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## INDUSTRY 4.0 AND INDUSTRY 5.0 – OPPORTUNITIES AND THREATS

**Abstract:** Industry 4.0, also known as the fourth industrial revolution, is a concept that refers to the application of high technologies, such as the Internet of things (IoT), cybernetics, machine learning, and automation, in production and business processes. One of the main goals of Industry 4.0 is to create "smart factories" that can adapt to changing market conditions and customer needs and increase efficiency and productivity through advanced technologies. This is achieved by connecting machines, devices, and systems to the internet, allowing them to communicate and share data in real-time. This enables the factory to be more responsive to demand changes and optimize production processes. Industry 4.0 also has the potential to change the way we work and interact with machines, through the use of advanced technologies such as augmented reality and human-machine interfaces. This can lead to more flexible and efficient work processes and create new opportunities for workers to develop new skills.

**Keywords:** Industry 4.0; Industry 5.0; Challenges; Smart factory; Human-centric

### 1. Introduction

Staying at the top is becoming increasingly difficult and challenging due to rapidly growing and variable digital technologies and artificial intelligence-based solutions. The world of technology, mass customization, and advanced production is undergoing a rapid transformation. Robots are becoming even more important as they can now be connected to the human mind through brain-machine interfaces and advances in artificial intelligence. Digitalization has created a new paradigm in production, where factories are becoming more modern and sophisticated. Although the manufacturing industry aims to establish nearly fully automated factories in order to achieve savings, it has raised concerns about the elimination of human jobs.

In 2011, the German government created the term Industry 4.0 to describe the increasing trend of automation and data exchange in manufacturing technologies (Lu, 2018). This term is widely used by the European Commission and the EU government to direct policy towards the development of innovation and digitization of European, namely small and medium-sized enterprises (SMEs) (Probst et al., 2018). Implementing Industry 4.0 requires significant transformations throughout the organization (Schneider, 2018; Sony & Naik, 2020). New technologies also require new workforce competencies (Pejic-Bach et al., 2020). Industry 4.0 brings a new concept of business, the so-called "smart factory" concept.

Smart factories operate as smart systems that rely on the ability to exchange information about inventory status, and order changes,

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aiming to achieve decentralized coordination between the processes themselves (Castelo-Branco et al., 2022). These types of factories increase business productivity, therefore, Industry 4.0 has certain limitations - the lack of collaboration between humans and machines.

Industry 5.0 changes the paradigm and provides a solution by reducing the focus on technology and emphasising the potential for progress based on collaboration between humans and machines. In modern business with continuous technological advancements, Industry 5.0 is necessary for gaining competitive advantages and economic growth for organizations. The concept of Industry 5.0 was introduced in 2015 and has the greatest impact on production automation, using artificial intelligence (AI) to improve production process performance. This revolution aims to shape and transform business activities through the use of smart tools (Halim & Javaid, 2019), to put the well-being of people at the centre of production systems and provide the opportunity for sustainable development for all of humanity (Leng et al., 2022).

Overall, current literature and research on Industry 5.0 are relatively scarce, and the industry is still emerging. This paper aims to analyze the potential applications of Industry 4.0 and 5.0 and the concept of human-machine collaboration.

## 2. Literature review

The new industrial revolution called Industry 4.0 encompasses almost all areas of industry and science in the context of automation and reducing the need for human labour (Buntak et al., 2021), which in some business systems, such as logistics, can significantly reduce costs and increase efficiency. However, parallel to the development of technological innovations within Industry 4.0 such as the Internet of Things, Digital

Twins, Big Data, artificial intelligence etc, a challenge arises related to data security (Kovačić et al., 2022) since these technologies function based on sharing data between different machines and devices, and access to such data by third parties can result in the risk of taking control and potential damage. Nonetheless, despite the described risk, according to (Flores et al., 2020), the emergence of new technologies and new risks related to new technologies also leads to the need to change the existing competencies of human resources, which require new knowledge based on managing new technologies, rather than simply executing tasks, which is a result of automation and reduced need for the workforce. Damayanti's research conducted in 2021 supports these conclusions: Speaking specifically about the new competencies required by employees, it is important to emphasize that these competencies are primarily related to increasing IT skills, primarily programming and maintenance of such technologies in the context of replacement and repairs, as emphasized by (Alhloul & Kiss, 2022). However, since the use of automated systems exclusively means the potential risk of reduced need for human labour, there is a significant risk of a lack of social responsibility, primarily towards the social component. Nevertheless, it should be emphasized that, from a system management perspective, the significant use of automated systems can contribute to increasing the organization's competitiveness and the ability to personalize products that customers demand from the organization, as written by (Saniuk et al., 2020).

