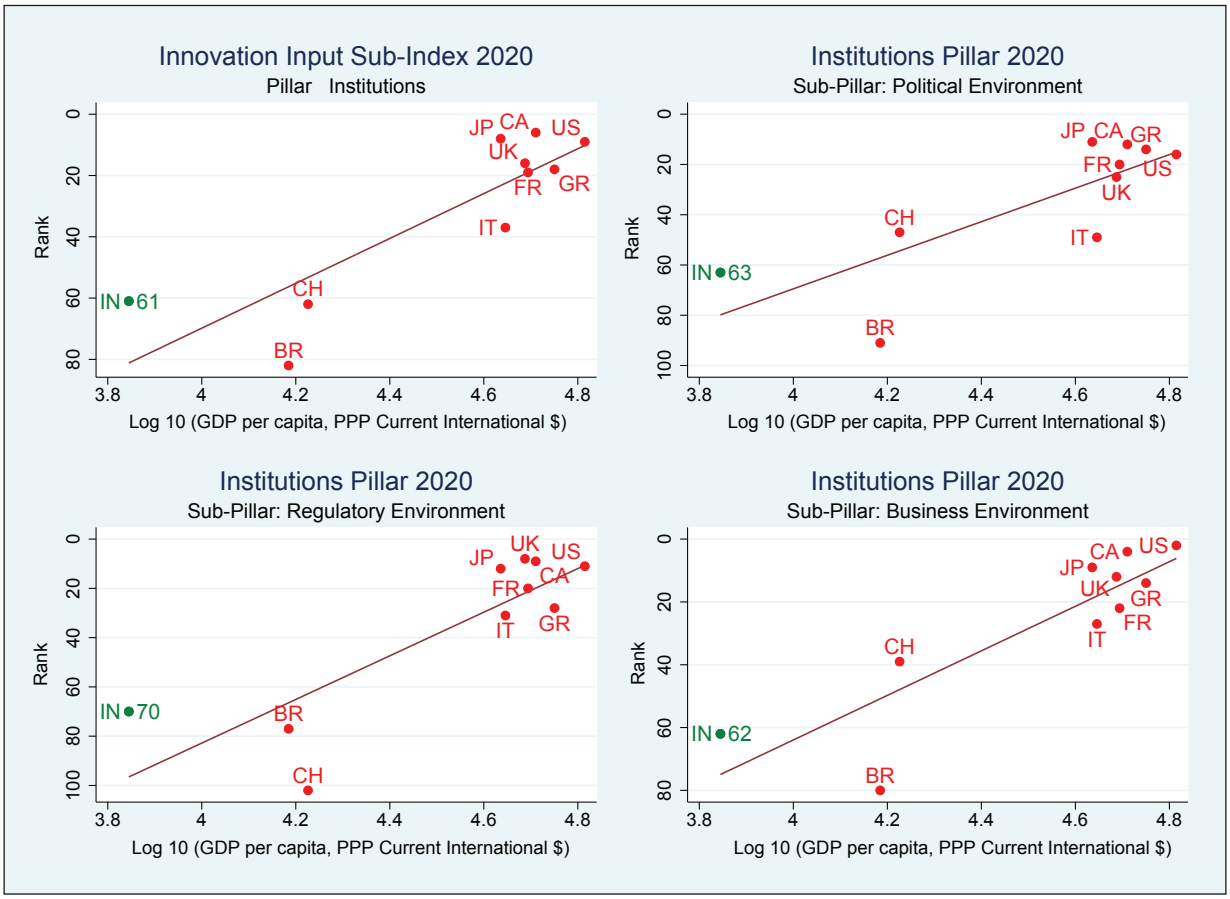
Figure 18: Performance of Top 10 Economies on Creative Outputs Pillar



Source: The World Bank and GII database
Note: Highest possible rank is 1. Figure shows India's innovation rank. US = USA, CH = China, JP = Japan, GR = Germany, IN=INDIA, UK = United Kingdom, FR = France, IT = Italy, BR = Brazil and CA = Canada.

8.24 Performance of top ten economies on the creative outputs pillar may be seen in Figure 18. India performs in line with its level of development on the creative outputs pillar, performing above expectation on online creativity and creative goods and services. However, India is ranked second lowest, after Brazil, on the creative output pillar and the intangible assets and creative goods and services sub-pillars. India ranks second lowest, after China, on the online creativity sub-pillar. While India performs close to expectation for its level of development on all three sub-pillars, China performs much higher than expected for its level of development on the creative outputs pillar and the intangible assets and creative goods and services sub-pillars.

Figure 19: Performance of Top 10 Economies on Institutions Pillar



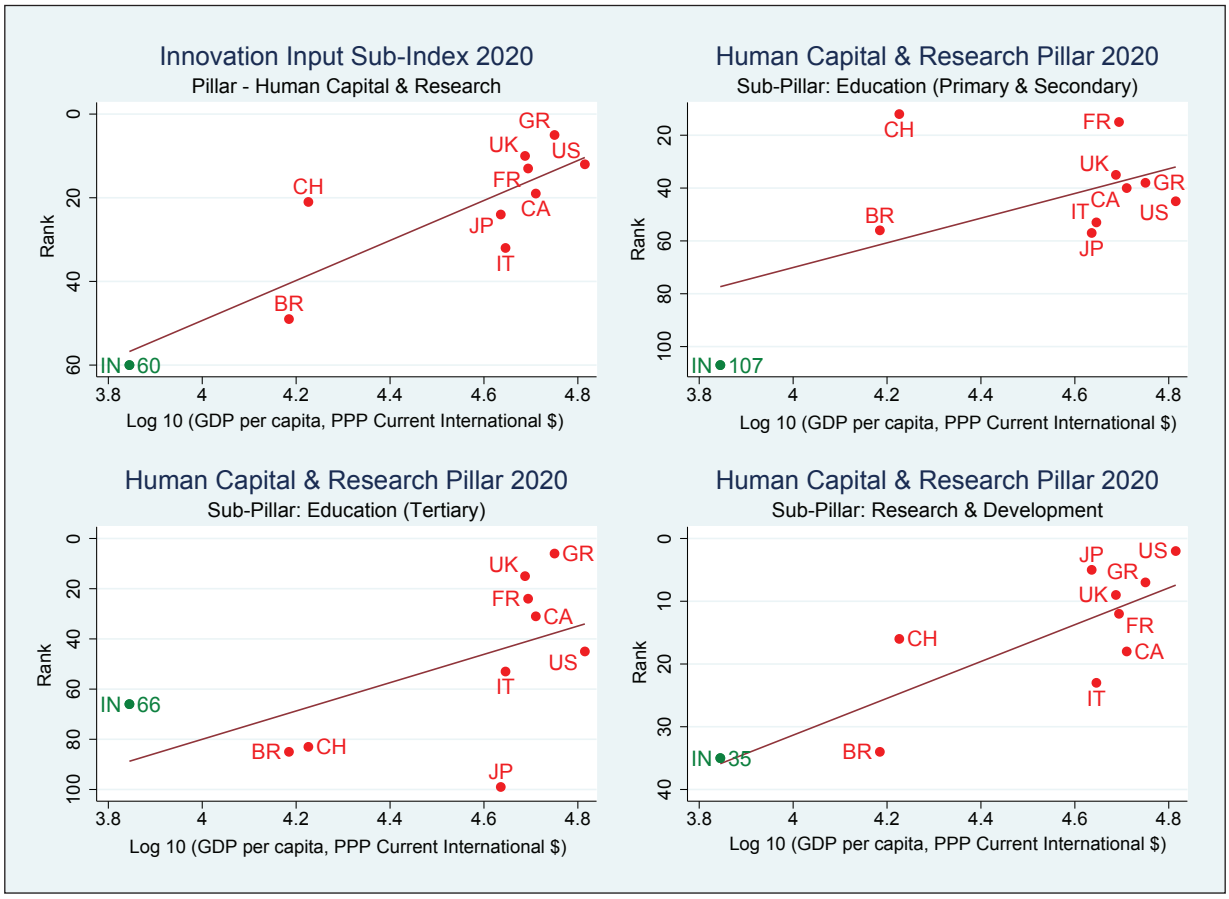
Source: The World Bank and GII database

Note: Highest possible rank is 1. Figure shows India's innovation rank. US = USA, CH = China, JP = Japan, GR = Germany, IN=INDIA, UK = United Kingdom, FR = France, IT = Italy, BR = Brazil and CA = Canada.

8.25 Figure 19 compares India's performance on institutions pillar w.r.t. the other largest economies. India performs above expectation for its level of development on the institutions pillar and each of its sub-pillars. However, India ranks third lowest, after Brazil and China, on the institutions pillar and regulatory environment sub-pillar. India ranks second lowest, after Brazil, on political and business environment sub-pillars.

8.26 Figure 20 compares India's performance on HCR pillar w.r.t. the other largest economies. India performs in line with its level of development on the HCR pillar and research & development sub-pillar, while it performs above expectation on tertiary education sub-pillar. However, amongst the top ten economies, India ranks lowest on the HCR pillar and the R&D and primary and secondary education sub-pillars. India ranks fourth lowest – after Japan, Brazil and China, on the tertiary education sub-pillar.

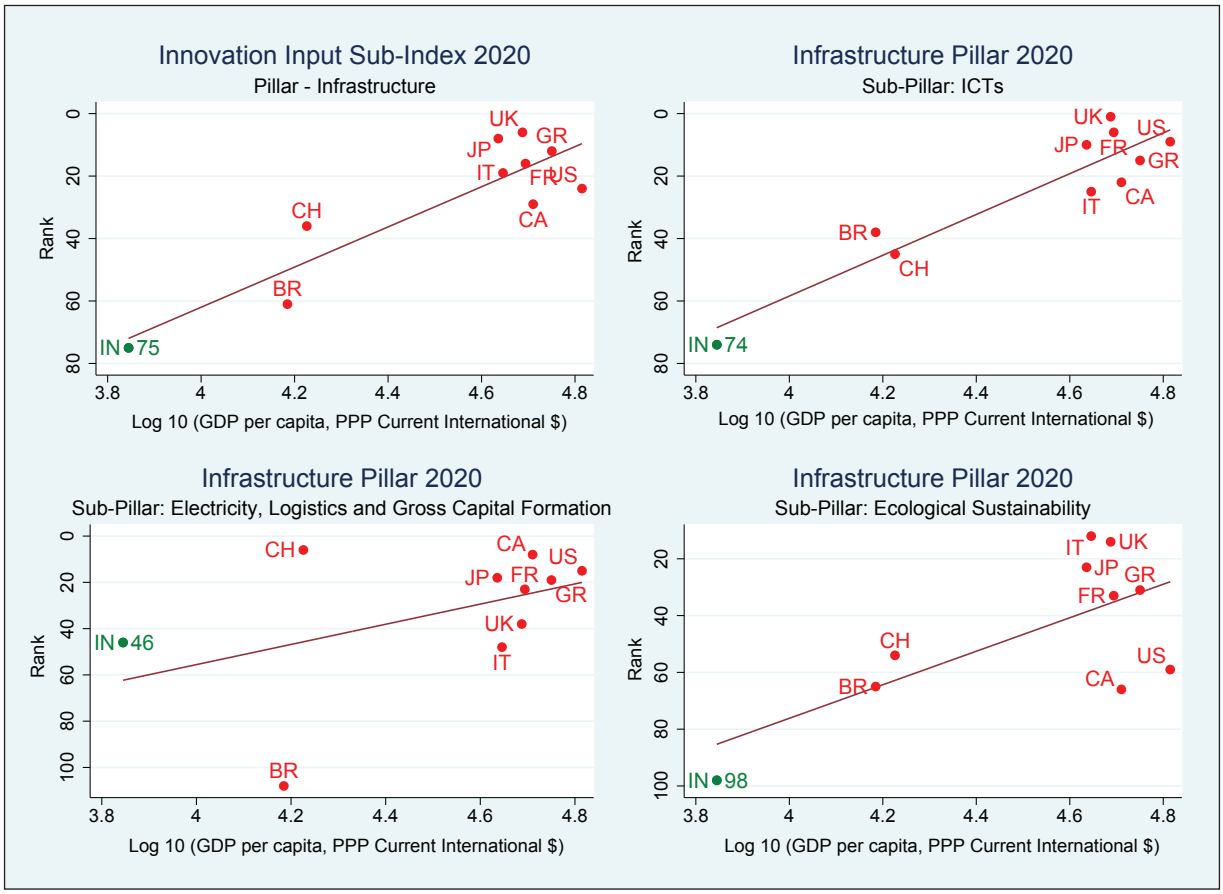
Figure 20: Performance of Top 10 Economies on HCR Pillar



Source: The World Bank and GII database
Note: Highest possible rank is 1. Figure shows India's innovation rank. US = USA, CH = China, JP = Japan, GR = Germany, IN=INDIA, UK = United Kingdom, FR = France, IT = Italy, BR = Brazil and CA = Canada.

