

Industry 4.0 – Digital Transformation, Challenges and Benefits

Monika Gadre
Assistant Professor, BBA(CA), MIT WPU, Pune

Dr. Aruna Deoskar
Principal, ATSS CBSCA

Abstract

The purpose of this paper is to study the basics of Industry 4.0, the trend towards automation and data exchange in manufacturing technologies and processes. This paper highlights the strategic roadmap that can serve manufacturers as a simple guide for the process of Industry 4.0 transition.

Digital technology has transformed the industrial and manufacturing world. To keep pace with the fast-growing technological enhancements accompanying Industry 4.0, there is a great need to evolve and change the way we work. We now stand on the crossover of this new era, where machines acquire human characteristics, including cognitive capabilities. Therefore, the question is - Are we ready for Industry 4.0? In addition, what are the challenges that we will face in the near future? Index Terms – Industry 4.0, automation, challenges, benefits

I. INTRODUCTION

Modern industry has seen countless developments since the industrial revolution in the 18th century. Manufacturing of goods, tools, clothes, weapons was manual, which changed in the end of the 18th century with the introduction of manufacturing processes. The progress from Industry 1.0 was then rapid up to the upcoming industrial era – Industry 4.0. The emergence of Industry 4.0 has come up with the rapid development of technology on one hand, and socioeconomic factors on the other. This paper provides an overview of this evolution, along with its challenges and benefits.

II. HISTORY OF INDUSTRY 4.0

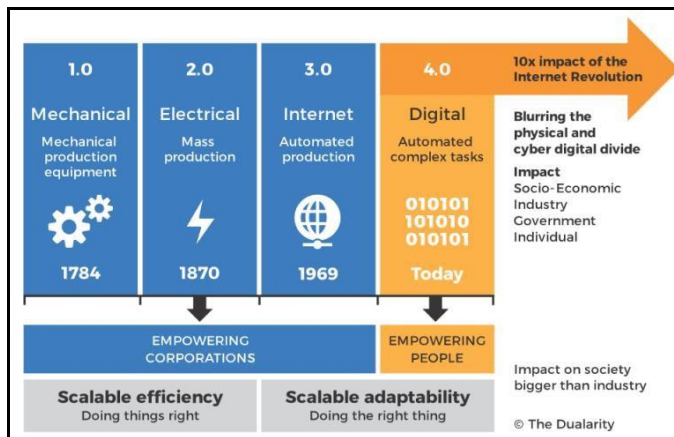


Fig. 1 Journey from Industry 1.0 to Industry 4.0

(Source: www.theduality.com)

Industrial Revolution is a period of major industrialization and innovation where change from an agrarian and handicraft economy to one dominated by industry and machine manufacturing had started. Industrial revolution is the paradigm shift in production technology [1]. It has shaped the societies we live

in today. The working conditions and lifestyles of the people have changed with the latest production technologies. The history of industrial revolution has been explained below:

The period between 1760 and 1820 is referred as the first industrial revolution i.e. Industry 1.0. It marked a transition from hand production methods to machines with steam and waterpower.

Industry 2.0, the second industrial revolution, the technological revolution is the period between 1870 and 1914. The main contributor to this revolution was the development of machines running on electrical energy. The first assembly line where streamlining the process of mass production was also introduced, which later on became a standard practice. The third industrial revolution or Industry 3.0 occurred in the late 20th century. It is also known as digital revolution because of the extensive use of computer and communication technologies in the production process.

Industry 4.0, or as is originally termed - “Industrie 4.0” [2] was the concept that originated in Germany. Industry 4.0 is a national strategic initiative from the German government through the Ministry of Education and Research (BMBF) and the Ministry for Economic Affairs and Energy (BMWi). It aims to drive digital manufacturing forward by increasing digitization and the interconnection of products, value chains and business models. Industry 4.0 leads to the digitalization era.

