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Industry 4.0: An Indian perspective

Anbesh Jamwal¹[0000-0003-4025-7145], Rajeev Agrawal¹, Monica Sharma^{1,2}, Saurabh Pratap³

¹ Department of Mechanical Engineering, Malaviya National Institute of Technology, Jaipur, India

² Department of Management Studies, Malaviya National Institute of Technology, Jaipur, India

³ Department of Mechanical Engineering, Indian Institute of Technology-BHU, Varanasi, India

ragrawal.mech@mnit.ac.in

Abstract. Industry 4.0 technologies have changed the manufacturing trends in global industries. Industries are adopting Industry 4.0 business models to complete mass customized demands and to compete with global industries. Industry 4.0 can be considered as the current trend of data exchange in manufacturing processes and automation. In India, Industry 4.0 is in its initial stages where the terms digitalization and Industry 4.0 are more widely accepted than fourth industrial revolution. The research work on Industry 4.0 is still limited in India. However, the Government of India has launched some policies and initiatives related to Industry 4.0 and its technologies. The main aim of this paper (1) to provide the more depth insight about the Industry 4.0 and similar terms. (2) to suggest the policies related to India for the transition to Industry 4.0. Indian industries should consider the Industry 4.0 practices seriously as they are shifting their business models from traditional to Industry 4.0 business models. Some issues related to Industry 4.0 implementation like cyber security, machine-to-machine interaction, reliability and stability of CPS should be considered in a better way. In this paper we have discussed about the different initiative by Government of India related for Industry 4.0 technologies. There is need to work on (1) Initiatives related to high investments and technological developments in SMEs and MSMEs industry sectors (2) Identification of infrastructure facilities required for Industry 4.0 and current readiness score of industries. (3) Initiatives related to awareness about Industry 4.0 benefits for industries as well as society.

Keywords: Industry 4.0; fourth industrial revolution; policies; challenges; sustainability; India

1 Introduction

The fourth industrial revolution is also known as Industry 4.0 which is current trend of data exchange and automation in industries [1]. In past few years, Industry 4.0 is emerged as an emerging area of interest for both academics and industries. “Smart manufacturing” is known as the central element for Industry 4.0 which considers the integration of manufacturing activities within the industry, includes supply chain activities and product life cycle [2]. The Industry 4.0 relies on the data gathering from manufacturing activities within industry, intelligent decision making based on data analytics and provide useful information for further actions [3]. The main key enabling

technologies for Industry 4.0 are CPS, machine learning, BDA, deep learning, blockchain technology, Internet of things (IoT) and cloud computing [4]. In Industry 4.0 “smart factory” can be referred to transition from traditional automation to fully flexible and connected manufacturing systems in which data from manufacturing activities can be used to learn and adapt the dynamic changes in market [5]. In the smart factories the term “Cyber physical systems” can be referred to monitor the physical activities and processes in the industry, make decentralized and intelligent decisions, create a virtual space of physical entities. The term “IoT” can be referred to CPS which can cooperate and communicate with humans as well as each other in real time with the help of internet services [6]. Global industries are now adopting Industry 4.0 practices to meet global standards and maintain market reputation [4, 7]. The concept of Industry 4.0 is widely accepted in both developing and developed nations [2]. However, few countries have achieved sustainability in Industry 4.0 practices while some are still struggling with the roadmap developments for Industry 4.0 [8]. India can be considered as a major manufacturing hub which manufacture in which automobile sector is main. Indian industries are now focusing on the implementation of Industry 4.0 technologies and practices [9, 10]. However, the term “fourth industrial revolution” is more familiar and appealing than “Industry 4.0” in most of countries and it has different level of acceptance [11]. It is true that we are in the initial phases of fourth industrial revolution where basic requirement is automation and digitalization of industries [12]. Advanced technologies like artificial intelligence, machine learning, deep learning and blockchain technology can be acts as an enabler for the transition of industries from Industry 3.0 to fourth industrial revolution. The terms “Fourth industrial revolution” and “Industry 4.0” are the same or there is any difference between these terms? Can we use these two terms interchangeably? In the present study we have used the “Industry 4.0” as the representative term to investigate whether these two terms are similar or there is any difference between these terms? What are the different policies for Industry 4.0 in India? These all questions have been addressed in this study. In the next section of paper, we have discussed different Industry 4.0 technologies, various challenges and enablers, design principles and value drivers for the better understanding of Industry 4.0 concept. In the last section of paper, we have discussed various policy and implications related issues for Indian industries.