8.27 Figure 21 compares India's performance on infrastructure pillar w.r.t. the other largest economies. India performs in line with its level of development on the infrastructure pillar and ICT sub-pillar and higher than expected on the electricity, logistics and GCF pillar. However, India ranks lowest on the infrastructure pillar and the ICT and ecological sustainability sub-pillars amongst the top ten economies. India ranks third lowest – after Brazil and Italy, on the electricity, logistics and GCF sub-pillar.

Figure 21: Performance of Top 10 Economies on Infrastructure Pillar

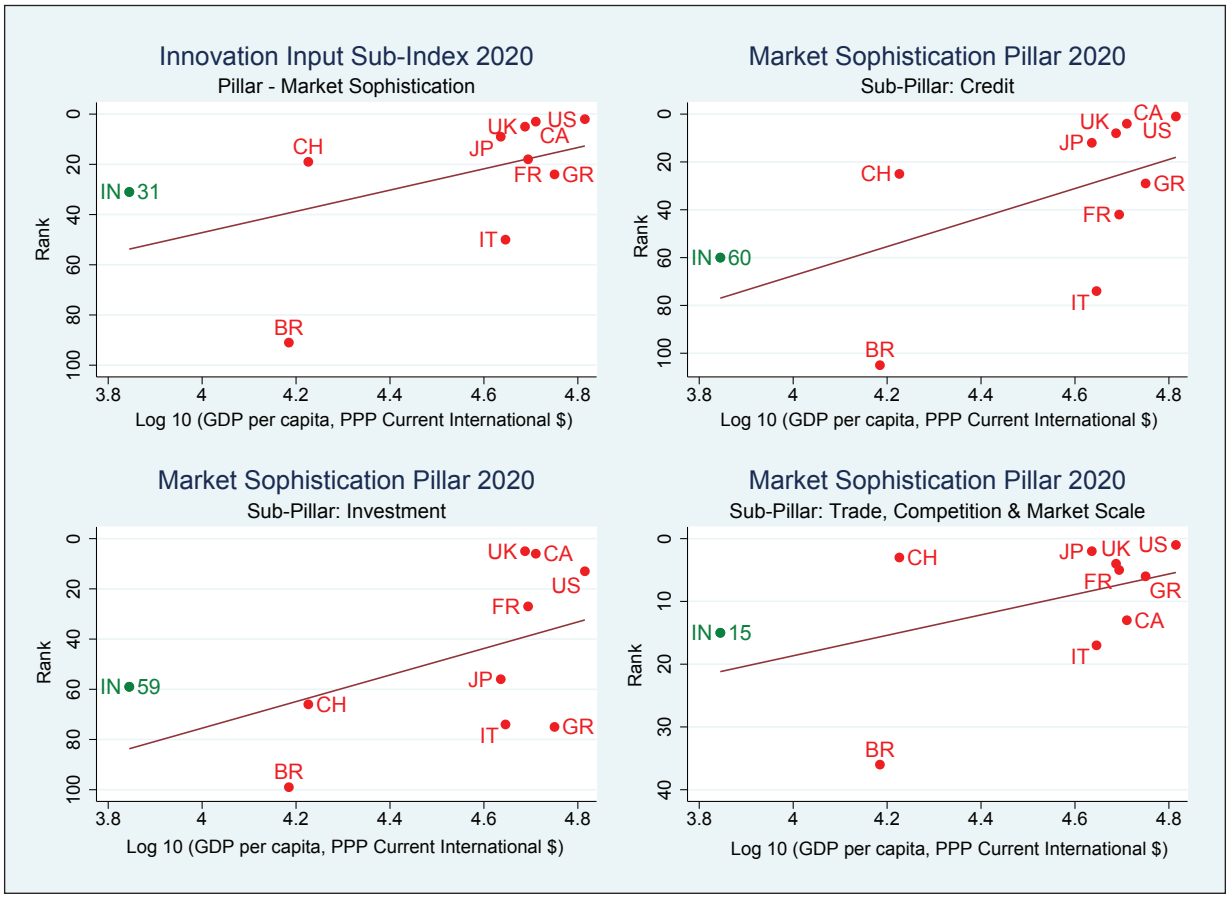


Source: The World Bank and GII database

Note: Highest possible rank is 1. Figure shows India's innovation rank. US = USA, CH = China, JP = Japan, GR = Germany, IN=INDIA, UK = United Kingdom, FR = France, IT = Italy, BR = Brazil and CA = Canada.

8.28 Figure 22 compares India's performance on its second best performing pillar – market sophistication, w.r.t. the other largest economies. India performs above expectation for its level of development on the market sophistication pillar and each of its sub-pillars. However, India ranks second lowest, after Brazil and Italy, on the market sophistication pillar and the credit and trade, competition and market scale sub-pillars. India ranks sixth highest on the investment sub-pillar amongst the top ten economies.

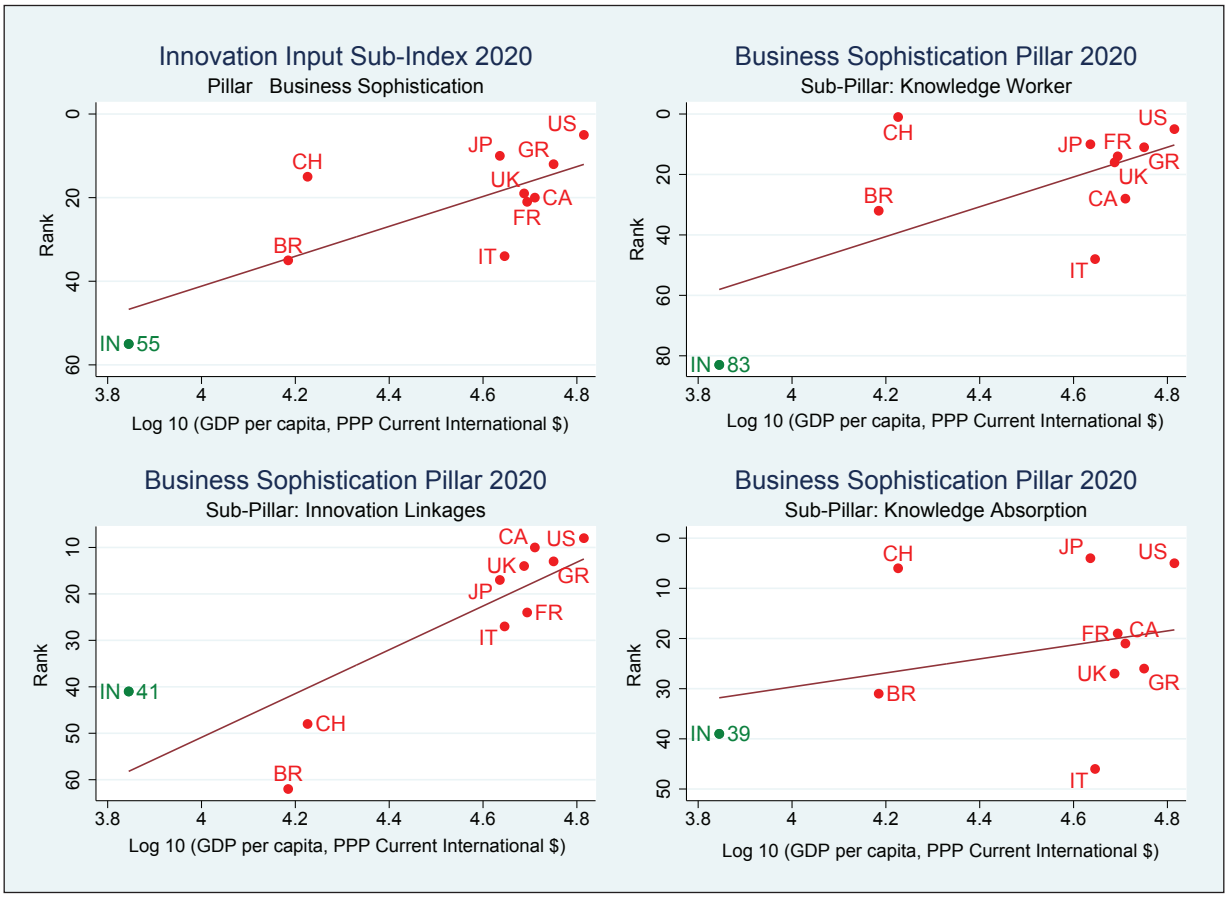
Figure 22: Performance of Top 10 Economies on Market Sophistication Pillar



Source: The World Bank and GII database
Note: Highest possible rank is 1. Figure shows India's innovation rank. US = USA, CH = China, JP = Japan, GR = Germany, IN=INDIA, UK = United Kingdom, FR = France, IT = Italy, BR = Brazil and CA = Canada.

8.29 Figure 23 compares India's performance on the business sophistication pillar w.r.t. the other largest economies. India performs above expectation for its level of development on the innovation linkages sub-pillar while it performs below expectation for the business sophistication pillar and its other two sub-pillars. Amongst the top ten economies, India ranks lowest on the business sophistication pillar and knowledge worker sub-pillar. It ranks second lowest, after Italy, on knowledge absorption sub-pillar. India ranks third lowest – after Brazil and China, on the innovation linkages sub-pillar.

Figure 23: Performance of Top 10 Economies on Business Sophistication Pillar



Source: The World Bank and GII database

Note: Highest possible rank is 1. Figure shows India's innovation rank. US = USA, CH = China, JP = Japan, GR = Germany, IN=INDIA, UK = United Kingdom, FR = France, IT = Italy, BR = Brazil and CA = Canada.

TRENDS IN INDIA'S INOVATION PERFORMANCE

8.30 India has consistently improved on GII from rank 81 in 2015 to rank 48 in 2020 (Figure 24). While India has performed impressively, there is scope for much more improvement. To put things into perspective, China has improved its rank from 29 to 14 during the same period. China embarked on an ambitious R&D roadmap to become an innovation-oriented economy (see Box 3). We therefore compare India's improvements vis-à-vis that of China on the various dimensions of innovation performance.

Box 3: R&D Roadmap of China

In January 2006, China initiated a 15-year "Medium to Long Term Plan (MLP) for the Development of Science and Technology". MLP called for China to become an "innovation-oriented society" by the year 2020, and a world leader in science and technology (S&T) by 2050. It committed China to developing capabilities for "indigenous innovation" and to leapfrog into leading positions in new science-based industries by the end of the plan period. The MLP of China used R&D as an important instrument for development of S&T ecosystem.

MLP – A Snapshot

Duration

- 15 years: 2006 to 2020

Goals

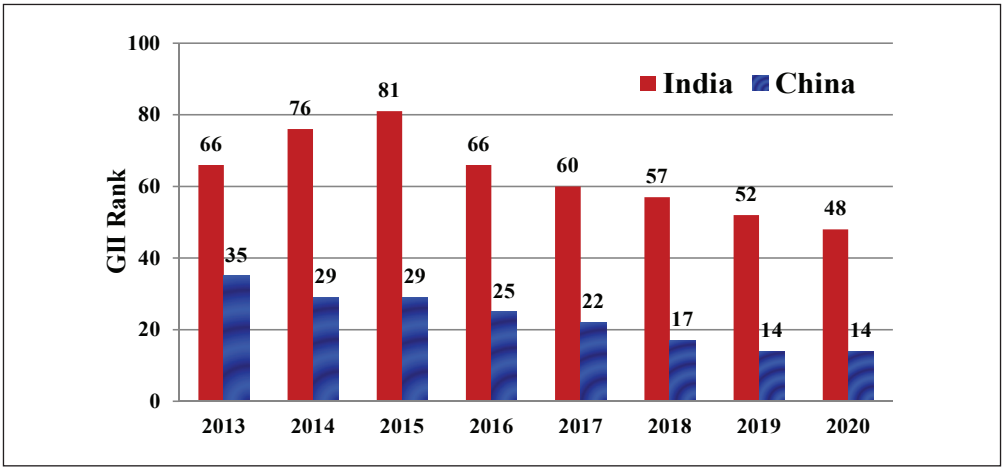
- China to become an "innovation-oriented society"
- A world leader in S&T by 2050
- Developing capabilities for "indigenous innovation" and to leapfrog into leading positions in new science-based industries

Targets and Instruments

- Gross domestic expenditure on R&D (GERD) as a percentage of GDP to increase from 1.35 per cent in 2005 to 2.5 per cent by 2020
- Raise contributions to economic growth from technological advance to more than 60 per cent
- Limit dependence on imported technology to no more than 30 per cent
- China to become one of the top five countries in the world in the number of invention patents granted to Chinese citizens
- Chinese-authored scientific papers to become among the world's most cited

Source: Office of Principal Scientific Adviser to the Government of India

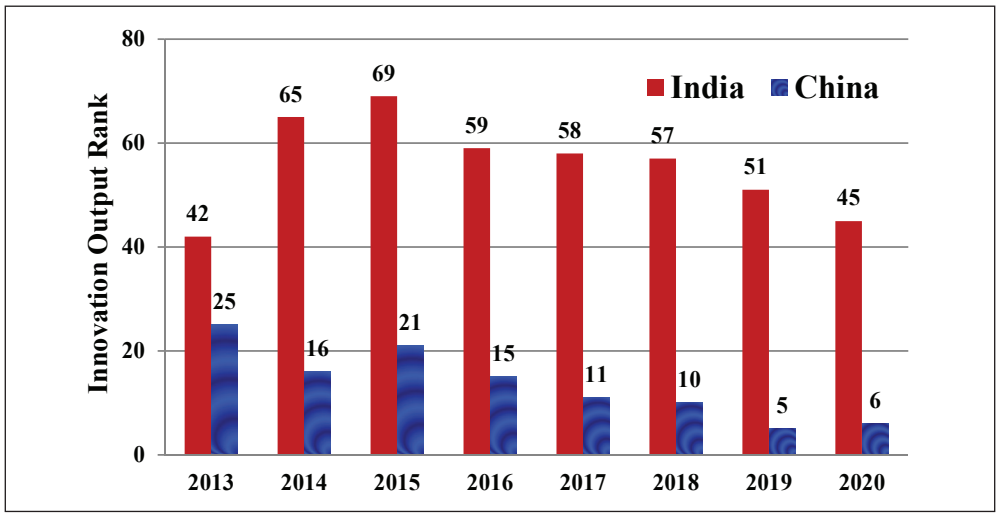
Figure 24: GII Performance (2013-20)



Source: GII database

8.31 India's GII rankings have been led by its performance in innovation outputs. Figure 25 shows that India has consistently improved on innovation outputs from rank 69 in 2015 to rank 45 in 2020. Meanwhile, China has improved its rank from 21 in 2015 to six in 2020.