The challenges described are becoming the basis for a new industrial revolution called Industry 5.0, which is based on collaboration between humans and automated systems (Xu et al., 2021). In other words, the concept of exclusive automation is being abandoned and a shift is being made towards

reintroducing humans as the centre of the process, with automated systems no longer operating independently but serving as an aid to humans, which significantly improves the quality of work performed as described by (Nahavandi, 2019). This reintroduces the creative component into the process, which has been significantly neglected until now since automated systems have not had the ability for creative thinking, as creative thinking is currently exclusively a human characteristic (Leng et al., 2022).

On the other hand, as stated in the research (Basten et al., 2020), increasing the competitiveness of organizations through the implementation of new technologies can lead to a widening gap between employees who possess the necessary knowledge and skills to work in Industry 4.0 and those who do not. Therefore, to reduce this gap, it is necessary to invest in education and workforce development to create qualified experts for Industry 4.0, as emphasized in the research (Ceric & Kascelan, 2020).

In conclusion, Industry 4.0 refers to the trend of automation and data exchange in manufacturing, which has great potential for reducing costs and increasing efficiency but also poses challenges in terms of data security. The application of new technologies also requires the development of new competencies for employees, as well as investment in education and workforce development to reduce the gap in skills and knowledge needed for work in Industry 4.0.

Besides, speaking in general terms, Industry 5.0 represents a continuation of Industry 4.0 and the technologies that were characteristic of Industry 4.0 is still being used, with the difference being that they are now being utilized by humans (Maddikunta et al., 2022). Nevertheless, one of the technologies that stand out, in particular, is artificial intelligence since it enables the analysis and execution of a large number of activities in a very short time with human instructions. This approach significantly impacts the

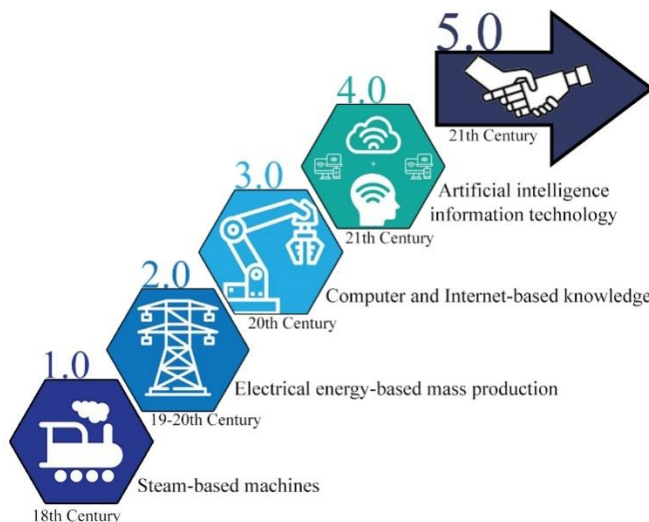
ability to collect and analyze large amounts of data in a short period, which is the basis for making decisions about future actions as discussed by (Stone et al., 2020). However, since Industry 5.0 is still in its early stages and some countries have not fully utilized the potential offered by Industry 4.0, it is expected that the full potential of Industry 5.0 technologies will only be seen in the future, according to (Leng et al., 2022).

### 3. Industrial revolution

Looking back to 1780, the first industrial revolution (Industry 1.0) was born with the generation of mechanical energy from water, steam, and fossil fuels (Nahavandi, 2019). The next shift towards the manufacturing industry between 1871 and 1914 was called Industry 2.0, which enabled a faster transfer of people and innovative ideas. This revolution was a period of economic growth and increased business productivity, which also led to rising unemployment as machines replaced factory workers (Amr, 2022). Almost a century later, in the 1970s, industrialists began to use electronics and computers in manufacturing. The Third industrial revolution (Industry 3.0) utilized microprocessors, information technology, and robots for high-level automation in production. Soon after, there was an increase in globalization and outsourcing of production due to the availability of skilled labour and lower production costs. Industry 4.0 means the integration of intelligent machines and systems and bringing changes to production processes to increase manufacturing efficiency. Industry 4.0 refers to resilient technology, new ways of working, and the role of people in the industry. Industry 4.0 brings about a wide range of innovations in the operations and factories of different industries and services, affecting the functioning of entire societies. At its core, it represents a trend towards automation and data sharing in production

technologies and processes, utilizing cyber-physical systems, the Internet of Things, cloud computing, cognitive computing, and

artificial intelligence (Grabowska et al., 2021).



