India and Industry 4.0

T.P. Bhat

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ISID
Institute for Studies in Industrial Development
4, Institutional Area, Vasant Kunj Phase II, New Delhi - 110 070
Phone: +91 11 2676 4600 / 2689 1111; *Fax:* +91 11 2612 2448
E-mail: info@isid.org.in; *Website:* http://isid.org.in

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T.P. Bhat*

*[**Abstract**: The term "industry 4.0" refers to the Fourth Industrial Revolution. It is the age where "smart devices" will assume major control over manufacturing and distribution machinery. India did not perform well during the first two industrial revolutions. However, the country befitted to some extent during the Third Industrial Revolution due to access to technology, rise in connectivity, and spread of computer power. Therefore, it is essential that India equips itself to avail the benefits of the ongoing Fourth Industrial Revolution. India has made some progress towards inducting new technologies in various sectors, and digitalisation is taking place in a number of industries; however, the penetration level varies according to sector requirements. The mega trends of technology together with globalisation, adoption of exponential technologies, and demographic changes will transform the Indian job market landscape. However, some experts are of the view that the use of industry 4.0 technologies, particularly automation, will result in job loss. Others observe that it will not result in job loss but may also not increase employment. Hence, in order to make progress under Industry 4.0, collaboration between stakeholders—specifically industry, government, and academic institutions—is crucial. Massive effort is needed to educate and train workers.]*

***Keywords**: Industrial revolution, demography, Make in India*

1. Introduction

The extensive application of information technology to all supply chain activities will change the way of doing business (Porter and Heppelmann, 2014). These changes are breaking the existing path and heralding the start of the industrial age. Many call it the Fourth Industrial Revolution (Schwab, 2016). In 2011, the expression "Industry 4.0" was coined in Germany in relation to the digital transformation in the manufacturing industry. This expression became the buzzword around the world. This new industrial paradigm is based on individualised production, horizontal integration in collaborative networks, and integration of the supply chain (Brettel *et al*., 2014; Kagermann *et al*., 2013). Though the technological advances *per se* may not be a fundamental disruptive change, their impact on production and distribution creates new added value for the product. It brings about

* The author is a consultant at the Institute for Studies in Industrial Development. This paper is submitted as part of the ICSSR sponsored programme on 'Pathways to India's Industrialisation Addressing Select Critical Issues and Concerns' in 2019.

change in international relations, working of the organisations, and eventually the society (Drath and Horch, 2014). It may be appropriate to draw inferences from previous three industrial revolutions.

The First Industrial Revolution was triggered by water and steam power, marking the transition from human labour to mechanical manufacturing. Toynbee (1884) coined the term "Industrial Revolution" by observing changes during the period 1760 to 1840. The period marked the end of the 18th century. The Second Industrial Revolution was built on electric power to facilitate mass production based on division of labour. It happened at the start of the 20th century. The Third Industrial Revolution used electronics and information technology to automate manufacturing. It began during the early 1970's. The Fourth Industrial Revolution is the current trend of automation and data exchange in manufacturing technologies (Arthur2020). The dominant technologies of Industry 4.0 will be IT, electronics, and robotics. It will also embrace other knowledge areas such as biotech and nano-tech. It is indeed based on the cyber-physical system (CPS).

To understand Industry 4.0 as the Fourth Industrial Revolution, it may be useful to adopt a systemic approach to analyse three main elements of each revolution: technical advances, economic scenario, and demographic conditions. In technical advances, the main technologies of each revolution need to be looked into. Economic scenario refers to capital availability and market dynamics. Demography is considered as the driving force of a revolution because it influences consumer demand and labour supply market.

As mentioned before, the First Industrial Revolution (1784–1870) was characterised by the substitution of human labour with water/coal/steam power and machines. These technologies enabled increased production, leading to the creation of the factory system. It resulted in increased productivity in several sectors; first in the textile industry then in other industries. The efficacy of this technology and its applications made it a universal prime mover of industries. The economic scenario was conducive. Two hundred years of uninterrupted growth made Britain a fertile ground for industrial revolution (Jensen, 1993). While the application of mechanised tools in agriculture increased food production, energy was produced from coal. It also changed the marketing system. It was during this period that technical skills were developed. Demography played an important role in this technology revolution. In the 18th century, population grew at a fast pace (Roser, Ritchie, and Oritz-Ospina, 2017). This had a two-sided impact on the economy: one, the fast growing population created demand which increased the labour supply; and two, there was a much larger workforce, lower wages, and lesser incentives to mechanisation. Nevertheless, this encouraged a deepening of capital in industry in Britain. It yielded radical changes in economic and social life.

At the end of the 19th century (1870–1969), the Second Industrial Revolution began with new sources of energy like electricity which enabled mass production. This revolution was led by the US (Freeman and Soete, 1997). The technical advances in energy had effects on many industries: railroads, steel and chemicals. At the same time, mass production became the order of the day given the use of interchangeable parts and assembly line techniques which helped increase the output. Highly specialised and expensive machines were employed, but investments were offset by the economies of scale (Jensen, 1993). As regards economic scenario, the period witnessed many vicissitudes, namely the Great Depression (the economic crash of 1930s) and the two world wars. In general, competition increased, leading to concentration of capital, which became an essential part of the revolution. From mid-19th century onward, the diffusion of industrialisation in Europe and the US intensified and the number of factories increased. The competition to use increasingly productive technologies led to overcapacity. Further, concentration of production created large corporations, beginning with the formation of trusts in railroad, steel and oil industries, and later with verticalisation of the automobile industry (Jacobides, 2005). The size and nature of these industries made scientific knowledge and investment necessary. In addition, many companies created R&D departments. Large quantities of the same product resulted in a reduction in prices, which allowed a greater number of people to buy them. On the other side, the production process became rigid and product variations became costly and time-consuming (Goldhar and Jelineck, 1983). There were changes in demography also. Industrial mass production created a demand for unskilled labour. As a result, population grew at a fast pace, steadily increasing the demand. This revolution increased the importance of companies and some large corporations became more powerful than their governments. Income grew and demand for consumer durables went up.

The Third Industrial Revolution may be, broadly, considered as the period from 1969 to 2010. It is characterised by the use of electronics and information technology (IT) to automate manufacturing. While the US is the leader of this revolution, Asia has become an important player. In terms of technical advances, this revolution introduced the computer, chips, internet and so on, which was a result of the massive investments in R&D by governments—first for safety reasons, and then for commercial purposes (Freeman and Soete, 1997). In manufacturing, electronics and IT automated series of activities even included planning and control. The diffusion of these technologies gave birth to advanced manufacturing technologies (AMT) during in 1980's. These set of technologies were referred to as computer integrated manufacturing (CIM), computer aided design (CAD), computer aided manufacturing (CAM), and flexible manufacturing system among others. The aim was to bring greater flexibility, shorter production cycle, more customised products, faster response to changing market demands, and better control and accuracy of processes (Goldhar and Jelinek, 1983).The economic situation was challenging with oil crisis, demand fall, and rise in inflation, so companies had to become more efficient to reduce costs. Many countries and companies became heavily indebted. Driven by cost savings, many manufacturing activities were shifted to developing countries, notably Asia, in the late 20th century (Porter, 1994). The globalisation intensified the application of IT due to communication needs. As labour costs from developing countries were low, there were no incentives to automation, although technology costs were not high. Demography, too, changed a lot during this revolution. The world population almost doubled which explains the low availability of labour and low wages. This led to the introduction of market-oriented reforms in some Asian countries towards the end of the 20th century.

A new set of technologies has emerged in recent times. This is the point of the Fourth Industrial Revolution. The main technology of Industry 4.0 is CPS. It is the combination of physical and cybernetic systems (Lee *et al*., 2015), wherein the two systems act as one. It can be applied to a wide range of sectors. The CPS is derived from important technological advances in the fields of internet, embedded systems, computer science, and artificial intelligence (AI). The combination of these technologies may be disruptive. Industry 4.0 implementation requires investments both at the corporate and government levels. Despite cost reduction in IT and electronics, there is a need to invest in equipment, infrastructure, and training and education (Kagermann *et al*., 2013). The trade-off between investments and gains will depend on the economic scenario. The race to innovate has generated a dynamic market, which means that competitive advantage has become temporary. It puts pressure on the companies to adopt continually. At the same time, collaboration is becoming more and more important so as to innovate (Chesbrough, 2006). It also includes activities like operatation, design, development, and related services. Simultaneously, several organisations need to act. In this process, the value chain undergoes intense change. The "servicisation" of manufacturing, new business models and deverticalisation are emerging trends. Some authors see that the world is becoming digital and that it will alter the industry's competitive landscape. As a result, a greater number of actors interact to add value to product and services. This culminates into the vanishing of big vertical corporations of the 20th century. More sophisticated demand will challenge companies to diversify their products (McKinsey Global Institute, 2012), and serve niche consumers. This is because of the reduction in the distribution cost.