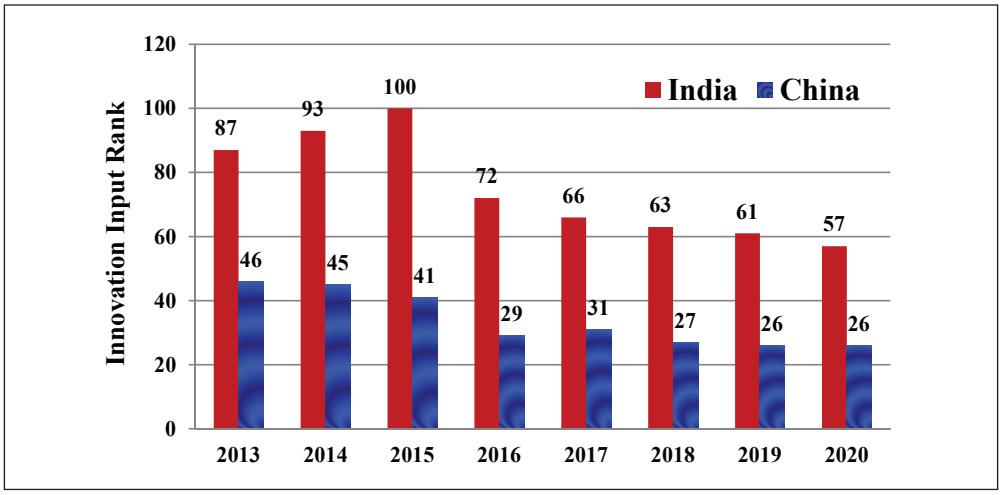
Figure 25: Innovation Outputs Performance (2013-20)



Source: GII database

8.32 Figure 26 shows that India has consistently improved on innovation inputs, from rank 100 in 2015 to rank 57 in 2020. China has improved from rank 41 in 2015 to rank 26 in 2020. The year 2016 marked a sharp improvement in India's performance in the innovation input sub-index on account of improvement in HCR, market sophistication and business sophistication performance.

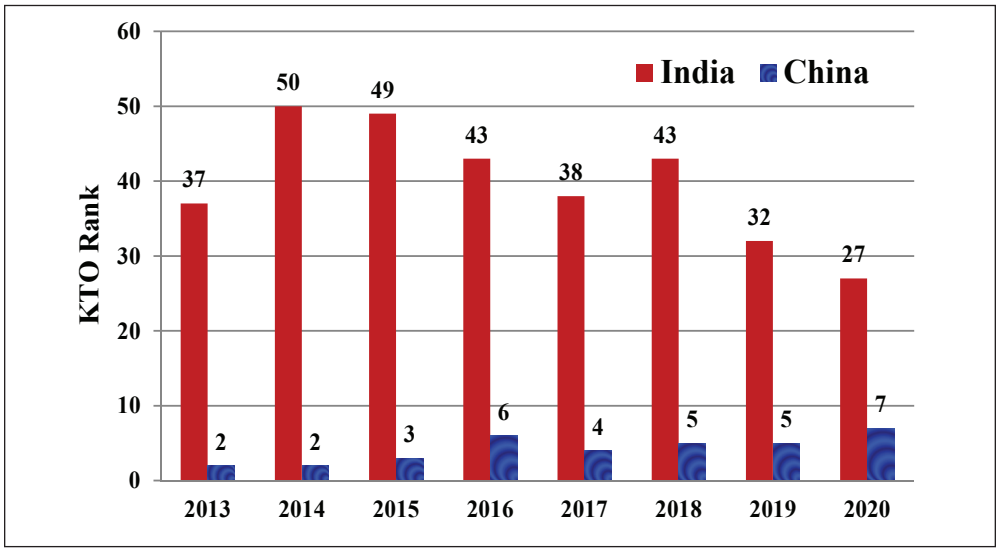
Figure 26: Innovation Inputs Performance (2013-20)



Source: GII database

8.33 Amongst output pillars, India has significantly improved on KTO pillar since 2014, almost halving its rank from 50 in 2014 to 27 in 2020 (Figure 27). China's performance slightly worsened, with its rank declining from 2 in 2014 to 7 in 2020 on KTO. India has consistently performed better in the knowledge diffusion sub-pillar as compared to knowledge creation and impact.

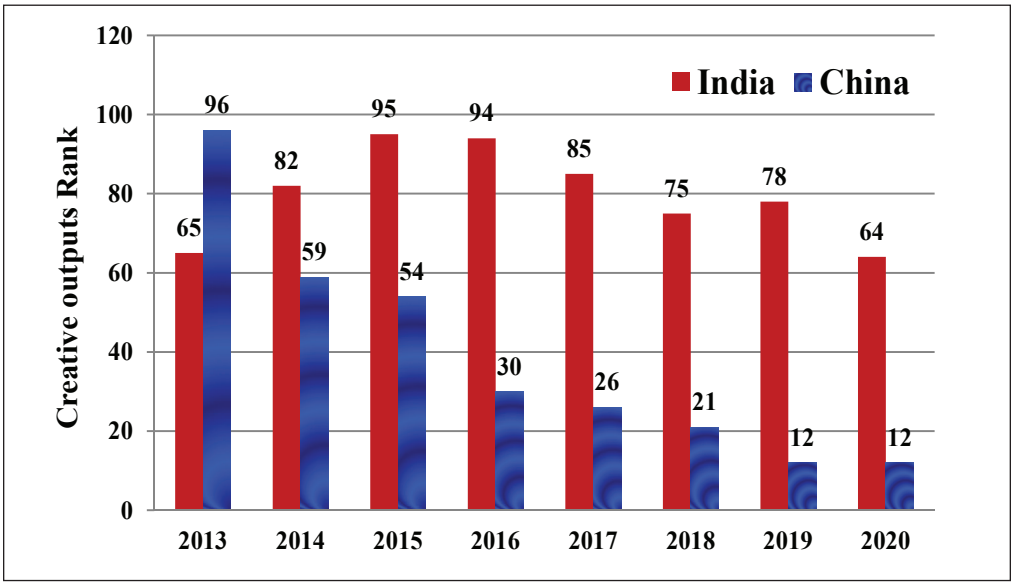
Figure 27: Knowledge & Technology Outputs Performance (2013-20)



Source: GII database

8.34 On creative outputs pillar, India's rank improved from 95 in 2015 to 64 in 2020 (Figure 28). Meanwhile, China's rank improved from 54 in 2015 to 12 in 2020. India has been performing better in creative goods & services sub-pillar than intangible assets and online creativity sub-pillars.

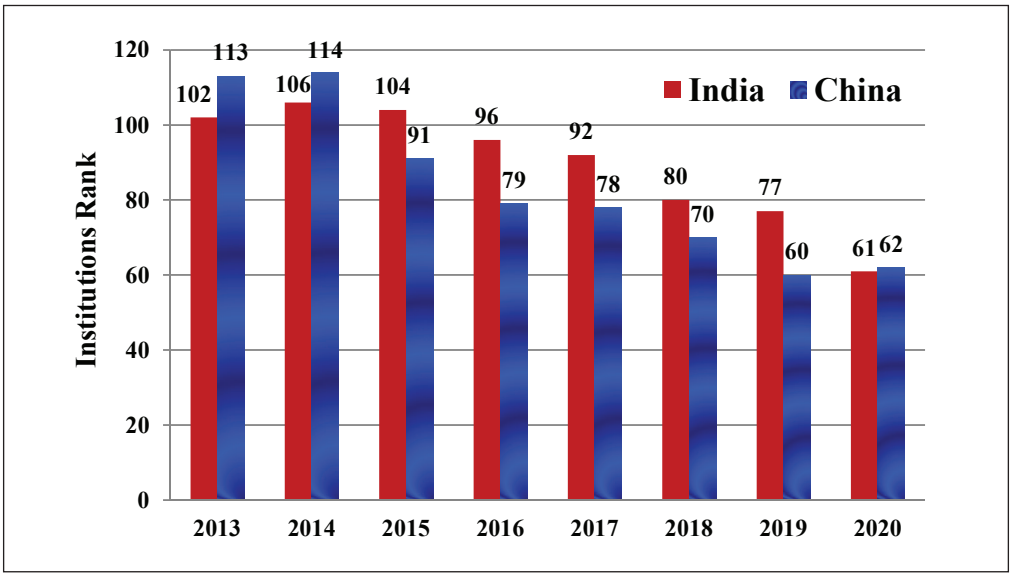
Figure 28: Creative Outputs Performance (2013-20)



Source: GII database

8.35 India has improved over time on input pillars as well. Figure 29 shows consistent improvement in India's rank on institutions pillar from 106 in 2014 to 61 in 2020. China's performance is close to India on this front, with rank 114 in 2014 and rank 62 in 2020. India's performance is led by marked improvement in the political and business environment. Business environment further registered a sharp improvement in 2020 as compared to 2019 on account of improvements in the parameter "ease of resolving insolvency".

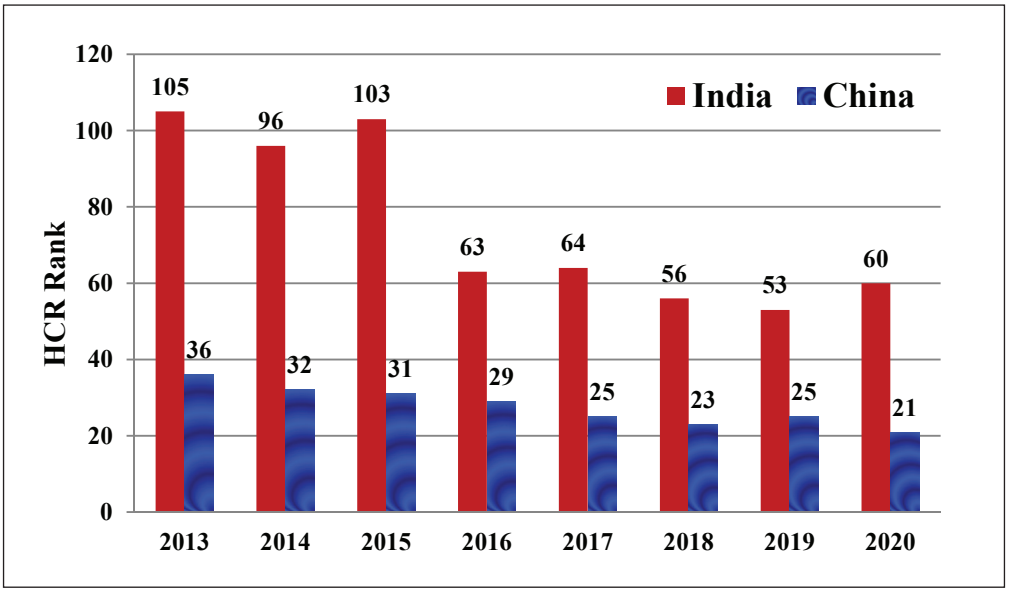
Figure 29: Institutions Performance (2013-20)



Source: GII database

8.36 India has significantly improved in the HCR pillar over time from rank 103 in 2015 to 60 in 2020 (Figure 30). China improved from rank 31 in 2015 to rank 21 in 2020. India's improvement in HCR pillar can be attributed to improvements in tertiary education sub-pillar. India has been performing poorly in the primary and secondary education pillar – making it an area requiring focussed attention.

