Industry 4.0: Evolution, Opportunities and Challenges

Arun Kumar
Professor
Department of Commerce
& Business Administration,
University of Allahabad
Prayagraj, Uttar Pradesh, India.

Satyam Kumar
Research Scholar
Department of Commerce
& Business Administration,
University of Allahabad
Prayagraj, Uttar Pradesh, India.

Abstract

Over the last few years, the term 'Industry 4.0' is a new buzz word for the Industrialists, Academicians, Engineers, Scientists, and many more intellectuals and it has attracted more and more attention all around the world. Earlier phases of Industrial Revolutions have been recognized only after they actually happened. But this is the first time when we are witnessing an Industrial Revolution which is currently on its way. Evolution and advancements in information and communication technology, Cyber-Physical Systems, Big Data, the Internet of Things (IoT), 3D Printing, Autonomous Robots, Cloud Computing, Augmented Reality, etc. are some of the key technology areas that will digitize the whole value chains in multiple industries. The results of the adoption of these technologies are expected to be enormous along all dimensions like efficiency, flexibility, quality, mass customization, larger product selection, automation, and increased customer satisfaction.

The paper aims to present and facilitate an understanding of Industry 4.0 and its elements and explore the opportunities and challenges in the adoption of Industry 4.0 technologies.

Keywords

Fourth Industrial Revolution, Industry 4.0, Internet of Things (IoT), Cyber Physical System, Big Data, Artificial Intelligence.

1. Introduction

There's no question that technology is playing a huge part in our everyday lives today, but the increasingly connected culture we live in is also having an impact on the world of industry. This is a point where Industry 4.0 evolves. Basically Industry 4.0 is a growing combination of traditional manufacturing and industrial platforms and practices with the latest smart technology.

The term 'Industry 4.0' originates from a strategy project within the German government. In 2011 at Hannover Messe, a German annual industrial gathering, the expression Industry 4.0 was presented. Industry 4.0 is an expression that defines the fourth industrial revolution. Germany Trade and Invest (GTAI) define Industry 4.0 as:

A paradigm shift, made possible by technological advances that constitutes a reversal of conventional production process logic. Simply put, this means that industrial production machinery no longer simply "processes" the product, but that the product communicates with the machinery to tell it exactly what to do-*German Trade and Invest (GTAI).*

2. Industrial Evolution

The fourth industrial revolution is going to transform the complete manufacturing scenario. But it doesn't begin all of sudden. There is a huge history of the Industrial revolution which starts with the 18th century.

From manual manufacturing to automated production, the world has seen a huge leap in the industrialization. We can begin to understand Industry 4.0 by examining how the industry developed throughout history. So, let's have a look at how the Industrial Revolution has evolved from the past to the present.
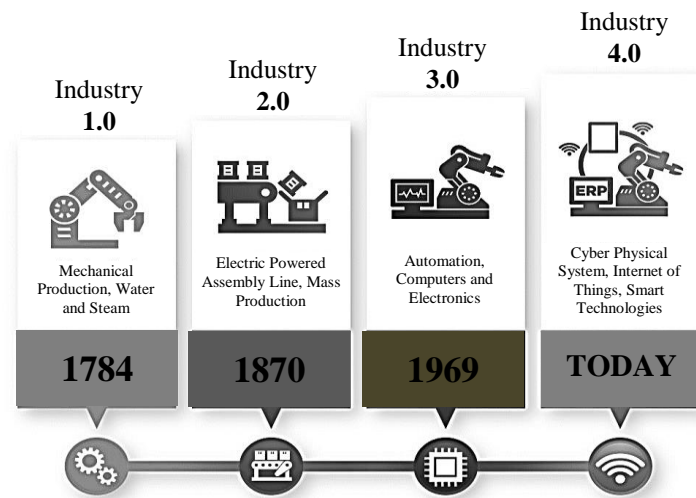
Figure 2: Industrial Revolution

Industry 1.0

The industrial revolution in Britain came with introducing machines into production by the end of the 18th century. In this era, steam-powered engines replaced the manual production system and water is being used as a source of power.

The textile industry was the first industry to adopt such innovative methods of production. It benefited the textile industry in multiple ways. It gave a very fine leverage to the British economy at the time.

Industry 2.0

After the mechanized production in the First Industrial Revolution, technological evolution took another leap towards advancement, referred to as the Second Industrial Revolution. The second one dates near 1870. During the beginning of the first technological revolution, railroads had already improved the transportation system. Improved way of transportation ensured the smooth and uninterrupted supply of raw materials and also facilitated the delivery of products in new and remotely located markets. The second industrial revolution had also witnessed the development of electrical technology which was technologically superior to steam power for the production works. Such advancements ensured the further up gradations so that the production

level could be taken to the whole new level. In this way the concept of mass production came to the public domain. Such technological advancements facilitated the development of heavy industries all around the world and many countries like Germany, Japan, USA, and England took a leapfrog as leading producers in heavy industry.