In this paradigm, demography plays a different role. At the global level, the population is growing; however, in developed countries, the working age population is on the decline. Even in China, the working age of the population peaked in 2014. This means that there is a problem of shortage of labour which leads to rising wages. In this context, initiatives relating to the total automation of production processes have intensified. Ageing is a context element that can accelerate the pace of Industry 4.0 (Kagermann *et al*., 2013). Germany, the US, and China consider Industry 4.0 as strategic for the development of their economies. Many nations in Europe and Asia are also demonstrating strong commitment to research and application of Industry 4.0 technologies. Industry 4.0 has just begun. Though some technologies are being used, still there are significant developments to be made. The institutional environment (like education and regulatory systems) also has its own challenges to deal with. It may take two or three decades to get full benefits though there may be adverse effects, too.

The technologies of the first three revolutions, i.e. steam, electricity/mass production, and electronic/IT, are general purpose technologies (GPT), which have three main characteristics: 1) pervasiveness, which means they are used in many fields; 2) improvement, which mean that their quality is gradually upgraded; and, 3) innovation spawning, because they make new invention easier. The main technology of Industry 4.0 is CPS, which can be applied in many fields as it enables a large number of innovations. For example, smart factory, smart firms, and smart cities. It has all the elements of a GPT. Some of the components of Industry 4.0 technologies were already present 20 years ago, but now with higher maturity of ICT and low-cost hardware and software, this paradigm is becoming feasible. For an invention to turn into innovation, diffusion is necessary. The main innovations of each revolution took some time to disseminate (Brynjolfsson & McAfee, 2014). However, the pace of diffusion has been increasing in recent years and technologies are evolving faster than ever, which may indicate changes in shorter periods. The innovation rhythm and globalisation create a hyper competitive business environment (D' Aveni, 1994). It means a shorter life cycle for products and services, which requires flexibility and agility. As Industry 4.0 poses a modular, self-configuring system that can be easily rearranged, it can be good response to this challenge. It will reduce the time to market. In addition, this system can produce low-cost personalised products, making it possible to obtain profit in even in small markets. The advances in technology, economic scenario, and demography were important for the first three revolutions as they made diffusion faster and wider. Although Industry 4.0 technologies are more evaluative than disruptive, their combination and the context in which they are developed promise major impacts on the economy and society—this is what characterises a revolution.

2. First Three Industrial Revolutions and India

In the past, India was involved in various economic activities which contributed to the growth of the economy. One of the earliest industries to come into existence in in India was the textile industry, which was the main contributor to the national income. Prior to industrial revolution, India had an internationally acclaimed cotton textile industry and its products were exported to various parts of the world including Europe and America. In fact, India is documented to have dominated the world's cotton textile markets in 1750. The Indian textile industry thrived due to its access to cheap labour and skill that resulted in high quality but low-priced calicoes (plain white or unbleached cotton cloth). These calicoes were popular in Britain during the late 17th century (Clingingsmith and Williamson, 2004). However, after the industrial revolution in Britain the table was turned as textile imports to Britain were prevented by stringent tariffs and other protectionist policies. Even though high tariffs frustrated the Indian textile industry, the superiority of Indian calicoes remained unrivaled and people still imported it. It was not until the discovery and use of steam power from 1815 onward that the Indian textile industry faced an export market threat. Steam power made the previous inventions of spinning mule and power loom more effective and efficient in reducing the cost of British cotton by almost 85 per cent and making it internationally competitive. By 1820, Britain was the leading exporter of textiles, significantly displacing India. In addition, India's colonial masters' imposed laws that dictated what kinds of crops were to be grown by the farmers. This led to a situation where not a single food crop was cultivated because the entire land was used for the production of raw material for the British industries. Therefore, industrial revolution turned India into a source of raw materials for British industries as well as a market for its finished products. The Indian economy shrunk because its industrialisation process was hurt (Bagchi, 1976).

The use of electric power for mass production was the key feature of the Second Industrial Revolution (1870 to 1960). During this period, jute mills were established in Bengal and textile mills in Bombay and Ahmedabad. In 1911, J.R.D. Tata set up the first steel mill in Jamshedpur. The first two world wars witnessed a slow, and even stagnating, industrial development in India. This trend was evident till India gained independence in 1947 (Chandavarkar, 1985). The successive five-year plans paved the way for industrial revolution, including the development of heavy industries, R&D institutions, higher technical education universities, and revolutions in agriculture. The industrial policy during the initial period was marked by extensive state intervention. At different times, industries such as chemicals, electric power, steel, transportation, coal, textiles, heavy machine building, and machine tools to name but a few were nationalised. Private sector production was subjected to permits and licensing. The economy was characterised as a "mixed economy." The market share of the firms were assured, which in turn established the sellers' market. There was hardly any competition due to severe restrictions on the imports of foreign products or induction of new relevant technology. Consequently, productive efficiency fell by the wayside. India failed to make a mark in the export sector. The government regulated the most basic business decisions for all firms above a certain size: borrowing for investment, capacity utilisation, pricing, and distribution. As a result, the second industrial revolution bypassed India.

The development of digital computing, personal computer, internet, renewable energy, automation, and communication laid the foundation for the Third Industrial Revolution (Schwab, 2016), which began in the 1980s. This era gave birth to new economic thinking in India. Economic liberalisation started with gradual relaxation of conditions governing technology induction in the Indian manufacturing sector. Increased degree of freedom was accorded to the private enterprises entering into technical collaboration with foreign firms. The import regime was partially liberalised so as to import machinery and tools required for production. This process did not go too far. The big bang approach to economic liberalisation came in 1991 with the removal of Licence Raj or Permit Raj. Globalisation and privatisation freed the industry from inherent limitations of protectionism and provided a global platform with a wide range of opportunities and challenges. Domestic companies undertook various initiatives like R&D, capacity expansion, improvement in productivity, and innovative management techniques for better allocation and utilisation of resources to enhance their competitiveness both in the domestic and international markets. Moreover, rising exports coupled with strong domestic conditions and relatively lower interest rates stimulated new investment and surge in FDI inflows; yielding additional impetus to the growth story (Roy, 2017).

In the mid-1990s, the Asian financial crisis of 1997 and 1998 yet again derailed the manufacturing growth. However, the period between 1998 and 2002 witnessed slight moderation in the overall industrial activity. Capacity expansion in anticipation of rising domestic demand and exports peaked in the 1990s, leading to a situation of excess capacity in many sectors. Consequently, it led to a decline in the demand for new investment. This coupled with infrastructure constraints led to considerable moderation in growth across the sectors. The period between 2003 and 2007 witnessed industrial production once again marching on a high growth path (Mukherji, 2009). The upsurge in industrial output mainly is attributed to the increase in exports, relatively lower interest rates, availability of retail finance, liberalisation of FDI policy, IT boom, rising household income, changing lifestyle, and evolution of big retail stores. Globally, the manufacturing sector is still struggling to reach its pre 2009 global financial crisis level. The growth momentum remains subdued as the global economy is still experiencing currency volatility, a sharp decline in commodity prices, slowdown in large manufacturing zones, and geopolitical instability. In such an environment, it becomes necessary for India to usher in structural reform, which can strengthen its manufacturing base to build resiliency towards both changes in demand and price variations. In addition, India's thrust towards reinvigorating its manufacturing sector now will not only help in employment creation, but also will help in generating domestic demand.

During the Third Industrial Revolution, India experienced a rise of information technology, internet, renewable energy, mobile phones and connected devices. This phase saw remarkable innovations and changed the way of life in India. This raises the question that is what Industry 4.0. It is a blend of advanced analytics, big data, robotics and automation, AI, internet of things (IoT), and process digitisation across the business value chain. Why should India adopt Industry 4.0? There are several advantages, for instance, it improves productivity growth in many sectors besides enhancing the competitive strength in the global market. Apart from these two advantages, the advanced analytics would help enhance production capacity and product quality. This production model would shift towards prediction and prevention of defects through data analytics. The adoption of robotics and automation would shorten the production cycle, reduce time-to-market, and cut down inefficient utilisation of resources. This digitisation of various business processes would lead to cost-saving and better experience for customers and employees. The loT along with connectivity of machines to people and machine to machine would tighten supply chain and reduce lead times. According to McKinsey's analysis, if Indian companies adopt Industry 4.0 across functions such as manufacturing supply chain, logistics and procurement, they can enhance their operating profits by 40 per cent at less than 10 per cent of the planned capital expenditure. However, the adoption of Industry 4.0 in India is at a nascent stage (Engineer Souls, 2019). Widespread implementation still looks to be some years away due to challenges such as the need for initial high investment outlay, lack of expertise, inadequate infrastructure and lack of cyber security norms.

3. Components of Readiness towards Industry 4.0

The holistic research by the World Economic Forum (WEF) is used to demarcate the adoption Networked readiness model by various countries. WEF investigated various countries and scored them on a seven point scale. Network readiness index is a key indicator of how countries are performing in the digital world. It depends on whether a country possesses the drivers necessary for digital technologies to meet their potential, and whether these technologies are actually having an impact on the economy and society. Digital revolution may change the nature of innovation, which is increasingly based on digital technologies and on the new business models it allows (Grant Thornton and Confederation of Indian Industry, 2017:11;). The 2016 index has highlighted a number of key issues such as

- Increasing pressure to innovate new technology,
- Competition with rapidly growing digital population by business and companies,
- Development of new types of behavior, and
- Leadership and governance mechanism, etc., to adopt digital technologies and also to capture the growing market.

