

# The Effect of Digitalisation on Industry 4.0: A Literature Review

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## ABSTRACT

In this study, the nature and components of Industry 4.0, as well as its historical transformation into Industry 5.0, are analysed chronologically. The impacts that may have on our lives in the future are examined. Most importantly, the advantages and disadvantages of digital transformation have been highlighted throughout the chapters. The overall perspective of this transformation and its impact on private and public sectors are presented. The increasing trend of Society 5.0 is explained by considering the technology-centred economic system. Since the concept of Industry 4.0 has joined the literature, the importance of government regulations has been a well-discussed topic in social and economic studies. The actions of the European Commission towards the European Digital Single Market are outlined in this study since they are crucial practices of the expected digital transformation. As a result of this systematic literature review, the impacts will become more apparent after the structural digital transformation is achieved on a global scale.

## 1. Introduction

Today, we summarise the Industrial Revolution periods by categorising them into five groups. The First Industrial Revolution is claimed to have occurred starting from 1765 with the push caused by mechanisation, mainly in Europe and North America. This revolutionary change created a new economic era due to the shift from agriculture to industry. The most important invention that affected this era was the steam engine. As a result, coal became one of the most desired products worldwide. During this period, coal was the primary energy source, and trains served as the primary mode of transportation. Textile and steel sectors had the most employment, production value, and capital investment.

Regarding the Second Industrial Revolution, mechanisation played a role in electrification. It covers the period from the late 1800s to the First World War. The need for new advanced sources increased due to rapid mechanisation, and this need enabled massive technological advancements. Above all, the internal combustion engine was invented in 1900, kicking off the Second Industrial Revolution (Xu et al., 2018). This resulted in rapid industrialisation, with oil and electricity driving mass production. At the beginning of the 1900s, steel, oil, gas, and electricity usage increased dramatically after the invention of planes and automobiles.

The Third Industrial Revolution began in 1960, marked by the use of electronics and information technology to automate industry. The dramatic change happened around the 1980s with rapid improvements in the digital arena. These changes are categorised under the Third Industrial Revolution. World Wars caused a massive demand for new telecommunication tools and new energy sources (e.g. nuclear energy). Production through IT systems and electronic tools significantly impacted the world economy. The new chapter started in this period when the internet took power, and digitisation challenged countries to adopt the new emerging technologies. The extraordinary improvements have seen the light of day since the beginning of the 21st century.

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The Fourth Industrial Revolution (Industry 4.0) is known as the peak pace of digitalisation. The scope of new technologies became wider in this period (For instance, robotics, artificial intelligence (AI), augmented reality (AR), virtual reality (VR), blockchain, crypto, cloud computing, nanotechnology, and industrial internet of things (IIOT)). All these revolutionary changes have influenced the global economy, starting from Industry 4.0. During the last decade, the most crucial question about the impact of digitalisation is "how countries can be impacted positively?". Each institution, whether government or organisation, is still struggling to answer this question since the speed of improvements cannot be stopped. When searching for the answers, it is essential to understand the industry's evolution. Therefore, one of the objectives of this study is to explain how to adapt to the new digital world and the impactful factors of this implementation process by understanding the ongoing industrial revolution.

The Fifth Industrial Revolution is the period we are currently in, and it started in the second decade of the 21st century. The most well-known notion that can describe this period is "personalisation" because people and machines start to have multi-level cooperation. Since artificial intelligence is updated to the level where robots have consciousness, the workload has been shared between people and machines (Lou et al., 2024). Furthermore, an additional concern with Industry 5.0 is the environmental impact of this mass production process.

In this study, the main focus has been given to the fourth industrial revolution and the impacts of rapid digitalisation on social and economic systems.