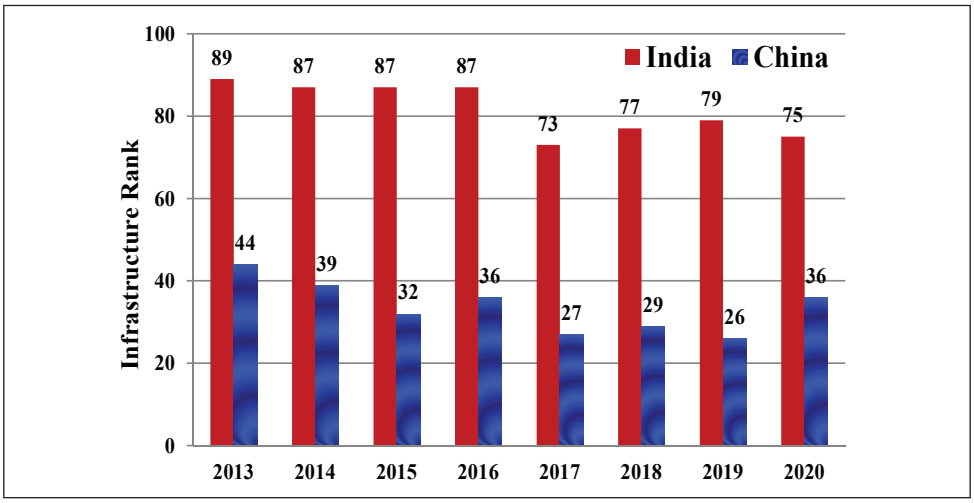
Figure 30: Human Capital and Research Performance (2013-20)



Source: GII database

8.37 On the infrastructure pillar, India's rank improved from 89 in 2013 to 75 in 2020 while China's rank improved from 44 to 36 during this period (Figure 31). India has been performing poorly on the ecological sustainability sub-pillar, leading to slow improvement on the infrastructure pillar.

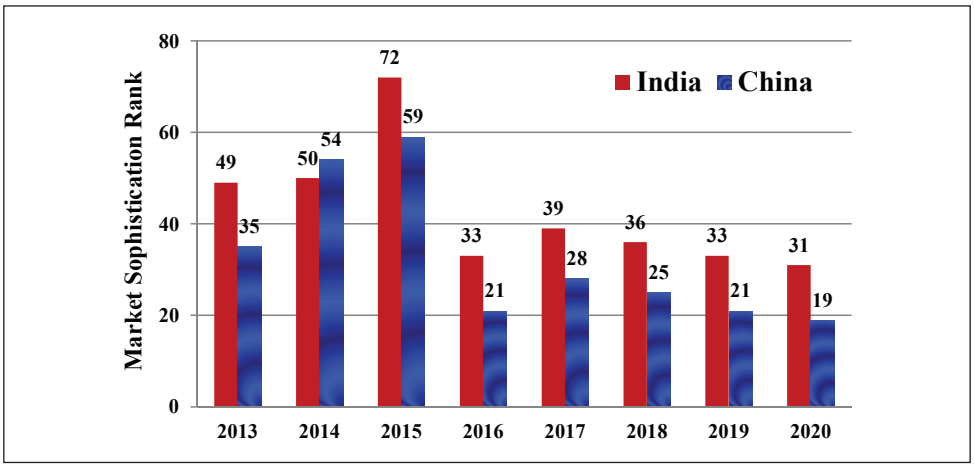
Figure 31: Infrastructure Performance (2013-20)



Source: GII database

8.38 India's rank has improved considerably on market sophistication pillar from 72 in 2015 to 31 in 2020 (Figure 32). China's rank has improved from 59 in 2015 to 19 in 2020.The introduction of domestic market scale as a parameter in market sophistication in 2016, led to India's rank improving from 72 in 2015 to 33 in 2016. Since then, India has consistently performed well in the trade, competition and market scale sub-pillar.

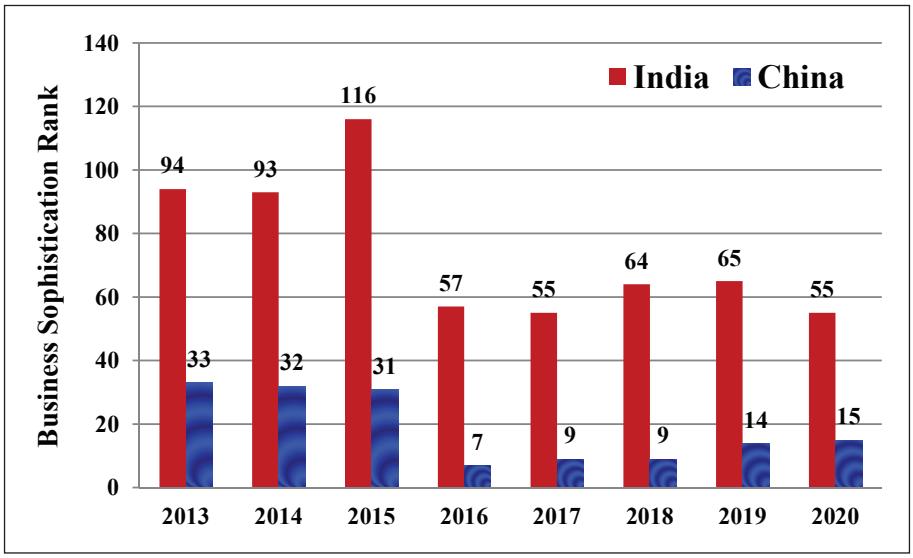
Figure 32: Market Sophistication Performance (2013-20)



Source: GII database

8.39 India's rank improved significantly on the business sophistication pillar from 116 in 2015 to 55 in 2020 (Figure 33). China's rank improved from 31 in 2015 to 7 in 2016, thereafter declining to 15 in 2020. India's business sophistication rank improved sharply from 116 in 2015 to 57 in 2016 on account of changed indicators in knowledge absorption sub-pillar and improvement in knowledge workers sub-pillar. In 2020, innovation linkage was overtaken by knowledge absorption as the best performing business sophistication sub-pillar for India. This improvement is a positive sign and can be expected to feed into further improvements. India has consistently lagged behind on the knowledge workers sub-pillar, making it an area warranting focussed attention.

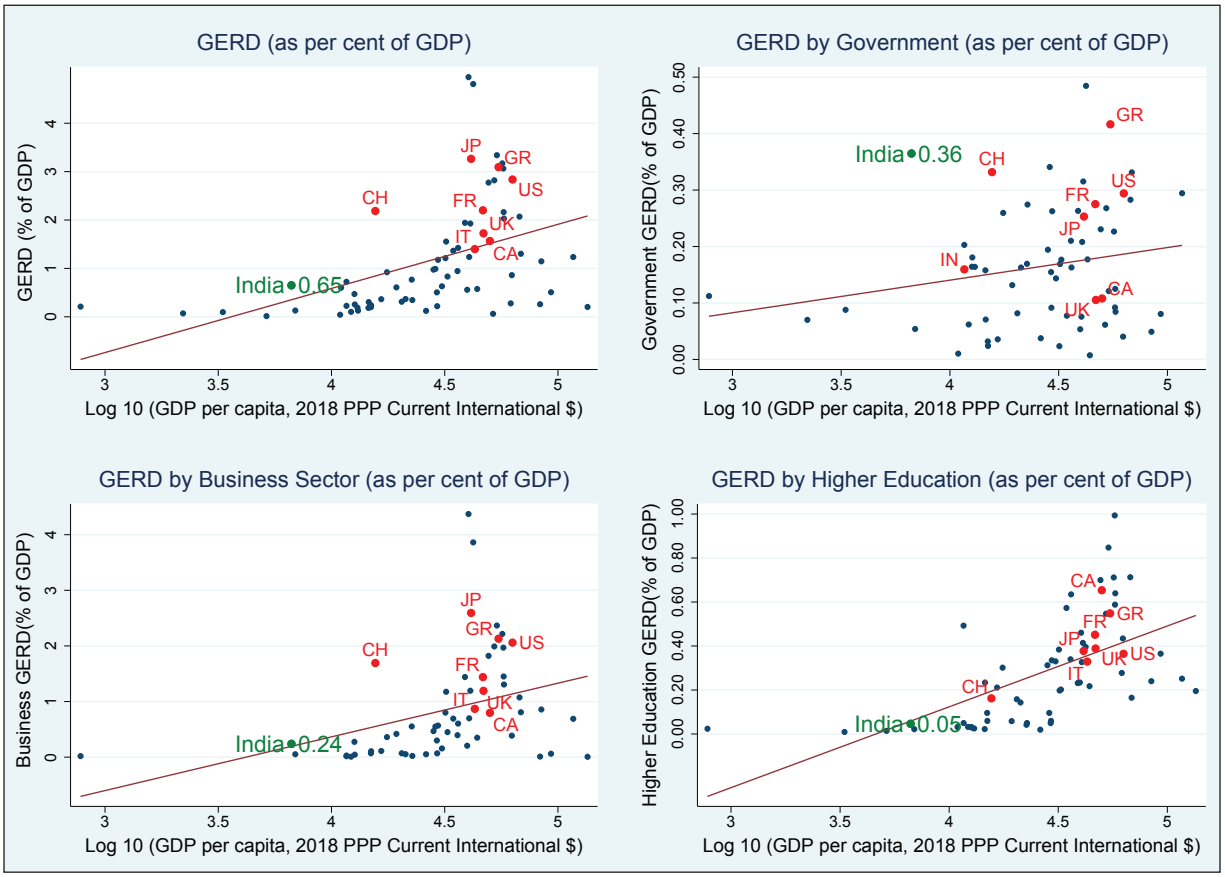
Figure 33: Business Sophistication Performance (2013-20)



Source: GII database

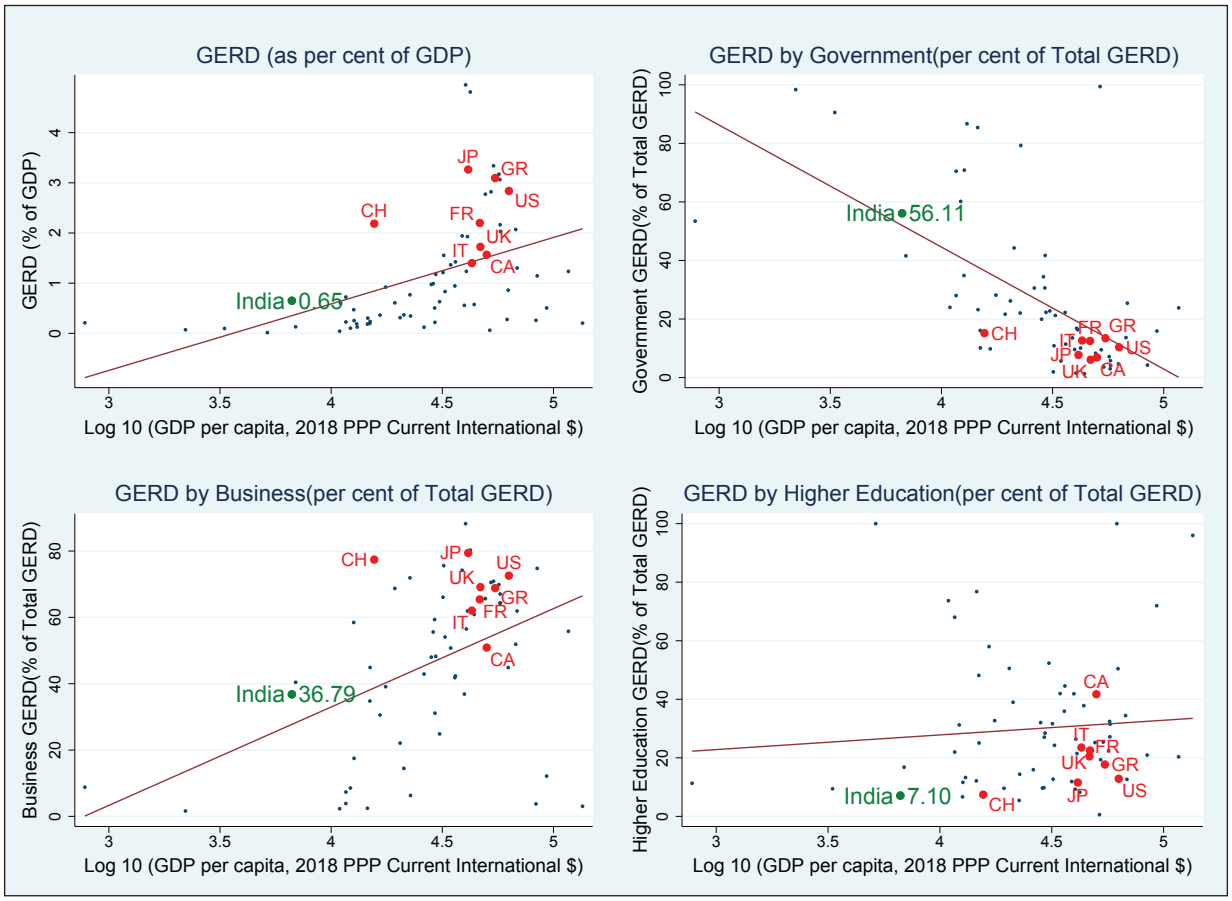
R&D EXPENDITURE IN INDIA

Figure 34: Total GERD and Sector-wise Contributions to GDP, 2018



Note: Figure shows India's GERD values. US = USA, CH = China, JP = Japan, GR = Germany, UK = United Kingdom, FR = France, IT = Italy and CA = Canada.
Source: The World Bank and UNESCO

