Industry 4.0: Overview, Components, and Initiatives of Indian Government

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Abstract

The term 'I4.0' or 'Industry 4.0' refers to the 'Fourth Industrial Revolution'. It's a new paradigm where smart Devices are capable of controlling and cooperating with the human being for efficient manufacturing and distribution processes. Since the 1st industrial revolution begun with the use of the steam powered engines, industrial production has seen a huge leap frog till the beginning of fourth industrial revolution. Now with the introduction of I4.0, industries are going to be transformed completely. This article comprises a literature review on recent research results analysing the meaning and elements of Industry 4.0. The aim of this research paper is to give an overview and develop an understanding of the concept of I4.0, its drivers, and components. This paper also provides an overview of government roles and initiatives taken in order to promote the use of technology and digitalization in manufacturing and production.

Keywords

Industry 4.0, Internet of Things, (IoT), Cyber-physical system, Smart manufacturing, 3D printing.

1. Introduction

The term 'Industry 4.0' was firstly coined in 2011 at the Hanover Trade Fair in Germany to showcase the competitive strategy model of the European Union governments and industries in relation to other international markets. Since this point in time Industry, 4.0 is a point of discussion among industrialists, researchers, technical experts, and many others. Now, in the era of industrial digitalization, companies are proactively investing in tools and technologies that allow their manufacturing and production processes, machineries, human resources, and even the product itself, to be integrated into a single integrated

network for data analytics, evaluation of company growth, and efficient performance.

Essentially, the industrial revolution means far more than technological improvements in reality. The word "revolution" refers to an abrupt and drastic changes in operations and management. I4.0 is also going to transform into whole industrial scenario. In order to remain effective and relevant in a global environment, manufacturers, and producers need to constantly update and upgrade their production system technology and accommodate the changing taste of consumers. We can also find that Network readiness index, India lags much behind Developed nations and few developing nations as well. This is the area where government needs to work upon. Tech-oriented strategy, good Industrial policy, and infrastructure development are highly expected from the government end. The purpose of this study is to explore the meaning and components of I4.0 in industrial production. This paper also presents a detailed literature review to explain the components of the fourth industrial revolution. Initiatives and the role of the Indian government have also been discussed in the paper.

2. History of Revolution

The 1st industrial revolution occurred in the last decades of the 18th century and entailed the mechanization of water and steam power. The 2nd revolution took place around the 1900s and was defined by mass production with assembly lines, powered by electricity. The 3rd industrial revolution started around the 1970s and represented the use of computers to further develop automated production processes and machines. The perception of Industry 4.0 or the 4th industrial revolution is symbolized by Smart Factories and the full use of digital manufacturing. (Rouse, 2018)