**Figure 1.** From Industry 1.0 to Industry 5.0 (Autor)

Industry 5.0 is an emerging technology that advances the design of the previous generation, with a focus on efficient and intelligent machines. The concept of Industry 5.0 was deliberated among participants from research and technology organizations at the Directorate "Prosperity" of the European Commission's DG for Research and Innovation from July 2 to July 9, 2020. The EC document presents assumptions about the concept of Industry 5.0, emphasizing the critical directions for change to achieve a more sustainable and human-centred industry (Breque et al., 2021). As a new and enhanced version of Industry 4.0, Industry 5.0 is being promoted as a model that will bring further prosperity and competitiveness to businesses while promoting a human-centric economic model.

#### 4. Distinguishing Industry 4.0 from Industry 5.0

In today's world, people work alongside machines and are connected to smart factories through intelligent devices. The world of technology, mass customization, and advanced manufacturing is going through a rapid transformation. Robots are becoming even more important because they can now be connected to the human mind through brain-machine interfaces and advancements in artificial intelligence. Today, robots are intertwined with the human brain and work as collaborators, not competitors. The Industry 5.0 revolution will likely stimulate more advanced human-machine interfaces using artificial intelligence algorithms (Grabowska et al., 2021). Industry 4.0 and Industry 5.0 refer to the integration of advanced technologies into the manufacturing process, but there are some key differences between them.

Industry 4.0 refers to the current trend of automation and data exchange in manufacturing technologies. It includes developments such as the Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML). The aim of Industry 4.0 is to create "smart factories" that can adapt to changing market conditions and customer needs and increase efficiency and productivity by using advanced technologies.

Industry 5.0 is built on the foundations of Industry 4.0 but takes it to a higher level by integrating even more advanced technologies such as quantum computing, 5G networks, and blockchain. The goal of Industry 5.0 is to create an even more flexible, efficient, and sustainable production process. By bringing human workers back to the factory floor, Industry 5.0 will pair humans and machines to further leverage the human brain and creativity to increase process efficiency by combining workflows with intelligent systems. While Industry 4.0's primary focus is on automation, Industry 5.0 will be characterized by a harmonious integration between humans and autonomous machines. The autonomous workforce will possess the ability to perceive and understand human intentions and desires. Humans and robots will work together as collaborators, without fear, but with a sense of ease, knowing that their robotic counterparts can comprehend and effectively cooperate with them. While Industry 4.0 focuses on automation as its main concern, Industry 5.0 will be a symbiosis between humans and autonomous machines. The autonomous workforce will be perceptive and informed about human intentions and desires. The human race will work together with robots not only without fear but also peacefully, knowing that their robotic collaborators understand them adequately and have the ability to effectively cooperate with them. This will result in an extremely efficient production process with added value, thriving reliable autonomy and reduced waste and associated costs. Industry

5.0 will redefine the word "robot" as not just a programmable machine capable of performing repetitive tasks, but as an ideal human companion for certain scenarios. Cobots, the next generation of robots, will already know or quickly learn what to do and will be aware of human presence, taking into account safety and risk criteria. They can perceive, understand and sense not only the human being but also the goals and expectations of the human operator. Like an apprentice, cobots will watch and learn how an individual performs a task and when they learn, they will perform the desired tasks like their human operators. Therefore, humans experience a different sense of satisfaction while working together with cobots (Nahavadi, 2019).

Contrary to the depiction of the future in science fiction movies, digitization will not render human workers in industrial production obsolete. Instead, it will integrate intelligent automation, devices, and systems in the workplace to enhance collaboration between humans and machines. This will allow highly skilled workers to lead smart machines and robots and work more efficiently alongside cobots.

Industry 5.0 would solve the need for personalization and mass customization of products for customers. This would stimulate and apply human intelligence and thought processes in computers - a process known as cognitive computing. Robots and automation are playing an increasingly important role in modern factories. Smart factory cobots would also be smart enough to understand the needs of the human operator, decide if they need assistance, and assist them accordingly. Cobots (robots designed to work alongside humans) can assist the human factor in factories in various ways, including:

**Improving safety:** Cobots can take on tasks that are dangerous or too strenuous for humans. For example, cobots can lift heavy objects, perform hazardous tasks in

dangerous environments (such as in mines or on oil rigs), or work in conditions with high temperatures or high levels of pollution.

**Improvement of product quality:** Cobots can be programmed to perform tasks with a high degree of precision, reducing the likelihood of errors and increasing product quality.

