*Industrial Revolution 4.0: Will it be different this time for India?**

The study explores the likely impact of the fourth industrial revolution (IR-4) on India's manufacturing sector. Industry 4.0 is integrating new technologies – like Internet of Things (IoT), cloud computing and analytics, artificial intelligence and machine learning - into manufacturing production processes and operations, ushering in a new era of 'smart manufacturing'. India's lead in information technology (IT) exports and presence of experienced IT professionals provides an advantage. However, when it comes to the quality of human capital in general and physical infrastructure required to make the great leap forward, India lags behind its competitors.

Introduction

Technological changes in the last decade have revolutionised the organisation of industrial production influencing supply chains and production processes. Industry 4.0 (IR-4 hereafter) has integrated new technologies – like Internet of Things (IoT), cloud computing and analytics, and artificial intelligence and machine learning into manufacturing production processes and operations, ushering in a new era of 'smart manufacturing'. The digital technologies used in the manufacturing processes promotes automation and self-optimisation leading to operational efficiency across the value chain.

Since the publication of the book "The Fourth Industrial Revolution", by Klaus Schwab, World Economic Forum Founder and Executive Chairman, it has generated considerable global attention. IR-4 amalgamates the use of digital technologies from the third industrial revolution with the latest biological and physical innovations which has a potential to transform institutions, industries, and individuals (Schwab, 2016).

This article explores the likely impact of IR-4 on India's manufacturing sector. Section 2 presents in brief the unique characteristic features of various Industrial Revolutions with a focus on IR-4. Section 3 analyses the current profile of India's manufacturing by exploring its share in global value chains and technology intensity of the sector. Section 4 offers an assessment of the potential for India to benefit from IR-4 and corresponding pre-requisites. Section 5 concludes the paper.

II. Industrial Revolution

The term Industrial Revolution, first coined in 1837 by Louis-Auguste Blanqui, a French economist, referred to economic and social changes driving the transition from industrial activity carried at homes with simple instruments to those undertaken in factories with the help of power-driven machinery[1]. Phases of major industrial revolutions have been differentiated into periods based on the access to and use of new technology – steam engine and railways (late 18th century); electrification enabling division of labour and mass production (late 19th century); electronics, IT, and automation (late 20th century) (Schwab, 2015) (Table 1). The world is currently going through a fourth industrial revolution, as production becomes increasingly automated and new networks of exchange of information between human and machine are formed (Popkova *et al.*, 2019).

IR-4 brings in major changes in industrial organisation and potential localisation of activities, altering the market dynamics through which value-added is generated and appropriated (Primi and Toselli, 2020). From the output side, products and services are expected to be highly interconnected making many of

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[1] The Oxford Companion to British History, 2ed., 2015.

Table 1: Different phases of Industrial Revolution

Period	Transition Period	Energy Resource	Main Technical Achievement	Means of Transport
1760-1900	1860-1900	Coal	Steam Engine	Train
1870-1940	1940-1960	Oil, Electricity	Internal Combustion Engine	Train, Car
1930-2000	1980-2000	Nuclear Energy, Natural Gas	Computers, Robots	Car, Plane
2000 and beyond	2000-2010	Green Energies	Internet, 3D printer, Genetic Engineering	Electric and driverless cars, Ultra-Fast Train, Drones, Air Taxis

Source: Schwab, 2015

the existing industry boundaries obsolete (Table 2). Data science, biotechnology and artificial intelligence will be used intensively as inputs, necessitating upskilling of the labour force.

The fourth industrial revolution is fuelled by four major components: widespread internet penetration; hyper-efficient processing technology (chips); artificial intelligence; and machine learning. While the earlier waves of automation due to past industrial revolutions popularised mass-homogeneous production systems, IR-4 brings to the fore more customised industrial production. With IR-4, new production models will emerge, where automated systems, data exchanges, 3-D printers and robots are used effectively in an environment of smart factories, which will make the production processes lean and flexible enabling optimum utilisation of resources. Lean manufacturing helps identification and steady elimination of all kinds of waste in a manufacturing system and flexible manufacturing enables computer-controlled production with customised volume, process and types (Lu, Morris, & Frechette, 2016).

The IR-4 technologies have found initial adoption in the manufacturing sector, where sizeable gains in productivity and efficiency can be unlocked in areas such as supply chain management, inventory management, shipping, construction and consumer analytics. The services sector could also face a radical change with services delivery becoming more targeted using digital platforms. Almost all sectors in the economy would be exposed to opportunities and challenges from technologies. For example, construction processes are changing, with off-site planning and assembling of building happening in a location other than the building site which have a dramatic impact on productivity and efficiency in delivery. In the health sector, wearable devices can not only track health vitals but also use information to predict possible risk factors using artificial intelligence. With the use of Internet-of-Things, care givers can track location and health and administer medicines remotely and more intelligently. The transportation sector is expected to face a major transformation with clean energy fuelled cars and driver-less vehicles ushering increased road safety and reduced pollution.

Table 2: Changing Dynamics of Production

	Yesterday		Tomorrow
Output	Product and Services	→	Data and Experiences
Core Value	Design and R&D	→	Integrated Systems & Platforms
Value Chain Organisation	Cost Optimisation Driven	→	Image and Reputation Driven

Source: Primi and Toselli, 2020

This changing nature of manufacturing process calls for a re-look at developing countries' export-led policies. The factors - like cheap labour and favourable FDI policies - that helped low-income economies to increase their productivity and income earlier, may not be the determining factor in this new era (Lee et al., 2020). Instead, technologically advanced economies with sophisticated labour force capable of spearheading the digital wave will have an edge over others. This may change the global value chains, with production process re-shoring to countries with higher technological capabilities. At present, with much of the technological advances concentrated in the developed economies which are labour scarce, the benefits emerging from these changes could be asymmetrical and skewed against labour rich developing economies and restrict the scope of low-income countries to benefit out of international trade, unless they adapt and enrich themselves to meet the challenges brought about by the technological developments.

Traditionally, manufacturing-led growth has yielded high economic growth, through productivity gains and job creation for the unskilled labour force (Hallward-Driemeier & Nayyar, 2018). Export-led manufacturing growth helped the East Asian economies to move up the ladder in the 1970s. More recently, China emerged as a global leader in manufacturing, largely benefitting from the third industrial revolution. The third industrial revolution led automation of routine tasks may however, stifle low income countries' economic catch-up, leaving them with stagnant productivity and per capita income growth (UNCTAD, 2017).