2 Industry 4.0

2.1 Definition and concept in literature

The term “Industry 4.0” was firstly coined at the Hannover fair, Germany in 2011 which has gained attention from practitioners, policymakers, politicians, government officials and researchers all over the world [1]. Basically, Industry 4.0 is driven by main disruptions are: IoT, additive manufacturing, BDA, machine learning, artificial intelligence, blockchain technology which are providing the digital solutions to the manufacturing organizations [4]. Industry 4.0 is characterized by the mass

customization of products within highly flexible and reconfigurable manufacturing systems [7].

In this context there is need for digitalize and redesign traditional manufacturing/production systems for the transition of Industry 4.0 from Industry 3.0. Also, the concept of Industry 4.0 is linked with the other emerging concepts e.g., circular economy, bioeconomy, green economy. Besides this, Industry 4.0 promises for shorter delivery time, higher quality products, more automated and efficient manufacturing systems, profitable and smart products and agility in production systems to handle volatile market demands [13]. These above characteristics and key enabling technologies are not the reason for “4.0”. However, it is true that this is major fourth upheaval in the manufacturing sector after the lean production systems revolution (1960s), flexible manufacturing systems (1980s), reconfigurable manufacturing systems (1990s), Automation and agent-based manufacturing (2000s). Most of digital technologies associated with Industry 4.0 have been developed few years ago and some of them are still not ready for use up to scale in most of developing nations. Few studies reported that these technologies are reliable and cost effective for some specific industrial applications in manufacturing sector [14, 15]. Table 1 shows the different key enabling technologies of Industry 4.0

Table 1. Different Industry 4.0 technologies with their description and benefits to industries

| Key enabling technology | Description | Benefits to industries |
|----------------------------------|--|--|
| Digital Twin | Digital twins are real time virtual representation of processes or physical entities in a system. These are virtual model of a product, process or service | Reliability improvement, productivity, reduce market reputation and product availability risks |
| Big data analytics | Big data analytics helps to extract to useful information from large volume of data. | Improved operational efficiency and customer satisfaction |
| Blockchain Technology | Blockchain technology is a decentralized and distributor ledger which records the provenance of digital asset | Reduced costs, better transparency, enhanced security |
| Cloud computing | Cloud computing is delivery of computing services which includes: storage, servers, software, analytics and database | Increased collaboration, quality control, cost savings |
| Internet of things | Internet of things defined as networking of physical objects embedded with sensors or software's | Cost reduction, mobility and agility |
| Artificial intelligence | It is the simulation of human intelligence processes by machines | Reduction in human errors, faster decisions |
| Machine learning & Deep learning | Machine learning is a approach for data analysis which automate analytical model development. Deep learning is the class of machine learning approaches uses multiple layers for data extraction | Optimization, conditional monitoring, predictive maintenance, simulation and modeling |

| | | |
|---|---|--|
| Additive manufacturing | Additive manufacturing is 3D printing process focus on layer-by-layer manufacturing for lighter and stronger parts | Cost reduction, mass customization, waste reduction |
| Flexible and Reconfigurable manufacturing | Flexible manufacturing systems can easily adapt the changes in quantity and type of manufacturing. Reconfigurable manufacturing systems helps to adapt the dynamic changes in market. | Cost reduction, quality improvement, customer satisfaction |
| AR and VR technologies | AR and VR technologies helps to bridge gap between physical and virtual world | Risk reduction, training |

Manufacturing in Industry 4.0 means machines are intelligent enough to operate themselves and adapt the dynamic changes in market [16]. Machines in Industry 4.0 considered as an independent entity which focus on data collection, analysis and intelligent decision making [17]. The concept of self-optimization, self-customization and self-cognition have made this possible through which manufacturers can communicate with the computers also. Smart factory can be considered as one of key feature in Industry 4.0 [18]. The term “Smart Factory” in Industry 4.0 describes highly connected and digitalized environment where the equipment and machines are able to improve the process with the help of self-optimization and automation [19].

