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An Indian perspective of fourth industrial revolution

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Abstract
There has been increasing interest in the use of Fourth Industrial Revolution (4IR) technologies, such as artificial intelligence, the Internet of Things, block chain, robotics, data analytics and others, to help achieve the Sustainable Development Goals (SDGs). Organizations such as UNESCO and the World Economic Forum have sponsored initiatives to make countries aware of the benefits of using 4IR technologies for sustainable development and to improve quality of life. The fourth industrial revolution is grounded on the fusion of a broad diversity of engineering sciences and concepts. Some of the technologies that are considered to be an integral part of the FIR have been used in manufacturing before, such as robotics and additive manufacturing. A number of developed countries such as Germany, the UK and USA have put in place public policies that focus on implementing Fourth IR in their respective countries. It is critical that developing countries also take steps to adapt Fourth IR in order to take advantage of it as well as not be adversely affected by these technologies if not adopted. The present article is a descriptive study of the Fourth Industrial Revolution in the Indian context.

Keywords: industrial revolution, UNESCO, SDGs

Introduction
In 2016, World Economic Forum founder and Executive Chairman Klaus Schwab published a book, *The Fourth Industrial Revolution*, a concept that has since held currency as the umbrella term to frame and examine the impact of emerging technologies on all aspects of society in the early 21st century. Artificial intelligence (AI), fifth generation mobile networks (5G), three-dimensional (3D) printing, cloud computing, robotics, drones, virtual reality (VR) and augmented reality (AR), the Internet of Things (IoT), genomics, biometrics, and block chain are commonly included in the list of present-day emerging technologies anticipated to provide human societies with the means to overcome global challenges like disease, poverty, and ignorance (Virginia Bacay Watson). In this direction, UNESCO organised two conferences in 2019: "Artificial Intelligence for Sustainable Development" and "International Conference on Artificial Intelligence and Education: Planning Education in the AI Era: Lead the Leap." At the same time, developing countries such as South Africa, India and China are relying on 4IR technologies to achieve future prosperity (Mohamed Ally and Norine Wark, 2020) [7].

Timeline of industrial revolutions
There are four distinct industrial revolutions that the world either has experienced or continues to experience today.

1. First Industrial Revolution
Happened between the late 1700s and early 1800s. During this period of time, manufacturing evolved from focusing on manual labor performed by people and aided by work animals to a more optimized form of labor performed by people through the use of water and steam powered engines and other types of machine tools.

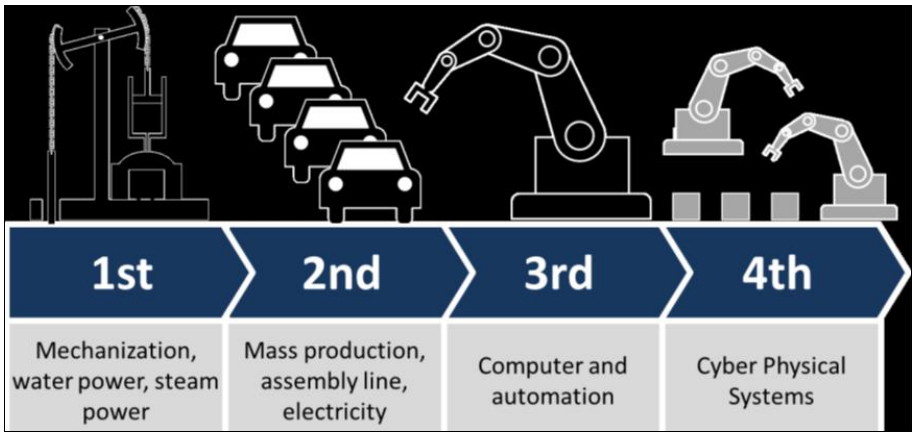
2. Second Industrial Revolution
In the early part of the 20th century, the world entered a second industrial revolution with the introduction of steel and use of electricity in factories. The introduction of electricity enabled manufacturers to increase efficiency and helped make factory machinery more mobile. It was during this phase that mass production concepts like the assembly line were introduced as a way to boost productivity.

3. Third Industrial Revolution
Starting in the late 1950s, it slowly began to emerge, as manufacturers began incorporating more electronic-and eventually computer-technology into their factories. During this period, manufacturers began experiencing a shift that put less emphasis on analog and mechanical technology and more on digital technology and automation software.