Figure 35: Sector-wise Contributions to Total GERD, 2018



Note: Figure shows India's GERD values. US = USA, CH = China, JP = Japan, GR = Germany, UK = United Kingdom, FR = France, IT = Italy and CA = Canada.
Source: The World Bank and UNESCO

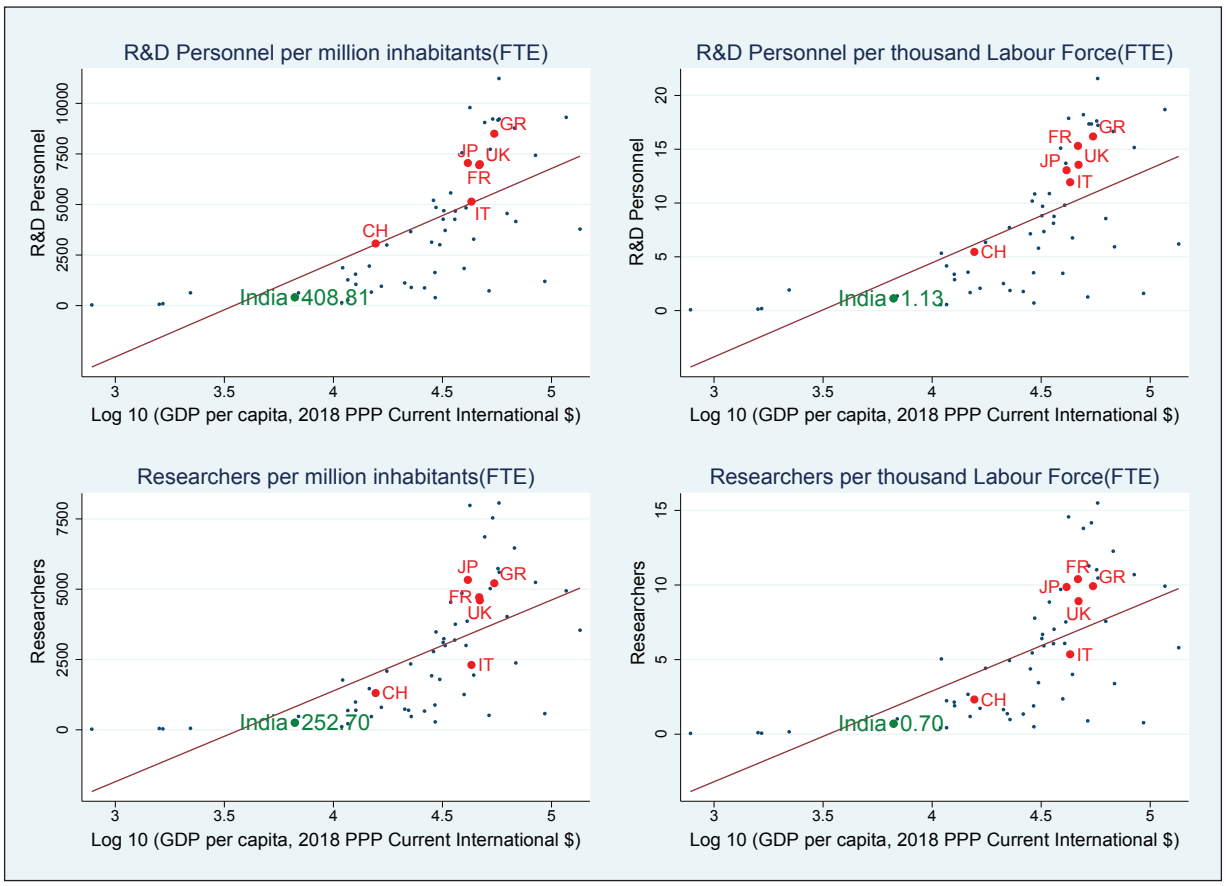
8.40 Research & Development (R&D) investment is a key input in innovation. Figure 34 shows gross domestic expenditure on R&D (GERD) as per cent of GDP in relation to the level of development measured by GDP per capita on PPP basis. Although India's GERD is in line with expectation for its level of development, there is much scope for improvement. Other top ten economies such as USA, China, Japan, Germany and France have higher than expected GERD for their level of development. India's business sector and higher education sector contribution to GERD as per cent of GDP is in line with its level of development. However, the business sector's GERD in USA, China, Japan and Germany is much higher as expected for their level of development. Higher education sector in Canada and Germany also has larger GERD than their level of development.

8.41 Figure 35 shows positive correlation between the level of development and GERD as per cent of GDP and business sectors' participation in total GERD while government sector's participation in GERD is negatively correlated with development. In India, the Government contributes 56 per cent of GERD while this proportion is less than 20 per cent in each of the top ten economies. Yet, India's GERD is much lower than that of the top ten economies because India's business sector contributes a much smaller per cent to total GERD (about 37 per cent)

than the business sector in all the other large economies such as China, US, Japan and UK (68 per cent on average). This can be clearly seen because the proportion contributed to GERD by higher education is similar in India as in the top 10 economies.

8.42 Figure 36 presents the total full time equivalent (FTE) R&D personnel and researchers in relation to the level of development. India performs below expectation for its level of development in terms of R&D personnel and researchers, making it an area warranting attention. Other large economies such as Japan, Germany and France have higher than expected R&D manpower for their level of development. India has amongst the lowest number of R&D manpower as compared to other top ten economies (GDP current US$).

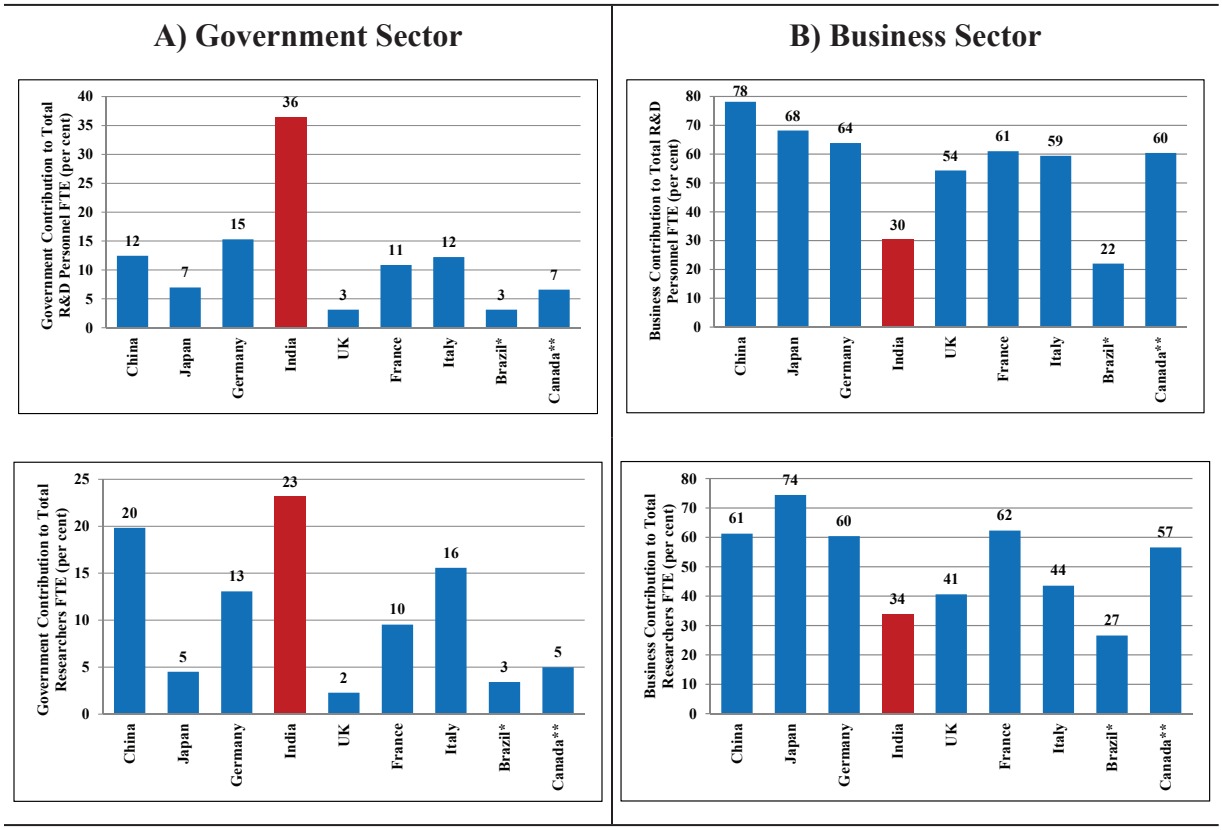
Figure 36: R&D Personnel and Researchers, 2018



Note: Figure shows India's Personnel/Researchers. CH = China, JP = Japan, GR = Germany, UK = United Kingdom, FR = France, IT = Italy.
Source: The World Bank and UNESCO

8.43 Figure 37 shows that government sector's contribution to total FTE R&D personnel (36 per cent) and researchers (23 per cent) in India was the highest amongst the top ten economies in 2018 (nine per cent on average). However, Indian business sector's contribution to R&D personnel (30 per cent) and researchers (34 per cent) was the second lowest, after Brazil, amongst the top ten economies (over 50 per cent on average).

Figure 37: R&D Personnel and Researchers by Sector, 2018



Source: UNESCO
Note: *Brazil data from 2014. **Canada data from 2017. Data for USA not available.

INDIA'S PERFORMANCE ON PATENTS AND TRADEMARKS

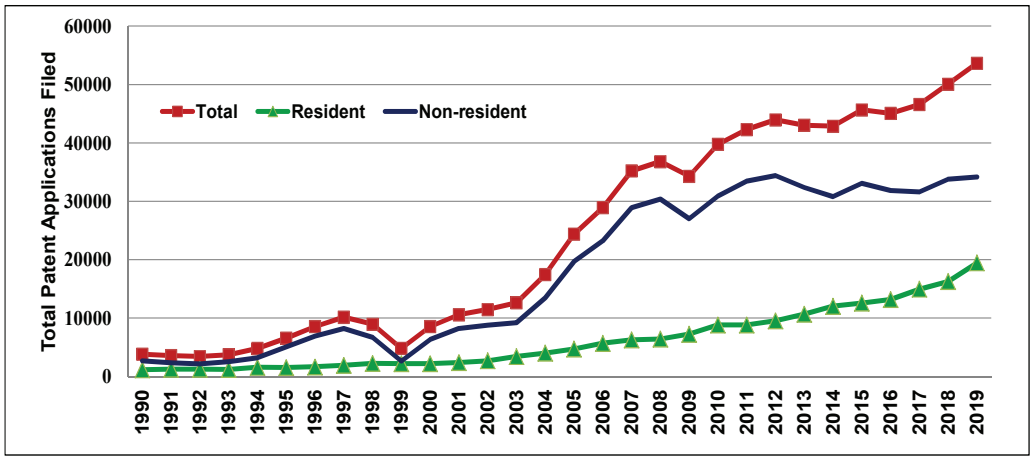
8.44 Figure 38 shows the trend in total patent applications filed in India by resident and non-residents during the period 1990-2019. The total number of patents filed in India has risen steeply since 1999, mainly on account of increase in patent applications filed by non-residents. While patent applications filed by residents have increased steadily since 1999, they have risen at a much lower rate than patent applications by non-residents.

Box 4: Non-Resident Indians and Innovation

Breschi, Lissoni and Miguelez (2017) estimated that around six per cent of US-resident inventors listed at the European Patent Office in 2009 had an Indian name and surname. This was roughly the same as the Chinese. This more than the French, Germans and Italians combined.

Large-scale out-migration of skilled workforce and students from India is not necessarily bad news for India's innovation aspirations. This could potentially result in return of higher-skilled workforce in future. However, this would require an enabling environment that facilitates re-entry into the Indian job-market and high-tech research opportunities.