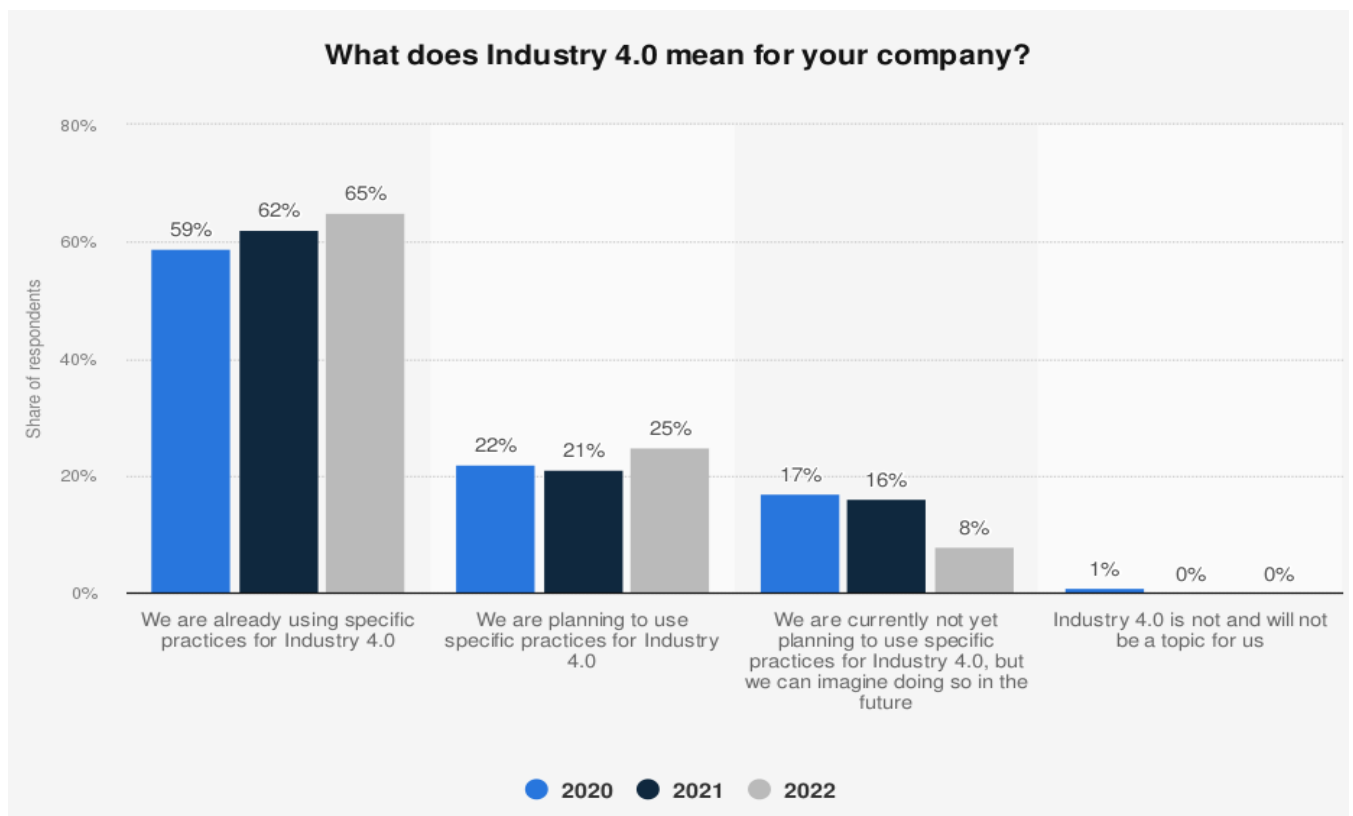
## 2. IMPACTS OF INDUSTRY 4.0

The evolution of mechanisation and automatisisation in industry reshapes factories. Industrial production processes change based on future-oriented technologies. The conditions of mass production evolve together with these changes. Industry 4.0 represents the combination of Internet technologies and smart machines/products. Industry 4.0, also known as the Fourth Industrial Revolution or Smart Production, was introduced by Germany in 2011 and included many technological developments. The basis of Industry 4.0 is the integration of machines with each other through cyber-physical systems, managing big data through cloud computing, and establishing communication between machines through the Internet of Things.