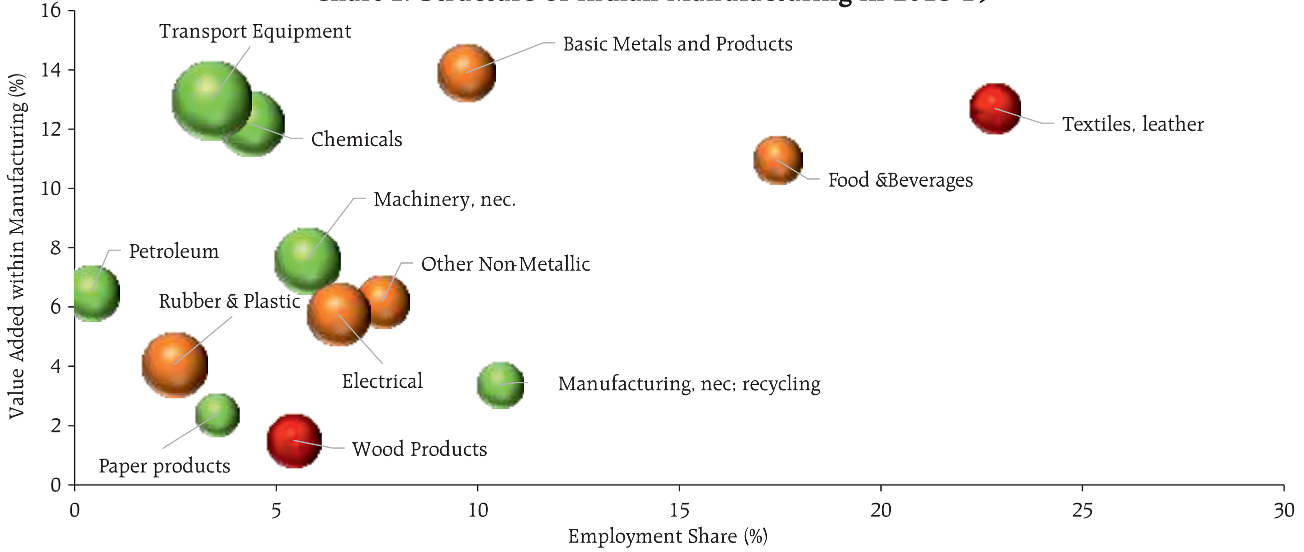
The new technological developments have brought to the forefront the Schumpeterian idea of Creative Destruction. While new technologies can create new jobs, it can also result in job displacements in certain sectors. Hence, it is crucial for labour rich developing countries to frame strategies for adapting to the changing scenario. The success of a country in harnessing the technological developments depends on the current state of industrial technology, the speed and extent of the acquisition of new technology and the demographic profile with focus on quality rather than quantity (WTO, 2020). Accordingly, we assess the current state of industrial development and human capital of India, next.

III. Status of India's Manufacturing Sector

The benefits from first and second industrial revolution largely escaped colonial India. The technological developments in the West resulted in de-industrialisation in India, limiting it to a raw material exporter for the factories in England. Accordingly, India's share went down from one fourth of world income in 1700 to 3.0 per cent in 1950 (Maddison, 2007). The Third Industrial Revolution, which began in the 1980s, coincided with the era of economic reforms in India. Economic liberalisation aided technical collaboration with foreign firms, and also relaxed norms governing technology induction in the Indian manufacturing sector (Bhat, 2020). Cross border production supported by advances in information and communication technology, among others, led to multi-country production networks with value generated across the globe (Seric & Tong, 2019). However, the benefits of third industrial revolution based on information technology was lopsided in India, with services sector taking off through IT and IT-enabled services (ITeS), e-commerce and e-governance while manufacturing sector was unable to benefit as much due to presence of inefficiency and backwardness in the organisation of industrial production (Singh N., 2016).

Over the years, India has moved up in terms of its share in world manufacturing GVA. As per UNIDO Competitive Index, India's rank in terms of World Manufacturing Value Added Index improved from 14 in 2000 to 5 in 2019. However, in terms of Competitive Industrial Performance Index, India ranked low at 38 in 2019 mainly due to low share of manufacturing sector in GDP. In 2019-20, the sector contributed to 17.1 per cent of GVA and 11.2 per cent of total employment. The manufacturing sector in India is capital intensive, with the organised sector contributing to nearly three fourths of manufacturing sector Gross Value Added (GVA). Textiles and leather products and food and beverages had the highest shares in employment as well as a high share in manufacturing GVA. Both these sectors have relatively higher unorganised sector contributions, with households contributing to 33.6

Chart 1: Structure of Indian Manufacturing in 2018-19



Note: Size of bubble indicates Total Factor productivity. And the colour shows contribution of household to sectoral GVA. Red colour indicates household contribution>25 per cent; Orange-medium share of household sector (5%-25%) and Green-low share of household sector (<5%).
Source: Authors' calculations based on NSO and KLEMS data.

and 14.7 per cent of their respective GVA. On the other hand, transport equipment, chemicals and machinery have high share in manufacturing GVA with lower employment elasticity. Productivity of these sectors are also high compared to labour intensive sectors (Chart 1).

Growth in manufacturing sector has moved in sync with export growth, making global demand an important determinant of manufacturing output growth. Exports accounted for 20.7 per cent of total manufacturing output in 2019-20. Hence, the impact of IR-4 on India's manufacturing sector could depend a lot on how it can improve its global competitiveness.

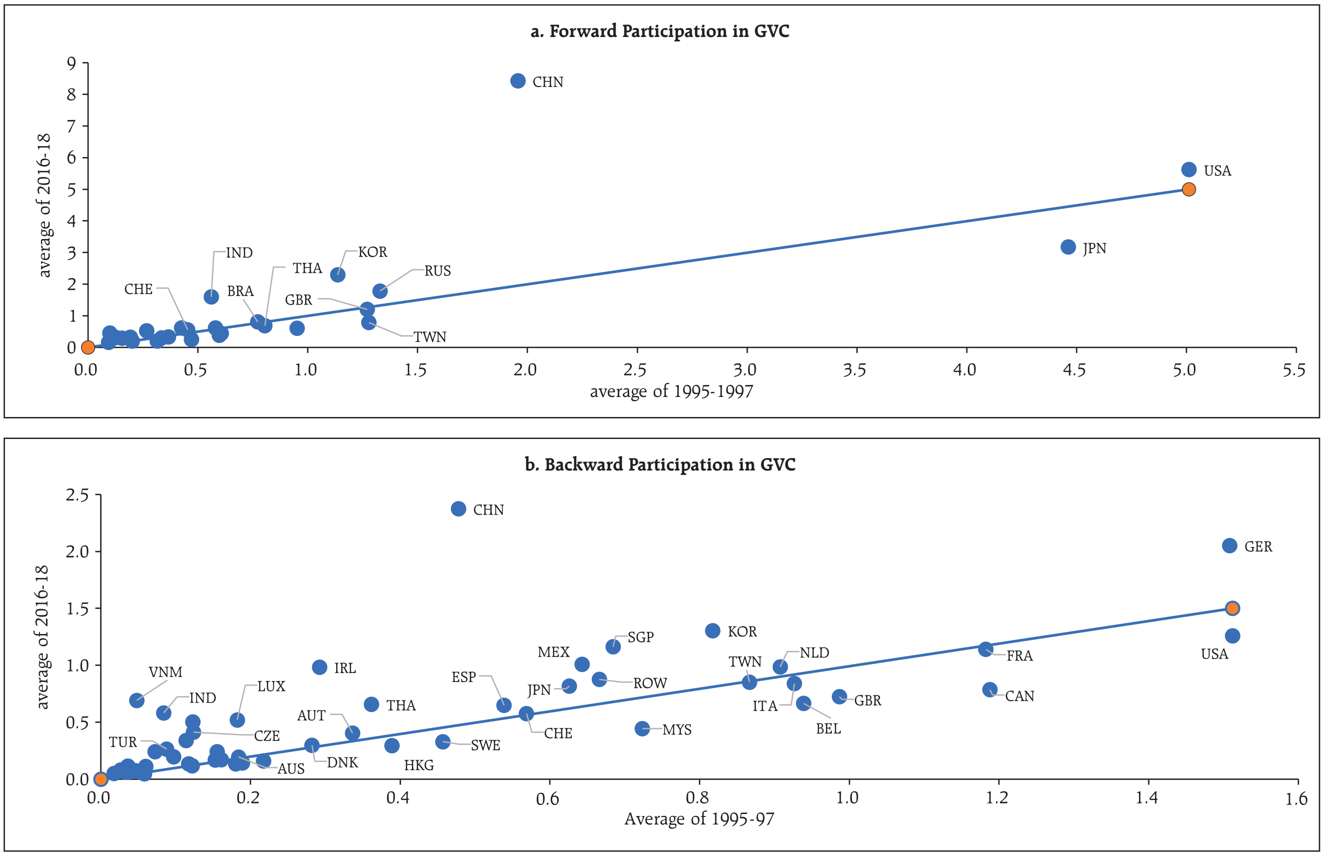
III.2 Participation in Global Value Chain

Industrial production since the 1970's has been organised in complex multi-country networks with suppliers and consumers spreading across various nodes of the supply chain. While India has made sustained strides in global markets, its share has remained limited in world trade and participation in the global value chain.