Industry 4.0 is the turning point to end conventional manufacturing. It resulted in merging the boundaries of physical and the virtual world to create Cyber Physical Systems. [3] Industry 4.0 means connectivity, and it will give an opportunity to change the way industry responds to the needs of society. Unlike previous industrial revolutions were led by innovations in manufacturing processes and systems, the advancements of Industry 4.0 are driven by smart, interconnected, pervasive environment.

Following table gives a summary of the four industrial revolutions, period and the features of each:

Table 1: Industry 1.0 to 4.0

Industry Revolution	Period	Features
Industry 1.0	1760-1840	☐ Water and steam powered mechanical manufacturing
Industry 2.0	1870-1914	<ul style="list-style-type: none"> • Mass production using electricity • Assembly line – division of labor
Industry 3.0	20 th century	☐ Digital Revolution – Extensive use of Computers
Industry 4.0	21 st century	☐ Virtual System, Cyber world, Internet of Things, Artificial Intelligence

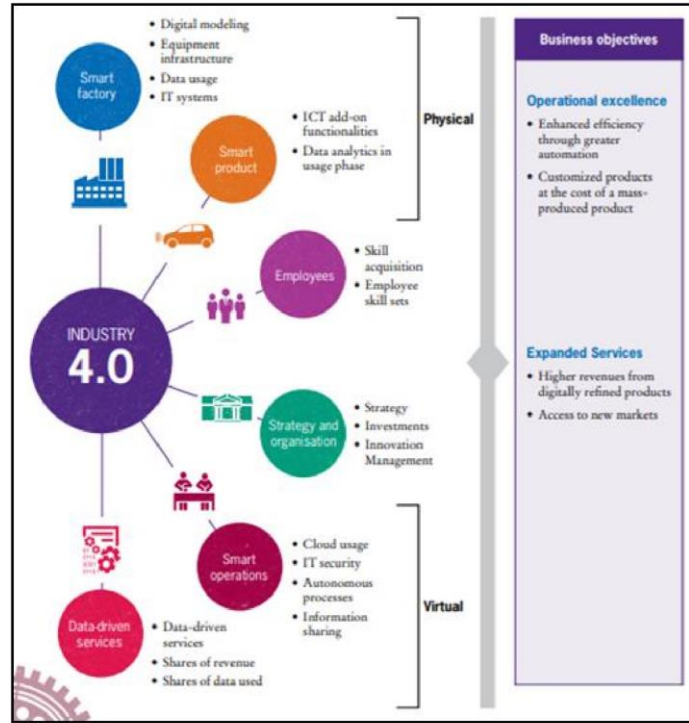


Fig. 2 Industry 4.0 - fusion of the physical and virtual worlds

III. LITERATURE REVIEW

As per National Science Foundation's (NSF) report 2017, the development of Industry 4.0 will likely follow an incremental approach in growing from the existing technologies. There has been an exponential progression in researches and publications on Industry 4.0 by academicians and Industrial experts. However, there are certain grey areas related to industry 4.0, which need great attention and can be the opportunities for further research.

Several research opportunities have been identified and presented below:

Table 2: Findings based on studied literature

S.No	Findings
1.	Industry 4.0 – A Glimpse (Saurabh Vaidya, Prashant Ambad, Santosh Bhosle) [4] Nine components of Industry 4.0 - Autonomous robots, big data, augmented reality (AR), additive manufacturing, cloud computing, cyber security, IoT, system integration, and simulation

2.	India's Readiness for Industry 4.0 (Global Innovation & Technology Alliance (GITA)) [5] <ul style="list-style-type: none">• Digital technologies are reshaping the industries in India• Tremendous opportunities for manufacturers to optimize operations quickly and efficiently <input type="checkbox"/> Need for a highly trained and flexible workforce
3.	Industry 4.0 technologies: implementation patterns in manufacturing companies [6] (Alejandro Germán, Frank Lucas Santos, Dalenogare Néstor Fabián Ayala) There is a gap between existing manufacturing units and the one needed for Industry 4.0 <input type="checkbox"/> Need for Internet-connected machinery to monitor and improve manufacturing process.
4.	Smart factory for Industry 4.0: A review (Elvis Hozdić) [7] <ul style="list-style-type: none">• Smart factory is highly digitized and connected production facility• Smart factory is an integral part of Industry 4.0 <input type="checkbox"/> It helps improve quality, enhances productivity and cost effective.