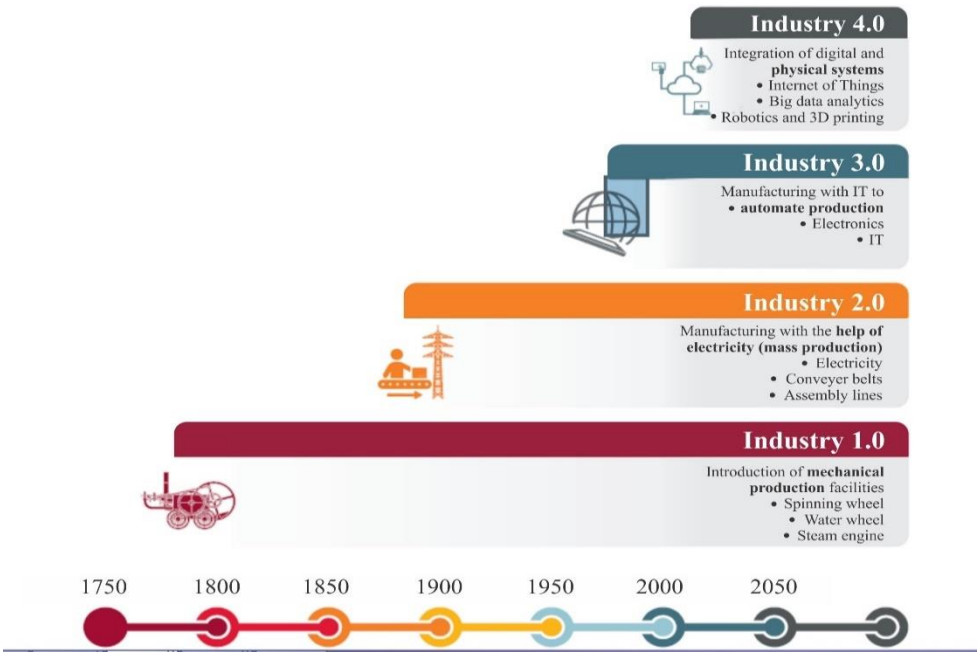

Figure 1: A History of Industrial Revolutions

Source: *Grant Thornton & CII, 2017*

For centuries, goods including food, clothing, houses, and weaponry were manufactured by hand or with the help of work animals. By the start of the 19th century, though, production started to extrude dramatically with the advent of Industry 1.0, and operations swiftly evolved from there. In the 1800s, water and steam-powered machines had been evolved to facilitate workers. At the beginning of the 20th century, electricity became the main source of energy. Easier to use than water and steam, it allowed companies to focus energy sources on individual machines. Mass production of goods with assembly lines became part of everyday routine. In the last decades of the 20th century, the invention and manufacture of electronic devices such as transistors and later integrated circuit chips allowed for greater automation of individual machines to supplement or replace operators. In the 21st century, Industry 4.0 attaches the IoT with manufacturing technologies so that systems can exchange information, analyze it, and use it for smart actions. It also includes cutting-edge technologies such as additive manufacturing, robotics, advanced materials, artificial intelligence (AI) and other cognitive technologies, and augmented reality. (Thangaraj & Narayanan, 2018)

3. What is Industry 4.0?

Various authors and organisations have defined Industry 4.0 as follows –

Table 1: Summary of Definitions of Industry 4.0

Author & Year	Definitions
(Grant Thornton & CII, 2017)	"Industry 4.0 is characterised by highly intelligent, interconnected systems that form a completely digital value chain. It is built on cyber-physical production systems, which integrate communications, information technology, data, etc. to turn traditional factories into smart factories. The objective is for machines to interact with other machines and goods in real-time, with data being processed and transmitted in real-time, resulting in significant changes across the industrial ecosystem."
(Campbell, 2018)	"Industry 4.0 creates a strong connection between machineries and their human counterparts. This new concept will have an influence on all personnel from all departments. Industry 4.0 refers to the interconnection of devices in order to establish an automated real-time manufacturing process that utilises the required data. It will transform how businesses respond to client needs and reshape the entire manufacturing chain."
(Schwab, 2016)	"Industry 4.0 is characterised by a few new technology characteristics, such as the physical, digital, and biological worlds. The advancement of technology has a considerable impact on the development plans of industries, economies, and governments. One of the most essential concepts in the growth of global industry and the global economy is Industry 4.0."
(Wang et al., 2016)	"To deal with global difficulties and raise industrial levels, Industry 4.0 makes full utilization of emerging technology and rapid development of equipment and tools. The fundamental idea behind Industry 4.0 is to implement IoT services using advanced information technologies. By using technical expertise, production can run more quickly and smoothly with less downtime. As a result, the finished product will be of higher quality, production systems will be more efficient, easier to maintain, and cost savings will be realised."

4. Components of Industry 4.0

Many technologies that are considered as the main component of the Fourth Industrial Revolution. There are nine main technological trends that are said to be primarily instrumental in shaping industrial manufacturing and production. (Gilchrist, 2016)

Boston Consulting Group also explains that in Industry 4.0, nine technologies constitute the components of the transformation. These technologies are; Big data and analytics, Robotics, Simulations, Horizontal and Vertical system integration, The Industrial Internet of Things (IIoT), Cybersecurity, Cloud computing, Augmented Reality, and Additive manufacturing. (BCG, sd)