In light of Industry 4.0, changes in the market, especially in operative conditions and consumer behaviour, can be observed. Increasing demand for the individualisation of products was one of the main effects of the Fourth Industrial Revolution. The time of development periods was expected to be shortened after the changes in the industry. This puts high pressure on enterprises to adopt new innovative technologies faster. Moreover, they have to make decisions faster to produce in a short period, which is only possible by decreasing the power of organisational hierarchies inside the factory (Skilton and Hovsepian, 2018). Mainly after Industry 4.0, together with the push from societies all around the world, the devastating impact of mass production on the environment is recognised by many enterprises. The importance of more efficient, sustainable, and ecological resources has become a concern (Balogun et al., 2019). In the sense of Corporate Social Responsibility, the focus changed to the necessity of resource efficiency and sustainable industrial manufacturing processes. For instance, digital targets of the European Commission have been developing with the policy programme "A Path to the Digital Decade". Green Deal and Digital Improvements have become the biggest concerns of the previous decade in the European Union (hereinafter EU). Therefore, the Commission announced it would cover these concerns as the Twin Challenge, where a green and digitally transformed market must be achieved together in 2030. This programme aims to push each enterprise in the EU to develop digital and eco-friendly innovations by funding and supporting digital transformation. The main goal is to integrate the companies in different member states through digital platforms such as Digital Innovation Hubs, DG Connect, and the European Data Portal.

Regarding the working process, innovative technologies are used less efficiently. Many renovations can be done using newly developed machines, software, and products related to each industry's needs. Autonomous manufacturing is one of the examples. Besides, digitalisation in manufacturing enables the efficient control and analysis of production processes (Moavenzadeh, 2015).

However, we should also consider the cost of all these digital evolutions. Some enterprises, primarily Small and Medium Enterprises (SMEs), cannot cover these costs, while other large companies have the advantage of keeping up. This advantage creates a considerable gap between enterprises in the market. A company without future-oriented technologies has less chance of competing in the market. The most crucial factor in the market is the needs of the consumer. They have changed in each industrial revolution correlated with technological developments such as product intelligence and product memory, which are crucial innovations expected to be designed according to the new production environment. The competitiveness of industrial enterprises has been challenged by developing these highly integrated and complex information systems (Lasi et al., 2014). Developing the system requires many resources, and after its implementation, it takes a great effort to maintain its prestige against competitors. These IT-driven developments in manufacturing systems due to Industry 4.0 caused changes in industries' hierarchical structure and increased the moves from product-oriented to service-oriented industries.



**Figure 1.** Opinions on industry 4.0 meaning for companies Germany 2022

Source: Bitkom Research, Statista 2022.

For instance, if we look at the case of companies in Germany and what Industry 4.0 means for these companies, we can see the answers in Figure 1. It is essential to mention that Germany is one of the leading countries, with the USA, Japan, and China. In 2021, 62% of the companies responded that they already use specific practices for Industry 4.0. This is an exceptionally high performance when we consider the implementation process (Niewöhner et al., 2020). However, many more companies should still be encouraged to reach a more efficient digital market.

Today, with its intelligent and autonomous systems, machine learning is one of the most substantial factors behind Industry 4.0. The goals of smart factories and fully implemented practices for Industry 4.0 can be achieved by incorporating the Internet of Systems, the Internet of Things (IoT), and cyber-physical systems (Marr, 2021). Decreasing waste and pollution factories create while increasing efficiency and productivity are the main roadmaps that enterprises should focus on to reach the standards of the new industrial revolution.

## 2.1. ADVANTAGES AND DISADVANTAGES OF INDUSTRY 4.0

As technology advances daily, reliable, durable, and fast products are produced. Industry 4.0 aims to promote factories with computer-controlled production processes to deliver products to customers more efficiently. Since the steps towards these innovative technologies will reduce costs, they will cause a decrease in the price of the products offered to the customer (Culot et al., 2020). In this context, the main advantages of Industry 4.0 can be given as increasing flexibility in production processes, ensuring continuity in products with a low error rate, scale-up in productivity, development of new services and business models, stability in environmentally friendly resource policies, more effective monitoring systems and fault detection processes, reductions in production costs, expanding global market.

Despite these advantages, many obstacles should be considered while implementing the Industry 4.0 system. The most crucial ones are data security issues, cyber security problems, sustainability in the quality of products and services, competition in emerging market conditions, long-term high spending over technical problems, and unemployment/employment issues (Javaid et al., 2021).