2.2 Value drivers, design principles and challenges in Industry 4.0

Industry 4.0 is one of the emerging concepts in the developing nations and delivering values to industries and manufactures. To experience the benefits of Industry 4.0 in developing nations there is need to consider both the role and opportunities of Industry 4.0 in industries [4, 9, 10]. In Industry 4.0 large amount of data is generated from manufacturing processes and activities which needs to processed and refined with the advanced analytical tools. For this purpose, machine learning and deep learning tools are the suitable approaches [14, 15]. Considering the current manufacturing scenario, it is important to focus on tool wear rate, predictive maintenance and machine degradation issues. Which type of data can be useful for the future reference and use? Which technology will give the most return in the investment and which technologies are not suitable for industry?

To answer such type of the questions a digital compass can be used presented in the Figure 1 which consists of eight main drivers of Industry 4.0 with 26 levers. Further, the design principles of Industry 4.0 can be divided into four main categories which can be classified as: (1) Technical Assistance (2) Interconnection (3) Decentralized decisions and, (4) Information transparency. Further, we have identified key barriers and enablers to Industry 4.0 implementation to Industry 4.0 which is shown and discussed in the Figure 2.

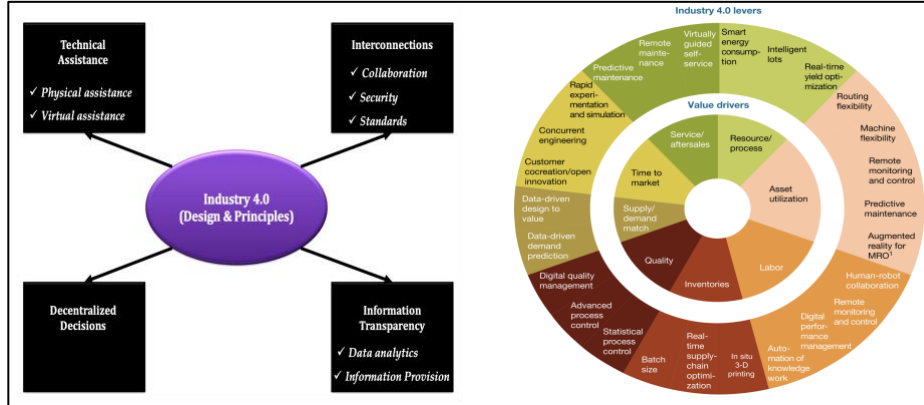


Fig. 1. Industry 4.0 design and principles, value drivers (Adapted from: [20])

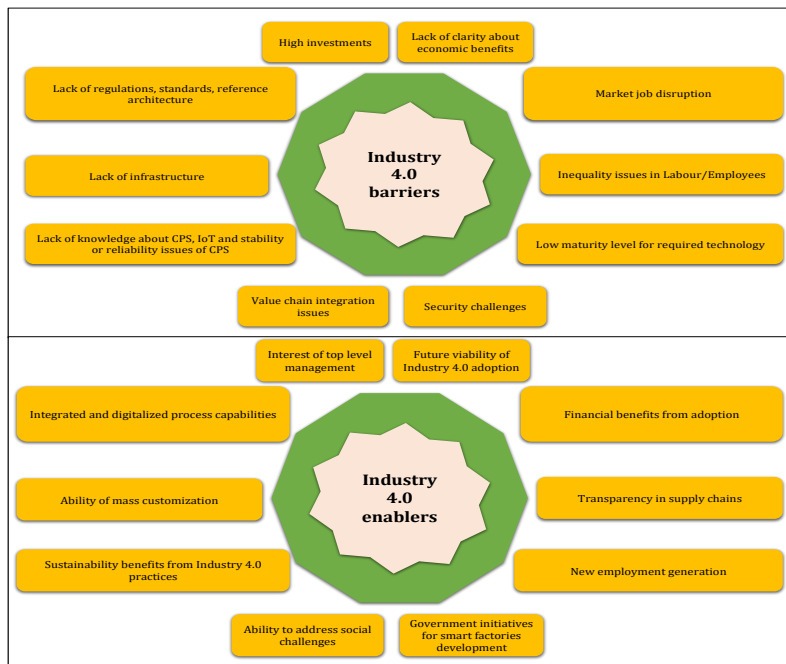


Fig. 2. Industry 4.0 implementation enablers and barriers (Adapted from: [4, 9, 10, 21])