As per the above-mentioned network readiness index criteria, India ranks 91 out of 139 countries.

Table 1: Network Readiness Index

Network Readiness Index	*Global Rank*	*Network Readiness Index*	*Global Rank*
Singapore	1	Republic of Korea	13
Finland	2	Germany	15
Sweden	3	China	59
Norway	4	Sri Lanka	63
USA	5	India	91
Japan	10	Pakistan	110

Source: Federation of German Industrie, The factory of the Future, 2015.

As per German Engineering Federation (VDMA) there are six-dimensional model to assess the readiness of enterprises, these includes following six dimensions:

1. Strategy and organization
2. Smart factory
3. Smart operations
4. Smart products
5. Data services
6. Employees

Two dimensions, namely, smart factory and smart products, relate to the physical world, while other two (smart operations and data driven services) represent the virtual representation of physical dimensions.[1] According to this concept, Industry 4.0 can be called as the fusion of the physical and virtual worlds. Industry 4.0 preparedness is assessed based on six components and its elements according to German Industry Federation (VDMA). It also takes into account the use of digital technologies, current openness and cultural interaction. The six dimensions indicated above include the following elements:

1. Strategy and organisation includes strategy, investment, and innovation management;
2. Smart factory includes digital modeling, infrastructure equipment, data usage, and IT systems;
3. Smart products include ICT add-on functionalities and data analytics in usage phase;
4. Smart operations include cloud usage, IT security, autonomous processes, and information sharing;
5. Data driven services includes data driven services, share of revenue and share of data used; and
6. Employees includes skill acquisition and employee skill sets.

4. Strategy and Organisation

Industry 4.0 offers an opportunity to develop new business models besides improving the current use of digital technologies. Present openness can be examined using the following criteria:

- Existing knowledge strategy implementation of Industry 4.0;
- Reviewing strategies through a system of indicators for better operations;
- Measure the enterprise investments relating to industry 4.0
- Understand the use of technology and innovation management; and
- Understand the current state of research and development.

Smart Factory

Smart factory is a production environment in which the production systems and logistic systems organise themselves without human intervention. It relies on CPS, which links the physical and virtual worlds by communicating through IT infrastructure/loT. The firm's progress in the area of smart factory can be measured using the following criteria:

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[1] Strategy and organisation, smart factory, smart products and employees represent physical dimensions, while smart operations and data driven services represent virtual world.

- Digital modeling
- Equipment and component infrastructure
- Data usage
- IT systems/infrastructure

Smart Operations

The technical requirement in production and its planning which are necessary to realise the self-controlling work piece are known as smart operations (Grant Thornton and Confederation of Indian Industry, 2015). The Industry 4.0 readiness for smart operations can be determined by:

- Information sharing
- Cloud usage
- IT security
- Autonomous processes

Smart Products

Smart products are the foundation of the “smart factory” and smart operations. It facilitates automated, flexible, and efficient production. Physical components are equipped with technical components such as sensors, RFID (radio-frequency identification), communication interface, etc., to collect data on their environment and their own status. Readiness in the area of smart products will be determined by looking at ITC add-on functionalities of products and the extent to which data from the usage phase is analysed (Federation of German Industrie, 2015).

Data Driven Services

Companies that are graduating from selling products to providing solutions substantiate data driven services, which are used to align future business models to enhance the benefits to customers. After sales service, business is based on the evaluation and analysis of collected data and reliance on enterprise-wide integration. The physical products themselves must be equipped with physical IT so they can send, receive and process information needed for the operational processes. Readiness in this area can be determined using following criteria:

- Availability of these services
- Share of revenue derived
- Share of data used

Employees

Employees help companies realise digital transformation plan. Readiness in this dimension can be determined by analysing employees’ current skills and ability to acquire new skills as employees are most affected by the changes in technology in an organisation; directly impacting their work environment. This requires them to acquire new skill to become well equipped in the digital work place (European Commission, 2017). This model will help assess the company's readiness on various parameters and analyse potential gaps which need to be addressed in order to adopt Industry 4.0 (Grant Thornton and Confederation of Indian Industry, 2015)

Industry 4.0 revolution is driven by four disruptions:

A) Amazing rise in data volumes, computational power, and connectivity,
B) Emergence of analytics and business intelligence capabilities,
C) New forms of human- machine interactions, such as touch interfaces and augmented reality (AR) systems. This resulted in creation of smart human-machine interfaces, and
D) Improvements in transferring digital instructions to the physical world such as advanced robotics and 3D printing.

These disruptions will take manufacturing to a newer level where factories would be called "smart factories." Manufacturing will be done by fusion of digital online world and industrial production. Factories would very flexible to deliver state-of-the-art products with less human intervention (Sigma Electric Manufacturing Corporation 2019).

5. Industry 4.0 in Some Leading Countries

Industry 4.0 era began in Germany with introduction of digitization in manufacturing activities. The momentum slowly picked up in the US, Japan, China, and Nordic countries. Business entities the world over are expecting dramatic increase in digitization at the earliest. By 2020, the US aims to achieve 74 per cent digitization from the 2016 level of 32 per cent. During the same period, Asia-pacific aims to achieve 67 per cent digitization and Europe 71 per cent. Automotive industry is the first to implement Industry 4.0 with Germany in the lead role. Its digitization level goes beyond Industry 4.0. The focus is on modernization of manufacturing through research and innovation. The German government provides support to its automotive industry to make use of Industry 4.0 technologies. The focus will be on finding new options for implementing Industry 4.0 rather than creating new business models. In order to promote new trends, it established partnership with countries such Japan, China, and Sweden. Many countries across the world are attracted to the concept of Industry 4.0 and want to adopt it to modernize their manufacturing sector (Schwab, 2016).

The US government has set up the National Network for Manufacturing Innovation (NNMI). This consists of various regional hubs that may tend to accelerate the development and adoption of cutting-edge manufacturing technologies for making new, and globally competitive products. To enhance manufacturing competitiveness, National Additive Manufacturing and 3D printing technologies are being used in various sectors. It has set up organizations such as the Digital Manufacturing and Design Innovation Institute (DMDII), American Lightweight Materials Manufacturing Innovation Institute (ALMMII), and Clean Energy Manufacturing Innovation Institute for Composite Materials and Structures. Besides, it has initiated programmes such as the National Export Initiative (NEI) and Startup America. These programmes are going beyond Industry 4.0 (Grant Thornton and Confederation of Indian Industry, 2015).

The US has made impressive progress in some Industry 4.0 technology areas. Among them automation with AI is one such area. Many organizations have adopted robotics to automate repetitive production processes. They are now seeking to scale these solutions with AI. Firms believe they can transform their business processes, achieving higher speed and accuracy by automating decisions on business structured and unstructured inputs. Artificial intelligence technologies have made game-changing impact on factory production processes and assembly lines (UNIDO, 2018). This has improved efficiency and enabled new products, services, and business models that were not possible before. Most manufacturers in the US recognise the potential of Industry 4.0 in creating value but do not necessarily see an opportunity and hence are in no rush to adopt it.

The US manufacturers have been ardent adopters of Industry 4.0. The global loT was worth $10.45 billion in 2016 and expected to reach $45.3 billion in 2022. Many US companies have integrated loT and big data in their manufacturing. The SMEs are quickly adopting digitization. Industrial corporations such as Boeing and their supply chains are using AI in marketing. American investment in AI appears strong. In 2015, the combined spending of large companies such as Google, Apple, Facebook, IBM, Microsoft, and Amazon was $54 billion, of which a major share went into AI research. Other factors determine a countries long-term competitiveness in terms of AI. Talent is one such important component. The US holds the largest share of 3D printing market. It has been driven by strong demand from aerospace, defense, healthcare, education, and consumer product industries. Fifty-five per cent of the US companies have adopted big data analytics to improve their operational efficiency.

The UK manufacturers' approach to Industry 4.0 is of gradual evolution rather than a revolution. This is because the UK manufacturers focus on niche products that are value-added and higher priced. There is little need to increase efficiency.

The 13th Five Year Plan (2016–2020), adopted in March 2016 by the Chinese Government, which aims to implement 'Made in China 2025' and 'Industry 4.0' initiatives simultaneously. Made in China 2025 aims for much higher levels of locally made contents in their core components and materials, increasing the levels to 40 per cent by 2020 and 70 per cent by 2025. Also, Industry 4.0 is expected to increase China's productivity by 25 to 30 per cent and lower unforeseen production losses by 60 per cent (Zhang *et al*., 2016). China's goal is to turn the country into a "manufacturing superpower." The program highlights the priority sectors which include new generation of information technology, advanced numerical control machine tools, robotics, aerospace technology including aircraft engines and airborne equipment, biopharmaceuticals, and high performance equipment. These are not new objectives but some are already present. Made in China 2025 was inspired by Germany's Industry 4.0 initiatives (Wubbeke and Conrad, 2015). Industry 4.0 of China will develop technologies such as manufacturing-3D printing, advanced human-machine interface, AI, industrial robots, big data and analytics, cyber security and cloud computing, horizontal and vertical integration, industrial loT, sensors, simulation, virtual reality and augmented reality, and predictive maintenance (Wubbeke and Conrad, 2015).