Industry 3.0

Apart from the other industrial revolution, perhaps today we are much more familiar with the third industrial revolution. This is because almost every tech-savvy is familiar with the use of digital technologies in the industrial production. The third industrial revolution appears around the second half of the 20th century.

It is often referred to as the Digital Revolution, and came about the change from analog and mechanical systems to digital ones. Due to the huge development in computers and information and communication technology, this time is also being called as Information Age. In this age, machines did not only dominate our everyday lives, but also began to abolish the need for human power in life.

Industry 4.0

Industry 4.0 focuses on how to integrate new technologies and digitization to gain manufacturing advantages. It visualizes a complete automated manufacturing and production system with total adaptability and nominal environmental impact while improving product quality. It refers to a mechanized system where machines and equipments will operate independently or can cooperate with human beings for customized production with continuous improvement. Adoption of Industry 4.0 can make a machine an independent entity, so it can be able to collect, store and analyze data, and taking decisions on its behalf.

These technological advancements become possible with the introduction of self-optimization, self-customization, and self-cognition techniques into the industries. With the introduction of it the manufacturer would be in a position to communicate with computers rather than operating them.

3. Key Elements of Industry 4.0

There are nine main pillars of the Fourth Industrial Revolution which are considered as key elements of Industry 4.0. These pillars outline the new technology manufacturers are using to improve all areas of production processes. Whether you work in the manufacturing industry or not, it is

very important to familiarize yourself with these pillars, as they are expected to have a widespread impact across all industries and society as a whole.
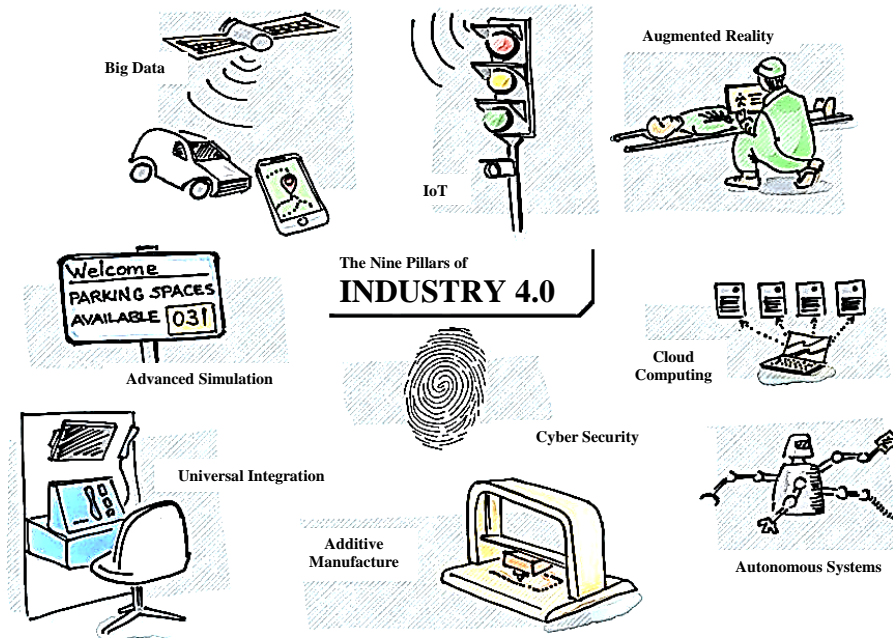

Figure 2: Nine Pillars of Industry 4.0

Source: www.plextek.com

3.1 Big Data and Analytics: In the current Information Age there are extensively huge amounts of untapped data available in the industrial world. Their analysis and use could help in saving energy, optimizing production quality, and improving the services. The main objective of big data analytics is to ensure 'Real-time Decision Making'. It might also help in Predictive maintenance. Predictive maintenance is economical and safer than the conventional method of routine maintenance.

3.2 The Internet of Things (IoT): "The Internet of Things (IoT) is a network of physical objects like sensors and actuators that are digitally connected to sense, compute, monitor and interact within the company and between multiple companies and its supply chain ensuring nimbleness, visibleness, tracking and information sharing to

ease timely management of the supply chain process". Many gadgets such as smartphones, tablets, laptops, wearables, cars, and any machine or device that facilitates the data transmission, are known as the Internet of Things.

In the world of manufacturing, this technology is often referred to as the Industrial Internet of Things (IIoT). Producers and Manufacturers can connect the sensors and actuators to machines and other physical objects to collect real-time data which might lead to more efficient and productive operations.

3.3 Augmented Reality: Augmented reality (AR) makes the digital content visible in the real world through any of the electronic devices, such as tablets, Mobile phones or special eyeglasses. There are a lot of different uses of this technology in the manufacturing industries, such as safety training, maintenance, etc. Augmented-reality tools are still in their infancy, but they can pave the way for new services. For example, they will provide operators with the real-time information they need for faster decision-making and for improving work processes.