In line with the global value chain literature, we use two indicators[2] to arrive at India's participation in global value chain. 'Climbing up the ladder', where a more than proportional increase of domestic value-added content of foreign exports, measures forward participation in value chain; and 'Deepening in assembly', where a more than proportional increase in foreign value-added content in domestic exports, measures backward participation in value chain (Primi & Toselli, 2020). Following Banga (2013), each indicator is then divided by "Global Value Added of Exports", which is arrived at by summing up the domestic value-added in exports of all countries. Global Value Added of Exports differs from Global Gross Exports as the former nets out double counting in global trade, which is caused by export and re-export of intermediate products in the trade network. Accordingly, countries that specialise in assembling with little value addition end up having a low share

[2] Analysis is carried out using OECD Trade in Value Added (TiVA) database. The data is available for the period 1995- 2018.

Chart 2: Participation in Global Value Chain (GVC)



Source: OECD Trade in Value Added (TiVA) database, 1995-2018.

in global value added of exports. The value arrived at gives the relative contribution of a country in Global Value Added of Exports (Chart 2a and 2b).

Since the data is available for the period 1995-2018, the analysis is carried out by taking an average of 1995-97 as the base. While both backward and forward participation of India has improved over period 1995-97, India' shares in gross exports of other countries have increased at a higher rate than other countries share in India's gross exports[3]. Between 1995-97 to 2016-18, India's forward participation in Global Value Added increased from 0.6 per cent to 1.6 per cent respectively, while backward participation increased by a meagre 0.5 percentage points from 0.1 per cent to 0.6 per cent. China's forward participation increased from 2.0 per cent to 8.4 per cent between the two-time periods. Backward participation was more spread out with most countries facing an increase in foreign share in their gross exports. Sector wise, compared to manufacturing, India's participation in services value chain and in particular trade in information industries is higher. Forward participation in information technology increased from 0.4 per cent in 1995 to 2.8 per cent in 2018 (Chart 3a and 3b). India's advantage in information technology service sector is expected to benefit adoption of IR-4 technologies in India. However, transforming the advantage that India has, in IT as a service to the manufacturing space will depend on technology intensity of India's manufacturing sector.

[3] Full country names against the codes are given in Annex 1

Chart 3a: Forward participation in Global Value Chain: India

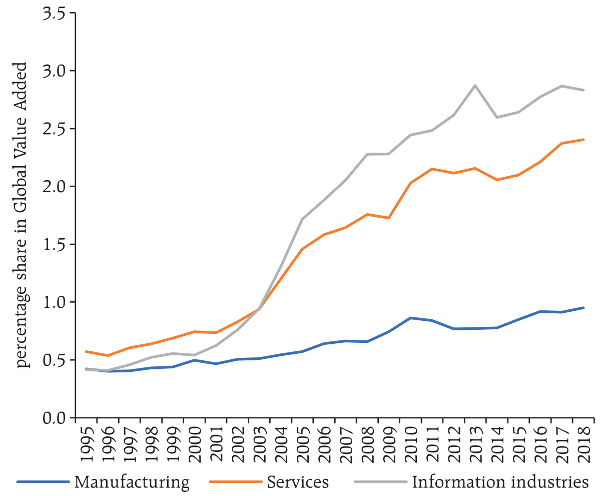
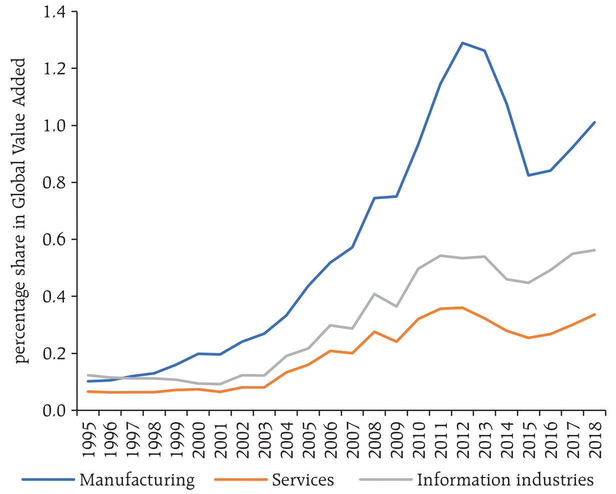


Chart 3b: Backward Participation in Global Value Chain : India



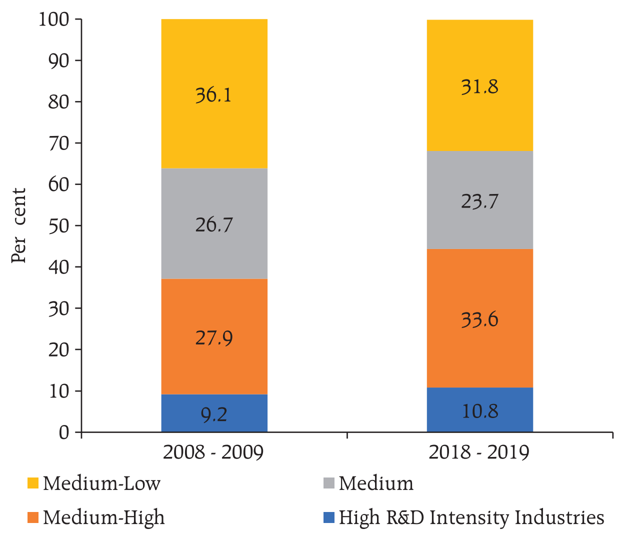
Source: OECD Trade in Value Added (TiVA) database, 1995-2018.

III.3 Technology Intensity of India's Manufacturing sector

Based on OECD classification of economic activities on Research and Development (R&D) intensity[4], India's manufacturing sector is divided into four categories: High R&D Intensive; Medium-High R&D Intensive; Medium R&D intensive; and Medium-low R&D Intensive. As of 2018-19[5], India's manufacturing sector is dominated by low-medium R&D industries, though its share has come down over the years. High and Medium R&D intensive industries are increasingly playing an important role in Indian manufacturing sector reflecting India's scope for benefitting from IR-4 (Chart 4).

Despite increasing importance of R&D intensive sectors in India's manufacturing sector, India's R&D intensity, measured as expenditure on R&D as a percentage of GDP, remains low. As per the latest available data for 2018, India's R&D intensity is about 0.7 percent in contrast to advanced nations' at about 3 per cent (Chart 5). Share of business in R&D expenses is low in India compared to other countries as, in 2018, 63.2 per cent of R&D came from the Government sector (Chart 6). India also has one of the lowest R&D personnel per thousand labour force (Chart 7).

