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INDUSTRY 5.0 – DIRECTIONS OF BUSINESS ACTION AND KNOWLEDGE OF TECHNOLOGY IN THE CONTEXT OF SURVEYS OF EMPLOYEES OF MANUFACTURING COMPANIES

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Purpose: The purpose of this article is to assess the familiarity of employees of manufacturing companies with Industry 5.0 technologies and to evaluate their level of knowledge about their employer's current activities aimed at implementing the Industry 5.0 concept.
Design/methodology/approach: The achievements and results presented in the article were obtained in a survey conducted. The survey covered manufacturing companies with their factories located in Poland. The duration of the survey work was from November 2022 to March 2023. The research instrument was a survey questionnaire. The survey was conducted using the Computer-Assisted Web Interview (CAWI) method. The empirical study involved 828 respondents.
Findings: Most of the surveyed employees are aware that the enterprise where they work is investing in modern Industry 4.0 technologies. A large proportion of respondents know what financial condition the enterprise is in, and are familiar with the enterprise's goals and strategic plans. On the other hand, the least number of employees declare that they know in what strategic direction the enterprise where they work is heading, or are not aware of the enterprise's activities aimed at implementing Industry 5.0. It turns out that for the most part, Industry 5.0 technologies are of very low or low familiarity to the surveyed employees.
Research limitations/implications: As a limitation of the study can be pointed out the fact that it was conducted in Polish conditions and only in relation to them can the conclusions drawn from it be read. Thus, it would be reasonable to conduct similar research in other cultural contexts in more and less developed countries. At this point it is also necessary to mention an important limitation of the study which is the subjectivity of the respondents.
Originality/value: Original achievements obtained during the research include obtaining results from assessing the knowledge of Industry 5.0 technologies among employees of manufacturing companies and evaluating their level of knowledge about their employer's current activities aimed at implementing the Industry 5.0 concept.
Keywords: Industry 5.0, technologies, employees**.**
Category of the paper: research paper.

1. Introduction

The current increase in the implementation of Industry 4.0 technologies and the focus of companies on the dehumanization of production systems have caused numerous concerns among workers, the public and even governments. In Industry 4.0, the work environment is determined by integrated and advanced manufacturing technologies equipped with sensors that track machine operation and communication systems that report data and perform advanced simulations. The role of current employees is very rarely mentioned. Numerous scientific studies (Romero et al., 2015; Longo et al., 2020; Mukherjee et al., 2023) emphasize the need to include the key role of humans in the assumptions of industrial development. In this regard, from July 2 to 9, 2020, the concept of Industry 5.0 was discussed among participants from research and technology organizations organized by the "Prosperity" Directorate of DG Research and Innovation of the EC. In the European Commission (EC) document you can find the assumptions of the Industry 5.0 concept. At the heart of the document are critical directions of change to make industry more sustainable and human-centered. The EC document (Industry 5.0 2021) identifies six areas of challenge for Industry 5.0:

1. Human-machine interaction;
2. Biotechnologies and smart materials;
3. Digital twins and simulation;
4. Data transmission, storage and analysis technologies (iv);
5. Artificial intelligence;
6. Technologies for energy efficiency, renewable energy and renewable energy.

The concept of Industry 5.0 involves the return of the human factor to industry, i.e. increased collaboration between humans and intelligent production systems. Combining the best of both worlds - the speed and accuracy guaranteed by automation with the cognitive skills and critical thinking of humans - ensures the success of Industry 5.0 (Yordanova, 2021; Doyle-Kent, Kopacek, 2019).

Hence, the purpose of this article is to assess the familiarity of employees of manufacturing companies with Industry 5.0 technologies and to evaluate their level of knowledge about their employer's current activities aimed at implementing the Industry 5.0 concept.

2. Industry 5.0 – literature review

Industry 4.0 puts technology at the center, while Industry 5.0 focuses on production workers who see progressive automation as a threat to job loss. Industry 5.0 recognizes the power of technology for industrial (business) development, but combines the achievement of business

goals with social goals in the workplace and beyond (social and environmental responsibility) (Ghobakhloo et al., 2023). Cyber-physical systems intertwined with social and environmental frameworks underpin the manufacturing process. Today, CPS operating in smart factories lead to economic growth and put people at the center of collaboration with smart resources and a more robust perception of sustainability (Sachsenmeier, 2016; Demir, Cicibas 2017, Raja et al., 2023).