3 Discussion and policy implications for Industry 4.0 for India

In India, the concept of digitalization is more popular than the Industry 4.0 and fourth industrial revolution because Government of India is promoting the concept of “Digital

India” to draw more attention of industries and stakeholders [22]. Also, “Digital India” concept is also helping the people to be prepare for digital technologies. Social media and other media platforms are also promoting the concept of Industry 4.0 and related technologies for the adoption of new industry practices [23]. MNCs are now investing more for Industry 4.0 in the India due to cheap labour and government policies related to Industry 4.0 [9, 10]. However, some of the researchers are also very concerned with the Industry 4.0 research trend in India since the Industry 4.0 and related technologies has not been clearly defined. Now the various industries are adopting the Industry 4.0 practices in India [24, 25].

Several studies reported that the developing nations like India still lacks in positive attitude, management support, skilled labour and infrastructure for Industry 4.0 practices adoption [9, 10]. There is need to rethink on the social, economic and environmental aspects of Industry 4.0 [26]. However, some studies reported the consideration of these three aspects in the framework development for Industry 4.0 practices for India [4, 9, 10, 27]. But these studies have some limitations and applicability in case of SMEs and MSMEs sectors. These points should be considered for the Indian industries to the shift towards the Industry 4.0 adoption. The ranking of developing and developed nations working for the Industry 4.0 is shown in the Table 2. In the results it can be seen that India is ranked at 91 and this ranking is low as compared to other developing nations.

Table 2. Global competitiveness ranking for Industry 4.0 (Adapted from The Global information Technology Report [12])

| Rank | Nation | Network Readiness Index | Environment Index | Readiness Index | Usage Index | Impact Sub-Index |
|------|---------------|-------------------------|-------------------|-----------------|-------------|------------------|
| 1 | Singapore | 6.0 | 6.0 | 6.1 | 6.0 | 6.1 |
| 2 | Finland | 6.0 | 5.6 | 6.6 | 5.8 | 5.8 |
| 3 | Sweden | 5.8 | 5.3 | 6.3 | 5.9 | 5.8 |
| 4 | Norway | 5.8 | 5.5 | 6.4 | 5.8 | 5.6 |
| 5 | United States | 5.8 | 5.3 | 6.4 | 5.8 | 5.8 |
| 6 | Netherlands | 5.8 | 5.5 | 5.9 | 5.9 | 6.0 |
| 91 | India | 3.8 | 3.7 | 4.4 | 3.3 | 3.6 |

European countries are more focused towards the Industry 4.0 practices. However, some studies have reported the consideration of sustainability aspects in Industry 4.0 practices in these countries [2, 8]. The developed nations have higher adoption level for Industry 4.0 practices because of infrastructure and technological advancements as an enabler and this acts as barrier for developing nations like India [4]. The main requirement for Industry 4.0 practice is shop floor digitalization and automation which is still missing in most of SMEs of developing nations [12]. These nations need to rethink and revisit their manufacturing systems in order to implement the Industry 4.0 practices effectively. In the European countries main participants for Industry 4.0 roadmap developments are universities, research institutes, central government and stakeholder’s support. This example of the developed nations can provide the guideline for roadmap development for Industry 4.0 for India. It is true that Industry 4.0 implementation barriers, policies and drivers are highly dependent on the geographical region but the theories for Industry 4.0 are same all over the globe. In the Table 3 we

have discussed the plans and initiative by Government of India for Industry 4.0 technologies.

Table 3. Initiatives by Government of India related to Industry 4.0 technologies

| Ministry | Initiative |
|--|---|
| Ministry of HRD | ICTs, National Digital Library, Shodhganga, Virtual Lab project |
| Ministry of Heavy Industries | Smart advanced manufacturing and rapid transformation hub (SAMRATH) |
| Department of Science and Technology | National mission on interdisciplinary Cyber physical systems |
| Ministry of Electronics and IT | Digital India for digitalization |
| NITI Aayog | National strategy on Artificial intelligence |
| NITI Aayog | Blockchain: The India Strategy |
| Ministry of Agriculture | RFID and Blockchain in Animal Husbandry and Dairying |
| Ministry of Electronics and Information Technology | National Strategy for additive manufacturing |
| Ministry of Electronics and IT | National cloud initiative of MeghRaj |
| Ministry of Electronics and IT | Cyber Swachhta Kendra |
| Department of Science and Technology | Cognitive science research initiative |
| Department of Science and Technology | Big data initiative |