IV. OBJECTIVES OF THE STUDY

The objective of the study is:

1. To understand what is Industry 4.0.
2. To identify the challenges of Industry 4.0.
3. To explore the benefits and applications of Industry 4.0.

V. BUILDING BLOCKS OF INDUSTRY 4.0

Industry 4.0 is the integration of data, artificial intelligence, machinery and communication. To create an efficient industrial ecosystem, industries must be both automated and intelligent. However, the technologies that are the foundation for Industry 4.0 are already in use in manufacturing industries. However, integrating them together will enable to transform the production with Industry 4.0.

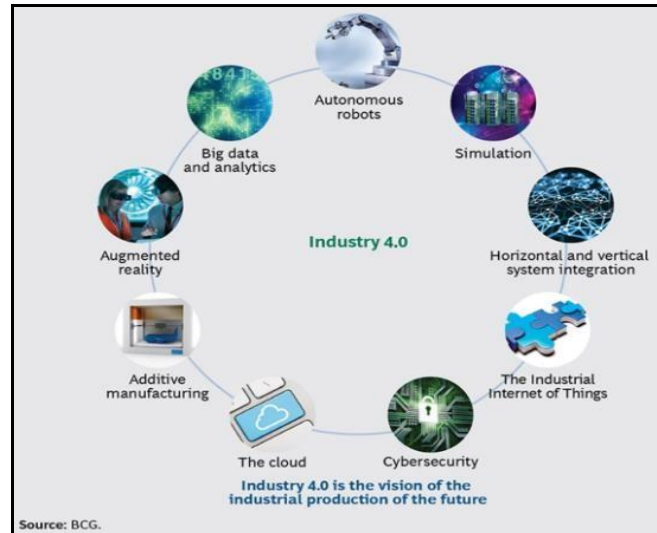


Fig. 3 Pillars of Industry 4.0

(Source: Report from the Boston Consulting Group (BCG)) KPMG-AIMA Report (2018) defines the technology levers or enablers for Industry 4.0 [8], as under:

1. **Internet of Things (IoT):** establishes a connected value chain by networking machine to machines.
2. **Cloud Computing:** provides huge storage, networking and computational capabilities enabling interaction between technologies.
3. **Big Data and data analytics:** creates capabilities to support intelligent and real-time decision-making, and reducing the downtime and wastage.
4. **Additive Manufacturing or 3D Printing:** Reduces leadtime from product design to release, permitting customization, and small batch production in a costeffective manner.
5. **Augmented Reality:** Uses mathematical modelling, artificial intelligence and virtual reality to enhance business generation.
6. **Robotics:** Improves efficiency through automated manufacturing processes.
7. **Cyber security:** ensures secured communication protocols enabling data security.
8. **Machine Learning:** exploits industrial sensors and instruments to record and communicate data directly with software.
9. **Simulation:** the imitation of the operation of a real-world process, which would help to visualize the design and identify the problems that might occur in a much earlier stage.