## 3. FROM INDUSTRY 4.0 TO 5.0

2020 has emerged as the year when the consequences of global warming were most observable in the world. These changes, the increase in sustainability awareness, and the social and physical constraints brought by the pandemic bring about the need to use existing technologies to support sustainability dimensions. Although Industry 4.0 maintained its bright production target, it did not aim to achieve balanced social, environmental, and economic benefits but aimed to accelerate production (Potocan et al., 2020). The Industry 5.0 model seeks to make a new industrial revolution by using Industry 4.0 technologies to achieve many social goals, including sustainability.

The concept of Industry 5.0 goes beyond the Industry 4.0 model, which aims at industry-technology integration where production is carried out by cyber-physical systems and shifts the focus and purpose of production systems from profit and market share to social contribution (Kent and Kopacek, 2021). It emerges as a paradigm shift aimed at The Industry 5.0 model also aims to use technologies such as "internet of things", "cloud computing", "production cloud", and "augmented reality", which were developed and frequently used within the scope of Industry 4.0, in a way that supports sustainability goals and focuses on human-machine collaboration (Adel, 2022).

"Sustainability" is a philosophy based on resource use, and it means "while meeting the needs of humanity today, it does so by taking into account the needs of future generations and without risking them". The concept of sustainability, at the centre of the Industry 5.0 model, aims to give a more balanced direction to the current industrial system focused on sales and profit increase. Industry 4.0 required innovative structuring for every sector. Examples include smart production, smart agriculture, smart tourism, and smart buildings. Similarly, Industry 5.0, the new industrial revolution, will change many sectors, such as Agriculture 5.0, Tourism 5.0, and Transportation 5.0. The adjective "smart" added to each sector in Industry 4.0 can be updated to "smart and sustainable" in Industry 5.0. In this case, smart and sustainable production, smart and sustainable agriculture, smart and sustainable tourism, and smart and sustainable buildings will determine the direction of the sector in the coming period.