4. Industry 4.0
Commonly referred to as the fourth industrial revolution, it is a name given to the current trend of automation, interconnectivity and data exchange in manufacturing technologies to increase productivity. Industry 4.0 is a complex Cyber-Physical Systems which synergizes production with digital technologies, the Internet of Things, Artificial Intelligence, Big Data & Analytics, Machine Learning and Cloud Computing.

Description of industry 4.0
After going through three industrial revolutions that brought about significant technological developments over a period of more than two centuries, the world is currently witnessing the fourth Industrial revolution, which is taking technology adoption by the world's factories to a whole new level. This fourth industrial revolution, or Industry 4.0 (I4.0), is bringing together the different silos in a production system via a network, allowing real-time data sharing and

facilitating machine-to-machine and human-to machine interactions of unprecedented speed and scale.
This is giving rise to seamlessly integrated value chains with inter-connected cyber and physical systems, enabling decentralised decision-making and unprecedented levels of automation. The digitalisation of the entire manufacturing value chain starting from the procurement of raw materials and extending right up to customer service using mobile devices, communication networks, sensors and actuators is completely transforming how the world's factories operate (Mohandas Pa, Sunil Kant Munjal, R. Gopalakrishnan, Ashokkumar Prabhakar, S.V. Sukumar, Pranjal Sharma and Ravind Mithe, 2018) [8].



***Source*:** Nirupam Bajpai and John Biberman. (2019) [9]. The Future of Work in India: Adapting to the Fourth Industrial Revolution. *Leibniz Information Centre*, 1-23.

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Technologies of the fourth industrial revolution
With the advancement of fields such as machine learning, data science and the Internet of Things, it is now possible to amalgamate these and related technologies to revolutionize manufacturing (Sohail Asghar, Gulmina Rextina, Tanveer Ahmed and Manzoor Illahi Tamimy, 2020) [12]. A better way to understand the Fourth Industrial Revolution is to focus on the technologies driving it:

Artificial intelligence
AI defines computers that can think like humans. They can recognize complex patterns, process information, draw conclusions, and make recommendations. AI has many applications, from spotting patterns in huge piles of unstructured data to powering the autocorrect on your phone, to the smallest chip to a big manufacturing process.

Blockchain
Blockchain is a secure, decentralized, and transparent way of recording and sharing data, with no need to depend on third-party intermediaries. The digital currency Bitcoin is the best-known block chain application. However, the technology has other applications like traceable supply chains, securing sensitive medical data anonymously, and combating voter fraud.

Faster computer processing
New computational technologies are making computers smarter as they enable computers to process vast amounts of data faster than ever before. The advent of the cloud has allowed businesses to safely store and access their information from anywhere with internet access. Quantum computing technologies will eventually make computers millions of times more powerful. These computers will have the potential to enhance AI, create highly complex data models in seconds, and speed up the discovery of new materials.

Virtual reality and augmented reality
Virtual Reality (VR) offers immersive digital experiences (using a VR headset) that simulate the real world, while augmented reality (AR) merges the digital and physical worlds. Examples include makeup apps, which allow users to digitally experiment with makeup products before buying them, and the Google Translate phone app, which allows users to scan and instantly translate street signs, menus, and other text.

Biotechnology
Biotechnology utilizes cellular and biomolecular processes to develop new technologies and products for developing new pharmaceuticals and materials, efficient industrial manufacturing processes, cleaner, more efficient energy sources, etc. Another example is our ability to edit the blocks of life has recently has been massively expanded by low-cost gene sequencing and techniques such as CRISPR.