As we have found that some of the initiatives are not clearly elaborated and defined and some of initiatives are still in their initial stages which requires coordination between the industries, stakeholders and ministries for respective initiatives. Indian government is quite aware about the digitalization concept and role of digitalization for the development of Industry 4.0 practices but still some of the initiatives are at initial stages and requires high level of effort for successful implementation. The following policies are suggested for the implementation of Industry 4.0 practices effectively in the India:

(1) The policies and strategies by the Government of India should be refined for the Industry 4.0 implementation and more elaborated towards the sustainability in manufacturing systems. In depth analysis of policies by Government of India for Industry 4.0 shows that industries and concerned stakeholders are recognizing the unfavorable conditions for social and economic aspects. (2) Initiatives related to high investments and technological developments in SMEs and MSMEs industry sectors. (3) Identification of infrastructure facilities required for Industry 4.0 and current readiness score of industries. (4) Initiatives related to awareness about Industry 4.0 benefits for industries as well as society. (5) There is need of concrete workplans which can help for the shift towards social and economic systems in Industry 4.0. (6) There is need of collaboration of local governments, SMEs, MNEs, MSMEs sector, universities and re- search institutes for Industry 4.0 awareness and establishment of required infrastructure. (7) There is need of sustainable scheduling and process plans to maximize the efficiency of operating systems. (8) There is need to minimize the polarization which may be occur due to the job loss or job change due to implementation of Industry 4.0 (9) To prepare and respond new workforce with required skills for Industry 4.0 and formulation of plans, roadmaps for effective

implementation of Industry 4.0 practices in India. (10) A collaborative platform for everyone where the effectiveness of policies and coordination among the different sectors can be ensured.

4 Summary and Conclusion

The main objectives of this paper are: (1) Detailed analysis and understanding of various technologies about the Industry 4.0 (2) Policies recommendation for Indian industries for the transition to Industry 4.0. Indian industries are now adopting the digital technologies in their industries. The term “Digitalization” and “Industry 4.0” is more acceptable in India than “fourth industrial revolution” because these terms look more familiar with the different cases and scenarios in India. It is true that we are in the initial stages of fourth industrial revolution which builds on digitalization and automation in manufacturing. However, the initiatives from Indian government are now addressing these challenges and technologies in a better way through the various programs. Industries from India needs to consider Industry 4.0 as a serious issue because in India the manufacturing sector is largely dependent on SMEs which are still following the traditional approaches. Some major issues like Machine-to-machine interaction, blockchain, high computation power, cyber security and reliability and stability of CPS should be taken care in a better way for the implementation of Industry 4.0. We have discussed the different initiative of Government of India and policies recommendation in the third section of study. In India, SMEs plays a significant role in development of the economy, the innovations in MNEs is also largely dependent on the SMEs. There is need to coordination between the SMEs in order to implement the Industry 4.0. Thus, it can be stated that digitalization of shop floor and automation is the main requirement for the implementation of Industry 4.0 in SMEs in India.

Like every research we have some limitation in this study. This study doesn't provide the validate empirical findings to support the policies implications as very few studies have been conducted on Industry 4.0 and most of them are not validated because in India Industry 4.0 is in initial stages. The policies recommended are based on the initiatives, developed nations and literature available. However, we have followed the reports and research findings presented in different seminars and awareness programs. Second, the difference between the synonyms of Industry 4.0 is provided but rationale is not well grounded. The reason behind this, mostly authors have used and using these terms interchangeably. The reliable statistics of actual progress about the Industry 4.0 implementation is not provided because most of the reports on the actual progress are not validated or empirically proven. This research can be extended in the different directions for Indian industries. In the future the impact of Industry 4.0 on the business, economic, social and environmental perspective can be investigated for SMEs or MSMEs. Inter country comparison can be also done for the Industry 4.0 practices in future. However, some studies have shown these cases but these studies having some limitations and limited applicability. This will help to find out the common driver and feature of Industry 4.0 for each nation because the theories related to the Industry 4.0 are same across the globe.

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