The guiding principles of China's Industry 4.0 are to enhance industrial capability through innovation-driven manufacturing, optimize the structure of the industry, emphasize on quality over quantity, train skilled work force, attract talent, and achieve green manufacturing. At the current stage, China is not the strongest player when compared to industrialized nations such as the US, Germany, and Japan. These countries have effectively deployed digital technology to create new industrial environment, produce new products and enhance their value. China has made huge investments in developing manufacturing capability, R&D, and human capital (Li, 2017). China's 2030 plan envisions building a $1 trillion AI industry. Chinese investors poured $45 billion into more than 200 AI companies between 2012 and 2017 (Davenport, 2018).The AI Advantage: How to put AI Revolution to work). China is determined to steal AI crown from the US. China has been ranked 14 among the 20 leading economies on IoT. Only 10 per cent of the manufacturers have begun transition to loT. Six per cent of the Chinese manufacturers have a clear road map for Industry 4.0. According to McKinsey and company, Chinese auto manufacturers lack the digital grounding to analyze, manage, and use data collected from production lines.

The Japanese government is adopting an initiative called "Society 5.0," under which it will adopt a new economic model and a broader societal vision by incorporating the technological innovations of Industry 4.0, which include infrastructure, fintech, healthcare, logistics, and AI. Artificial intelligence is particularly being deployed in the automobile industry. As Industry 4.0 is about the digital transformation of manufacturing, society 5.0 aims to tackle several challenges by going beyond "just digitalization" of the economy to create a Super Smart Society. Japan is trying to set a framework for facilitating the use of AI, and the exchange of data to support local companies including SME's (Granrath, 2019).

Readiness for Industry 4.0 is considerably greater in western and northern Europe. The front-runners are those countries that have a large manufacturing industry as well as modern and forward-looking business conditions. These are Germany, Ireland, Sweden, and Austria. Potential countries are those that are experiencing a decline in manufacturing but possess a modern and innovative outlook on implementing Industry 4.0 technologies. These countries are Belgium, Finland, the Netherlands, Denmark, the UK, and France. Many Eastern European countries have thriving manufacturing industries, which could make them promising Industry 4.0 markets. So far, they focus on traditional manufacturing and are not ready for digitization. The rest of the countries such as Italy, Spain, Portugal, and Poland have not yet woken up to the realities of Industry 4.0 (Kumar and Singh, 2018).

Vietnam is embracing Industry 4.0 in an attempt to turn itself into a technology hub within South-East Asia and move away from being a low-cost export-oriented manufacturing destination. It has established a National Innovation Centre (NIC), which will become operational in 2020. Increased focus is accorded to AI and big data analytics. Malaysia, the Philippines, and Thailand are at initial stage of adopting Industry 4.0.

6. Status of Industry 4.0 in India

At the global level, the Industry 4.0 market is expected to be $214 billion[2] by 2023. Countries such as the US, China, Japan, UK and many EU have adopted Industry 4.0. Germany adopted Industry 4.0 in 2010 as a strategic initiative to establish itself as a leading provider of advanced manufacturing solutions. It also identified three-dimensional approach to progress in an organized manner. As a part of this, the government provided education and resources to small and medium enterprises and signed collaborative agreement with countries such as China and Japan (Bajpai and Biberman, 2019).

India is the sixth largest manufacturing country, given its strong focus on Industry 4.0 through the "Make in India" plan for future development. The government aims to augment the share of manufacturing in GDP to 25 per cent by 2022 from the present 16–17 per cent. The government has undertaken many policy reforms such as implementation of GST and liberalizing FDI policy. Given the task, Industry 4.0 offers a great opportunity to the Indian manufacturing industry as a whole. At present, India lags behind its global peers in terms of the adopting Industry 4.0. A large part of the manufacturing sector is still in the phase of post-electrification, with the use of technology limited to the systems that function independently of each other. With the integration of the physical systems on cyber platform, the basic premise of Industry 4.0 is still in its infancy (Aulbur and Singh, 2014). More importantly, the micro, small and medium enterprises (MSME) segment has very little access to modern technology due to its high cost. The progress that India is witnessing in two critical enabling Industry 4.0 technologies, i.e. IoT and Big Data, appears to be developing the right platform to base its "small factories." India is expected to command 20 per cent of the global loT market, which is estimated to reach $3 billion by 2020 (Government of India, 2018). Furthermore, industrial loT, or the segment of the loT market that particularly caters to the manufacturing sector, currently accounts for 60 per cent of the Indian loT market. The big data analytic market in India is estimated to be about $2 billion and is expected to grow at a CAGR 26 percent, reaching about $1.6 billion by 2025, Make in India accounts for 32 per cent of the overall global market share (Nishimura, T, 2018).

[2] In rupee terms it is estimated to be Rs 13,90, 647 crore (converted to US $1= Rs. 64.9835).

Digitalisation of various industries is taking place in India. However, the penetration level varies according to the sector requirements. Some sectors have started experimenting with idea of a connected factory at shop floors and assembly lines. To leverage technologies, some of these enterprises are testing or creating small-scale solutions for Industry 4.0. Nonetheless, capital-intensive industries such as the automotive industry that require high-skilled labourers are the ones that are pioneering the adoption. The Indian automotive industry is at the forefront of adoption of key elements of Industry 4.0. Evolving technology, an increasing number of parts, growing competition and rising labour costs have forced the automotive firms to adopt the key components of Industry 4.0 such as robotics. The robot density of Indian automotive industry is 58 robots per 10,000 employees. Much higher than the average Indian manufacturing sector which is 3 robots per 10,000 employees (Roehricth, K. 2016) Additionally, some of the automotive OEM (Original Equipment Manufacturer) and auto component manufacturers are using additive manufacturing/3D printing in their R&D centres to develop prototypes.

Table 2: Robot Density in Manufacturing Industries 2016 (Number of Installed Industrial Robots per 10,000 employees

Countries	*Number*	*Countries*	*Number*
R. Korea	631	Singapore	488
Germany	309	Japan	303
US	189	UK	71
China	68	Brazil	10
Russia	3	India	3
Global average	74		

Source: Robot Density Rises Globally, International Federation of Robotics, 7, Feb 2018, Executive Summary World Robotics, 2017, Industrial Robots.

Table 3: Annual Shipment of Industrial Robots into India (Number of units)

Year	*Number of units*	*Year*	*Number of units*
2015	2065	2016	2627
2017 (E)	3000	2018 (F)	3500
2019 (F)	5000	2020 (F)	6000

E- Estimate and F- forecast.

Source: Robot Density Rises Globally, International Federation of Robotics, 7, Feb 2018, Executive Summary World Robotics, 2017, Industrial Robots.

The Indian automotive industry has taken some steps towards Industry 4.0. For example, Bajaj Auto taken steps to initiate automation in 2010. Today, it uses 100–120 “Co-bots” (collaborative robots) in its production processes. Maruti Suzuki manages 7 process shops and 5 assembly lines through nearly 1700 robots. Ford manages to operate the assembly lines and body shop at its Sanand plant with the help of 437 robots. Hyundai has taken steps to minimise its labour cost by using 400 robots. The production lines of Tata Nano consist over 100 robots at Tata Motors. Renault is working in the field of automation to prevent accidents. The large two-wheeler manufacturers are using additive manufacturing for product designing of all two-wheeler parts for fitment and functional testing. This has enabled companies to reduce their time to market. Sectors such as textiles and packaging are adopting Industry 4.0 technologies (Chiplunkar, P. 2017). A Mumbai based multinational company uses intelligent framework to connect all machines and examine the rate of work and efficiency. The framework allows reducing wastage and organizing production flows. Yet another Bengaluru-based packaging company has connected machines through a network that provides a monthly dashboard about machine conditions. It helps the company to keep predictive maintenance program in place.

Matrix Tools and Solutions (Matrix), a company based in Pune, provides product designs and helps in adopting new technologies for transforming production processes. Kirloskar Brothers (KBL) is using 3D printing and loT in the production operations, particularly casing in foundries. They also make use of loT in water management at factories. The plants are run through remote management system. Raymonds is increasingly using new technologies in its factories. The company has adopted robotics, big data, and material science technologies in manufacturing textiles (TNN and Agencies, 2016). Marico Industries has been piloting sensor-based systems to capture manufacturing information on a real-time basis, which leads to real-time production diagnostics. The data collected on this basis is used for improving the performance of the plant. In one way, Marico is implementing the cyber physical system (Monte, 2015). GE India, a multi-sector company has presence in transportation, medical systems and energy and aviation. In several of its activities adopted AI, big data, and additive manufacturing (3D printing). In India, Honeywell offers automation, big data and material technology. Logistics and services companies such as GreyOrange, DHEL and Airtel have adopted AI, big data, and robotics in their business.