Robotics

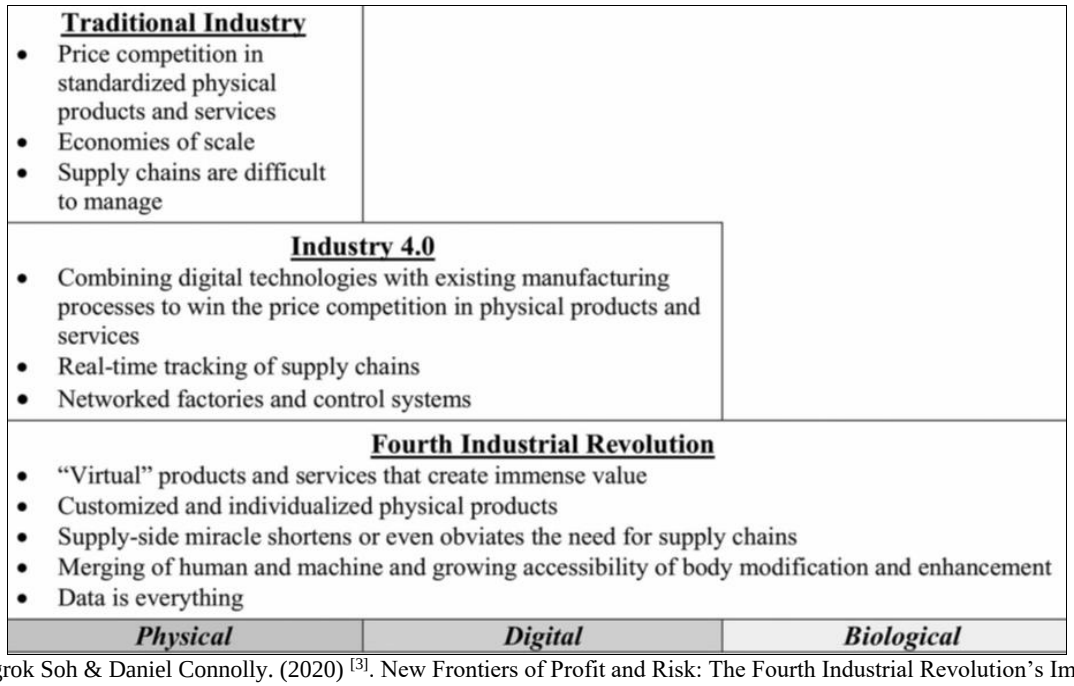
It refers to the design, manufacture, and use of robots for personal and commercial use. While the use of robot assistants in every home is still to be a reality, technological advances have made robots increasingly complex and sophisticated. They are used in fields as wide-ranging as manufacturing, health and safety, and human assistance.

The Internet of Things

The IoT describes everyday items from medical wearables that monitor users' physical condition to cars and tracking devices inserted into parcels connected to the internet and identifiable by other devices. Businesses can collect customer data from constantly connected products, allowing them to better gauge how customers use products and tailor marketing campaigns accordingly. There are also many industrial applications, such as farmers putting IoT sensors into fields to monitor soil attributes and inform decisions such as when to fertilize.

3D printing

3D printing allows manufacturing businesses to print their parts, with less tooling, at a lower cost, and faster than via traditional processes. Designs can be customized to ensure a perfect fit (CLEARIAS TEAM, 2022) [4].



Source: Changrok Soh & Daniel Connolly. (2020) [3]. New Frontiers of Profit and Risk: The Fourth Industrial Revolution's Impact on Business and Human Rights. New Policy Economy, 1-19.

4IR in India

India is the second largest emerging economy after China. The Government of India has taken several policy initiatives like Make in India, Digital India, Startup India etc, to carve a niche for the country on the global map, still, India lags behind its global peers in adoption of 4IR. The country has started taking baby steps to improve productivity by adopting new age technologies to achieve the target set by the government to have 25% contribution in GDP of the country from manufacturing sector by 2022. Over the past few years, due many policy initiatives of the Government, India is able to improve its ranking in several Global Index. India is able to position itself as one of the country with focus on innovation and competitiveness.

India's Global Innovation Index ranking has improved considerable since 2015. In 2017 it ranked 57th among 126 countries owing to its large pool of science and engineering graduates. (WEF October 2018) Further, due to several initiatives of Government of India to make India a digital economy, there is considerable improvement in indicators like mobile phone and broadband subscriptions, internet bandwidth per user and internet access in schools etc. This helped India to achieve 40th rank in the Global Competitiveness Report 2018. (WEF October 2018) In its drive to imbibe Industry 4.0, Government has taken several initiatives in recent times, to provide the necessary infrastructure within the country to facilitate adoption of 4IR (Alka Maurya, 2019).