Chart 4: Technology Intensity of India's Manufacturing Sector

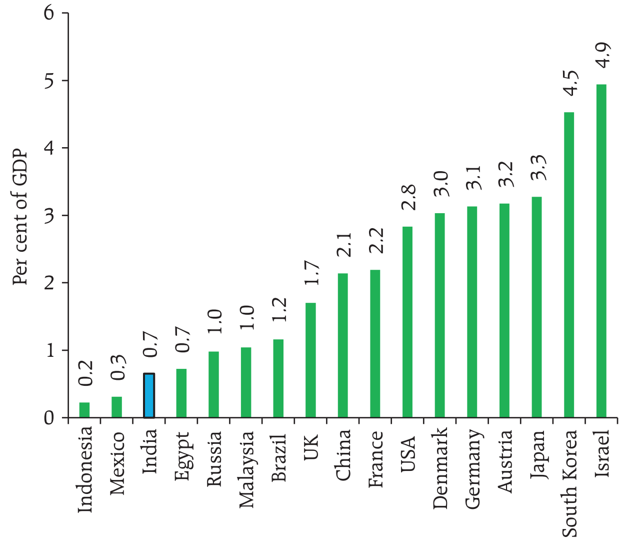


Source: Calculations based on Annual Survey of Industries.

4 Detailed OECD (2016) classification given in Annex 2

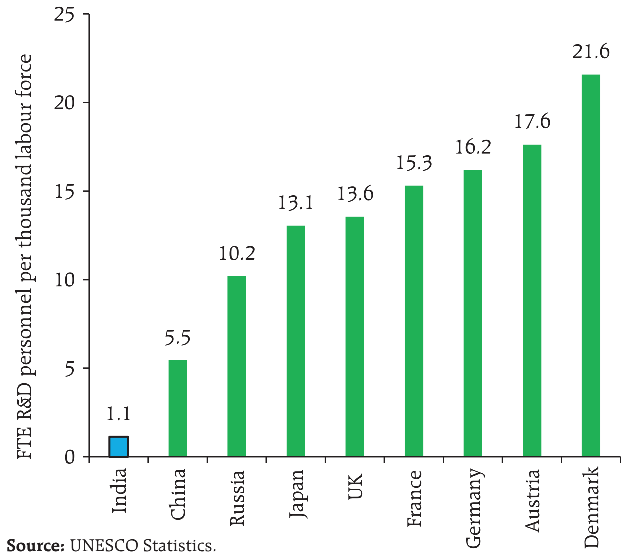
5 Classification based on Annual Survey of Industries data, latest data available is 2018-19.

Chart 5: R&D as per cent of GDP: 2018



Source: UNESCO Statistics.

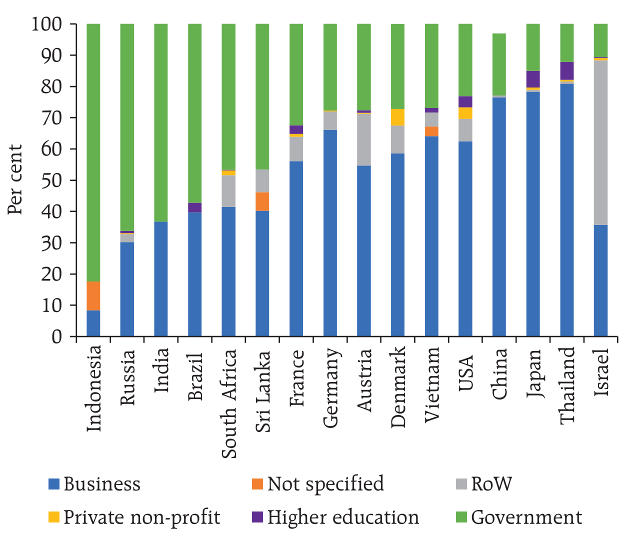
Chart 7: R&D Personnel per thousand Labour Force-2018[6]



Source: UNESCO Statistics.

To harness opportunities in IR-4, concerted actions are required to channelize India's strength in digital technologies to develop smart manufacturing. A pre-requisite for this transition is investment in R&D and strengthening the knowledge base of human capital. To understand the determinants of R&D expenditure in India's manufacturing sector, a panel data analysis using CMIE Prowess database, is carried out on 1,438 manufacturing enterprises covering 26 manufacturing sub-sectors, for the period 2014-15 to 2018-19 (*i.e.*, pre-COVID period). The explanatory variables used are firm age- based on incorporation year, firm size- based on total assets, growth in net sales, profitability- based on net profits before tax and extraordinary items; debt-equity ratio; and tech to asset ratio. Robust standard errors are used to control heteroscedasticity and serial correlation, whereas two-stage least square (2SLS) is used to control endogeneity by using lags of tech to asset ratio as instrumental variable. Endogeneity exists in a model when the residual of the regression model correlate with the explanatory variables (Gujarati *et al.*, 2012) and instrumental variables are used to control it. Tech to asset ratio is taken as the instrumental variable here as it was the

Chart 6: Source wise R&D Expenditure-2018



Source: UNESCO Statistics.

6 The Full-time equivalent (FTE) of R&D personnel is defined as the ratio of working hours actually spent on R&D during a specific reference period (usually a calendar year) divided by the total number of hours conventionally worked in the same period by an individual or by a group.

only variable found to be significantly correlated with the residual term. Lag of Tech to Asset is considered as the instrument as lag values prove to be the best instruments to check endogeneity (Mohmed *et al.*, 2020). Given the linear regression,

$$Log\ R\&D = \beta_1 + \beta_2 Log\ Age + \beta_3 Firm\ Size + \beta_4 Sales\ Growth + \beta_5 Profitability + \beta_6\ Debt\ to\ equity\ ratio + \beta_7 Tech\ to\ Asset\ Ratio + \varepsilon$$

Where,

Log R&D: Log research and developments expenses

Log Age: Log (1+age)

Firm Size: Log total assets

Sales Growth: Percentage change in Net Sales
i.e., (Net $Sales_t$ - Net $Sales_{t-1}$/ Net $Sales_t$) X 100

Profitability: Percentage change in net profits before tax and extraordinary items
i.e., (Net $profits_t$ - Net $profits_{t-1}$/ Net $profits_t$) X 100

Debt to Equity Ratio: Debt/Total equity- directly from prowess

Tech to Asset Ratio: presents gross technical know-how including product designs/formulae etc. as a ratio of total assets. Technical know-how means the knowledge and technical/ practical skill, use of specific technology or way of doing something more efficiently and effectively. As for the world of businesses, technical know-how often takes shape of computer software, technology development and related knowledge. However, the meaning is not exhaustive may include product designs, formulae, databases etc.