**Increased flexibility:** Cobots can be quickly reprogrammed to work on different tasks, making the production process more flexible and adaptable.

**Improving employee satisfaction:** Cobots can take over tasks that are uninteresting for humans, allowing them to focus on more creative and challenging tasks. This can lead to increased employee satisfaction and reduced stress.

**Cost reduction:** Although the initial investment in purchasing and implementing robotic equipment is high, the use of robotic technology can lead to long-term cost savings. Cobots can reduce labour costs, reduce material losses, and increase production process efficiency.

To better utilize human creativity and brainpower and improve operational efficiency, I would combine intelligent systems with existing workflows. This would shift the focus in factories away from mass production, automation, and digitization, which were the key elements of Industry 4.0. In summary, cobots can aid the human factor in factories in numerous ways by increasing efficiency, safety, and product quality. This will lead to better integration, allowing for faster and better automation in combination with the power of the human brain. It also means that robots will not take over control of production plants shortly, as previously feared in the era of Industry 4.0.

In conclusion, Industry 5.0 represents a more advanced and holistic approach to production, aiming not only to increase efficiency and productivity but also sustainability and a human-centric approach. This involves combining the best of both

worlds - human and machine - to increase productivity (Grabowska et al, 2021).

#### **4.1. The concept of people and machines**

Industry 4.0 is based on the concept of smart factories. Smart factories are factories equipped with modern technology and systems that enable high automation and optimization of production processes. The following key drivers can be identified:

- **Internet of Things (IoT):** IoT enables the connection of different devices, sensors, and machines into a unified system and the exchange of data between them. This enables a high level of automation as well as real-time monitoring of machine performance and maintenance.
- **Artificial Intelligence (AI):** AI enables machines to learn and improve their performance over time based on the analysis of large amounts of data. AI can be used for optimizing production processes, reducing material losses, monitoring and predicting failures, and other purposes.
- **Robotics:** Robotics is crucial for the automation of production processes. Robots can be used for various tasks, including lifting and moving heavy objects, assembling products, inspecting quality, and other tasks typically performed manually.
- **Cloud technologies:** Cloud technologies enable the storage and processing of large amounts of data remotely. This allows for real-time monitoring of machine performance as well as data analysis to improve efficiency and reduce costs.
- **Advanced sensors:** Advanced sensors enable the measurement of various parameters in real-time, including temperature, humidity, pressure, speed, and other



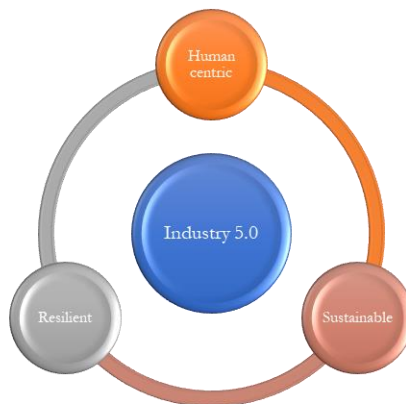
parameters. This enables monitoring of performance and prediction of failures before they occur.

- Digital simulation: Digital simulation allows for testing and optimization of manufacturing processes before they are implemented in practice. This can help reduce costs and increase production efficiency.

Industry 5.0 is characterized by its focus on sustainability, which means it's not only

concerned with increasing efficiency and productivity, but also with reducing the impact of production on the environment, utilizing more renewable energy sources, and promoting a circular economy. These technologies enable high automation and optimization of production processes, resulting in increased efficiency, cost reduction, and improved product quality.

Three fundamental principles of Industry 5.0. (Figure2) are human-centricity, sustainability, and resilience(Gonçalves, 2022):



**Figure 2.** Industry 5.0 with three key drives (Zizic et al., 2022)

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Human centricity is one of the key principles of Industry 5.0, which places people and their needs at the centre of the manufacturing process. This approach recognizes that

technology should serve people and society and emphasizes the importance of adapting technology to meet the needs of workers, rather than forcing workers to adapt to technology. Manufacturers must recognize the potential of technology to enhance the work environment, while also addressing concerns around autonomy and privacy (Amr, 2022).

Sustainability is one of the three fundamental principles of Industry 5.0, which aims to use resources that meet the current needs of the manufacturing industry. The collaboration between humans and machines promotes flexible business models and reducing waste and overproduction is essential. The

promotion of local production can help to make the economy more sustainable. Industry 5.0 fosters the development of sustainable policies, such as minimal waste creation and efficient management, using corporate technologies. It emphasizes creative research and knowledge to drive innovation and evolution.