Current status of industry 4.0 in India

Globally, the I4.0 market is expected to reach INR 13,90,647 crore by 2023. Countries such as the U.S., China, Japan and European nations like U.K., Ireland, Sweden and Austria all have started adopting I4.0. In India, the sixth-largest manufacturing country, the manufacturing sector forms an integral part of the country's long-term vision as seen by the government's strong focus on the 'Make in India' campaign. The government aims to augment the share of manufacturing in GDP to 25 per cent from the current 17 per cent, by 2022. A number of initiatives and policy reforms, such as implementation of the GST (Goods and Services Tax) and easing FDI policy have been taken by the government.

At present, India lags its global peers in I4.0 adoption. A significant portion of the Indian manufacturing sector is still in the post-electrification phase with use of technology limited to systems that function independently of each other. The integration of physical systems on cyber platforms, the basic premise of I4.0, is still at its infancy. Furthermore, the Micro, Small & Medium Enterprises (MSME) segment has very little access to automation technology due to the high

cost barrier. The current scenario of I4.0 implication in India can be summoned by following way:

1. Non-awareness of the technology
2. Systematic approach towards modernization.
3. Non-Willingness to adopt the new technologies
4. Availability of Cheap labor initiates reluctance to adopt automation
5. Volume of products is not very high so as to adopt the automation increases ROI for the investments.
6. Non availability of skill set to adopt the Automation (Viraj Vijay Jadhav, Ravindra Mahadeokar, 2019) [15].

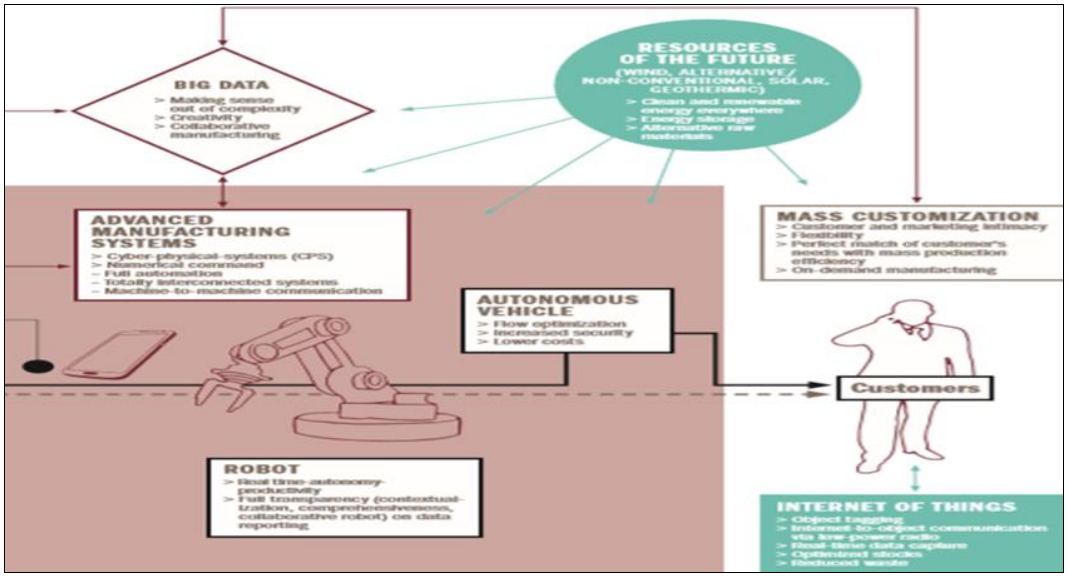
Industrial Revolution 4.0 can help in transforming India by:

1. Alleviating poverty.
2. Better and low-cost healthcare.
3. Enhancing farmer's income.
4. Providing new technology and equipment to farmers.
5. Strengthening infrastructure, improving connectivity.
6. Improve ease of living and ease of doing business.

(Kazim Rizvi and Pranav Bhaskar Tiwari, 2019) [5]

The fully connected way of making things

Industry 4.0 is based on new and radically changed processes in manufacturing companies: Factory 4.0. In this concept, data is gathered from suppliers, customers and the company itself and evaluated before being linked up with real production. The latter is increasingly using new technologies such as sensors, 3D printing and next-generation robots. The result: production processes are fine-tuned, adjusted or set up differently in real time.



Source: The New Industrial Revolution How Europe Will Succeed. (2014). Roland Berger Strategy Consultants, 1-24.