As with Industry 4.0, Industry 5.0 is defined in the literature in terms of many perspectives, but there is still no universally accepted, unambiguous definition of it. Table 1 presents selected definitions of Industry 5.0.

Table 1.
Selected definitions of Industry 5.0

Author	Definitions
V. Özdemir, N. Hekim (2018)	Industry 5.0 is evolutionary and incremental, is based on the concept of Industry 4.0. Industry 5.0 uses digital technologies such as big data and IoT to democratize knowledge, leading society to a sustainable ecosystem.
S. Nahavandi (2019)	This is an evolutionary step towards human-machine symbiosis. Industry 5.0 aims to address the aspect of human centricity, an aspect of sustainability in which robots cooperate with operators instead of compete.
F. Longo et al. (2020)	Industry 5.0 represents a new revolution in which cyber-physical manufacturing systems and human operators are integrated to realize CPPS and human agents to create a symbiotic factory concept. Value-oriented and ethical technology is one of the critical aspects of the Industry 5.0.
X. Xu et al. (2021)	It is an evolutionary paradigm that complements Industry 4.0, driving innovation that promotes environmental and social values. Technologies that enable virtualization and integration of the machines are central to Industry 5.0.
D. Ivanov (2022)	It is a multifaceted phenomenon that draws on technological innovation to promote sustainable development. The scope of Industry 5.0 includes corporations, supply networks and society. Industry 5.0 values resilience over value creation, humanocentrism and social needs.
S. Huang et al. (2022)	It is a futuristic paradigm that applies adaptable and flexible technological innovations to promote industrial development and environmental protection.
J. Leng et al. (2022)	It is a dynamic and evolving paradigm that pursues a vision of co-creation and industrial development driven by shareholders.
M. Sharma (2022)	Industry 5.0 represents a revolutionary and disruptive innovation that changes the paradigm of production, realizing the transition from a linear economic model to a circular economy.

Source: Own elaboration based on Ghobakloo et al., 2023.

Analyzing the definitions summarized in Table 1, it can be assumed that, in general, the concept of Industry 5.0 extends the ideas of Industry 4.0 in a broader and more human- and social-friendly way. What is most important is that Industry 5.0 is based on three basic pillars (European Commission, 2021):

- Sustainability, which involves 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 a focus on sustainable production and consumption. Consequently, there is a need for a greater focus on applying the principles of a digital closed-loop economy and reducing the negative environmental impact of industry (Maddikunta et al., 2022).

- Human-centered, based on the use of human potential in machine learning or close cooperation between humans and cooperating 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, Leirmo, 2023).
- Resilience, which stems from the recent experience of an industry that, thanks to the overdevelopment of global supply chains, has become resilient to disruptions caused by geopolitical changes, crises such as the COVID-19 pandemic, armed conflicts, restrictions, etc. (Rožanec et al., 2022; van Oudenhoven et al., 2022). Resilience can be defined as the ability to cope with disruptions using Industry 4.0 technologies.

In 2020, the European Commission has distinguished six basic categories of technology solutions relevant to Industry 5.0, which combine the use of existing Industry 4.0 technologies to achieve the goals of the Industry 5.0 concept (European Commission, 2021):

- Human-centric 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 prediction of human intentions, technologies for tracking mental and physical workload and employee stress.
- Biologically-inspired technologies and smart materials that enable the use of materials with embedded sensors and enhanced functions, while being recyclable.
- Digital twins and real-time simulations to model entire cyber-physical systems. These technologies optimize production, test products and processes, and detect possible harmful effects on the safe operation and maintenance of production systems.
- Cyber-secure data transmission, storage and analysis technologies that are capable of handling data and system interoperability. This technology area can include: the use of network sensors, scalable, multi-tiered cyber security, and cyber security (secure IT infrastructure in the cloud).
- Artificial intelligence, for example, detects causes in complex, dynamic systems, leading to practical information. Currently, the greatest hopes for the development of artificial intelligence lie in the development of technology based on causality, not just correlation.
- Technologies for Energy Efficiency targeted at the development of renewable energy integration, support for hydrogen and Power-to-X technologies, and the development of low-energy data transmission and data analysis technologies.