Writers Corporation, a global company known for its moving, reallocation and cash management services, makes use of AI and robotics. An automotive group, Mahindra and Mahindra is focusing on digital technologies such as blockchain, big data analytics, IoT, even augmented reality (AR), and virtual reality (VR) to enhance efficiency and boost growth. There are several areas where digital technology has contributed to healthcare. The increased adoption of telemedicine, health information system, electronic health records, mobile health and web-based services have amplified the use of hospital data and enabled mapping of digitization trends in health information and electronic health records. Robot-assisted surgery is done at Fortis and Max hospitals. Artificial intelligence has also been used in diagnostics. Hospitality and travel companies such as OYO, MakeMyTrip, and Lalit and Taj hotels and provide services to their customers through AI and big data analytics. Many banks, finance services companies, food processing and energy generation and distributing companies are deploying Industry 4.0 technologies, however, the number is still small and the services provided are limited (Sharma, P. 2017).

Many Indian companies are thinking about the idea of connected machines. While Industry 3.0 simply was about the automation of isolated machines, whereas Industry 4.0 concentrates on the end-to-end digitization of all physical assets and their integration into digital ecosystems with value chain partners. In essence, the new paradigm is about integration. Currently, foreign firms are adopting Industry 4.0 technologies.

7. India's Competitive Landscape

The Manufacturing landscape is changing. Countries are constantly challenged on technical capabilities and manufacturing value-addition. Specifically, India faces competition from China and Europe and there is a risk of her being crowded out by the increasing technical capabilities of these regions as they are focusing on medium-value segment where India has always been operating. Historically, China has focused on low-value technology, low manufacturing value-add space while Europe has focused on high technology, high value segment. India's manufacturing zone of comfort has been in the middle, both on technology and value-added axis. Now, a significant push from China to move up from the low Technology-low value-added zone and expand into medium technology zone has been observed, thereby expanding the market for Chinese companies (AIMA and KPMG, 2018). Concurrently, there is a push from Europe to move down from high-technology high value-add zone and expand into medium technology zone, thereby expanding the market for European companies. This has led to a crowding out effect, affecting India's manufacturing base in addition to increasing competition from emerging manufacturing bases like Vietnam and Turkey. At the same time, it might give India an opportunity to become the destination for other countries. India may look at Industry 4.0 as an additive advantage for manufacturing and lucrative investment destination by other countries (Grant Thornton and Confederation of Indian Industry, 2015).

8. Perspective on Jobs

There are many causes of disruption and their impact will be felt on a range of mega trends that will transform the Indian job market landscape. There are three causes which determine job trends. Primary forces behind the current disruption are globalisation, adoption of exponential technologies by Indian industry, and demographic changes. The interplay of these three primary forces has given rise to a range of trends which are shaping the future of jobs in India. A growing middle class, creation of the highly optimised supply chains, and bunch of smartly connected products and services are significantly changing the job landscape in India.

Globalisation: Over the years, globalisation has resulted in trade liberalisation and emerging market growth. However, this phenomenon received a setback due to rise of nationalist sentiments in the West, with the scraping of the Trans-pacific Partnership (TPP) trade deal, Brexit, and so on leading to an emergence of a multi-polar world. These trends disrupt existing business models by creating new competitors, reordering supply chains and creating lower price points. The next waves-including emergence of BRICS as a major economic block and a multi-polar world – will augment complexity and require flexible business models to respond to global shifts.

Adoption of Exponential Technologies: This has been a disrupting competitive strategy and business model for many years. For instance, industrial revolution eliminated guilds and caused massive labour displacement. The successive waves of IT revolution (personal computer, online, mobile, and social media) have democratised the data, empowered consumers and spawned scores of new industries. The next wave of technological disruption—the loT, VR, AI, machine learning (ML), big data, Robotic Process Automation (RPA)—are proving to be even more revolutionary.

Demographic Changes: Demographic changes have determined evolutionary restructuring in the past. In the coming decades, relatively higher birth rates will make Asia and Africa engines of economic opportunities. Aging population will transform and mature everything from healthcare to real estate in majority of the advanced countries. The new workforce from developing countries is reinventing the workplace. Similarly, urbanization is increasing cities' economic and policy influence, even as it strains their ability to grow in a sustainable manner. Migration and immigration will also have a profound impact on the workforce and on economic development. These demographic shifts will require new strategies and business models.

Adoption of Industry 4.0 will lead to increase in automation of the shop floor. The robots will be capable of performing multiple tasks with high levels of accuracy and with shorter duration than humans. Besides, robots will be an effective replacement for labour. For example, an employee whose job is to fix specific parts while assembling an engine will be replaced by robot that will carry out the same job accurately and in less time. The quantum of job loss, however, is expected to vary with country, industry, and employed levels of automation.

Some experts on the other side are of the view that the use of Industry 4.0 technologies will not result in job loss, if not an increase in employment. The logic behind this statement is that Industry 4.0 will result in an increase in labour productivity and improve the quality of the manufactured products. As a result, the demand for quality products will increase, rendering firms with no option but to increase the capacity to meet the overall demand. There is no doubt that certain low-skilled jobs will be eliminated. However, an increase in capacity will have a positive effect on the creation of jobs, requiring higher-level skills. Employees who were rendered jobless due to elimination of low-skilled jobs need to be reskilled or upskilled to prepare them for new requirements. Overall, the creation of new high-skilled jobs will compensate, largely, for the elimination of low-skilled jobs.

With changes in technology and process of production, the job profile in the Indian economy will also change drastically. There will be creation of new skilled jobs, which will require altogether different types of training and knowledge. By 2022, the expected job profiles likely to be: 1) 9 per cent of the workforce would be deployed in new jobs that do not exist today**;** 2) 37 per cent of the workforce may be deployed in jobs that will have radically changed skill sets**;** and 3) 54 per cent will fall under the unchanged job category (NASSCOM, FICCI and ERNST & YOUNG, 2018). According to this classification, by 2022 future jobs in the organized sector would be:

Table: 4 Displacement of Jobs

Sector	***Workforce that***		
	Deployed in new jobs that do not exist today (projected for 2022)	*Deployed in jobs that have radically changed skill set (projected for 2022)*	*Will face an existential threat to their jobs (for 2017)*
IT/BPM	10 to 20%	60 to 65 %	20 to 35%
Automation	5 to 10 %	50 to 55%	10 to 15 %
Textiles &Apparels	5 to 10%	35 to 40%	15 to 20%
BFSI	15 to 20 %	55 to 60%	15 to 20%
Retail	5 to 10%	20 to 25%	15 to 20%

Source: EY Future jobs - respondent analysis, 2018.

New job roles in IT/BPM (Business Process Management) sector will be;

- Visual effect (VFX) artist
- Computer vision engineer
- Wireless network specialist
- Embedded system programmer
- Data scientist
- Data architect
- Data analylist
- AI research scientist
- RPA developer
- Language processing specialist
- Deployment engineer
- 3D modelling engineer
- Cloud architect
- Migration engineer
- Android/IOS app developer
- Digital marketing.

New jobs in Automation:

- Automobile analytics engineer
- 3D printing technician
- Machine learning based vehicle cyber security expert
- Sustainability integration expert

New jobs in Textile and Apparel sector:

- Apparel data analyst/scientist
- IT process engineer
- E-textile specialist
- Environment specialist
- PCL maintenance specialist

New jobs in BFSI sector:

- Cyber security specialist
- Robot programmer
- Blockchain architect
- Process modeler expert

New jobs in Retail sector:

- Customer experience leader
- Digital imaging leader
- IT process modeler
- Digital marketing specialist
- Retail data analyst

Industry 4.0 technologies will adversely affect the jobs and skills in the traditional sectors in the short run, owing to the creation of new engines of employment creation. The conventional definition of "job" will change. One of the main jobs in the market will be that of "entrepreneurial employee (NASSCOM, FICCI and ERNST & YOUNG, 2018). Therefore, the landscape of 2022 is expected to have multiple categories of workers and they consist of:

- Employees in exponential technologies – impacted by traditional sectors,
- Contract employees in the infrastructure sector,
- Micro-entrepreneurs supported by MUDRA schemes, and
- Employer-entrepreneurs in technology enabled employment models, namely freelance workers (online platform models); Uber workers; SME and artisan entrepreneurs on e-commerce platforms; delivery workers and service providers in the e-commerce ecosystems; and, employees and contract workers in tech-startups.

Adoption of exponential technologies by Indian firms is a critical element. The rate of diffusion of these technologies from advanced countries to India is important (FICCI, 2017). It would depend on:

- The rate of falling cost curves of these technologies to levels that would render them economically viable in the Indian market,
- The level of globalization of the Indian industry – share of exports in total industry output and presence of offshoring opportunities and share of FDI and,
- The level of globalization of consumer taste trends in a sector.