Traditional industry vis-à-vis fourth industrial revolution

The Fourth Industrial Revolution (4IR) is distinct from prior revolutions in at least three ways. First, building upon the legacy of digital networks from the Third Industrial Revolution, the speed, scope, and scale of technological advance and diffusion in 4IR is quite unlike the world has ever seen before. It is evolving at an exponential rate and transforming virtually every industry in every country and all aspects of societal life. Second, it is about the dynamic fusion of digital, physical, and biological technologies. This merging is producing innovations that are issuing paradigm-shifting norms and upending existing ones. And third, many of the emerging technologies are personalized in nature that, while facilitating rapid societal integration, also create new normative challenges that require major changes in the foundations of existing technology governance institutions (Virginia Bacay Watson).

Table 1

Traditional Industry	Fourth Industrial Revolution
Actors	
Multinational corporations Local communities	Disruptive startups Consumers
Value	
Price Competition Locational advantages through the creation of globalized supply chains	Competition in digital services Network effects by having more users Data stockpiles
Workplace	
Disciplined workforce gathered in a physical location	Creative employees who may be disturbed via the cloud
Human Rights Issues	
Threats to bodily integrity in the workplace Displacement of local communities for industrial projects	To attain network effects, tech companies must be human friendly State pressure to share data stockpiles

***Source*:** Changrok Soh & Daniel Connolly. (2020) [1]. New Frontiers of Profit and Risk: The Fourth Industrial Revolution's Impact on Business and Human Rights. New Policy Economy, 1-19.

Industry 4.0 in the automotive sector in India

The Indian auto industry became the 4th largest in the world with sales increasing 9.5 per cent year-on-year to 4.02 million units (excluding two wheelers) in 2017. It was the 7th largest manufacturer of commercial vehicles in 2018. The Two Wheelers segment dominates the market in terms

of volume owing to a growing middle class and a young population. Moreover, the growing interest of the companies in exploring the rural markets further aided the growth of the sector.

There are 4 major automobile clusters in India namely:

1. Delhi – Gurgaon – Manesar – Neemrana,
2. Kolkata – Jamshedpur,
3. Chennai – Bengaluru – Hosur,
4. Mumbai – Pune – Nashik – Aurangabad.

India is also a prominent auto exporter and has strong export growth expectations for the near future. Automobile exports grew 14.5 per cent during FY 2019. It is expected to grow at a CAGR of 3.05 per cent during 2016-2026. In addition, several initiatives by the Government of India and the major automobile players in the Indian market are expected to make India a leader in the two-wheeler and four-wheeler market in the world by 2020.The Government of India encourages foreign investment in the automobile sector and allows 100 per cent FDI under the automatic route. The government aims to develop India as a global manufacturing centre and an R&D hub.

Under the National Automotive Testing and R&D Infrastructure Project (NATRiP), the Government of India is planning to set up R&D centres at a total cost of US$ 388.5 million to enable the industry to be at par with global standards. The Ministry of Heavy Industries, Government of India has shortlisted 11 cities in the country for introduction of electric vehicles (EVs) in their public transport systems under the FAME (Faster Adoption and Manufacturing of (Hybrid) and Electric Vehicles in India) scheme. The government will also set up incubation centre for start-ups working in electric vehicles space. In February 2019, the Government of India approved the FAME-II scheme with a fund requirement of Rs 10,000 crore (US$ 1.39 billion) for FY 2020-22. The automotive sector across the world is witnessing technological up-gradation in the garb of Industrial Revolution 4.0 and the Government of India is catering to the same in India.

Review of Literature

UNIDO (2016) [14] reports that Industry 4.0 is one of the major drivers of the Fourth Industrial Revolution. The first industrial revolution was triggered by water and steam power to move from human labour to mechanical manufacturing. The second industrial revolution built on electric power to create mass production. The third used electronics and information technology to automate manufacturing. The fourth is the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Industrial Internet of Things (IIoT), and cloud computing. Industry 4.0 is gradually implemented, often with digitalization as the first important step. Digital technologies allow for new business models and value-producing opportunities, and are attainable for most developing countries (UNIDO, 2016) [14].

Shawqi Al Dallal (2019) [11] focus on the implications of scientific theories, particularly quantum theory, general relativity, and superstring theory, on current and future industrial revolutions. The Fourth Industrial Revolution lies at the heart of major technological advancements we have been witnessing since the inception of the Twenty First Century. Successive industrial revolutions have been built upon well-established scientific theories that open new horizons for numerous potential applications. In human history, translating theoretical scientific ideas or research work into reality always presents a tremendous challenge to the industrial world. Examining the road to development of new technologies provides the humanity with a deeper insight in the working of science. It was found that scientific theories have to wait decades or more until they are translated to practical technologies (Shawqi Al Dallal, 2019) [11].