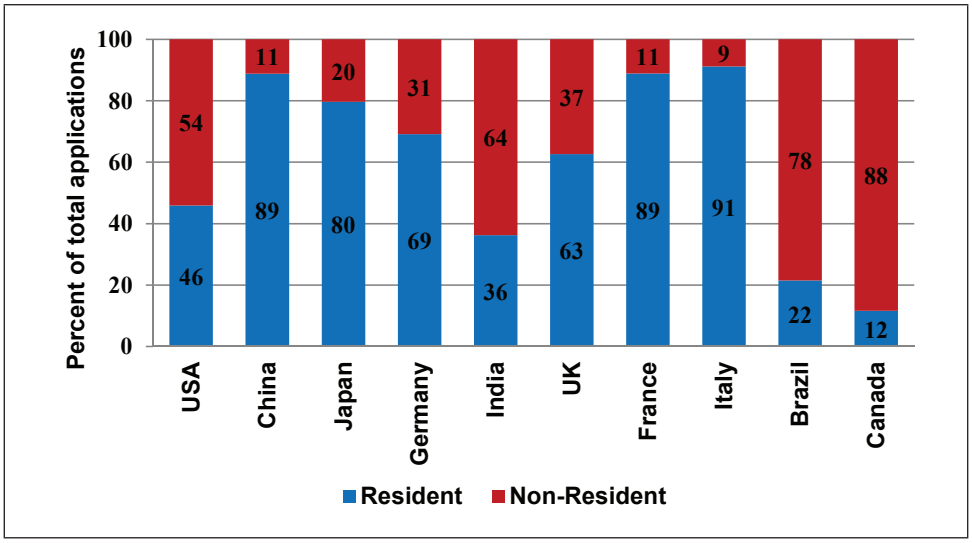
Figure 38: Trend in Patent Applications Filed in India



Source: WIPO

8.45 Unlike India, Brazil and Canada, other top ten economies (GDP current US$) have a higher share of patent applications by residents than non-residents (Figure 39). Improving resident share in patents should be a matter of priority to make advancements in innovation.

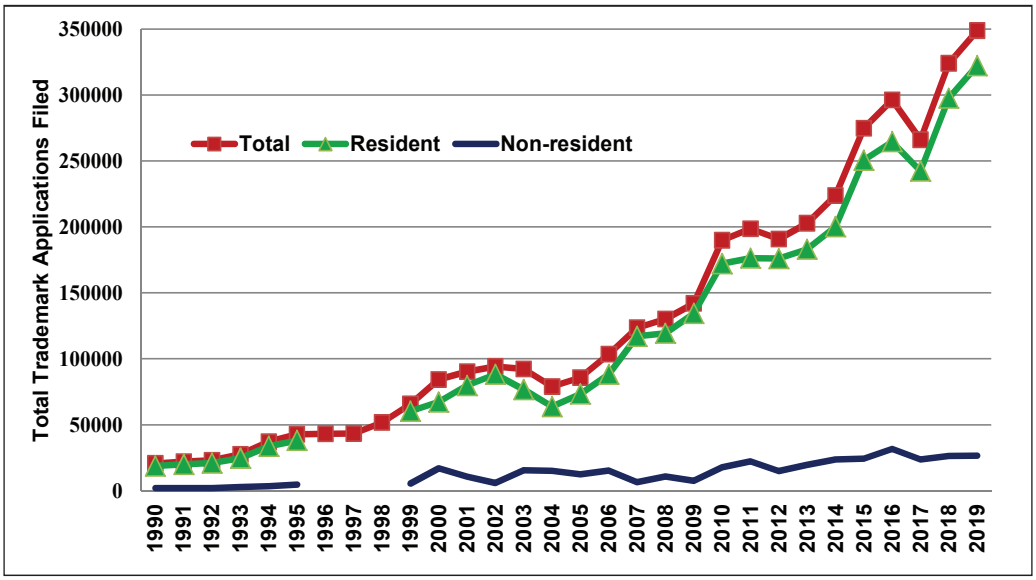
Figure 39: Patent Applications Filed by Residents and Non-Residents, 2019



Source: WIPO

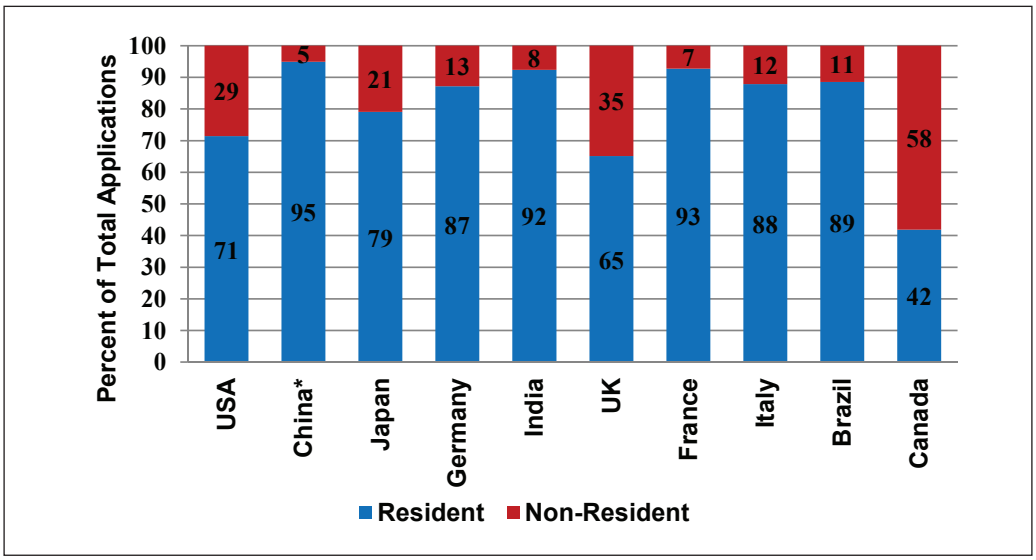
8.46 Figure 40 shows the trend in total trademark applications filed in India by resident and non-residents during the period 1990-2019. Unlike patents, the total number of trademark applications filed in India has risen steeply since 1999 mainly on account of increase in trademark applications filed by residents.

Figure 40: Trend in Trademark Applications Filed in India



Source: WIPO

Figure 41: Trademark Applications Filed by Residents and Non-Residents, 2019



Note: * China data pertains to 2014.
Source: WIPO

8.47 India's trend of larger resident-share in total trademark applications is similar to that observed across other top ten economies (GDP current US$) except Canada (Figure 41). Larger share of residents in total trademark applications filed in India is a positive sign for advancement in innovation.

IS INDIAN INNOVATION AFFECTED BY ACCESS TO FINANCE?

Box 5: Methodology for Estimating Correlation between Financial Development and Innovation

Hsu, Tian and Xu (2014) observed that industries that are more dependent on external finance, and are more high-tech intensive, exhibit disproportionally higher innovation in countries with well developed equity markets. This may be on account of four reasons. Firstly, because there are no collateral requirements for equity financing, additional equity financing doesn't increase firms' probability of financial distress (Brown, Fazzari, and Petersen, 2009). Secondly, under rational expectations, equity markets enable investors to extract relevant, but noisy, information from equilibrium prices (Grossman, 1976; Levine, 2005). Thirdly, as information on the prospects of innovative projects is either sparse or hard to process, evaluating innovative projects is difficult. Equity markets can facilitate this evaluation through information embedded in stock market prices (Allen and Gale, 1999). Finally, equity financing can be particularly well suited for innovative projects that are riskier (Levine, 2005). New technology stocks can also be priced higher when information about their greater productivity, but higher uncertainty, reaches stock investors (Pástor and Veronesi, 2009).

On the other hand, Hsu, Tian and Xu (2014) observed that developed credit markets appear to discourage innovation in industries that are more dependent on external finance and are more high-tech intensive. This may be on account of two factors. Firstly, innovative firms may have limited collateral to deploy for debt financing by way of tangible assets, restricting their use of debt (Brown, Fazzari, and Petersen, 2009). Secondly, risk-averse banks under-invest in high-uncertainty innovative projects (Stiglitz, 1985). Some studies have found that due to banks' informational advantages, they could even inhibit innovation by extracting rents (Hellwig, 1991 and Rajan, 1992).

Based on Hsu, Tian and Xu's findings, access to equity capital is measured using two indicators:

i. Market capitalisation of listed domestic companies (per cent of GDP)
ii. Venture capital availability rank (based on Venture Capital Availability Index)

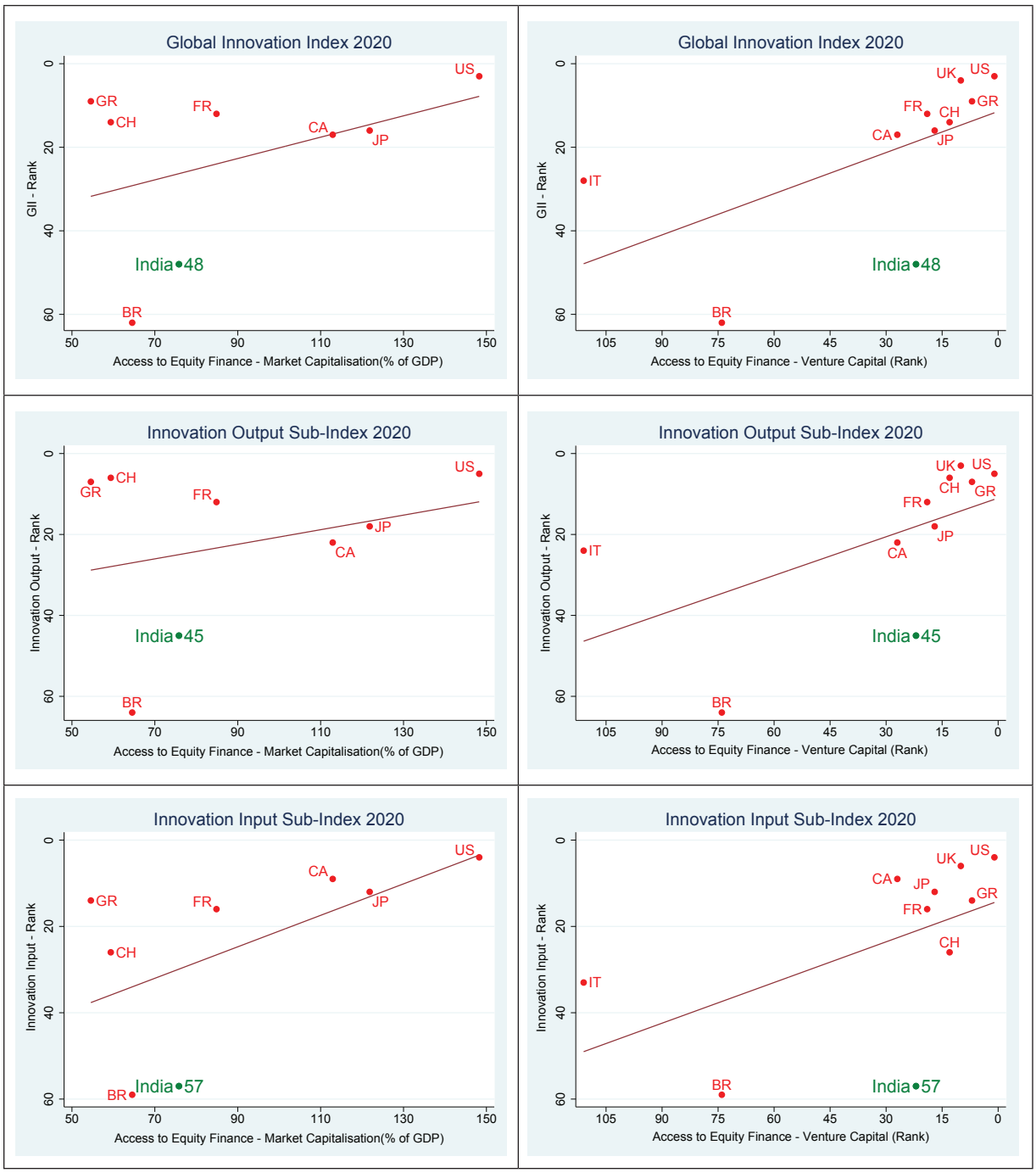
Similarly, access to debt capital is measured using the following indicator:

i. Domestic credit to private sector by banks (per cent of GDP)

8.48 Figure 42 examines the performance of top ten economies (GDP current US$) on innovation with respect to availability of equity finance – market capitalisation of listed domestic companies (as per cent of GDP) as well as venture capital availability rank. India and Brazil rank much below expectation for their level of equity market development in the overall GII, innovation outputs and innovation inputs amongst the top ten largest economies. Given that most of these large economies are more innovative than India and equity market development facilitates greater high-technology innovation, this potentially indicates that innovation in India needs to become more high-tech intensive.