In the context of the above, in the 2022 timeframe there is a need to explore five trends with respect to the adoption of exponential technologies by Indian industries:

- Creation of optimized supply chains;
- Launch of smart connected products/services;
- Business innovation;
- Demand for resourceful planet and sustainability, and
- Network arrangements

The future jobs in India will be determined by the quantum and sophistication of demand from the domestic market. The first, i.e. quantum of demand, would be driven by the growing size of the middle class. Secondly, sophistication of demand would be driven by the size of the affluent class and young population as well as by the growing urbanization (Grant Thornton and CII, 2015).

There are four possibilities in job landscape for each sector in year 2022:

- New jobs being created;
- Existing jobs being threatened;
- Changing jobs with respect to skill sets; and
- Unchanged jobs

Over the years, the employment elasticity to output has been declining in many sectors. The firms are squeezing out inefficiencies in their supply chains by redesigning their business processes by optimizing technologies (NASSCOM, FICCI, and Ernst & Young, 2018). The employment elasticity for the key sectors is given in table 5

The employment elasticity to output is further expected to decline with the gradual adoption of exponential technologies by Indian firms. The pace of structural shift of labour from traditional sectors (such as farming and petty trade) to modern organized sectors (manufacturing and skilled service jobs) is slowing down. Agriculture in 2012 had a negative elasticity of 0.4 per cent.[3] This surplus labour deployed in organized sector also

[3] This means that for every 10 per cent in agriculture GDP, employment declined by 0.4 per cent. For details see Misra and Suresh (2014).

found employment in other sectors on either contract basis or self-employment/entrepreneurship.

Table 5: Employment Elasticity of Key Sectors 2012

SNo.	*Sectors and sub-sectors*	*Employment elasticity (%)*
1	Overall manufacturing	0.29 to 0.33
A	Apparel	0.79
B	Leather and leather products	0.64
C	Motor vehicles and trailers	0.58
2	Mining and quarrying	0.52
3	Construction	1.3
4	Utilities	0.04
5	Trade and transport	0.19
6	Finance and real estate	0.66
7	Other services	0.08

Source: Misra and Suresh (2014).

The internet and exponential technologies are creating space in which potentially gainful employment opportunities are emerging. While the same technologies are responsible for a job slowdown in the organized sector, if supported, they have the potential to transform the job landscape in the economy. The impact of these technologies is felt on both white collar and blue-collar jobs. The first area of employment opportunities will be the emergence of new white collar jobs. Economists Otto Kassi and Villi Lehdonvirta (2016) measure the utilization of online labour across countries and occupations by tracking the number of projects and tasks posted on platforms in near-real time (Kuek 2015). India is leading destination for online labour, accounting for 24 per cent of the total online labour market share. For relative comparison, see table below:

Table 6: Some Top Countries with Online Workers (in percentage)

Country	*Percentage*
India	24
Bangladesh	17
US	12
Pakistan	10
Philippines	7

Note: Online workers include software development and technology, creative and multimedia, clerical and data entry, sales and market support, writing & translation, and professional services.

Source: Kuek, S.C. et al, The Global Opportunity in Online Outsourcing, Report No. ACS14228, World Bank Group.

The gig economy[4] is providing employment opportunities to Indian software developers, creative and multimedia professionals, online sales and marketing professionals, writers, translators and data entry operators. This employment pattern is expected to expand significantly in the coming years. The second area that is generating employment opportunities is the technology aggregator model. It enables organization of highly inefficient markets. The Uber model of technology aggregation of cab service providers on the one side and retail customers on the other, is being applied much beyond cab-hailing services; it is being used for building repair and maintenance, healthcare, and other home services. The Indian informal sector provides close to 50 per cent of output and 92 per cent of jobs and encompasses over 80 per cent of the firms. The technology aggregation models that address informal sector issues would be able to organize the market and provide increased employment and income generation opportunities to many new job seekers. The third area where potential employment opportunities are being created is E-commerce. India is witnessing significant growth in e-commerce retail segment. E-commerce companies have been able to provide market linkage platforms to SME entrepreneurs and artisan enterprises. Companies like Amazon, Flipkart and Paytm work with merchants and artisans on the supply side providing market linkages for their products. On the delivery side, these E-commerce firms have created a number of jobs in the logistic sector – drivers, delivery boys, warehouse assistants and managers. In addition to this, there are number of service providers who find employment opportunities on their platforms, providing services on the supply side. These include content developers, web- designers, digital photographer's sales and marketing professionals and so on (AIMA and KPMG, 2018).

There are a large number of tech startups. They focus on the application of exponential technologies for creating new business models (KPMG and FICCI, 2018). Some of the features of the startup ecosystem are as follows:

- India has the third largest startup ecosystem with 4750 plus tech startups as of December 2016. Of these 1400 + new tech start-ups were set up in 2016. The year-over-year (YoY) growth was 10–12 per cent. Accounting for 36 to 40 per cent of the market share, the business-to-business or B2B startups have gained importance (NASSCOM, 2016).
- The start-up sector has been able to attract around US$ 4 billion. Investors are looking at e-commerce, fintech, healthtec, edutech, and agritech models. Technologies such as cloud computing and big data/analytics were key focus for the new start-ups.
- More than hundred and forty incubators and accelerators have been set-up by the end of 2016. A number of incubators and accelerators have also witnessed 40 per cent YoY growth in 2016, with 35 new additions under the Startup India initiative.

[4] In a gig economy, the labour market is characterised by the prevalence of short-term contracts or freelance work as opposed to permanent jobs.

Tier ll/lll cities are gaining traction with 66 per cent of total new incubators set up by the end of 2016.

Some of these employment models are not being captured as "jobs," specifically the "entrepreneurial - employee" work arrangement does not fit the conventional definition of a "job." Therefore, while technology may affect jobs and skills in the traditional sectors in the short run, it will also create new engines of employment creation. Thus, the job landscape of 2022 is expected to have multiple categories of workers:

- Employees in exponential technologies – impacted traditional sectors;
- Contract employees in infrastructure sector;
- Micro-entrepreneurs supported by MUDRA schemes;
- Entrepreneurial employees in technology enabled employment models:
    - Freelance workers – online platform models;
    - Uber workers;
    - SME and entrepreneurs on e-commerce platforms;
    - Delivery workers and service providers in the e-commerce ecosystem; and
    - Employees in tech – startups.

Globalization is one of the drivers behind the functioning of the job market. In the last two decades, globalization has done positive impact on the Indian domestic market. It has created new jobs and opportunities and helped many to come out of poverty. Four prime trends are identified that would affect the future of jobs in India (CII, 2014). They are:

- The level of exports of companies that have based their manufacturing operations in India would significantly impact jobs in India;
- Rapid adoption of exponential technologies in advanced markets would affect offshoring of manufacturing and services to India. Technology, particularly automation, is expected to reduce the number of offshore jobs in manufacturing industries where Indian companies are locked in vertically integrated global supply chains. Similarly, Indian IT/BPM industry is being impacted by the adoption of these exponential technologies in their advanced markets;
- Increasing/shrinking overseas job market for Indian workforce would impact the future jobs in domestic market, impacting the wage- levels; and,
- Level of FDI flows appears to be favorable in recent times. India became one of the top FDI destination in 2016. These FDI flows are expected to drive investments. However, the nature of FDI investments (Greenfield or M&A) would determine whether there would be significant job creation, both direct and indirect.

Adoption of exponential technologies by Indian industry would be a factor of the rate of diffusion of technologies from advanced markets to India. This would depend on:

- The rate of falling cost of these technologies to the levels that would make them economically viable in the Indian market;
- The level of globalization of Indian industry – the share of exports in total industry output, presence of offshoring opportunities and FDI;
- The level of globalization of consumer spending trends in a sector; and,
- The presence of start- up or disruptor firms in the sector.

It may be useful to explore four trends with respect to the adoption of exponential technologies by Indian industries:

- Creation of highly optimized supply chains;
- Lack of smart connected products/services;
- Business innovations; and,
- Network arrangements.

The demographic changes are of critically important in this context. The future jobs in India would be determined by the quantum and quality of product demand of the domestic market. The quantum of demand will be driven by the rising size of the middle class whereas the sophistication of demand would be driven by the size of the affluent class, young population and increasing urbanisation. Availability of the right kind of training institutions is also critical. Changes are required at the grassroot level to change the orientation of the labour entering the labour market. These are expected to change the job landscape of India by 2022 (NASSCOM, FICCI, and Ernst & Young, 2018).

9. Growth Potential in Indian Economy

There some sectors which offer plenty of opportunities for growth as well as creation of new jobs. These are healthcare, education, construction, transportation, logistics, tourism, and hospitality.