Sohail Asghar *et al*. (2020) [12] propound that Technological advancements and the amalgamation of several fields, including Advanced Robotics, Artificial Intelligence (AI), Big Data Analytics, Cyber Security, Cloud Computing, and Internet of Things (IoT) have brought the world on the cusp of a Fourth Industrial Revolution (FIR). This industrial revolution has the potential to sky rocket economic growth or on the other hand, cause countries to lag behind in terms of economic development if the potential of FIR is not exploited. There are a number of reasons why developing countries are not able to fully implement FIR technologies such as lack of commitment, infrastructure and lack of skilled workers (Sohail Asghar, Gulmina Rextina, Tanveer Ahmed and Manzoor Illahi Tamimy, 2020) [12].

Viraj Vijay Jadhav *et al*. (2019) [15] propagate that I4.0 brings together technology forces such as Internet of Things (IoT), cloud computing, big data analytics, additive manufacturing, Augmented Reality (AR), robotics, cyber security and Machine-to-Machine (M2M) communication. While some of these digital technologies are already in use in industrial applications, some others are still not ready for application at scale. Manufacturers need to carefully pick the right mix of technologies that would maximize returns on investment (Viraj Vijay Jadhav, Ravindra Mahadeokar, 2019) [15].

M M Singh opines that there will be tremendous impetus towards modern manufacturing including advanced materials, advanced robotics and 3D printing, among others. Industry 4.0 has many facets to it including the upcoming trend of automation and data exchange in manufacturing technologies, cyber-physical systems, the Internet of things, cloud computing and lot more. It creates what has been called a "smart factory". In smart factories, machinery, storage systems and production are capable of carrying out complex tasks, exchanging information and giving instructions to each other, without the need for human involvement. There is a need of a platform where different stakeholders can discuss the related issues and see how it may be used to the advantage of Indian Industry (M M Singh).

Sameer Gandhi (2018) [1] contend that the growth in the manufacturing sector is expected to create up to 90 million domestic jobs, which can be addressed by harnessing Industry 4.0. However, recruiting and retaining manpower with the right skills-set, could prove to be a challenge for manufacturing companies. Businesses can meet the challenge by adopting active or experiential learning methods to address their training needs. The new technology-enabled trend in training is catching up in India, with several organisations deploying experiential training activities for their corporate learning initiatives. The Indian manufacturing sector is at the cusp of major technological transformation. Blending advanced manufacturing technologies and Industry 4.0 with low cost labour available in the country, India can fast-track its transformation as the (Sameer Gandhi, 2018) [10].

Challenges of industry 4.0 from a developed country perspective

Indicating that Industry 4.0 also has the capacity to kill jobs and exclude parts of society, Ms. Diedrichs asked Prof. Karlsson what he sees as the challenge regarding jobs and the skills needed in the future.

Prof. Karlsson responded that Industry 4.0, including the next wave of automation, would be profoundly transformative and outlined three clusters of challenges:

1. Awareness and readiness

Uncertainty is a key factor - there is a need for experimentation and learning - and even unlearning. Companies must challenge their own business assumptions.

2. Explosion of data

Ericsson is currently exploring the fifth generation of mobile systems - 5G- which will see faster connectivity, more data being transmitted over wireless connections and to more devices. This will be the platform that connects people and things, sometimes called the Internet of Things (IoT). An estimated five billion things are already connected, a figure that will rise to almost 20 billion in five years. Building a digital ecosystem will require seamless connectivity, data sharing, and agreed standards for the exchange of data and components that are parts of systems. As data starts to accumulate and be shared, other issues come to the forefront, such as data security and privacy.

3. Workforce transformation

The shift in employment will be gradual but profound. Digital labour, such as the use of smart drones, robots and intelligent assistance will enter the workforce. New industry sectors will emerge, such as digital medicine, precision agriculture and new jobs, medical robot designers, and grid modernization managers. There will also be a transformation in existing jobs. For example, virtual reality and augmented reality will assist workers to become more productive and make their work environment safer.

