

CHAPTER 3

The Industry 5.0 Concept as a Game Changer for the Fourth Industry Revolution

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Abstract: The concept of Industry 5.0 is a game changer for the fourth industrial revolution. It extends the ideas of Industry 4.0 with values related to sustainable development, human focus and resilience of the industry. The purpose of the chapter is to identify the critical areas of digital technologies used during the fourth industrial revolution and to identify their impact on achieving the main goals of Industry 5.0, i.e., human orientation, sustainable development and resistance to all kinds of interference. The authors used the method of critical analysis of the literature and conducted an expert survey of selected experts representing the business and academic communities. In addition, the chapter draws attention to the increase in competency requirements of employees related to the implementation of Industry 5.0 technology areas.

Keywords: Industry 5.0, human-centric, resilience, sustainability, competencies

3.1. Introduction

Today, industries that are changing as part of the Fourth Industrial Revolution are having a transformative impact not only on the economy, but also on society. The dynamic development of automation and digitization of processes, which characterizes the concept of Industry 4.0, may undermine the social role of industry as an employer and engine of prosperity (Bai et al., 2020; Ghobakhloo, 2020; Xu et al., 2021). The emergence of these

changes and problems, which are closely linked to purely technological innovations, requires industry to rethink its place and role in society. This is what we call a kind of game changer.

The dehumanization of industry by focusing solely on the implementation of Industry 4.0 technologies has led to many concerns among workers, governments and the public about new working conditions and the role of people in industry and the economy (Olsen & Tomlin, 2020). Thus, a new concept of industrial transformation called Industry 5.0 has emerged, which is currently being supported by the European Commission (European Commission [EC], 2021). Many scientific studies point to the need to include the important role of humans in the assumptions of future industrial development. The humanization of the technological environment built for Industry 4.0 is one of the first factors in the evolution from Industry 4.0 to Industry 5.0. Industry 5.0 is a synergy between humans and machines that significantly changes the playing field in manufacturing enterprises (Grabowska et al., 2022).

In addition to the important factors in the development of cooperation between human capital and intelligent machines, very important environmental aspects related to sustainability and aspects of the lack of resilience of processes and even entire business models were included. The aspect of lack of resilience was particularly noticeable during the COVID-19 pandemic or the start of the war in Ukraine (Javaid et al., 2020). Recognizing the validity and importance of the goals of Industry 5.0, there is a need for research in the field of implementation of digital technologies simultaneously conducive to the development of the Industry 5.0 concept (Ivanov, 2022).

The aim of the chapter is to identify key areas of digital technologies currently used in industry that will strengthen the implementation process of the Industry 5.0 concept. Achieving the aim of the paper requires answering the following research questions: Which Industry 5.0 technologies have the most impact on the Industry 5.0 pillars? The research uses a critical analysis of the literature and the results of an expert study.

3.2. Review of the Subject Literature

Industry 4.0 Towards Industry 5.0

The concept of Industry 4.0 was introduced more than a decade ago in 2011, while research on Industry 5.0 has only gained momentum in the last few years. Academic research on Industry 5.0 has begun sporadically around the world over the past five years. In February 2023, there were 315 articles indexed in the WoS database that include the phrase "Industry 5.0" in their titles, abstracts or keywords. The main research areas covered in these publications relate to the concept of Industry 5.0 focus on man, his cooperation in the human-technology and man-machine system. In technological aspects, research is related to the application and future of the Internet of Things, virtual and augmented reality, Autonomous Vehicles, blockchain and Collaborative Robots. Human-centred research mainly included studies on predicting future working conditions and education of industrial workers, integrated human

and technological aspects, i.e., human-centred manufacturing technology and the quality of human-robot collaboration in the future. Overall, the concept of Industry 5.0 extends the ideas of Industry 4.0 in a broader and more human- and society-friendly way.

Industry 5.0 is based on three essential pillars (EC, 2021).