It can be said unequivocally that Industry 5.0 is about realizing the collaboration between the digital world and people's critical and creative thinking abilities, while maintaining flexibility and resilience in processes, with due attention directed toward sustainability.

History has already shown that previous industrial revolutions have taken decades or centuries to enable the emergence of disruptive technologies, which industries adapt slowly before moving from one "revolution" to another. This is aptly called a "revolution" because the level of innovation behind the technologies is capable of completely revolutionizing entire industrial practices, rather than just providing incremental improvements. However, if the insights of scientists and business practitioners are taken into account, the next big thing will be the collaboration of people with digital technologies, with an additional focus on economic, social and environmental sustainability (Raja Santhi, Muthuswamy, 2023).

Sustainability is among the most important goals of developed countries. With the world's natural resources dwindling, it has become a major challenge for producers and consumers to act on the principle of "how to get more by using less". In order to deal with this challenge at a time of rapid climate change and increasing demand for energy and resources, a whole range of strategies and initiatives have been introduced aimed at sustainable consumption and production. These should contribute to an overall increase in the environmental performance of products throughout their life cycle, to increasing demand for better products and production technologies, and to consumers making informed choices (Kirkby et al., 2023). The challenge for developing economies is to balance economic growth and the pursuit of prosperity with environmental concerns. To achieve this goal, it is necessary to balance the three aspects of development: economic, social and environmental, which necessitates continuous improvement of products, optimization of production technologies, so that with the least possible consumption of raw materials and impact on the environment, products with the best possible performance and economic profitability are produced.

In terms of topics in the area of Industry 4.0, much attention is paid to aspects of sustainability - consumer, business models, economy (Srhir et al., 2023). From the perspective of sustainability, T. Stock and G. Selinger (2016) defined Industry 4.0 as a stage towards more sustainable industrial value creation. Arguing that industrial value creation must be oriented toward sustainability and Industry 4.0, providing tremendous opportunities to realize sustainable production. By providing detailed information on every point of production, processes, resources and energy consumption can be optimized across the value network (Gabriel, Pessel, 2016). Artificial intelligence and digitization will increase the predictability of demand and supply for renewable energy sources, improve energy storage, help the integration and reliability of renewables, and enable dynamic pricing, creating market incentives (Liu et al., 2023; Khan et al., 2023). New technological solutions promoted under Industry 4.0 should help increase both the efficiency of production and the environmental performance of products throughout their life cycle. This also implies an increase in demand for smart products and smart manufacturing technologies. In a sustainable market, customers (consumers) should make informed choices by buying "environmentally friendly" products, i.e. those that are recycled, serviced, renewable, shared, etc. (Ramanujan et al., 2023; Yavuz et al., 2023).

Sustainable production and sustainable consumption attempts to combine, on the one hand, the need to meet needs, improve the quality of life, and on the other hand, improve resource efficiency, increase the use of renewable energy sources, minimize waste. Integration of these elements is the main goal of modern economies, which want to provide the same or better services to meet the basic requirements of life and aspire to improve the quality of life while continuously reducing environmental damage and risks to human health. A key issue, therefore, is the extent to which the necessary improvements in environmental quality can be achieved by bringing more efficient and less polluting goods and services to market (consumption patterns) rather than by reducing the amount of goods and services consumed (consumption levels). This implies the need to change consumption patterns and reduce the volume of consumption (Grabowska, 2022).

Industry 5.0 goes back to the origins of sustainability, emphasizing that purely profit-driven business is becoming increasingly difficult to sustain in a globalized, highly volatile and unpredictable environment. Underlying the development of the new concept are social and environmental needs (Xian et al., 2023). The industry must incorporate social and environmental aspects to become a provider of true prosperity. The symbiosis of the three segments: technological, social and environmental is the essence of Industry 5.0 (Elfar et al., 2021).