3.4 The Cloud: The operating processes of Industry 4.0 require more data sharing across numerous sites and companies. Cloud is a remote system that can be accessed provided from anywhere using the internet. As the use of technology and data sharing at manufacturing companies grows, cloud computing provides scalable storage and increased computing power. The cloud also improves data accessibility and integrity, helping to eliminate data silos.

3.5 Autonomous Robots: More systems in business are becoming autonomous and need less human intervention to provide effective results. Robots can work with and without human beings and can learn the human skills. The use of robotics in manufacturing could result into cost efficient and improved production outcomes in comparison to traditional manufacturing systems. Now robots are assembled and designed to work as similar to humans, with the added ability to monitor and transmit data with more accuracy.

3.6 Additive Manufacturing: Recently many companies have initiated the introduction of 3D printing for unit production and prototyping as well. With the adoption of Industry 4.0, the use of these

technologies will be made for very high performance in producing small quantities or batches of customized products and in designing and prototyping. 3D printing facilitates the decentralized production systems and it can reduce the cost of transportation and inventory management.

3.7 Cyber Security: As connectivity increases, the risk of a potential cyberattack grows alongside it. Any security breach could damage multiple areas of the business, from supply chain to operations. It's absolutely critical that companies prepare and protect their information systems and production lines from cyber threats. Secured and encrypted identity and machine access management systems will be used to provide secure, reliable communications.

3.8 Horizontal and Vertical System Integration: Today, information systems are not well integrated. A lot of Companies are still not connected with their supply chain system. For example, engineering design departments are rarely linked directly to the production house within its own manufacturing unit. But with Industry 4.0, the entire organization could be interconnected, and companies will be able to interact and connect with one another.

3.9 Simulation: Simulations follows the real-time data to visualize and reflect the physical world of product development and production processes in a virtual environment. Simulation can be used to access the real-time data to process more efficient tests, so that processes and settings are improvised and optimized even before the starting of production. It may help in reducing time lapse and improving product quality.

4. General Opportunities and Challenges

Developing countries must keep up with technological changes to ensure that they are not left behind by Industry 4.0. Applying Industry 4.0 technologies can be a gradual process and some solutions do not have to be expensive. Good ICT infrastructure is needed to help SMEs move into the digital economy. Countries and companies will need a digital strategy, and a strategic vision for a fully integrated multi-stakeholder policy approach to adopt such kind of technological changes. Education and technical qualifications should play an integral role in digital strategy

and a business-friendly environment. Government organizations and society have a key role to play in building awareness of the potentials of new technologies for inclusive and sustainable industrial and economic development through establishing platforms for dialogue, knowledge, and experience sharing.

To thrive and indeed survive in tomorrow's world, we need to stay updated in terms of technology. The adoption of industry 4.0 can provide a competitive edge over the competitors. At the same time we need to focus on each of the following challenges and act upon them as soon as possible. Businesses or organizations require fresh thinking, a positive mindset, for understanding the power of connectivity (made possible by new technologies) to adopt Industry 4.0. After being progressive and able to adopt a new mindset and refreshing the company culture, Industry 4.0 will definitely help a business to become smarter and more efficient. To summarize, here are the key opportunities and challenges of the new industrial revolution.

4.1. Opportunities

- Economic gains, such as increased revenues because of lower transaction and transportation costs.
- Higher quality products as a result of real-time monitoring.
- Enhanced productivity through optimization and automation.
- Eliminate human dependency.
- Shift to mass customization.
- Enabling innovation across many applications, with a much larger economic impact on growth.
- Energy-efficient and environmentally sustainable production and systems.
- Effective use of human recourses and materials.
- Increased food security and safety.
- Improvements in the health and safety of workers.
- Changes in education and training systems.
- More open innovation systems.
- Predictive and Remote maintenance.

4.2. Challenges

- Change management, something which is too often overlooked.
- Examination and Review of company culture.
- Proper interconnection of all departments of the organization.

- Recruitment and development of the new talents.
- Cyber security.
- Huge initial Investments.
- Collaboration.
- IT modernization.
- Infrastructure gaps.
- Continuous learning and on-the-job training.
- Outdated international rules and regulations.
- Data ownership and security.
- Reliability and stability of CPSs.
- Transparency, privacy, ethics and security.

5. Conclusion and Future Work

The fourth industrial revolution is a new industrial revolution of the 21st century, which enables companies to go for smart, efficient, effective, individualized, and customized production at a reasonable cost. The paper mainly focuses on the concept of Industry 4.0, its evolution, and its elements. An effort has been made to elaborate on the multiple phases of industrial evolutions. The nine pillars of industry 4.0 explained with the Opportunities and Challenges of Industry 4.0 adoption. Since the Industry 4.0 is in its transitional phase, many more challenges might be visible in the future. Adoption of Industry 4.0 can not only transform the whole organization and value chain system but also provides the competitive edge over the competitors, which is very essential in the current global economy. Not just the business advantages, but it also contributes to transparency, good governance, and social upliftment.

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