Table 3: Regression results

Log R&D	Coefficient	p-value
Log age	1.334568***	0.000
F. Size	0.1228386*	0.060
Sales Growth	0.00000583	0.700
Profitability	0.00000172*	0.090
Debt to equity	0.0002413	0.100
Tech to asset	0.00000448**	0.010
Constant	-0.065827426	
N (Observations)	1860	
N (Companies)	639	
Wald Chi^2	1.36	
p-values	0	
R-square	0.1712	

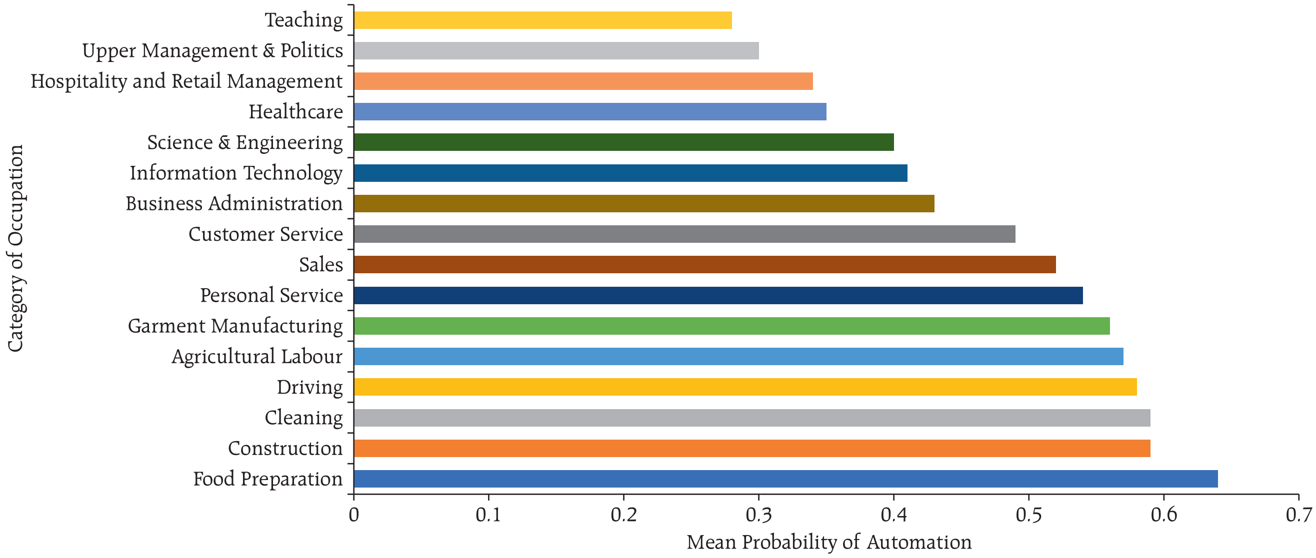
Notes: ***, **, * presents level of significance at 1%, 5% and 10 % respectively.

The results show that maturity, size, profitability and technical know-how determine R&D expenditure in India's manufacturing sector. Older companies, large sized firms, firms with high profitability and technical know-how have higher level of R&D expenses (Table 3). The results suggest that mature companies invest considerably in innovative activities, as they are more experienced and have stability in the market. Since large companies have greater amount of funds available with them and need to develop themselves continuously in order to thrive in the market, the positive coefficient value in the regression depicts a direct influence of firm size on research and development expenses. Profitability and tech to asset ratio have a small yet significant influence on research and development expenses of an organization. Companies earning higher profits and having exposure to technology incur higher research and development expenses. Further, the positive coefficient value of tech to asset ratio depicts that companies with better knowledge regarding the use of specific technology or way of doing something more efficiently and effectively, have higher investment in research and development. As companies with technical know-how are already equipped with basic pre-requisites for research, they may prefer to induce it. The findings are in line with existing literature (Lee, K., 2019).

IV. IR-4 and Human Capital

Like past Industrial Revolutions, IR-4 is also expected to bring about far-reaching changes in the labour market with technology shaping the type and nature of work. According to Frey and Osborne (2013),

Chart 8: Susceptibility to Automation Across Jobs

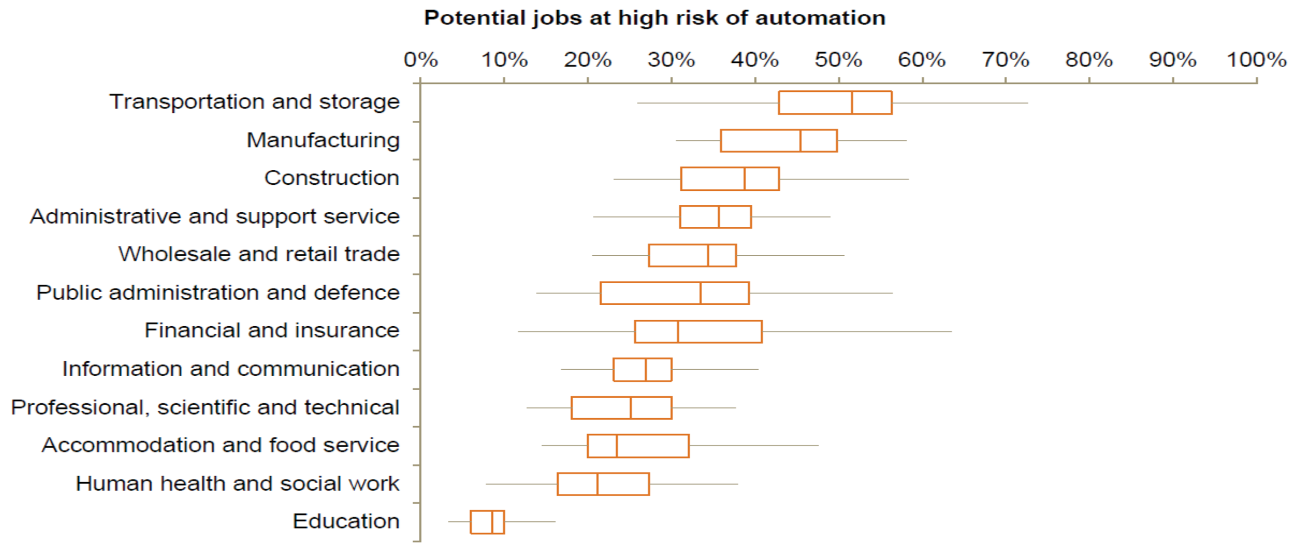


Source: Nedelkoska, L., & Quintini, G. (2018).

47 per cent of jobs in the United States are at a high risk of being automated. Similarly, in a cross-country study of 32 countries, close to one in two jobs are likely to be significantly affected by automation, based on the tasks they involve (Nedelkoska, L., & Quintini, G. 2018). About 14 per cent of jobs in OECD countries are highly automatable (*i.e.*, probability of automation of over 70 per cent); another 32 per cent of jobs have a risk of automation between 50 per cent and 70 per cent, pointing to the possibility of significant change in the way these jobs are carried out (Chart 8).