- Sustainability which implies the use of cyber-physical production systems using renewable energy sources. The European Commission indicates in its report that reducing carbon emissions by 55% by 2030 requires a sustainable industry and an orientation toward sustainable production and consumption. Hence, there is a need for greater orientation toward applying the principles of the digital closed economy and reducing the negative impact of industry on the environment (Maddikunta et al., 2022).
- Human-centric, based on the use of human potential in machine learning or close cooperation between humans and collaborative robots (cobots). The use of digital technologies must not infringe on workers' basic rights, such as the right to respect for privacy, independence and human dignity. Combining the best of two worlds – the speed and accuracy guaranteed by automation – with the cognitive skills and critical thinking of humans is expected to ensure the success of Industry 5.0 (Adel, 2022; Wan & Leirimo, 2023).
- Resilience which stems from the recent experience of the industry, which, through the overdevelopment of global supply chains, has become irrisilient to disruptions caused by geopolitical changes, crises in the form of, for example, the COVID-19 pandemic, armed conflicts, restrictions, etc. (Rožanec et al., 2022; Van Oudenhoven et al., 2022).

In 2020, the European Commission distinguished six basic categories of technological solutions relevant to Industry 5.0, which combine the use of existing Industry 4.0 technologies to realize the goals of the Industry 5.0 concept (EC, 2020) (Figure 3.1).

1. Human-centred solutions and human-machine interaction technologies that combine the strengths of humans and machines. The scope of this area should include, among others, technologies for speech and gesture recognition and predicting human intentions, technologies for tracking the mental and physical workload and stress of employees.
2. Biologically inspired technologies and smart materials that enable the use of materials with embedded sensors and enhanced functions, while being recyclable.
3. Digital twins and real-time simulations to model entire cyber-physical systems. These technologies optimize production, test products and processes, and detect possible detrimental effects on the safe operation and maintenance of production systems.
4. Cybersecure technologies for data transmission, storage and analysis can handle data and system interoperability. This technology area can include networked sensors, and scalable, multi-level cybersecurity (secure IT infrastructure in the cloud).
5. Artificial intelligence, for example, detects causes in complex, dynamic systems, leading to practical information. Currently, the greatest hopes for the development of artificial intelligence are related to the development of technology based on causality, not just correlation.

6. Technologies for energy efficiency targeting the development of renewable energy integration, support for hydrogen and Power-to-X technologies, and development of low-energy data transmission and data analytics technologies.