The principle of resilience is one of the three pillars of Industry 5.0, which emphasizes the need to enhance the robustness of production and supply chains. This makes them more resistant to disruptions and able to secure and support critical infrastructure during crises. This principle complements the sustainability principle. As environmental shocks become more prevalent, companies will need to be flexible enough to handle the unforeseen consequences of unpredictable weather conditions.

#### **4.2. Benefits of implementing Industry 5.0.**

Industry 5.0 represents a new paradigm of industrial production that involves collaboration between humans and machines to create highly customized and personalized products. Although this paradigm is still in its infancy, there are some predictions about its development and use in the future:

- **Increased production flexibility:** Industry 5.0 enables the production of personalized products in smaller batches, which increases the flexibility of the production process. This should lead to a reduction in product storage and transportation costs, as well as a reduction in waste.
- **Increased efficiency:** Integration of digital and physical systems allows for the optimization of production processes and reduces unnecessary energy consumption. This should lead to a reduction in production costs and an increase in efficiency.

- **Increased collaboration between humans and machines:** Industry 5.0 enables real-time collaboration between humans and machines, which should lead to increased productivity and reduced errors.
- **Reduced need for physical labour:** The introduction of automation and robotics in production reduces the need for physical labour. This could lead to increased productivity and reduced costs.
- **Potential for new types of business:** Industry 5.0 enables the creation of new types of businesses, such as personalized products and services, which could lead to economic growth and the creation of new jobs.

Industry 5.0 is expected to introduce a new position in the production process: Chief Robotics Officer (CRO). The CRO will be a specialist in robotics and the interaction between robots and humans. Their role will be to make decisions about adding or removing machines or robots from the factory floor in order to optimize performance and efficiency. The CRO will have expertise in robotics, artificial intelligence, human factors modelling, and human-machine interaction. With access to collaborative robotic technologies and leveraging advancements in computing, the CRO will be well-positioned to positively impact environmental management. This will ultimately lead to increased sustainability by reducing pollution and waste and preserving the planet.

Contrary to the assumption that people will lose their jobs due to artificial intelligence, many studies have shown different results. It is estimated that future technologies will contribute to expanding the global production workforce by up to 4% by 2030, from the current 1.2 billion people (McKinsey Global Institute, 2017). Supply chain management in all industries would



also become more agile and innovative due to increased investment in research and development, intelligent sales and marketing, distribution, and value-based pricing.

However, it should be noted that Industry 5.0 is still evolving and it is difficult to accurately predict its future benefits and challenges

## 5. Conclusion

Based on the analysis presented in this paper, it can be concluded that in Industry 4.0, companies worldwide are automating their production setups and connecting smart devices to enable digital communication between them. This has allowed machines to perform repetitive and laborious tasks. The upcoming Industry 5.0 will focus on bridging the gap between robots and highly skilled human workers to produce and deliver the best individual products, services, and customer experiences. Here, human intervention would be more intellectual than physical.

Industry 5.0 will bring unprecedented challenges in the field of human-machine interaction, as machines will be brought very close to the everyday life of every person. Moreover, it is expected that Industry 5.0 will open up many job opportunities in the field of human-machine interaction and computer analysis of human factors.

Industry 5.0 will revolutionize production systems worldwide by taking away "boring", dirty, and repetitive tasks from the human

workforce wherever possible. Intelligent robots and systems will penetrate supply chains and manufacturing facilities to an unprecedented level. This will be enabled by the introduction of cheaper and highly capable robots made of advanced materials such as carbon fibre and lightweight yet strong materials, supported by highly optimized batteries, reinforced with cyber attacks, with stronger data handling processes (data and artificial intelligence) and networks of intelligent sensors. Industry 5.0 will increase productivity and operational efficiency, be environmentally friendly, reduce workplace injuries, and shorten production cycles. However, contrary to the desire for digitalization and automation of work processes, Industry 5.0 will create surplus jobs. A large number of new jobs will be opened up in the field of intelligent systems, artificial intelligence and robotic programming, maintenance, discovering new types of robots for production, etc. In addition to all the above, tasks that are currently being repeated in certain processes will no longer need to be performed by humans in the future. This will enable creativity to be encouraged in the work process, encouraging everyone to innovatively use different forms of robots in the workplace. However, as a direct impact of Industry 5.0, a large number of start-up companies will build a new ecosystem of providing customized robotic solutions, in terms of hardware and software, worldwide. All of this will further stimulate the global economy and increase the inflow of money worldwide.

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