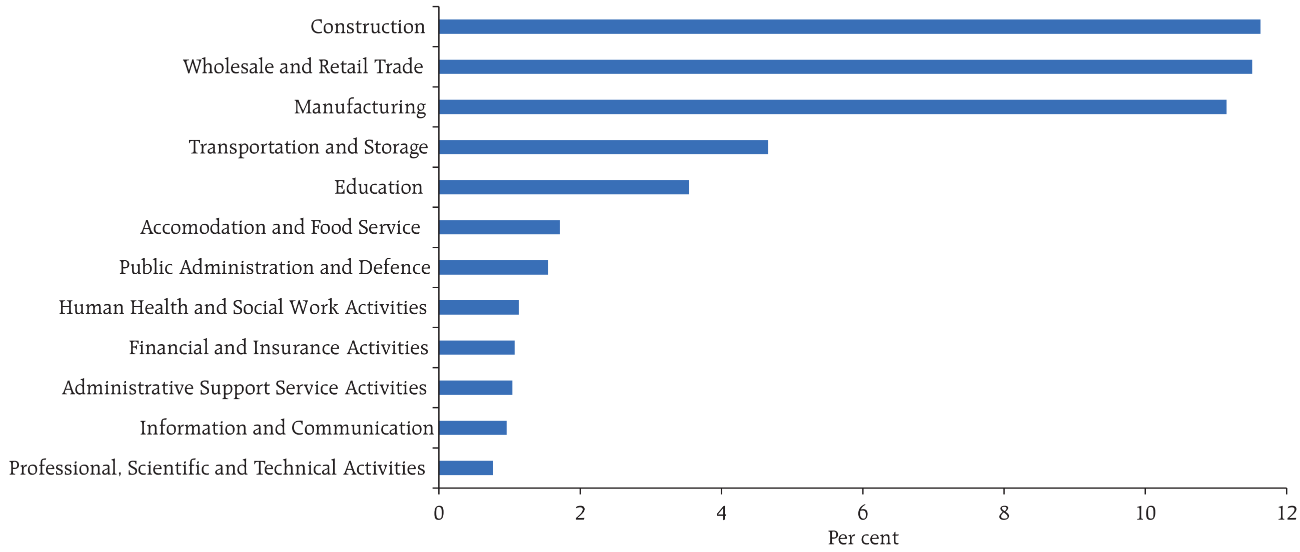
Sectors with higher possibility of increased automation and displacement of significant labour force include transportation, storage, manufacturing and construction (Chart 9). A comparison with India's

Chart 9: Share of Jobs with Potentially High Automation Rates by Industry



Source: PricewaterhouseCoopers, 2018.

Chart 10: Percentage Distribution of Workers by Industry - India

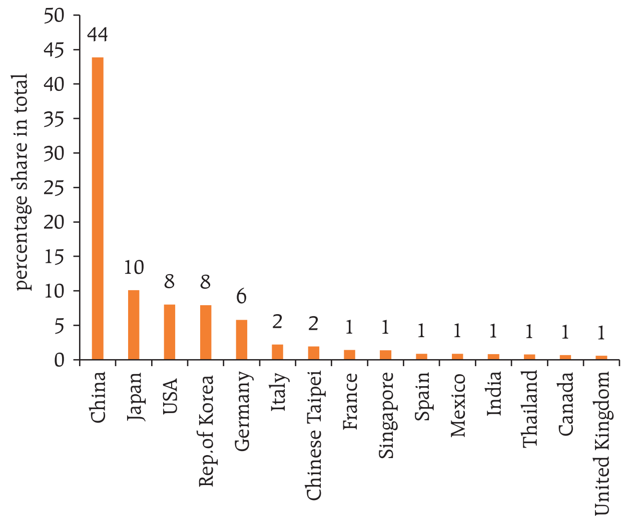


Source: Periodic Labour Force Survey, 2019-20.

employment structure reveals that more than three fourths of India's workforce outside agriculture is employed in these sectors (Chart 10). Thus, India has a high share of workers employed in sectors with high risk of automation. Manufacturing sector, which is already capital intensive in India may be impacted further by automation as many of the assembly lines can be run by machines and production and distribution processes can be streamlined using advanced technologies, making it even more capital intensive. Further, many of the services that are used in the manufacturing processes would also be impacted by automation, limiting employment potential in manufacturing going ahead.

Use of industrial robots in manufacturing is progressing gradually with five major markets accounting for 76 per cent of industrial robots' installations (Chart 11). India, with a share of 0.8 per cent, is a small player in this segment. In 2020, the world average robot density in the manufacturing sector was 126 robots per 10,000 employees, with Asia having an average robot density of 134 units per 10,000 employees. As per the International Federation of Robotics, World Robotics, 2021, robots' installation has increased by 0.5 per cent in the pandemic year 2020, making it the third most successful year in robotics industry after 2017 and 2018. The main growth driver was the electronics industry (29 per cent of installations) which surpassed the automotive industry (21 per cent of installations) as the largest customer of industrial robots followed by metals and machinery (11 per

Chart 11: Industry Robot Installations 2020: Country-wise



Source: International Federation of Robotics.

cent), plastics and chemical products (5 per cent) and food and beverages (3 per cent).

Those jobs which are repetitive, routine cognitive, and manual have high chances of automation (Autor, Levy and Murnane, 2003). While it is highly plausible that occupations involving routine tasks, cognitive or otherwise, are at a higher risk of getting replaced, the tasks having more social requirements are well-placed to survive and thrive. The premium is placed on occupations that deal with managing and improving these technologies and the ones that require human understanding. Therefore, it is important to look at the evolution in skill demand due to these frontier technologies.

Like every new technology in the past, IR-4 also brings with it hope of generating new occupations and tasks. Technology has brought higher labour productivity to many sectors by reducing the demand for workers in routine tasks. It also creates proximity to distant markets, facilitating creation of new and more efficient value chains (World Bank, 2019).

As the risk of automation is inversely proportional to the skill levels of the workers, the level of human capital development is an important marker of the risks to automation across various countries. Accordingly, the level of educational attainment of the workforce becomes an important variable for deciding the automation potential of the occupations employing the workforce (Ilavarasan, 2017) (Table 4).

IV.2 India's Prospects

Successful adaptation to IR-4 require development of skill sets among the working population. While India has made rapid strides in education, three-fourths of the population has educational qualification of only up to secondary level, which are categorised as unskilled to low skilled with high probability of facing the rile of automation. Only 11.8 per cent of the workforce has educational qualifications of graduate and above. India's tertiary[7] enrolment ratio in 2019 was lower than both low-middle income countries and the world average (Chart 12).

Further, notwithstanding the fact that employability is high for technically trained personnel, only 3.2 per cent of the workforce have formal vocational/technical training in India (PLFS 2019-20). Many of the task-specific/occupation-specific skills were traditionally transferred either within a family from one generation to another *via* a family vocation or by learning on the job from veteran skilled workers.

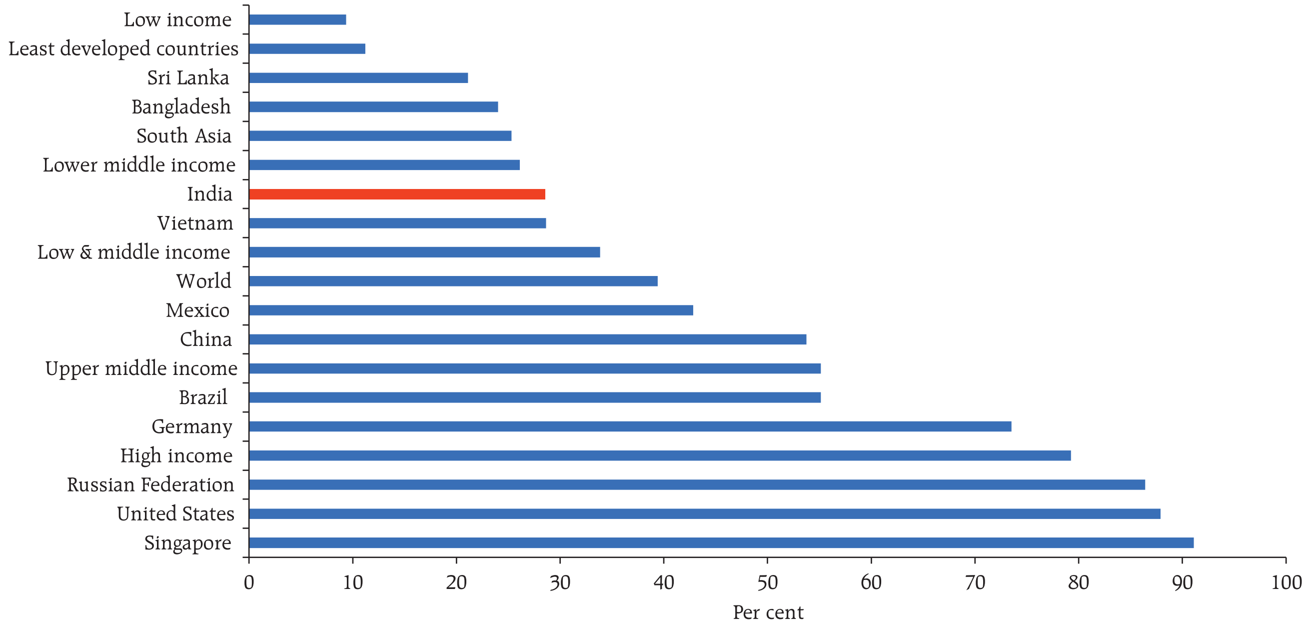
Table 4: Skill levels, education, occupations and automation