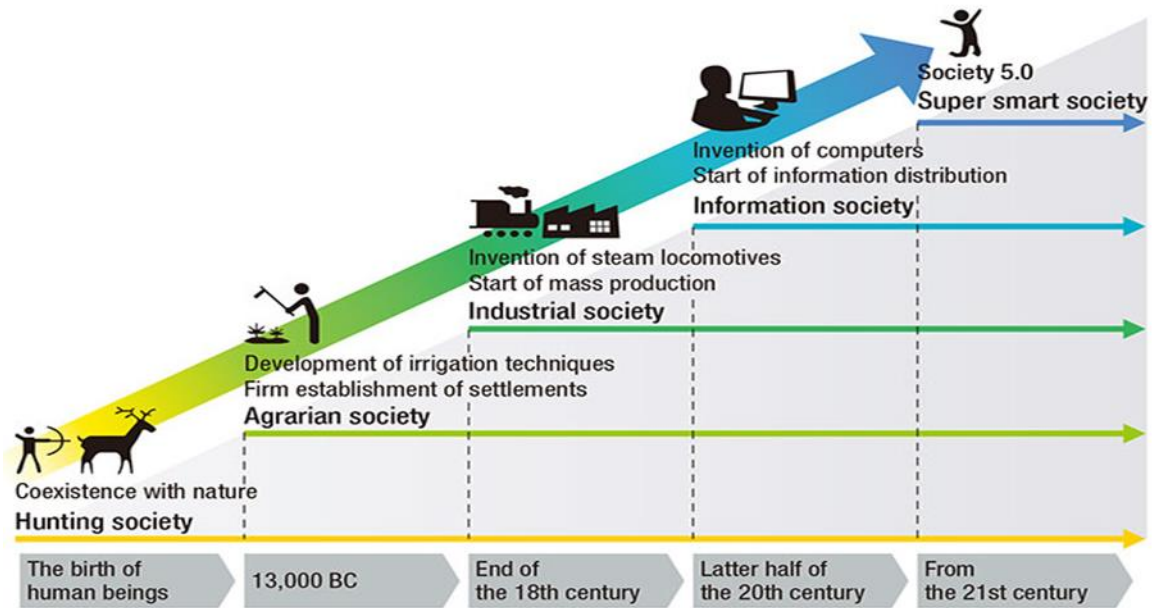


Figure 2. The “Super Smart Society” Aimed for by Society 5.0

Source: Keidanren, 2016

Additionally, the concept of Social 5.0 emerged in Japan in 2015. In 2016, the "super smart society" vision was presented by the Japanese government in the "Fifth Science and Technology Plan" dedicated to innovation and digitalisation, and the concept was made a fundamental part of the "The Investment for the Future. Strategy 2017: Reform for Achieving Society 5.0" (Figure 2.). Fukuyama (2018) states that Social 5.0 aims to create a society where people enjoy life to the fullest. Economic growth and technological development exist for society, not for the welfare of the few. The power of the Society 5.0 plan is that it aims to provide solutions to the needs of each person. In summary, it is a government initiative with ambitious reach and transformative potential without clear budget lines and specific targets typically associated with national innovation policies and government economic development strategies. However, this should not create the impression that Society 5.0 is aimless. This initiative calls on all public and private sector participants to move toward a community-first trend (Wongmonta, 2021).

#### 4. RESULTS

Industry 4.0 represents the digitalisation and integration of all production processes from start to finish. Therefore, Industry 4.0 is seen as a revolution in the world. The concept of Industry 4.0 is not only related to the manufacturing processes of businesses. It includes all functions of businesses, from supply to financing and services to customers. The Industry 4.0 revolution is based on the integration of production processes. It covers the Internet of Things, cloud technology, big data, 3D printers, autonomous robots and augmented reality applications. It will be necessary for businesses to make structural changes in line with these innovations (Tomor et al., 2019). Entrepreneurs must be ready for an innovative and competitive application system while implementing these developments.

To be successful in this process, it is critical for the countries first to develop education policies to provide trained human resources. It is essential to carry out the necessary studies for all these technologies. Setting targets, making sustainable plans, increasing investments, and promoting R&D studies in this field by providing government support must be considered essential (Moyne et al., 2020). There must be a transition from a consumption society to a production society for the countries that set the goal to closely follow the transformation from Industry 4.0 to Industry 5.0.

The decrease in employment is considered the most significant disadvantage of Industry 4.0, but it can be an excellent opportunity for societies. One of the top priorities of Industry 4.0 and Society 5.0 is qualified labour. A significant contribution to this process can be made by promoting digital skills in

societies. Young generations are mainly competent to respond to the different needs of the business world with an innovative approach, and they must be encouraged to do so.

## CONCLUSION

The economic system that exists in the world has a structure that triggers the private sector. In this context, an economic order dominated by the private sector emerges. This situation causes the public to focus on innovation and changes in coordination, supervision and regulatory activities. In this context, while all sectors, regardless of private or public, benefit from information and communication technologies, societies are naturally affected. Governments and international organisations need to make the necessary regulations for societies to integrate with a new technology-centred industry.

The industries and manufacturing systems will keep evolving rapidly. Today, it is inevitable that these new technologies will be adopted to become successful in the market. Some possible applications to adopt these changes include optimising operations, logistics, and supply chains. This is possible with the adjustment to autonomous equipment, vehicles, and robots. Additionally, 3D printing (additive manufacturing) has been creating dramatic improvements in the industries. Cloud and IoT enable companies to store data most efficiently. These applications allow others (especially SMEs) to access the developed technological changes that large enterprises store. Businesses that cannot keep up with innovations and transformations cannot adapt to the new economic system. Industry 4.0 has many potentials for more efficient and productive production processes. The enterprises that are open to taking revolutionary steps in the industry will be the winners of the future.

Undeniably, the new digital era will lead to an increase in inequality in income distribution around the world, and underdeveloped countries will be victims of the digital divide. This could lead to the extinction of small and medium-sized businesses. It is a wrong perspective to expect businesses that survive with limited resources to suddenly keep up with digital transformation. In this regard, governments and international organisations should play a regulatory role to ensure that businesses are least negatively affected by digital transformation. Nowadays, these new technologies are becoming more affordable, and some industries take cooperative action to adopt them. If we consider how fast technology is growing daily, more changes are yet to come in the industry.

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