Prof. Karlsson emphasised the need to deal with these challenges and reform the education system and upgrade skills in the workplace. Policy incentives are needed to encourage businesses to do this reskilling, and we must learn to collaborate and coexist with intelligent machines (UNIDO, 2016) [14].

Cost and technical issues

- **Lack of Adequate Infrastructure:** physical and digital: Despite continuous effort of the government, India still lacks basic infrastructure such as roads and electricity. Additionally, India's telecommunication network still suffers from low data speeds and unstable connection.

- **Cyber Security:** According to KPMG in India's 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 Technologies:** Building the factory of the future having an entirely connected system could require significant capital outlay. Getting access to digital technologies for MSMEs, that forms the base of Indian manufacturing sector, remains a challenge due to the high cost of these technologies (Viraj Vijay Jadhav, Ravindra Mahadeokar, 2019) [15].

4IR and the challenge of the supply and demand of skills

This landscape is made even more complex by the tangible implications of 4IR, which holds significant promise for business as it relates to the rapidly expanding use of robots and process automation, big data to create smarter supply chains, and artificial intelligence (AI) for decision-making. These innovations have helped redefine the work week, created a new economy of gig-based independent contractors who are reshaping when and where work is done, and blurred the traditional definitions of formal and informal employment.

There are seemingly unlimited possibilities related to increased human connectivity and access to knowledge. These possibilities will likely be multiplied by emerging technology in AI, robotics, automation, 3-D printing, biotechnology, and quantum computing that could potentially displace more than 5 million jobs by 2020, with most of this loss concentrated in low- and middle-skill jobs.

For businesses to remain competitive, they should rethink how and where work is done, there by potentially reshaping their organizational structures, cultures, and processes to fit these changing developments. The speed of technological updates often surpasses the speed at which current and future talent can be up skilled and trained, leaving a gap between skills needed and skills available (Wadia Ait Hamza).

Adoption of 4ir technologies through sdg target year 2030

While some Asia-Pacific countries have taken policy initiatives to digitalise at a fast pace and adopt 4IR technologies, there are variations across countries. Some countries, especially developing countries and LDCs, are yet to implement policies in crucial areas like data protection and data sharing and are facing challenges with respect to skill mismatches and availability of finance for implementing 4IR technologies. There is apprehension that some of them may not be able to meet their 2030 SDGs if there is no prompt action.

With respect to SDG Goal 9, while sub-regions such as Southeast Asia has made relatively good progress, but a number of countries (especially the Pacific Island countries such as Kiribati, Fiji, Tuvalu, etc., which have not been included in most indices on innovation, digital competitiveness, among others), have a long way to go. In countries which are almost on track, most of the progress has been made in terms of provision of access to mobile networks. While the region shows a mixed picture with respect to progress on achieving the SDG targets by 2030, greater collaboration and technology/knowledge transfer can help accelerate adoption of 4IR across the countries. Investment in R&D needs to be enhanced and focus should be on increasing the share of manufacturing value addition in medium and high-technology industries.

To achieve SDG targets, while each country has the primary responsibility to implement its SDGs, mobilization of financial resources as well as capacity-building and the transfer of technologies to developing/LDCs countries on favourable terms, including on concessional and preferential

terms, will support them in implementing their SDGs. There is need for greater multi-stakeholders' engagements in the Asia-Pacific region in this regard. There is need for more partnerships in capacity building, strengthening data collection and well-defined numerical targets. Greater North- South, South-South, triangular, regional and international cooperation; access to science, technology and innovation and enhanced knowledge sharing on mutually agreed terms, and through a global technology facilitation mechanism will help to attain the SDGs (Arpita Mukherjee and Angana Parashar Sarma, 2022) [2].

Conclusion

Previous industrial revolutions had major impacts on societies. In the past, the invention of steam power and machines significantly affected transportation and agriculture. Technologies of the 4IR are making huge differences in business and industry, and they are affecting education. Given the strong role of advanced technology in Industry 4.0, there is also a need to demystify the core skill requirements of Industry 4.0 through education and enablement. Best practices from nations that have succeeded with Industry 4.0, such as Germany, show that the government has a strong role to play here too by mandating relevant curriculum in educational institutes as well as in the vocational training infrastructure. Partnering with the industry, the government can use its vast research infrastructure to encourage innovation and learning around Industry 4.0.

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