Skill Levels, Education, Occupations and Automation				
Skill Level	**Skill Definition**	**Education**	**Occupation - Divisions**	**Automation Possibilty**
I (unskilled)	Routine physical and/or manual tasks	Primary (upto 10 years of formal/informal skills)	Elementary occupations; Armed Forces Occupations	Very high
II (low skilled)	Operating machinery, electrical equipment, driving vehicles, repairing, storage info	Secondary (11-13 years)	Clerical Support Workers; Services and Sales Workers; Skilled Agri, Forestry & Fishery Workers; Crafts & Related Trades Workers; and Plant and Machine Operators & Assemblers, Armed Forces Occupations	Very high
III (skilled)	Complex technical and practical tasks which need knowledge in specialized fields	First Univ. (14-15 years)	Technicians and Associate Professionals; Managers	High & Moderate
IV (high skilled)	Tasks require complex skills, knowledge in a specialised field	Post Graduate (More than 15 years)	Professionals; Managers; Armed Forces Occupations	Low

Source: Ilavarasan, V. (2017).

7 Education at the post-secondary level.

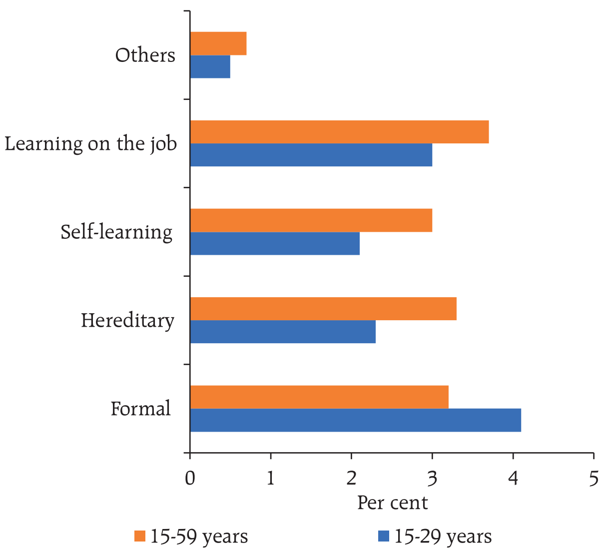
Chart 12: Teritiary School Enrollement



Source: World Bank, World Development Indicators.

In recent years, more institutionalised mechanisms of imparting skills are spreading across India. PLFS (2019-20) reveals that the younger workers (15-29 years) are increasingly getting vocationally/technically trained from formal institutions as compared to the workers in the 15-59 years age cohort (Chart 13).

Chart 13: Vocational/Technical Training Received

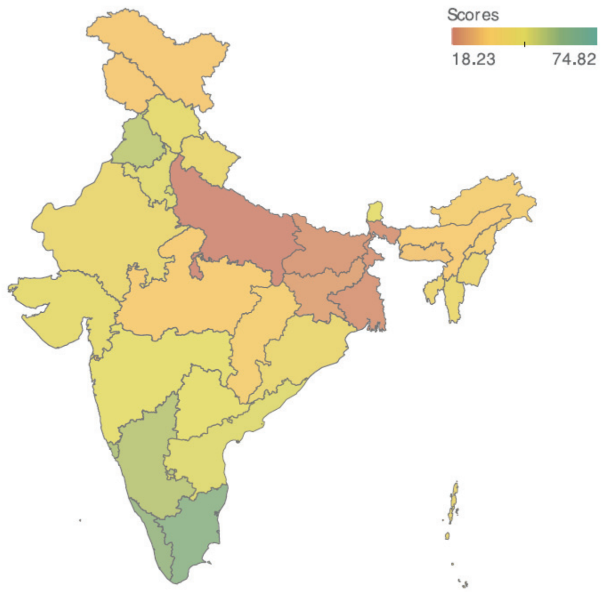


Source: Periodic Labour Force Survey (2019-20).

IR-4 technologies demand digital and analytical skills, which make it imperative to expand the spread and scope of technical courses. All-India Survey of Higher Education (AISHE) 2019-20 paints a hopeful picture as enrolment in engineering and technology courses at undergraduate level is the third highest in the country. Similarly, the number of post-graduate and higher degree courses in the engineering and technology domain remains high. However, wide divergence across states in human capital also needs to be addressed. States like Tamil Nadu, Kerala, Karnataka and Punjab have a relatively higher level of human capital development as compared to northern and eastern states of Uttar Pradesh, Bihar, West Bengal and Jharkhand *etc.* (Chart 14).

New technologies would place higher demands on the IT infrastructure – the availability and reliability of ICT services, the data ecosystem, skills, and intellectual property rights become important in this context. India's density of cellular subscriptions has reached 84 per cent, but it lags major comparable economies on access to digital

Chart 14: Regional mapping of human capital scores



Source: India Innovation Index Report, 2020 (NITI Aayog).