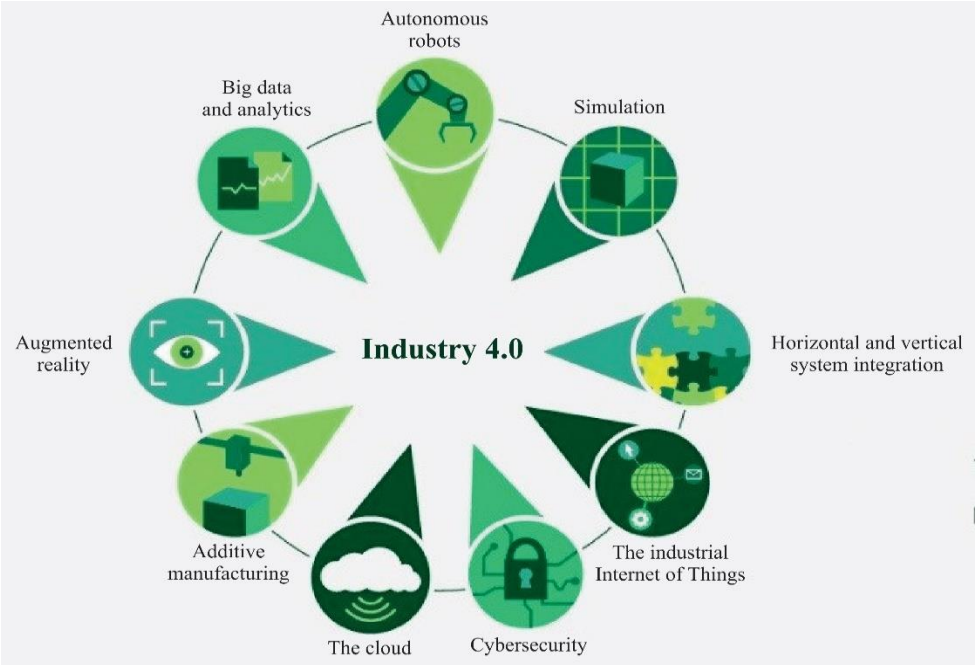

Figure 2: Nine Pillars of Industry 4.0

Source: *BCG*

4.1 Big Data and Analytics

Authors and organisations define it as follows –

Table 2: Summary of Definitions of Big Data and Analytics

Author & Year	Definitions
(Subodh, 2019)	"Data is now being acquired at an unprecedented rate from many sources. To identify hidden patterns, connections, and other insights, this massive amount of data must be deciphered. With increased processing power, we can now analyse a huge quantity of data in real time. Data collected from various sources, including production equipment and systems on the one hand, and corporate and customer management systems on the other, will need to be compiled and will eventually graduate to become the standard for supporting real-time decision making. Big data will also influence key business choices as it becomes more predictive, providing insights into causal relationships, future trends, and other factors."
(BCG, sd)	"In the context of Industry 4.0, Data gathering and analysis from multiple sources, including industrial equipment and systems as well as corporate and customer management systems, will become common practice."
(Roche, 2019)	"Data analytics, which was formerly considered an IT application, is increasingly making inroads into the industrial and supply chain industries. In the industrial industry, data analytics and pattern recognition may be used to decrease downtime and waste. Data may be gathered at various stages of the production process in our facilities."

4.2. Robotics

Authors and organisations define it as follows –

Table 3: Summary of Definitions of Robotics

Author & Year	Definitions
(Senn, sd)	"While the industrial industry has made significant progress in terms of automation in recent years, there is still a huge deal of untapped potential. Collaborative robots are intended to bridge the gap between regular robots and human workers, allowing for new automation opportunities. These robots are made to work in similar ways to people, but with the extra capability of monitoring and transmitting data."
(BCG, sd)	"Autonomous robots can interact with others and work safely side by side with humans. These robots will cost less and have an increasing range of capabilities over time."
(Subodh, 2019)	"The necessity for the manufacturing sector to boost productivity in a variety of ways is what prompted Industry 4.0 in the first place, and it will be the first workplace to have robots that will work together with people to expand current skills and capacities."

4.3. Simulations

Authors and organisations define it as follows –

Table 4: Summary of Definitions of Simulations

Author & Year	Definitions
(Senn, sd)	"Simulations leverage real-time data to project the physical world of product development and production processes in a virtual environment. These models might be used to run more efficient tests so configurations and processes are optimized before production even starts, reducing downtime and improving quality."
(BCG, sd)	"Simulations are an important part of the I4.0. They're widely employed in plant operations to make use of real-time data and to simulate the actual environment. When used correctly, these models allow users to test and improve settings in a wide range of scenarios, reducing machine setup times and improving quality."