VI. CHALLENGES OF INDUSTRY 4.0

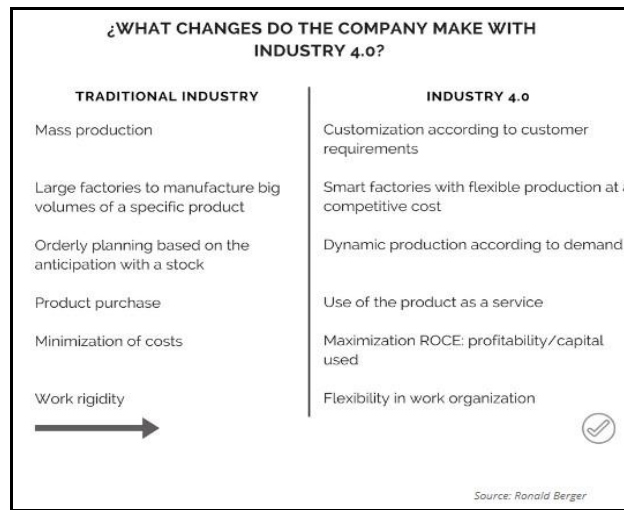


Fig.4 Challenges of Industry 4.0

Many opportunities are waiting for Industry 4.0 to take shape. Industry 4.0 will affect all sectors and disciplines therefore there is a need to address the below listed pain points [9]. According to McKinsey, “Industry 4.0 disrupts the value chain and requires companies to rethink the way they do business. They need to drive the digital transformation of their business to succeed in the new environment.” [10]

Following are the major challenges faced in the implementation of Industry 4.0:

Table 3: Challenges of Industry 4.0

S. No	Findings
1.	Huge investment - With the emergence of Industry 4.0, industry’s functioning has become more processdriven, which demands for large investment for smooth digital transition and transformation [11]. In addition, in training the existing workforce.
2.	Need to consider new business models -With Industry 4.0, companies are in a new industrial paradigm wherein there is a need to transform the way we interact with the customers, understand business cases, changing operations for manufacturers and how customers receive and engage with products. [12]
3.	Resistance to change - There is need to examine the company culture and enhance the flexibility in adopting the change for the good. There is lack of courage to launch the radical digitalization plan.[13]

4.	Reorganizing the processes- For Industry 4.0, there is a need to automate and integrate horizontal and
----	---

	vertical value chains. Therefore, it is essential to understand where there is a need for action [14]. In addition, it is required to conduct pilot study to leverage better outcomes.		an average, companies expect to reduce operational costs by 3.6% p.a., while increasing efficiency by 4.1% annually. [20]
			Future Generation Communication and Networking Vol. 13, No. 2, (2020), pp. 139 - 149
5.	Workforce - Current technological trends are bringing about the change at an unprecedented rate and there is a lack of in-house talent to meet those changes. To improve quality and efficiency it is essential to develop and train the existing employees as the skill sets, they possess are getting obsolete. New categories of jobs will emerge and there is a need to hire new breed of tech-savvy employees. According to the 2018 Global Trends report released by World Economic Forum, 76% of recruiters and hiring managers think that Industry 4.0 will have a significant impact on the recruitment industry. [15]	2.	Revenue gains <input type="checkbox"/> Through optimization and automation efficiency and productivity is enhanced
6.	Standardization - The world is undergoing a digital transition phase that will enter and change all areas of industry. Industries require norms and standards to ensure that the individual components are compatible and interoperable. [16]	3.	Improved supply/demand <input type="checkbox"/> With the availability of real time demand and supply are improved
7.	Data Management - Industries are generating a lot of real-time production and quality data. There is a need to make data readily available and accessible.[17]	4.	Reduced machine downtime • Improved productivity • Predictive maintenance
8.	Competition - Increasing competition is driving an integration between the customer and manufacturer at various stages of product.[18]	5.	Quality products • Customized as per requirements • Monitored and rectified in every phase of manufacturing <input type="checkbox"/> Quality control
9.	Data security - Industry 4.0 deals with large amount of data. To achieve the true potential of Industry 4.0 security is a major concern. It is essential to implement end-to-end encryption to avoid vulnerability, phishing and various other attacks.[19]	6.	Speed of delivery • Use of 3D printers for faster prototyping, reducing the cost of engineering and speeding up time to market • Reduce variability of operations
		7.	Customer Satisfaction • Tailor made and personalized products • Identifying new value generating services
		8.	External factors <input type="checkbox"/> Government incentives to promote Industry 4.0. Smart Advanced Manufacturing and Rapid Transformation Hub (SAMARTH) - Udyog Bharat 4.0 is an Industry 4.0 initiative of Department of Heavy Industry, Government of India under its scheme on Enhancement of Competitiveness in Indian Capital Goods Sector. [21]