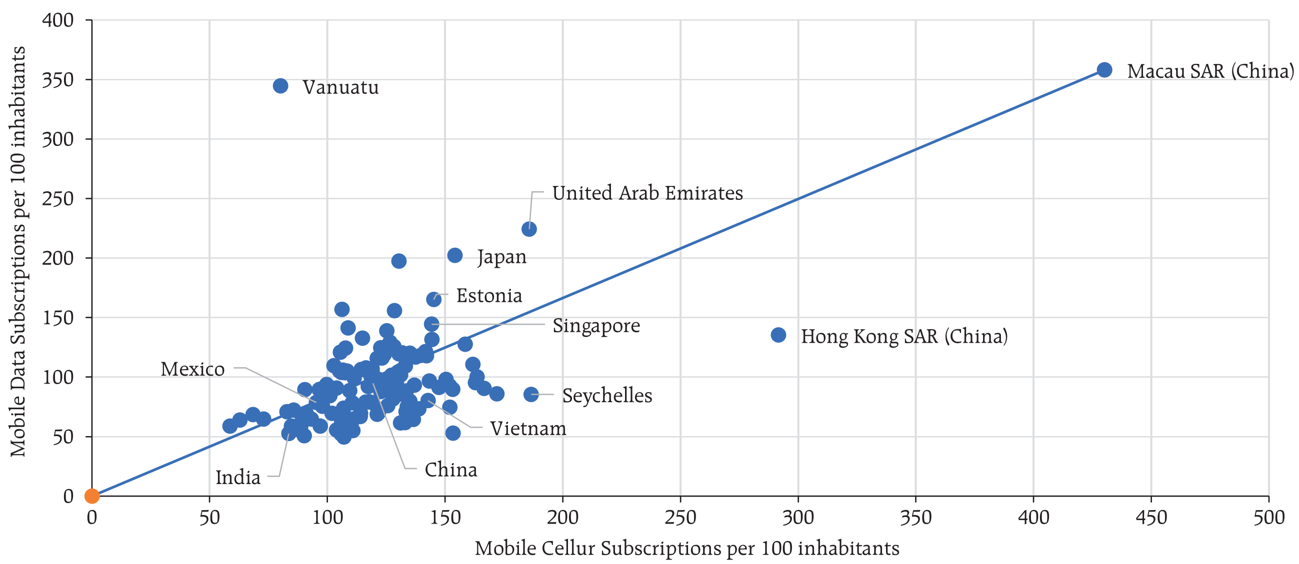
technology (Chart 15). Similarly, in terms of usage of internet, 41.0 per cent of individuals used internet, lower than the global average of 56.7 per cent [World Development Indicators (World Bank, 2019)].

V. Summary and Conclusion

The new age technologies are expected to bring about far-reaching changes in production processes in India's manufacturing sector. In terms of its participation in global value chain and technology intensity, the sector is assessed to be in a relatively better position to reap the benefits of emerging tech revolution. India's advantage in technology exports and presence of experienced professionals also provide an added advantage. However, when it comes to the quality of human capital and physical infrastructure required to make the great leap forward, India lags its competitors. Unless the vast labour force is upskilled, the benefits from IR-4 will be more than offset by large scale labour displacement.

India has made giant strides in digital space implementing unique, large-scale projects powered by public digital infrastructure, particularly in the payment infrastructure. Efforts are being made in harnessing digital technologies for providing large scale public solutions through the Unified Payments

Chart 15:Access to Digital Technology



Source: International Telecommunication Union.

Interface, Aadhar, Cowin, Jan-Dhan Yojna, E-shram portal, eNational Agricultural Market (eNAM), and Direct Benefit Transfer. These open digital platforms being affordable and interoperable are catalysts for innovation and adoption, aiding India's entrepreneurs to build technologies and provide solutions at scale. India's start-up landscape has grown exponentially in recent years driven by the underlying infrastructure of increased internet usage and accessibility, providing digital based solutions across sectors. Indian services sector has gained renewed vigour, but large-scale adoption of IR-4 in the manufacturing sector is yet to happen.

The importance of adopting new technologies is not lost to the Government. Some initiatives undertaken include, setting up of the Centre for the Fourth Industrial Revolution in India in 2018, for elaborating new policy frameworks for emerging technologies. Samarth Udyog Bharat 4.0 (Smart Advanced Manufacturing and Rapid Transformation Hubs) under the Department of Heavy Industries (Ministry of Heavy Industries & Public Enterprises) is another initiative to push for Industry 4.0 implementation with an aim to propagate technological solutions to Indian manufacturing units by 2025 through steps like awareness programme, training, demo centres etc. The new technologies also got a push under the Performance Linked Incentive Scheme (PLI).

As new business models challenge incumbents in novel ways and rapidly render skills obsolete, proactive measures are required for faster adaptation of work-force to the new world. This calls for broad and flexible government policies that stay ahead of the curve facilitating smooth transition focusing on developing skill set to the large section of population. While government policies to support digitalisation and improve governance have benefitted the economy, large scale adoption of technology will require extensive knowledge diffusion, higher industry -research collaborations, robust industry infrastructure and inclusive policies for MSMEs. Further, manual, low skill labour displacement will have to be countered by up-skilling labour to reap the advantage of new skilled jobs created. Simultaneously, new avenues of products, services and solutions necessitates prerequisites of local capability and capacity for providing cyber security solutions to protect IR 4.0 applications. Increased funding and incentives to support innovation in manufacturing remain fundamental policy imperatives.

An underlying requirement for successful adaptation of fourth IR is an accomplished third IR. Unless the shift to automation and digitization is adequate, the benefits may be partial. While new fields of telemedicine, tele lawyering and edu-tech can ease access to services and create jobs, the job content will become more skill-intensive. These new sectors will not only need resources to develop but also global standard data protection frameworks to thrive. At the state level, innovation hubs need to be developed that are interactive and integrated at the national level. Education system needs to be revamped, to not only include digital education but also improve on the existing quality of education. Future of manufacturing and future of economy depends a lot on how quickly India can improve its human capital and work towards developing a skilled workforce.

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Annex 1: Country Codes and Names

Country Code	Country Name	Country Code	Country Name
CHN	China (People's Republic of)	HUN	Hungary
GER	Germany	SWE	Sweden
KOR	Korea	DNK	Denmark
USA	United States	HKG	Hong Kong, China
SGP	Singapore	TUR	Turkey
FRA	France	RUS	Russian Federation
MEX	Mexico	SVK	Slovak Republic
NLD	Netherlands	BRA	Brazil
IRL	Ireland	AUS	Australia
ROW	Rest of the World	IDN	Indonesia
TWN	Chinese Taipei	PRT	Portugal
ITA	Italy	FIN	Finland
JPN	Japan	NOR	Norway
CAN	Canada	ZAF	South Africa
GBR	United Kingdom	PHL	Philippines
VNM	Viet Nam	ISR	Israel
BEL	Belgium	ROU	Romania
THA	Thailand	GRC	Greece
ESP	Spain	BGR	Bulgaria
IND	India	MAR	Morocco
CHE	Switzerland	SVN	Slovenia
LUX	Luxembourg	CHL	Chile
POL	Poland	SAU	Saudi Arabia
MYS	Malaysia	MLT	Malta
CZE	Czech Republic	LTU	Lithuania
AUT	Austria	NZL	New Zealand

Source: OECD TiVA database.

Annex 2: Classification of Manufacturing Activity based on R&D Intensity

	NIC 2008	Manufacturing
High R&D intensity industries	303	Air and spacecraft and related machinery
	21	Pharmaceuticals
	26	Computer, electronic and optical products
Medium-high R&D intensity industries	252	Weapons and ammunition
	29	Motor vehicles, trailers and semi-trailers
	325	Medical and dental instruments
	28	Machinery and equipment n.e.c.
	20	Chemicals and chemical products
	27	Electrical equipment
	30	Railroad, military vehicles and transport n.e.c. (NIC 302, 304 and 309)
Medium R&D intensity industries	22	Rubber and plastic products
	301	Building of ships and boats
	32	Other manufacturing except medical and dental instruments (ISIC 32 less 325)
	23	Other non-metallic mineral products
	24	Basic metals
	33	Repair and installation of machinery and equipment
Medium-low R&D Intensity Industries	13	Textiles
	15	Leather and related products
	17	Paper and paper products
	10-12	Food products, beverages and tobacco
	14	Wearing apparel
	25	Fabricated metal products except weapons and ammunition (ISIC 25 less 252)
	19	Coke and refined petroleum products
	31	Furniture
	16	Wood and products of wood and cork
	18	Printing and reproduction of recorded media

Source: OECD 2016, "Taxonomy of Economic Activities Based on R&D Intensity.