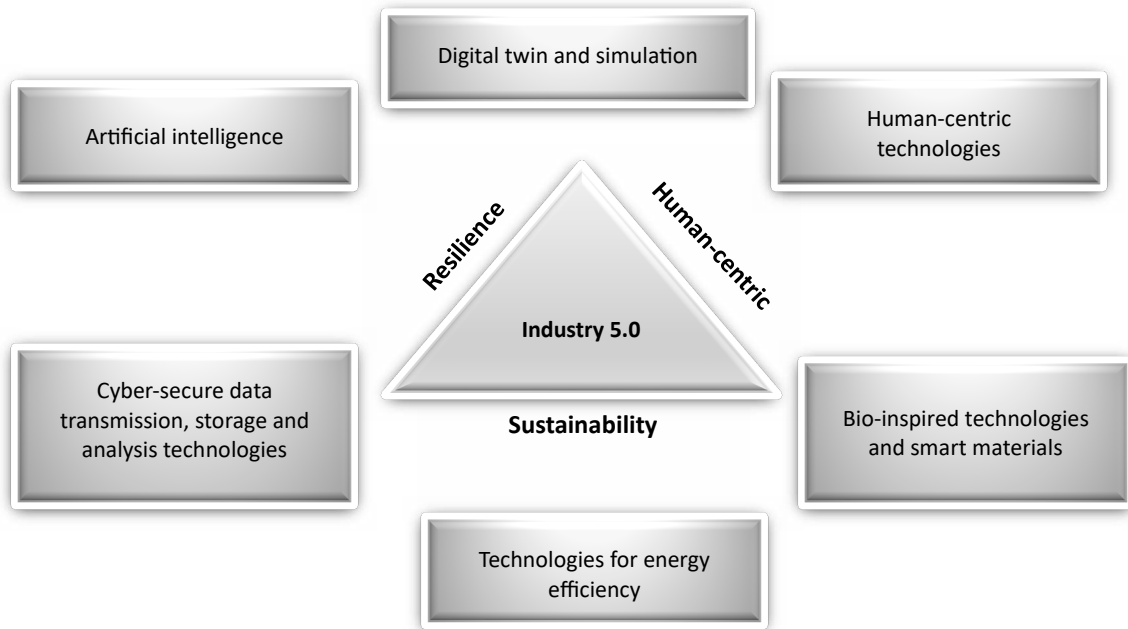


Figure 3.1. Technology categories of relevance to Industry 5.0

Source: own elaboration.

Competency Requirements for Industry 5.0

The case of Industry 5.0 appears to be a special case of a general change in the demand for skills due to the combination of digitization and employee intelligence. In this context, the level of highly-skilled workforce, the ability to transfer knowledge, teamwork and openness to unrestricted communication through the aforementioned digital areas of technology become important (Leng et al., 2022). The skills needed to implement the Industry 5.0 concept are mainly related to digitizing the production environment, collecting and analysing large data sets, ensuring data security, and effectively creating cyber-physical networks of intelligent resources of cooperating enterprises and people. This means changes in education, which should move towards developing professions such as mechatronics, automation, IT, and data analytics, among others, and new skills in place of existing ones, whose share will steadily decrease. Machines are replacing traditional skills, and the emergence of new expected skills requires adaptation to new technologies. An industry transformation focused on creating cyber-physical systems will require new knowledge and competencies from Industry 4.0 engineers and Industry 5.0 managers (Lu et al., 2022).

There is also a need to train next-generation leaders and young talent in Performance Augmentation for Industry 5.0 and Additive Manufacturing, which allows for shorter production runs, the ability to produce parts with geometries not possible with current methods, generating unique features for the design changes that need to be achieved from customer expectations (Orso et al., 2022).

Based on the literature on the knowledge and skills of human resources to implement the Industry 5.0 concept, the following problems can be identified in the area under study (Broo et al., 2022; Cillo et al., 2022):

- employees need knowledge and a new paradigm of skills resulting from the digitization of systems and the cooperation of humans with intelligent cobot machines, which should lead to an increase in the overall efficiency of production systems, the efficiency of operational management and the efficiency of production and support processes;
- there is a need to recruit highly skilled personnel who are characterized by openness to change, ability to transfer knowledge and teamwork in cyber-physical systems;
- it is important to be able to combine knowledge in the area of information and production technologies in the Industry 4.0 and Industry 5.0 environment with management science, especially in the areas of strategy development and case analysis, planning and implementation, collaboration and networking, business models, human resources, change and leadership;
- there is definitely a growing importance of lifelong learning in the Industry 4.0 and 5.0 environment, which requires: promoting a climate of innovation and learning, changing the ways of learning (e.g., remote learning), new approaches to developing human resources talent.

The success of any enterprise highly depends on its employees, who possess the necessary skills, knowledge, and competence to play a crucial role in the growth and development of the organization. With advancements in digital technologies and innovation, employers face new challenges in personnel development, motivation, and management, especially for those employees with above-average abilities (Ustundag et al., 2018). Talent management will be crucial to human resources management in Industry 5.0. With increasing competition in the market, the organization's success will depend on its employees' unique competencies and talents.

3.3. Materials and Methods

A literature synthesis – research studies and expert studies – was used to achieve the paper's aim and answers to research questions. The chapter proposes an expert method involving interviews with experts with experience in implementing Industry 4.0 technologies. The study used an individual in-depth interview (IDI) with selected experts using a structured questionnaire supported by a Computer-Assisted Web Interview data collection technique.

The selection of experts was purposeful based on the adopted criterion, which meant participation in implementing at least three Industry 4.0 technologies in practice. Three representatives of the scientific community (professors) and eleven managers representing companies that have implemented Industry 4.0 technologies were invited to participate in the study. The companies mainly represent the automotive, food and mechanical processing industries. The study is a pilot study and constitutes a basis for further in-depth research. Data for analysis were collected from December 2022 to February 2023.