Healthcare

The market size of the Indian healthcare segment was around US$160 billion in 2017 and it is expected to expand to US$372 billion by 2022. Its CAGR would be in the rage of 16–17 per cent. Cumulative FDI inflows from April 2000 to March 2016 was US$ 22.41 billion to this sector. The government spending in 2017 was 1.2 per cent of GDP and in 2022, it is expected to be 2.5 per cent of GDP. In terms of employment, healthcare accounts for 4 per cent across all sectors in India. Number of employees in this sector was 1.2 million by the end of 2017. The healthcare sector is expected to employ 1.54 million additional doctors and 2.4 million nurses to meet the demand by 2025. Nearly US$ 200 billon is expected to be spent on medical infrastructure by 2024 (Grant, Thornton and CII, 2015). The Ayushman Bharat scheme, the largest government-funded healthcare programe of the Government of India, aims to cover over 100 million poor and vulnerable families. It brings about transformative change in healthcare by shifting focus from healthcare to "wellnesses." There are two components of the scheme. One, Healthcare and wellness centre, which will bring healthcare services closer to home. It has a provision of inclusive healthcare, free essential drugs, and diagnostic services. In addition, the national health promotion scheme, i.e. Pradhan Mantri Rashtriya Swasthya Suraksha Mission. It provides an insurance cover of over $7000 (approximately 500,000 Indian rupees) per family per year for secondary and tertiary healthcare; over 1.4 million people will be covered. The key emerging trend in this sector would be:

- Use of mHealth apps,
- Telemedicine (growth of 20 per cent CAGR during 2016–2020 reaching $32 million by 2020,
- Rise in medical tourism (market worth increased to $6 billion by 2020 from $3 billion in 2017),
- Adoption of loT platform for insurance and management – will push to internet of Medical Things (loMT) forward, and wearable devices will be used to identify risk factors,
- Development of blockchain technology to facilitate transparency and administrative cost, etc.,
- Development of electronic health record (HER), and
- Use of AI powered robots.

Education

The size of the education market is estimated to be around $ 97.7 billion in 2016. In the same year, there were 1.52 million schools and 850 universities. The students enrolled in the schools were 260.2 million, and in higher education, it was 33.3 million. FDI flows in the education sector, as a whole was $ 1.67 billion during 2000–2012. The digital learning market was around $ 2 billion in 2016 and is expected to be around $ 5.7 billion by 2020. The total employment in this sector was 18.2 million in 2018.

Many key emerging trends are noticed. India's education landscape of the future is characterized by blurring of boundaries; this process has already begun and will continue until 2030. The society will embrace a culture of lifelong learning. There will be a much closer nexus between education and industry; there will be a rise in industrial contribution to the development of education. Geographical boundaries will become less relevant and there will be an increase in global education delivery and accreditation. The space of education will alter drastically with limited face-to-face interaction between students and teachers.

There will be considerable increase in the use of technology in all spheres of education. This will be in form of:

- An increase in the use of big data to analyze student information and customization of online content in the near future;
- Digital platforms weaving path for massive open online courses (MOOC) such as edX, Udemy, Coursera, SWAYAM (MHRD platform where online course are offered by institutes such as IITs and IIMs)
- Heightened internet penetration leading to the emergence of mobile education (mEducation), which has the potential to revolutionize India's vast network of rural and semi-urban school network, that are currently facing challenges in terms of quality teachers and infrastructure;
- Blockchain technology has given way to micro credentials and badges. Micro credentials have grown in popularity among both brick-and-mortar institutes and digital platforms such as Coursera and edX;
- Gamification- and simulation-based teaching-learning ecosystem is emerging, leveraging the strengths of technologies such as Augmented Reality (e.g. Google cardboard, Microsoft HoloLens and Eon Reality);
- AI based facial recognition software like SAFR (Secure, Accurate Facial Recognition) are being deployed in schools for analyzing student behavior for better monitoring;
- Data driven decision-making is redefining education management and administration through creation of class schedule; and,
- Technological tools such as AI and RPA that are being utilized in assessment software's such as eLumen, WEAVEonline and EvaluationKIT, are supplementing learning outcomes.

Megatrends that will drive the Indian education sector in the future will be:

- Setting up of satellite campuses and student exchange programmes by foreign universities,
- Broadening geographical presence to include socioeconomic groups with low participation,
- Increasing collaboration with industry, to boost the research and development initiatives, and
- Tutoring in the K2 market, which is emerging as a major segment.

Construction sector

Construction sector contribution to GDP was 9 per cent and is growing at 15.7 per cent; it will be nearly $738.5 billion by 2022. The sector employs 44 million workers. The cumulative inflow of FDI was $24.8 billion during the 2000–2018 period. There are many key emerging trends. These are increasing use of loT devices in smart buildings for collecting and analyzing data from sensors to understanding signals and patterns, deploying real time solutions, cutting costs, prioritizing preventive maintenance, and preventing unplanned downtime. Building Information Modeling (BIM) is yet another technique. Indian firms such as HCC and Tata project have initiated the use of BIM to establish transparency in design, costing, and progress, visualization as well as to improve on-site monitoring of materials, labour, and equipment productivity. These techniques are made use of by Nagpur Metro Rail Corporation and IBIS hotel chain in India. Off-the-shelf robotic applications are being utilized to work in parallel to manual labours at construction sites, for e.g., WALT a robotic developed by Hyderabad based Endless Robotics can paint walls about 30 times quicker than a human (NASSCOM, FICCI, and Ernst & Young, 2018).

India's Smart Cities mission is an initiative to develop advanced and modern urban localities by leveraging cloud computing, big data mobility, and loT. Under this, 100 smart cities are envisaged to be developed by 2020. The government has accorded priority to some schemes like Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Heritage City Development and Augmentation Yojana (HRIDAY), Pradhan Mantri Awas Yojana, Bharatmala, and the Delhi-Mumbai Dedicated freight corridor that are providing major growth thrust. Green infrastructure projects have led to eco-friendly end-to-end construction mechanisms, from materials, method to equipment with parameters of reduced carbon footprint, energy efficiency, and water conservation. These are some of the key trends.

Transportation and Logistics Sector

1. **Roads and Highway segment:** Road network in India is one of the largest in the world, spanning over 5.6 million kms in 2018. Roads handle more than 65 per cent of freight and 80 per cent of passenger traffic in the country. The market for roads and highways is projected to grow by 36.16 CAGR during 2016–2025. In 2018, the government allocated $10.97 billion for the development of national highways. Overall, the annual freight traffic is estimated to reach 168,000 billion-passenger km by 2030.
2. **Railway Segment:** India has the 4th largest rail freight carrier network in the world. Indian Railway runs 13329 trains, carrying 22.4 million passengers every day. It employs close to 1.3 million people and is the world's eighth largest employer. Capital expenditure has been pegged at $22.85 billion in 2018. Passenger traffic is expected to advance to 15.20 billion by 2020 from 8.29 billion in 2018. There will be a rise in freight traffic also. New technologies will be used in many activities.
3. **Aviation segment:** India is the 9th largest market for civil aviation in the world. Aviation industry is expected to witness $15.52 billion worth investment in the next five years. By 2020, passenger traffic at Indian airports is expected to increase to 421 million from 309 million in 2018. The industry witnessed a 13.4 per cent growth in foreign tourist arrival in 2018. Domestic aviation passenger traffic grew

YoY by 18.28 per cent in 2018 while international passenger traffic grew YoY by 10.43 per cent in 2018.

4. **Ports and Shipping segment:** India is the 16th largest maritime country in the world. Total investment in ports by 2020 is expected to reach $43.03 billion. Cargo traffic at the end of 2018 was 174 million tonnes. The 'industry's fleet strength is 1301 vessels. Its freight capacity is expected to increase to 1451 million tonnes by 2020 from the present level of 965 million tonnes.

There are many key emerging trends in this segment. The use of augmented reality for warehouse planning, pick-and-pack service, and last mile delivery has shown significant improvement in productivity by shortening the learning curve, improving warehouse workflow, and providing constant picking and packing validation updates in real time. It will also enable IoT based real time integration of data across supply chain partners for real time tracking; for example. integrated devices with real time analytics and predictions. Robots and automated guided vehicles are already solving the picking and sorting challenges in warehouses; for example, Kiva and Butler are touted as the future warehouse workforce. Social media and mobile applications are being used to generate one-on-one interaction with customers to obtain feedback and provide customer services; for example, mobile ride sharing application leveraged by user in order to carpool. Big data analytics is being leveraged for long-term demand forecasts, transportation fleet capacity optimisation, and planning and management; for example, analytics is being used to identify carriers that have the capacity to accommodate additional freight/passengers.

Tourism and Hospitality Sector

The market size of this sector was $230 billion. Its contribution to GDP was 9.4 per cent. This sector is expected to reach $424 billion by 2027. The sector employs 44 million workers (as of 2016). International tourist arrivals were estimated at 8.8 million while the domestic tourist visits were estimated to be 1.6 billion. The emerging trends are:

- RPA is increasingly being embraced as a tool for business travel management in the 24x7 booking/reservation system;
- Hotels and multiplexes are making use of augmented reality to allow tourists to engage in a close to real life experience through multi-media resources;
- Big data is being used by the hospitality industry players, exploiting analytics for targeted marketing of their services through data collected via social media channels;
- AI based guest system is being deployed to provide personalized experience to customers regarding their tastes or consumption by accessing real-time information;

- Companies have started using private blockchain to handle internal processes and manage distribution of hotel and restaurant inventory and other assets. It is also being used to streamline their loyalty management programmes;
- India is emerging as the preferred destination for medical tourism as it offers advanced facilities, skilled doctors, and low cost treatment to foreign patients; and
- E-Tourist visa, launched by the Government of India, has resulted in an increase in the number of tourist visas issued in the country. Arrivals through e-Visa have increased by 57.2 per cent to 1.69 million during 2017.