VII. BENEFITS AND APPLICATIONS OF INDUSTRY

4.0

The emerging Industry 4.0 technologies can entirely transform the manufacturing value chain. The benefits of digitalization are noteworthy from enhanced production efficiency to innovative product and services deployment. Like digital transformation, the benefits of Industry 4.0 will ultimately help a business become smarter and more efficient.

To summarize, here are the key benefits of Industry 4.0:

Table 2: Key benefits of Industry 4.0

Industry 4.0 aims to increase productivity and profits by using machines and intelligent components connected to the internet.

Following are the application areas of Industry 4.0:

S.No	Key Benefits	
1.	Cost <ul style="list-style-type: none"> • Significant reduction in production cost due to minimized wastage and automation to prevent errors • Reduced labour costs • Boost in labour productivity According to 2016 Global Industry 4.0 Survey, on	
S.No	Application Areas	Benefits
1.	Internet of Things	<ul style="list-style-type: none"> • To perform digital manufacturing. • Sensors provide data to devices, robots, simulations, and tools
2.	Embedded System	<input type="checkbox"/> shift from centralized to decentralized product[22]
3.	Big Data and Data Analytics	<ul style="list-style-type: none"> • streamline production process data • predict equipment failures
4.	Machine to Machine Communication (M2M)	<input type="checkbox"/> Data Collection, Assessment of Data, Actionable Data
5.	Cloud Solutions	<input type="checkbox"/> network model of
		interconnected services, combining operational technology (OT) with Information Technology (IT)
		<input type="checkbox"/> customized products[23]

6.	End-toEnd Software Integration	<ul style="list-style-type: none"> • Production lines • Logistics
7.	Simulation	<ul style="list-style-type: none"> • Product Delivery • Assembly line production
8.	Additive Production (3D PRINTING)	<ul style="list-style-type: none"> • Mass production of standard products • Customized products
9.	Cyber Security	□ to track third-party acceptance and risk
10.	Smart Sensors	<ul style="list-style-type: none"> • Trend Monitoring • Optimization • Safer Data Storage

VIII. CONCLUSION

The main aim of this paper was to provide an overview of Industry 4.0, challenges and benefits of implementing Industry 4.0. It was been found that Government and various private sectors are coming forward and adapting to the latest trends in the technologies. Therefore, it is evident that Industry 4.0 will bring substantial growth in the country's economy, creating more opportunities in principal sectors like agriculture, health, manufacturing and transportation.

Findings reveal that Industry 4.0 is key to the growth of sustainable business performance. However, the structure and process of the organization must be supportive for implementing the latest technology and get the maximum benefit from Industry 4.0. [24]

Industry 4.0 would certainly revolutionize the education sector. The future will belong to the ones who are ready to accept changes and adapt technology like new rules of the game. Industry 4.0 in education domain will be a beginning of new era where learning and exploring things would happen in a distinct way.

Disruptive technologies, driven by Industry 4.0 will greatly affect the future jobs. Indian universities are not exactly the hotbeds of great ideas, innovation and entrepreneurial activities whereas globally Universities are always welcoming the wave of change. Is India's higher education "relevant to the era"? With the educational transformation, country will be able to reap the benefits better in times of Industry 4.0. The government, industry and academia needs to collaborate to enable an Industry 4.0-ready workforce.