The experts were tasked with assessing the impact of the six technology areas proposed by the European Commission on the three pillars of Industry 5.0: human orientation, sustainability and resilience. Impact was assessed using a 5-point Likert scale of 1 – no impact, to 5 – very high impact.

3.4. Results and Discussion

Noteworthy in the Industry 5.0 concept is the comprehensive approach to implementing individual technologies. That is the need to combine different technologies to achieve all the goals associated with the Industry 5.0 concept, namely sustainable economic development, orientation to human well-being in production systems, and achieving a high level of resilience to all kinds of disruptions (Huang et al., 2022). Figure 3.2 illustrates experts' responses regarding the impact of implementing the various areas of Industry 5.0 technology on the role of humans in cyber-physical systems. Experts unequivocally indicated a significant impact of human-oriented technologies and human-machine interaction technologies. They also highlighted the relatively high impact of digital twin and simulation technologies. The lowest impact on human orientation in the Industry 5.0 environment was shown by the experts in relation to technologies for energy efficiency.

Figure 3.3 shows respondents' answers regarding the impact of Industry 5.0 technology areas on sustainability. In this case, experts singled out energy efficiency techniques, bio-inspired technologies, and smart materials. High importance was also given to the implementation of digital twin and simulation technologies. Similarly, human-oriented solutions and human-machine interaction technologies significantly impact sustainability. Other technologies are of medium importance, according to experts. No area was indicated as having no impact on sustainability.

Figure 3.4 shows the experts' opinions on the impact of the proposed technology areas on the resilience of Industry 5.0 systems. Experts see a significant role in achieving greater resilience to all kinds of disruptions in implementing technologies for energy efficiency, technologies related to cyber security and technologies for transmission, data storage and analysis, digital twins and simulation, and the use of artificial intelligence in production systems. According to experts, the medium impact on resilience comes from human-centred solutions, biology-inspired technologies, and smart materials.

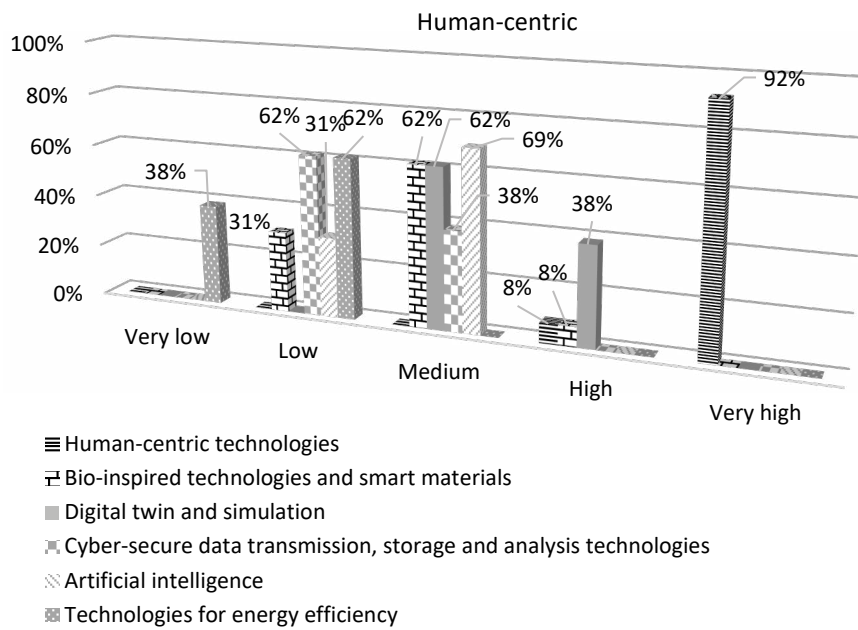


Figure 3.2. The impact of Industry 5.0 technology areas on the human-centric pillar

Source: own elaboration.