There are new dimensions to the technology developments in Industry 4.0. According to Sharma (2017) there are three types of technological developments taking place. The first consists of innovations that are happening in the West but are being deployed or have a potential to be deployed across the world. These include the sharing economy initiatives, led by Uber and Airbnb. The second comprises solutions meant only for local needs. These low-tech and affordable solutions work in emerging markets. The third is being created in emerging markets but has a potential to be scaled up across the world; OYO hotel is an example. The successful adoption of Industry 4.0 technologies depends on the role of the government, industry, and academia. The government should act as an enabler. It should encourage and promote original research aimed at developing technologies in emerging areas, mandating an industry-oriented curriculum at graduation level in state education boards. There is a need to bolster vocational training infrastructure in partnership with the private sector and include elements of Industry 4.0. The government should also work as a facilitator. There should be a dedicated wing in the Industry Ministry to oversee and promote Industry 4.0 adoption. It may establish a network of 'test labs' that will work with enterprises, industry bodies, academia, and labour organisations to advance Industry 4.0 goals. The government has a critical role as a policy formulator. It may provide financial incentives and aid to MSMEs through tax breaks and subsidies to make Industry 4.0 technologies affordable for them. It should continue to push initiatives such as Smart Cities, Digital India and Make in India. Further, it must improve telecommunication infrastructure to ensure seamless loT implementation and formulate adequate cyber security policies (AIMA and KPMG, 2018).

The role of the industry is highly important in creating and defining Industry 4.0, which would be mostly management-related. It should provide reskilling opportunities by identifying a core set of industry relevant skills and imparting them to the employees. It must be able to provide cross-functional exposure to employees, i.e. an opportunity to learn outside their own disciplines. Industry must actively participate in public-private partnership initiatives and conduct programmes in vocational training. It must undertake and invest in R&D for Industry 4.0 Technogym. The academia can play an important role in enhancing the quality of teachers and modernizing the learning infrastructure. It should align course curricula in tandem with Industry 4.0 requirements, with well-regulated industry-relevant updated content. Focus should be more on practical result-oriented knowledge over theoretical content. Academia should be in a position to collaborate more with industry players to enable workers to attain requisite skill needed for the job. Overall, widespread adoption of Industry 4.0 would require collaborative efforts of industry associations. These associations can take initiatives to identify technological developments, reorganize infrastructure and political needs, assess the impact on sectors, and plan a workforce up-skilling road map (AIMA and KPMG, 2018).

10. Opportunities and Risks

There are a number of risks associated with the adoption of Industry 4.0. India still suffers from lack of adequate infrastructure, both physical and digital. Despite continuous efforts of the government, the country lacks basic infrastructure such as roads and electricity. Besides, India's telecommunication network still suffers from slow data speed and unstable connections. According to KPMG India Cybercrime Survey Report 2017, 79 per cent of corporations in India have acknowledged cyber security as one of the top five business risks. Apart from cyber security, the regulatory environment pertaining to data privacy would also need to be strengthened. High cost of digital technology is yet another factor. Building the factory of the future with an entirely connected system could require significant capital outlay. Getting access to digital technologies for MSME's, which form the base of India's manufacturing sector, remains a challenge due to the high cost of these technologies (Bajpai and Biberman, 2019).

There is still a leadership gap. India lacks business leaders ready for Industry 4.0 era, which would hinder the country's attempt to widespread adoption. Although Indian companies have strong traditional leadership, there is a deficiency of digital experts with a strong vision for Industry 4.0 adoption. India's present workforce lacks skill and expertise in new age technologies such as data analytics, additive manufacturing, and loT. The government, industry, and academia need to collaborate to enable an Industry 4.0 ready workforce. The right set of talent will be key to success. The availability of adequate talent—both at the strategic leadership level as well as on the factory floor—can prove to be a significant challenge for Indian companies on their way to Industry 4.0 maturity. Building leadership that can successfully navigate their companies in digital age and up-skill the workforce will require proper planning, investment, and collaboration from all stakeholders (PWC and FICCI, 2019).

The traditional organizational structure incorporating human-human hierarchy is likely to be gradually replaced by functions where humans and machines would interact at strategic and operational levels. The digitalized Industry 4.0 ready Indian companies therefore need to redefine leadership and build a new breed of leaders who will have to work with a network of teams, operating in a fast-paced technological environment. Most importantly, there is a need to change traditional mindsets and skillfully manage that change across organization. With Industry 4.0 automating most of the technical tasks, the focus could turn to soft skills for employees to be successful. This re-engineering at the leadership level is of paramount importance.

A skilled workforce would form a key element for Industry 4.0 adoption. The current workforce would need to be re-engineered to fill new roles. The next generation workers need to be digitally strong. At present, India is struggling with low vocational training capacity. It is only 0.8 per cent of the total workforce as compared to 6.7 per cent in the US and 11.5 per cent in China. Formally, the skilled workforce is only 4.7 per cent in India as compared to 24 per cent in China and 96 per cent in South Korea (PWC and FICCI, 2019). Repetitive jobs may disappear. This is likely to leave a deep impression on employment landscape. There may be new role for the labour force in the form of supervisory, managerial and cross-functional, demanding diverse skill-sets. Industry 4.0 is likely to create widespread disruption in the labour market. The key stakeholders—the government, industry and training institutions—have to come together to re-engineer the education system to make employees competitive. The stakeholders need to change the skill map to accommodate fast-paced technology trends.

11. Conclusions

India should embrace digital technologies to become a global manufacturing powerhouse. Since the launch of "Make in India," some progress has been made. The global manufacturing landscape is transformed by digital technologies such as IoT and robotics. Productivity gains are being realized through cost reduction, quality improvement, customization, and a quantum leap in performance. However, adoption of digital technologies in Indian industry is still in its infancy. There are many advantages for India. It has a number of factors in its favor, which include a huge and growing domestic market, a large pool of workers with diverse skills, demographic dividend, English-speaking scientists and engineers, research and development institutions, and a large startup technology base.

While being a catalyst for growth, digital technologies may be disruptive with far reaching effects on productivity and employment. They are leading to key structural shifts in global manufacturing. One, cost economics and competitiveness of manufacturing are fundamentally changing, with the trade-off between labour and automation swinging in the latter's favour. This has enabled small-scale, highly automated localized manufacturing close to end consumers and hence disrupting the existing low-cost labour arbitrage based global value chain model. Two, with the boundary between products and services blurring, digital services are becoming the growth and profit drivers for manufacturing industry. Three, rapid growth of exchange of products on digital platforms like Amazon is creating digital market places, reducing the need for investing in individual asset-heavy supply chains, and enabling small businesses to participate. Four, digital economy skills, including cross-domain skills, are becoming critical factors of production and drivers of competitiveness (Gaur, 2017).

What are the implications for India? One, India's low labour cost advantage is being eroded, but its demographic dividends have the potential to getting convert into a strategic resource for digital revolution. Two, with the right ecosystem, India could gain a significant share of embedded software services, data management, and supply chain restructuring. Three, beyond physical infrastructure, large-scale investments in requisite digital ecosystem are needed. Four, highly competitive MSMEs can be central to the growth of manufacturing with small-scale localised smart manufacturing becoming feasible. They can compete multi-national enterprises on digital platforms without creating their own supply chains.

India needs a new policy to incentivize adoption of digital technologies, develop requisite digital ecosystem, augment competitiveness, and allow leapfrogging into the digital 21st century, while meeting the requisite skill gaps and ensuring jobs for millions entering the job market. The government announced the rollout of new manufacturing policy to push its share to 25 per cent of GDP by consolidating Make in India and embracing Industrial Revolution 4.0.

Advanced technologies such as 5G mobile network, wireless sensor network, 3D printing, industrial e-commerce, cloud computing, AI, and big data will determine industrial competitiveness. Global industry is at the brink of the next technological revolution. The combination of intelligent machines, modern communication, big data, and cloud computing is causing disruptive changes in industrial production. "Smart Manufacturing," "Industry 4.0," and "Industrial Internet" are labels that will characterize the upcoming transformation. The new technology paradigm will reshape the dynamics and the rules of global competition. The race for advanced industrial production may decide the fate of large corporations, and also determine the overall development of the economies.

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ISID

Institute for Studies in Industrial Development

4, Institutional Area, Vasant Kunj Phase II, New Delhi - 110 070

Phone: +91 11 2676 4600 / 2689 1111; Fax: +91 11 2612 2448

E-mail: info@isid.org.in; Website: http://isid.org.in