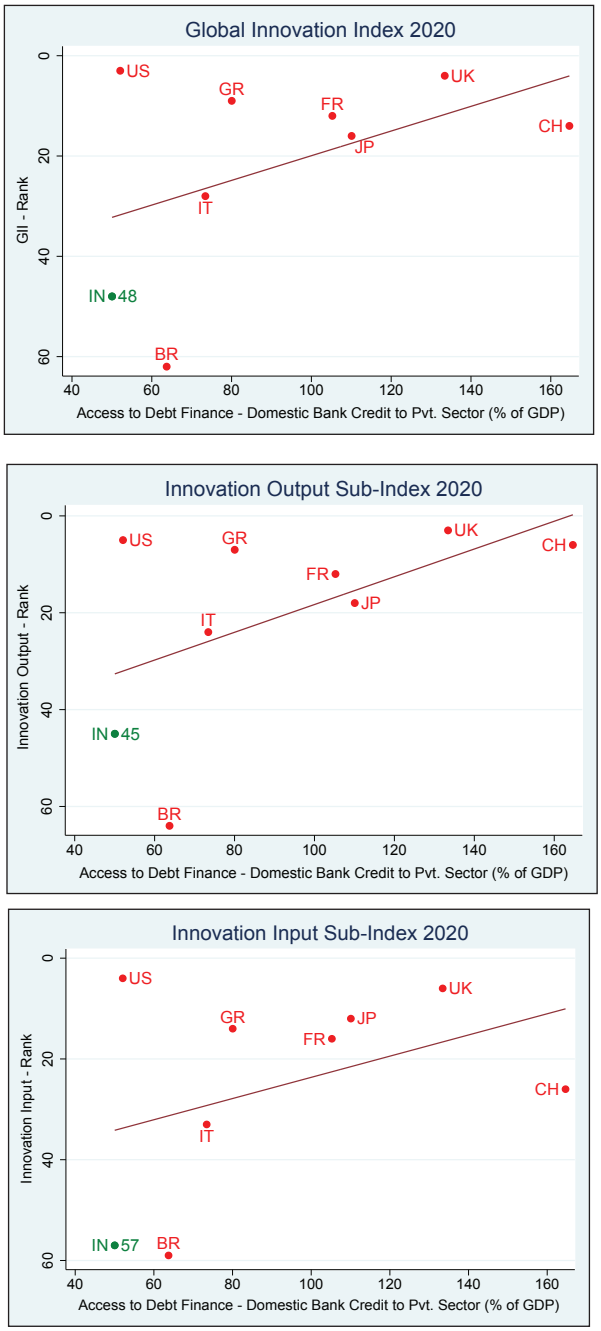
Figure 42: Innovation and Access to Equity Finance

A) Equity Capital (Market Capitalisation) **B) Equity Capital (Venture Capital)**



Note: Highest possible rank is 1. Figure shows India's Innovation rank. US = USA, CH = China, JP = Japan, GR = Germany, UK = United Kingdom, FR = France, IT = Italy, BR = Brazil and CA = Canada. Venture capital ranks are from 2019. Market capitalisation data for USA, France and Canada are from 2018, rest are from 2019.
Source: The World Bank and GII database

Figure 43: Innovation and Access to Debt Finance



Note: Highest possible rank is 1. Figure shows India's Innovation rank. US = USA, CH = China, JP = Japan, GR = Germany, IN = India, UK = United Kingdom, FR = France, IT = Italy and BR = Brazil. Debt finance data pertains to 2019

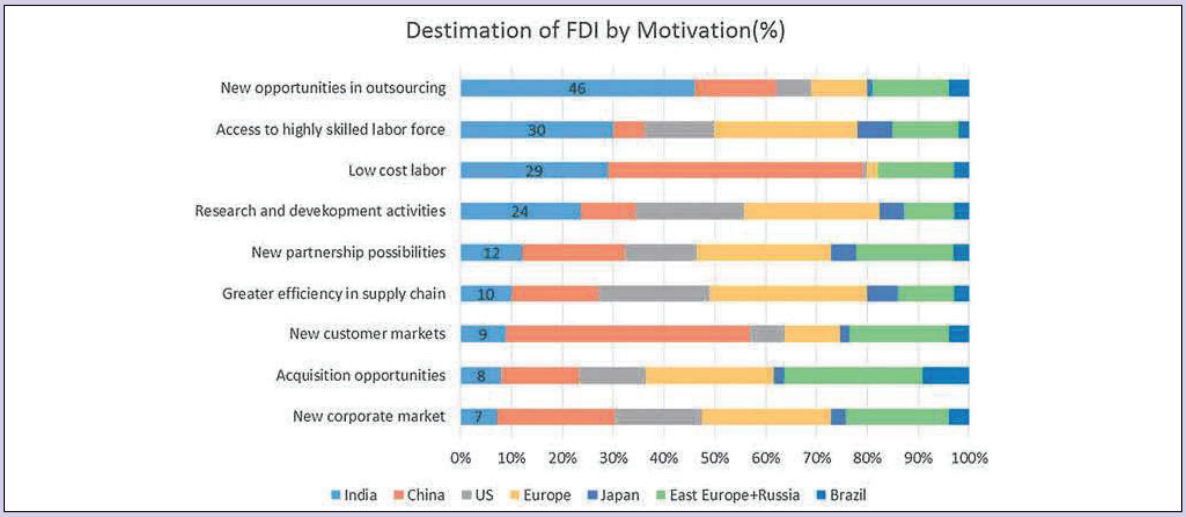
Source: The World Bank and GII database

8.49 Figure 43 shows the performance of top ten economies (GDP current US$) on innovation with respect to availability of debt finance in the form of domestic credit to the private sector by banks (per cent of GDP). India and Brazil rank much below expectation for their level of debt market development in the overall GII, innovation outputs and innovation inputs amongst the top ten largest economies.

Box 6: R&D Activities in India

Motohashi (2015) suggests that India is a highly attractive R&D destination on account of the opportunities offered for outsourcing, highly skilled labour force, low cost labour and R&D activities. This has led to large scale off-shoring from US firms, especially in the IT industry and that *"companies such as IBM, Intel, and GE conduct cutting-edge R&D in India. The economic growth and increasing income levels in India have made the Indian market attractive, and local R&D activities have been on the rise, particularly in the automotive market. Thus, India has world-class potential both as a global R&D center targeting global markets and as a regional R&D hub for its local market and markets in emerging countries"*

Attractiveness of FDI Destination by Host-Country and Motivation (per cent), 2004



Source: Motohashi (2015)

Highlights of R&D incentives in select countries (2012-17)

Countries	Tax Allowance/ Deductions	Tax Credit	Accelerated Depreciation on the R & D assets/Capital	Reduced Tax Rates	Tax Holiday	Tax Deferrals	Tax Exemptions (Excise & Custom duty)	Grants
Brazil	√		√	√				√
China	√		√	√			√	
India	√		√		√		√	√
South Africa	√		√					
Germany								√
Japan		√						
Malaysia	√							√
Republic of Korea		√						
Thailand	√			√				√
USA		√				√		

Source: Saha and Shaw (2018)

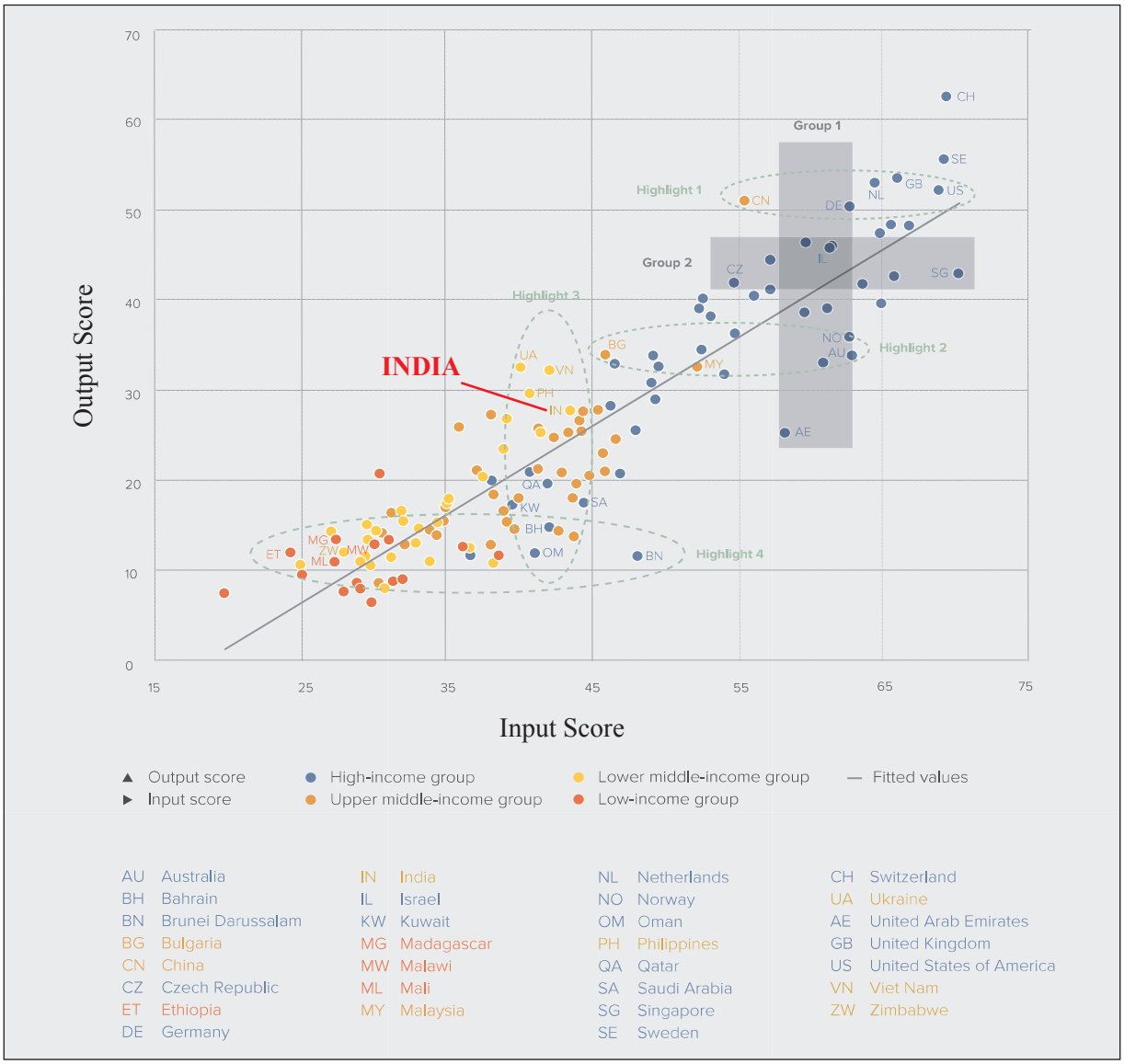
R&D Tax Incentives in India: India has had a generous R&D tax incentive framework. Finance Act 2016, w.e.f. April 2018, allowed a weighted deduction of 150 per cent of expenditure w.r.t. scientific research on in-house R&D facility as compared to 200 per cent earlier. Finance Act 2016 further allowed for reduction of this deduction to 100 per cent from assessment year beginning on or after April 1, 2021. The Taxation Laws (Amendment) Act 2019 amended the Income Tax Act 1961 and Finance (No. 2) Act 2019, allowing domestic companies the option to pay income tax @22 per cent subject to the condition that they will not avail any exemption/incentive. The effective rate for these companies was made 25.17 per cent inclusive of surcharge and cess. These companies were also not required to pay Minimum Alternate Tax.

To put this in perspective, the USA provided R&D tax relief in 2019 through an incremental R&D tax credit with four components: two main modalities – regular research credit (20 per cent headline rate) and alternative simplified credit (6-14 per cent headline rate) - which were mutually exclusive in their use and two additional specific schemes (20 per cent headline rate), which only applied to certain expenses for basic research and energy research (OECD). China in 2019 provided R&D tax relief through volume-based R&D tax allowance, with headline rates being 75 per cent for SMEs and large enterprises, which increased from 50 per cent earlier (OECD). In 2019, Japan offered volume-based and incremental tax credits that could be claimed in combination, with headline rates under different schemes ranging between 6-30 per cent and overall R&D tax benefits capped at 45 per cent of the corporate income tax liability before the credit was applied (OECD). Germany offered no expenditure based R&D tax support (OECD, 2018)

IS INDIA EFFECTIVELY TRANSLATING INNOVATION INPUTS INTO INNOVATION OUTPUTS?

8.50 Figure 44 examines the relationship between innovation inputs and innovation outputs. Economies below the line are unable to effectively translate their costly investments in innovation inputs to better quality and more innovation outputs. It may be seen that India is able to effectively translate investments in innovation inputs to produce a higher level of innovation outputs. This implies that India stands to gain more from its investments into innovation than many other countries. With higher investments, it may be possible that this relationship between innovation inputs and innovation outputs becomes even more favourable for India, and there is greater "bang for the buck" as regards India's investments in innovation.

Figure 44: Innovation Input to Innovation Output Performance, 2020



Source: GII 2020 Report

Which innovation inputs can best explain innovation outputs?

Box 7: Methodology of Estimating Elasticity of Innovation Output Ranks to Innovation Input Ranks

We used a balanced panel of 117 countries, omitting 14[1] countries with missing data, for the years 2013-20. We first performed a Fixed Effects (FE) regression with Country and Time fixed effects. The Null Hypothesis that coefficients for all years are jointly equal to zero, couldn't be rejected. Hence, time fixed effects were not needed. Thereafter, a Hausman test for Fixed Effects vs Random Effects was run, leading to rejection of Random Effects model.