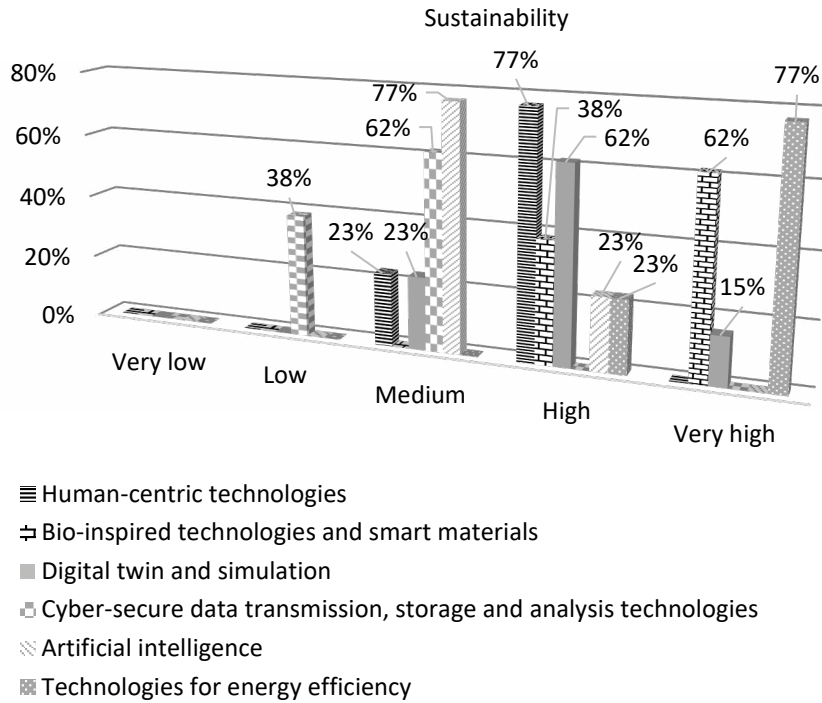


Figure 3.3. The impact of Industry 5.0 technology areas on the sustainable development pillar

Source: own elaboration.

and consumption, which is reflected in, among other things, a higher level of orientation to personalized production and a higher level of servitisation of enterprises.

In this context, the level of a highly-skilled workforce, the ability to transfer knowledge, teamwork and openness to unrestricted communication through technologies such as the Internet of Things, Big Data, Cloud Computing, Blockchain, etc., becomes essential. Industry 5.0 is a challenge in diversifying the competence of employees, especially engineers. However, it should not be forgotten that the essence of the functioning of the enterprises of the future is the employees. Their competencies, knowledge and skills will allow the company to grow. Employers are increasingly being forced to take on new challenges in enterprise social capital management, development, motivation, and talent management.

The presented research results were based on a small group of experts, which limits the generalization of the presented results. However, the obtained results may inspire further, more in-depth empirical analyses based on research on enterprises implementing Industry 4.0 and 5.0 technologies.

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Koncepcja Przemysłu 5.0 jako game changer dla czwartej rewolucji przemysłowej

Streszczenie: Koncepcja Przemysłu 5.0 to zmiana gry dla czwartej rewolucji przemysłowej. Rozszerza ona idee Przemysłu 4.0 o wartości związane ze zrównoważonym rozwojem, skoncentrowaniem na człowieku i odpornością branży. Celem rozdziału jest identyfikacja kluczowych obszarów technologii cyfrowych wykorzystywanych w czwartej rewolucji przemysłowej oraz identyfikacja ich wpływu na osiągnięcie głównych celów Przemysłu 5.0, czyli orientacji na człowieka, zrównoważonym rozwoju i odporności na wszelkiego rodzaju zakłócenia. Autorzy wykorzystali metodę krytycznej analizy literatury oraz przeprowadzili badanie eksperckie wśród wybranych ekspertów reprezentujących środowisko biznesowe i naukowe. Ponadto w rozdziale zwrócono uwagę na wzrost wymagań kompetencyjnych pracowników związany z wdrożeniem obszarów technologicznych Przemysłu 5.0.

Słowa kluczowe: Przemysł 5.0, orientacja na człowieka, odporność, zrównoważony rozwój, kompetencje