Author & Year	Definitions
(Roche, 2019)	"In the present era, simulations are used to develop components that are being manufactured. It may be used in Industry 4.0 to create a virtual environment of the factory using real-time data and assess productivity before making a change in the factory. This allows engineers to better envision the design, allowing them to see issues and bottlenecks early on."

4.4. Horizontal and Vertical System Integration

Authors and organisations define it as follows –

Table 5: Summary of Definitions of Horizontal and Vertical System Integration

Author & Year	Definitions
(Subodh, 2019)	"Individual activities have traditionally been disconnected from other tasks in the production process. These tasks must be integrated to anticipate requirements and plan for contingencies, synchronise operations, optimise different resources, and perhaps interface with systems outside the framework in order to automate the process. This is intended to operate throughout the whole value chain to build a more coherent network by collaborating across organisations, departments, functions, and capabilities."
(Senn, sd)	"The goal of Industry 4.0 is to improve communication across the spectrum, not only between machines. Currently, many production systems aren't fully linked. Companies may become more integrated from both the external and internal sides by improving system integration. As a result, a flexible manufacturing environment will be created, enabling for real-time production adjustments and twists."
(BCG, sd)	"Companies, divisions, operations, and capacities may all benefit from Industry 4.0. The emergence of cross-company, universal data-integration networks has enabled completely automated value chains."

4.5. The Industrial Internet of Things

Authors and organisations define it as follows –

Table 6: Summary of Definitions of Industrial Internet of Things

Author & Year	Definitions
(BCG, sd)	"As part of Industry 4.0, more gadgets will have embedded computing capabilities. This method enables devices to communicate and interact with one another as well as with centralised controllers. It also decentralises analytics and decision-making, allowing for real-time reactions."
(Roche, 2019)	"IoT refers to an ecosystem in which all sensors and actuators have the capacity to work independently while communicating with each other. Industrial IoT is similar to consumer IoT, but it is more robust to sustain the harsh conditions of the industry."
(Senn, sd)	"The networking and connection of smart devices are referred to as the Internet of Things. Smartphones, tablets, and laptops come to mind when people think about the Internet of Things. Also consider wearables, vehicles, and any equipment or gadget that permits data to be sent, even our freezers. The term Industrial Internet of Things (IIoT) is used in the industrial scenario to describe this technology (IIoT). Sensors are being attached to machines and other physical assets on the factory floor to collect data that impact real-time decisions and leads to greater performance and efficiency."

4.6. Cyber Security

Authors and organisations define it as follows –

Table 7: Summary of Definitions of Cybersecurity

Author & Year	Definitions
(Senn, sd)	"As the level of connection rises, so does the chance of a cyber-attack. Any security compromise might have repercussions across the whole company, from supply chain to operational activities. Companies must stay prepared for cyber-attacks and secure their information systems and manufacturing processes at all costs."

Author & Year	Definitions
(BCG, sd)	"It's no wonder that Industry 4.0 promotes more connection and the usage of industry-standard communication protocols. As a result, protecting vital industrial systems and production lines from cyber - threats has never been as important as of now. As a result, secure, reliable networking, as well as smart machine access management and user identity verification, is critical."
(Subodh, 2019)	"The growing connection of devices, as well as the constant flow of data back and forth across open networks, makes the system vulnerable to cyber threats such as malware and spyware. It is critical to identify these risks and safeguard the data in order to retain the integrity of the functioning protocols and systems while also keeping the data's confidentiality."

4.7. Cloud computing

Authors and organisations define it as follows –

Table 8: Summary of Definitions of Cloud Computing

Author & Year	Definitions
(Subodh, 2019)	"The usage of different services through the internet, such as software development platforms, servers, storage, and software, is referred to as "cloud computing." Data sharing and functionality across systems will traverse several sites and companies, reducing communication and response times to milliseconds. More data-driven services for production and service integration will result as a result of this."
(Senn, sd)	"Cloud computing delivers expandable storage and enhanced processing capacity as industrial businesses' usage of technology and data exchange develops. The cloud also helps to reduce data silos by improving data accessibility and integrity."
(BCG, sd)	"The more production-related activities a firm takes on, the more data must be shared between locations. Meanwhile, cloud computing is becoming quicker and more powerful. Machine data and analytics will increasingly be deployed to the cloud, allowing for more data-driven services for manufacturing and production systems."