[1]Benin, Brunei Darusallam, Cabo Verde, Ethiopia, Ghana, Iran, Lao, Mauritius, Morocco, Myanmar, Trinidad & Tobago, Uzbekistan, Yemen and Zimbabwe

Table 1 below report results for the following form of FE regression:

Log Innovation Output rank = β_1 Log Institutions rank + β_2 Log HCR rank + β_3 Log Infrastructure rank + β_4 Log Market Sophistication rank + β_5 Log Business Sophistication rank + Controls for GDP/ GDP per capita/ population (depending on Model 1-5)

Table 2 below report results for the following form of FE regression:

Log Knowledge & Technology Output rank = β_1 Log Institutions rank + β_2 Log HCR rank + β_3 Log Infrastructure rank + β_4 Log Market Sophistication rank + β_5 Log Business Sophistication rank + Controls for GDP/ GDP per capita/ population (depending on Model 1-5)

Table 3 below report results for the following form of FE regression:

Log Creative Output rank = β_1 Log Institutions rank + β_2 Log HCR rank + β_3 Log Infrastructure rank + β_4 Log Market Sophistication rank + β_5 Log Business Sophistication rank + Controls for GDP/ GDP per capita/ population (depending on Model 1-5)

8.51 Table 1 reports panel Fixed Effects (FE) regression results for dependant variable Log Innovation Output rank for five models with different independent variables - Log input pillars, Log GDP, Log GDP per capita and Log population. Among the input pillars, it shows that Log Institutions rank and Log Business Sophistication rank is highly significant and positively correlated with Log Innovation Output rank, controlling for other pillars, income and population. Log population, when included, was found significant and positively correlated with Log Innovation Output rank, controlling for other pillars and income. This suggests that improvements in institutions and business sophistication could lead to higher innovation output performance.

Table 1: Panel Regression Results: Fixed Effects

Dependant Variable: Log Innovation Output rank					
	(1)	(2)	(3)	(4)	(5)
VARIABLES	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Log Institutions rank	0.175***	0.173***	0.162***	0.168***	0.162***
	(0.0536)	(0.0549)	(0.0537)	(0.0546)	(0.0537)
Log HCR rank	-0.0099	-0.0103	-0.0043	-0.0101	-0.0043
	(0.0376)	(0.0378)	(0.0375)	(0.0377)	(0.0375)
Log Infrastructure rank	-0.0179	-0.0192	-0.0226	-0.0219	-0.0227
	(0.0334)	(0.0329)	(0.0323)	(0.0326)	(0.0323)
Log Market Sophistication	0.0106	0.0107	0.0149	0.0116	0.0149
rank	(0.0325)	(0.0325)	(0.0324)	(0.0324)	(0.0324)
Log Business Sophistication	0.0998***	0.0993***	0.0934***	0.0975***	0.0933***
rank	(0.0339)	(0.0343)	(0.0342)	(0.0344)	(0.0342)
Log GDP (PPP)^		-0.0187	-0.112		
		(0.0604)	(0.0728)		

Log Population^			0.495**		0.384**
			(0.214)		(0.183)
Log GDP per capita (PPP)^				-0.0641	-0.114
				(0.0704)	(0.0727)
Observations	936	936	936	936	936
Adjusted R-squared	0.960	0.960	0.960	0.960	0.960
Country FE	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
^2019 figures

8.52 Table 2 reports panel Fixed Effects (FE) regression results for dependant variable Log Knowledge & Technology Output rank for five models with different independent variables - Log input pillars, Log GDP, Log GDP per capita and Log population. Among the input pillars, it shows that Log Business Sophistication rank is significant and positively correlated with Log Knowledge & Technology Output rank, controlling for other pillars, income and population. It also shows that Log Human Capital & Research rank is significant and negatively correlated with Log Knowledge & Technology Output rank, controlling for other pillars, income and population. This suggests the potential for higher business sophistication to lead to better performance in knowledge & technology outputs.

Table 2: Panel Regression Results: Fixed Effects

Dependant Variable: Log Knowledge & Technology Output rank					
	(1)	(2)	(3)	(4)	(5)
VARIABLES	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Log Institutions rank	0.0409	0.0339	0.0287	0.0303	0.0283
	(0.0514)	(0.0511)	(0.0507)	(0.0508)	(0.0506)
Log HCR rank	-0.0935**	-0.0948**	-0.0920**	-0.0938**	-0.0919**
	(0.0399)	(0.0400)	(0.0408)	(0.0400)	(0.0408)
Log Infrastructure rank	0.0204	0.0158	0.0142	0.0142	0.0140
	(0.0377)	(0.0374)	(0.0374)	(0.0374)	(0.0374)
Log Market Sophistication	-0.0220	-0.0215	-0.0196	-0.0205	-0.0194
rank	(0.0373)	(0.0371)	(0.0372)	(0.0370)	(0.0372)
Log Business Sophistication	0.134***	0.132***	0.130***	0.131***	0.129***
rank	(0.0429)	(0.0427)	(0.0433)	(0.0428)	(0.0433)
Log GDP (PPP)^		-0.0666	-0.110		
		(0.0678)	(0.0969)		

Log Population^			0.231		0.125
			(0.314)		(0.253)
Log GDP per capita (PPP)^				-0.0982	-0.114
				(0.0847)	(0.0968)
Observations	936	936	936	936	936
Adjusted R-squared	0.948	0.948	0.948	0.948	0.948
Country FE	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
^2019 figures

8.53 Table 3 reports panel Fixed Effects (FE) regression results for dependant variable Log Creative Output rank for five models with different independent variables - Log input pillars, Log GDP, Log GDP per capita and Log population. Among the input pillars, it shows that Log Institutions and Log Business Sophistication ranks are significant and positively correlated with Log Creative Output rank, controlling for other pillars, income and population. Population, when included, was found significant and positively correlated with Log Creative Output rank, controlling for other pillars and income. Log GDP and Log GDP per capita, when included with population, were found significant and negatively correlated with Log Creative Output rank, controlling for other pillars. This suggests that improvements in institutions and business sophistication could lead to higher creative output performance. Higher income is also expected to lead to better performance in creative outputs, and hence ranks closer to one (thereby reflecting a negative correlation).

Table 3: Panel Regression Results: Fixed Effects

Dependant Variable: Log Creative Output rank					
VARIABLES	(1) **Model 1**	(2) **Model 2**	(3) **Model 3**	(4) **Model 4**	(5) **Model 5**
Log Institutions rank	0.160**	0.150**	0.130*	0.140**	0.130*
	(0.0695)	(0.0702)	(0.0702)	(0.0702)	(0.0702)
Log HCR rank	0.0327	0.0308	0.0412	0.0322	0.0414
	(0.0602)	(0.0600)	(0.0590)	(0.0595)	(0.0590)
Log Infrastructure rank	-0.0598	-0.0669	-0.0730	-0.0717	-0.0729
	(0.0802)	(0.0813)	(0.0809)	(0.0810)	(0.0809)
Log Market Sop rank	0.00327	0.00411	0.0113	0.00618	0.0115
	(0.0451)	(0.0449)	(0.0447)	(0.0448)	(0.0447)
Log Business Sop rank	0.0766**	0.0736**	0.0634*	0.0697*	0.0631*
	(0.0365)	(0.0364)	(0.0363)	(0.0363)	(0.0364)
Log GDP (PPP)^		-0.103	-0.267***		
		(0.0775)	(0.0986)		

Log Population^			0.871***		0.604**
			(0.304)		(0.255)
Log GDP per capita (PPP)^				-0.189**	-0.267***
				(0.0917)	(0.0985)
Observations	936	936	936	936	936
Adjusted R-squared	0.918	0.918	0.919	0.918	0.919
Country FE	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
^2019 figures

POLICY IMPLICATIONS

8.54 India needs greater thrust on innovation to catapult itself to a higher growth trajectory and become the third largest economy in GDP current US$ in the near future. This requires boosting gross expenditure on R&D from 0.7 per cent of GDP currently, to at least the average level of GERD in other top ten economies (GDP current US$) of over two per cent. It also involves significantly scaling up R&D personnel and researchers in the country, especially in the private sector.

8.55 Despite heavy lifting by the government sector in GERD of almost three times the average of other top ten economies, India's GERD remains low. Moreover, India's performance on innovation has been lower than expected for its level of access to equity finance. India's business sector needs to rise to the occasion and significantly ramp up its gross expenditure on R&D to a level commensurate to India's status as the fifth largest economy in GDP current US$. This requires boosting business sector contribution to total GERD from 37 per cent currently, to close to 68 per cent – the average business contribution in GERD of other top ten economies. Indian business sector's contribution to total R&D personnel and researchers also needs to be scaled up from 30 per cent and 34 per cent per cent respectively to the average level in other top ten economies (58 per cent and 53 per cent respectively).

8.56 India has had a generous tax incentive structure to boost R&D in the country as compared to several other top ten economies. However, this did not generate a corresponding level of private participation in GERD in India. Given the low level of contribution to GERD by the business sector despite the generous incentive regime prevailing earlier, businesses in India must focus on innovation to remain competitive in the new economy.

8.57 For India to become an innovation leader, its residents' share in total patent applications filed in the country must rise from the current level of 36 per cent. As a thought experiment, assume that the number of non-resident patent applications in India remain the same from 2019 to 2030. Then, if India's share of resident patents were to rise from 36 per cent in 2019 to the average share of resident patents in total patent applications amongst the other top 10 economies (62 per cent) by 2030, resident patents would have to increase at a CAGR of 9.8 per cent. While ambitious, this has been achieved by another country - China's resident patents have increased at a CAGR of 21 per cent from 2000 to 2019 and at a CAGR of 16 per cent from 2010 to 2019.

8.58 India should focus on improving its performance on institutions and business sophistication since higher performance on these dimensions seem to consistently suggest higher innovation outputs performance (Tables 1-3). The importance of institutions for innovation is consistent with an emerging literature that emphasizes the same (see Acharya and Subramanian, 2009; Acharya et al. 2013, 2014, Sapra et al. 2014). Table 4 highlights some areas that India could focus on within the institutions and business sophistication input pillars to further augment its performance in innovation outputs.

Table 4: Suggested Focus Areas for boosting Innovation Performance

Input Pillar and Potency of Expected Impact	Build on strengths	Improve
Institutions **Potency of potential impact:** One standard deviation improvement in Institutions rank from 61 in 2020 to 23 is expected to increase overall Innovation Output rank to 40 from 45 in 2020	• Ease of resolving insolvency (rank 47) • Government effectiveness (rank 55)	• Ease of starting a business (rank 105) • Political and operational stability (rank 83) • Regulatory quality (rank 84) • Rule of law (rank 62) • Cost of redundancy dismissal (rank 61)
Business Sophistication **Potency of potential impact:** One standard deviation improvement in Business Sophistication rank from 55 in 2020 to 17 is expected to increase overall Innovation Output rank to 42 from 45 in 2020	• Intellectual Property payments as % of total trade (rank 27) • High-tech imports as % of total trade (rank 29) • % of Firms offering formal training (rank 37) • State of cluster development (rank 37) • Research talent, % in business enterprise (rank 38) • University/Industry research collaboration (rank 45) • JV-strategic alliance deals/ bn PPP$ GDP (rank 47) • Patent families 2+ offices/ bn PPP$ GDP (rank 47) • % GERD financed by business (rank 48)	• % of Females employed with advanced degrees (rank 101) • FDI net inflows as % of GDP (rank 92) • % of Knowledge intensive employment (rank 90)

8.59 As Economic Survey 2019-20 discussed in the chapter "Entrepreneurship and Wealth Creation at the Grassroots", the Startup India campaign of the Government of India recognises entrepreneurship as an increasingly important strategy to fuel productivity growth and

wealth creation in India. This assumes greater importance in the context of enhancing private participation in innovation in India - in terms of contribution to gross expenditure on R&D, R&D personnel and researchers, and share in patents filed in the country. The lessons drawn therein on the crucial role of literacy, education, physical infrastructure and policies enabling ease of doing business, as drivers of new firm creation and entrepreneurship, remain relevant in this analysis.

CHAPTER AT A GLANCE

- India entered the top 50 innovating countries for the first time in 2020 since the inception of the Global Innovation Index in 2007, by improving its rank from 81 in 2015 to 48 in 2020. India ranks first in Central and South Asia, and third amongst lower middle-income group economies.
- For India to become an innovation leader, it needs greater thrust on innovation. India's aspiration must be to compete on innovation with the top ten economies. India's gross domestic expenditure on R&D (GERD) is lowest amongst other largest economies. The government sector contributes a disproportionate large share in total GERD at three times the average of other largest economies. However, the business sector's contribution to GERD is amongst the lowest. The business sector's contribution to total R&D personnel and researchers also lags behind that in other large economies. This situation has prevailed despite the tax incentives for innovation having been more liberal than other economies. India's innovation ranking is much lower than expected for its level of access to equity capital. This points towards the need for India's business sector to significantly ramp up investments in R&D.
- Indian residents' share in total patents filed in the country stands at 36 per cent. This lags behind the average of 62 per cent in other largest economies. Resident share in patent applications must rise for India to become an innovative nation.
- India must focus on improving its performance on institutions and business sophistication innovation inputs. These are expected to result in higher improvement in innovation output.

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