REFERENCES

- [1] Xifan Yao & Yingzi Lin "Emerging manufacturing paradigm shifts for the incoming industrial revolution", The International Journal of Advanced Manufacturing Technology
- [2] Shu Ing Tay, Lee Te Chuan, A. H. Nor Aziati, Ahmad Nur Aizat Ahmad "An Overview of Industry 4.0: Definition, Components, and Government Initiatives", Journal of Advanced Research in Dynamical and Control Systems 10(14):14 · December 2018
- [3] V.Alcácerac V.Cruz-Machado "Scanning the Industry 4.0: A Literature Review on Technologies for Manufacturing Systems" , Engineering Science and Technology, an International Journal

- [4] Saurabh Vaidyaa, Prashant Ambad, Santosh Bhosle, "Industry 4.0 – A Glimpse", 2nd International Conference on Materials Manufacturing and Design Engineering
- [5] Swarnima Chouhan, Priyanka Mehra, Ankita Dasot , "India's Readiness for Industry 4.0"– A Focus on Automotive Sector, Grant Thornton Report
- [6] Alejandro Germán, Franka Lucas, Santos Dalenogare, Néstor Fabián Ayala, "Industry 4.0 technologies: Implementation patterns in manufacturing companies", International Journal of Production Economics
- [7] Elvis Hozdic, "Smart factory for industry 4.0: A review", International Journal of Modern Manufacturing Technologies
- [8] KPMG-AIMA Report (2018)
- [9] United Nations Industrial Development Organization (UNIDO), "Industry 4.0 – the opportunities behind the challenge"
- [10] McKinsey & Company, "Manufacturing's next act"
- [11] Judit Nagy, Judit Oláh, Edina Erdei, Domicián Máté, and József Popp, "The Role and Impact of Industry 4.0 and the Internet of Things on the Business Strategy of the Value Chain—The Case of Hungary", Multidisciplinary Digital Publishing Institute (MDPI)
- [12] Dorleta Ibarraa, Jaione Ganzaraina Juan, Ignacio Igartua "Business model innovation through Industry 4.0: A review", Procedia Manufacturing Volume 22, 2018, Pages 4-10
- [13] Juergen Radel "Organizational Change and industry 4.0 (id4). A perspective on possible future challenges for Human Resources Management", Research Gate
- [14] Maximiliane Wilkesmann, Uwe Wilkesmann, "Industry 4.0 – organizing routines or innovations?" VINE Journal of Information and Knowledge Management Systems
- [15] The Future of Jobs Report 2018
http://www3.weforum.org/docs/WEF_Future_of_Jobs_2018.pdf
- [16] Nancy Velásquez Villagrán ; Elsa Estevez ; Patricia Pesado ; Juan De Juanes Marquez; "Standardization: A Key Factor of Industry 4.0", 2019 Sixth International Conference on eDemocracy & eGovernment (ICEDEG)
- [17] Theofanis P. Raptis, Andrea Passarella, and Marco Conti, "Data Management in Industry 4.0: State of the Art and Open Challenges" IEEE Access (Volume: 7), Joaquim G. Antunes, António Pinto, Pedro Nogueira Reis, Carla Henriques, "Industry 4.0: a challenge of competition", ResearchGate
- [19] Beyzanur Cayir Ervural, Bilal Ervural, "Overview of Cyber Security in the Industry 4.0 Era", In book: Industry 4.0: Managing The Digital Transformation, pp.267-284
- [20] Dr. Reinhard Geissbauer, Jesper Vedso, Stefan Schrauf, "Industry 4.0: Building the digital enterprise", 2016 Global Industry 4.0 Survey
- [21] "APO COE on IT for Industry 4.0"
- [22] Luis Miguel Pires "The Importance of Smart Embedded Systems in Industry 4.0"
- [23] Nancy Velasquez, Elsa Estevez, Patricia Pesado, "Cloud Computing, Big Data and the Industry 4.0 Reference Architectures"
- [24] Jammu Anu Naga Chandra Krishna Teja, Kirtiranjan Mohanty, Janga Naveen Reddy, Jammalamadaka Sai Krishna, Arun S K, P Srinivas, Industry 4.0, India Today and Tomorrow, International Journal of Research in Advent Technology, Special Issue, March 2019