4.8. Augmented Reality

Authors and organisations define it as follows –

Table 9: Summary of Definitions of Augmented Reality

Author & Year	Definitions
(Senn, sd)	"Augmented reality (AR) uses a device like a phone or special eyewear to show digital material in the actual world. This technology has a variety of applications in the industrial business, including safety training, streamlined logistics, and maintenance**."**
(Roche, 2019)	"The IT sector is being ravaged by augmented reality-based technologies. A few years ago, they were used only in flight simulators. Remote repair instructions may now be transmitted to virtually any location on the planet with an internet connection. It allows technicians to improve their abilities by repeatedly performing high-end repairs and maintenance using augmented reality."
(Subodh, 2019)	"AR is still in its early stages, and public adoption is just now gaining traction. It overlays a virtual layer on top of real-world elements to provide more information and dimensions for better comprehension and visualisation. It is expected to give real-time information to workers and users, leading to better decision-making and work processes."

4.9. Additive Manufacturing

Authors and organisations define it as follows –

Table 10: Summary of Definitions of Additive Manufacturing

Author & Year	Definitions
(BCG, sd)	"3D printing is the most well-known example of additive manufacturing. Companies may now create small quantities of customised items instead of prototyping individual components. The advantages include the ability to quickly manufacture complicated, lightweight designs."

Author & Year	Definitions
(Roche, 2019)	"Additive manufacturing techniques such as 3D printing are already being used by businesses to create prototypes and proof of ideas. Industry 4.0's versatility allows us to create sophisticated designs that would be almost difficult to create using traditional production techniques. The majority of traditional manufacturing methods are subtractive, resulting in the waste of raw materials. Additive manufacturing significantly lowers, if not completely eliminates, raw material waste."
(Senn, sd)	"While businesses are aiming to increase their usage of additive manufacturing in their processes, 3D printing technologies are already playing a major role in three main areas: design, prototyping, and low-volume production**."**

5. Initiatives of Indian Government

If a country wants to emerge as a techno-giant and global leader in terms of production and manufacturing, it needs to work upon strengthening its industrial production by adopting the latest technological advancements. For a democratic country, where capitalism and socialism have equal values and existence, support from the government is highly expected to adopt such technologies. This support could be expected in different forms. Being a policy-maker, the government needs to adopt and demonstrate a proactive role as an enabler and facilitator to promote the adoption of industry 4.0 by the industries. The globalization and tremendous competitiveness are forcing nations to rethink and innovate their production and manufacturing processes by adopting the technologies of Industry 4.0. With the 'Make in India' initiative government has taken a bold step to boost Industrial production with the consistent development of IT and infrastructure.

In the Industry 4.0 revolution, the Indian government plays the position of a crucial stakeholder. Moving India's MSMEs sector to the forefront of I4.0 will require significant efforts in terms of resources, infrastructure, know-how, and exposure areas where government intervention will have a significant impact and the benefits of Industry 4.0. Furthermore, the role of government in the history of Industry 4.0 in India goes far beyond the mere empowerment of the MSME segment. Given the important role of advanced technologies in Industry 4.0, it is

required to demystify the core competency requirements of I4.0 through education and skills. The government's role as an enabler is not only to expand support for manufacturing, but also to take reform measures to encourage broader technology adoption. Based in countries like Germany, the central government could propose suitable regulatory frameworks, develop a competitive spirit and create a conducive political environment for a conducive I4.0 ecosystem in the country. For the effective implementation of I4.0, the government may also play an important role in encouraging employment and closing skills shortages. The government needs to ensure that I4.0 is accessible to the MSME segment, the India Inc. segment, which includes approximately 60 million companies and accounts for 45 percent of the country's total manufacturing output. (Jadhav & Mahadeokar, 2019)

In his speech on the 22nd of September in Houston, Texas, Prime Minister Shri Narendra Modi emphasised the importance of 'Industry 4.0' in the global economy and India's advantage. The Modern Coach Factory (MCF) in Raebareli is launching a pilot project to introduce "Industry 4.0" to the country. By establishing a pilot implementation at MCF, Raebareli, the Ministry of Railways and the Department of Science and Technology have collaborated with IIT Kanpur to embark on a unique Industry 4.0 initiative. The full transition to a digital factory using 'I4.0' across the entire value chain from designing to production will greatly improve productivity by providing an insight into the production process to make real-time decisions, minimising human errors through effective monitoring, and ensuring that resources are put to the best possible use as measured by the Overall Equipment Effectiveness (OEE). (Press Information Bureau, 2019)

India was ranked 61 on the Network Readiness Index in 2013. India was rated 91st out of 139 nations in 2016. India ranked 91st, ahead of a few nations such as Pakistan (110) and Bangladesh (122), but below its neighbours Sri Lanka (63), Malaysia, (31), and China (32). (59). for the second year in a row, Singapore topped the rankings. The United States came in fifth place. The World Economic Forum's study makes it apparent that there is a significant difference between industrialised and developing countries due to a variety of causes. According to the report, the digital economy has separated industrialised and developing countries into two groups. The rankings of the top-ranked industrialised countries, such as the United States and Singapore, are nearly constant. However, several emerging countries, particularly India, saw their rankings fall. (Grant Thornton & CII, 2017)

According to the 2016 UNIDO International Yearbook of Industrial Statistics, with a ranking that has improved in three places, India now

ranks sixth among the 10 largest producing countries in the world. India is no exception to this worldwide trend, and its proportion of global manufacturing GDP is continuously growing. All leading countries are taking important initiatives to promote manufacturing by adopting Internet and information technology advancements. The German government announced "Industry 4.0", while the governments of China and India have their own programs focused on "Made in China 2025" and "Made in India" respectively. The goal is to encourage global companies to select India to manufacture their products. With an abundance of outdated regulations and underdeveloped infrastructure, the government is aiming more at enabling policies and improving infrastructure for certain key sectors. According to the IBEF, the Indian government has set a progressive target of maximising the contribution of manufacturing from the current 16 percent to 25 percent of gross domestic product (GDP) by 2025. Globally, the market is expected to I4.0 reach INR 13.90.647 billion by 2023.1. Countries like the US, China, Japan, and European nations like the UK, Ireland, Sweden, and Austria have started adopting I4.0. In India, the 6th largest manufacturing country, the manufacturing industry is an essential part of the country's long-term vision, as evidenced by the government's strong focus on the Make in India campaign. (Kalaria, 2020)

The government focuses to increase the share of the manufacturing sector in GDP from the current 17 percent to 25 percent by 2022, which has been taken over by the government. India is currently lagging behind its global competitors in adopting I4.0. A significant part of India's manufacturing sector is still in the post-electrification phase, with technology limited to systems operating independently of one another. The core assumption of I4.0, the integration of CPS on cyber platforms, is still in its initial phase. Furthermore, due to the high-cost barrier, the Micro, Small, and Medium Enterprises (MSME) group has limited access to automation technologies. (Jadhav & Mahadeokar, 2019)

6. Discussion and Conclusion

Understanding the fourth Industrial Revolution and its disruption potential are critical for all nations and especially the developing countries. India has potential to become a global leader in terms of manufacturing by adopting digital technologies. Since the adoption of these technologies is in its infancy, the government and industries need to embrace them with open hands. An initiative like “Make in India” is also a point of attraction for foreign industrialists. If we look at the Indian population we find that it could be a favourite destination for the producers of capital and consumer goods. There is always been a good

scope of demand and market expansion. Further, India needs to work more on strategic planning for incentivizing the adoption of digital technologies and developing the requisite digital ecosystem, especially in regard to industrial manufacturing.

This paper primarily focuses on the concept of the fourth industrial revolution and also presents an overview of its components. The nine pillars of I4.0 explain the multiple dimensions of technology with examples to understand the application of I4.0. I4.0 allows smart, efficient, effective, integrated, autonomous, individualized, and customized production at a reasonable cost. In short, we can summarize that I4.0 is the future of global manufacturing due to having such unique features. Industries that require a higher a degree of flexibility due to having a high level of product variants, such as the automotive and food-and-beverage industries, will get the most benefit from these technologies.

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