The goal of Industry 5.0 is a higher standard of living and creativity with high-quality, custom-made products. The theme of Industry 5.0 is simply sustainability. It should be noted that in recent years, many companies have started green manufacturing and production programs. In addition, they are focusing on social responsibility projects. People's awareness of environmental protection is increasing. Customers are beginning to choose products created by companies that promote green manufacturing (Grabowska, 2022).

3. Material and methods

The survey covered manufacturing companies with their factories located in Poland. The duration of the survey work covered the period from November 2022 to March 2023. The research instrument was a survey questionnaire. The survey was conducted using the Computer-Assisted Web Interview (CAWI) method. The questionnaire was validated, and a pilot survey was conducted among 12 experts with knowledge of the Fourth Industrial Revolution. The experts included 6 entrepreneurs and 6 scientists.

The survey consisted of selecting enterprises using paid enterprise databases (BNF and ZNDirect), Internet search engines, and the use of a database of companies cooperating with the Silesian University of Technology. Due to the nature of the research, the survey questionnaire was addressed to 250 manufacturing companies located throughout Poland. The empirical study involved 828 respondents, including 422 (51%) women and 406 (49%). Citing data from the Central Statistical Office (CSO) stating that large enterprises in Poland employed 3.22 million workers at the end of 2022, assuming a confidence level of 95% and an error of 4%, it was estimated that the minimum sample size to be representative must be 600 respondents. The resulting survey sample (828 surveys) can be considered quasi-representative.

The age of the respondents was presented in five categories, where the largest age group was between 36 and 45 years old (46.6%). On the other hand, the smallest age group consisted of those in the 19 to 25 age range (2.4%). Other age groups ranged from 26 to 35 (9.7%), 46 to 55 (23.2%) and 56 to 67 (18.1%). The data obtained indicate that the study had the highest number of middle-aged people (36-55).

Characterization of the study group was also based on the presentation of the percentage distribution of education of the subjects. The declarations of the subjects were divided into three groups of education obtained. The largest number of respondents declare that they have secondary education (47.8%). On the other hand, the smallest number of respondents declared that they had vocational level education (20.2%). Other groups of respondents declared that they had higher education (32%).

4. Results

The starting point was to verify the level of familiarity with Industry 5.0 technologies among the surveyed employees. It turns out that for the most part, the technologies listed are of very low or low familiarity to the surveyed employees.

Respondents rated their familiarity with Industry 5.0 technologies:

- Human-centered solutions and human-machine interaction technologies - 37.4% of respondents rated their familiarity with these technologies as very low, 36.4% as low, 15.5% as medium, 9.7% as high, 1.1% as very high;
- Biology-inspired technologies and smart materials - 39.4% of respondents rated their knowledge of these technologies very low, 34.4% low, 16.2% medium, 8.9% high, 1.1% very high;
- Digital twins and real-time simulation - 40.5% of respondents rated their knowledge of these technologies very low, 32% low, 16.8% medium, 9.7% high, 1.1% very high;

- Cyber secure data transmission, storage and analysis technologies - 47.2% of respondents rated their knowledge of these technologies at a very low level, 23.1% at a low level, 19% at a medium level, 9.7% at a high level, 1.1% at a very high level;
- Artificial intelligence - 41.2% of respondents rated knowledge of this technology at a very low level, 29.5% at a low level, 18.6% at a medium level, 9.7% at a high level, 1.1% at a very high level;
- Technologies for energy efficiency aimed at developing the integration of renewable energy sources - 47% of respondents rated their knowledge of these technologies at a very low level, 23.3% at a low level, 16.85 at a medium level, 11.8% at a high level, 1.1% at a very high level.

The result of the frequency analysis is shown in Figure 1.

Next, the declarations of respondents were analyzed in relation to the question of whether they are aware of the current activities of the enterprise aimed at implementing the concept of Industry 5.0. It turns out that most of the surveyed employees are aware that the enterprise where they work is investing in modern technologies (86.9%). A large proportion of respondents know what financial condition the enterprise is in (39.8%) and know the goals, strategic plans of the enterprise (35.3%). On the other hand, the least number of employees declare that they know in what strategic direction the enterprise in which they work is heading (21.7%), or are not aware of the enterprise's activities aimed at implementing Industry 5.0 (14.7%). The result of the analysis is shown in Figure 2.

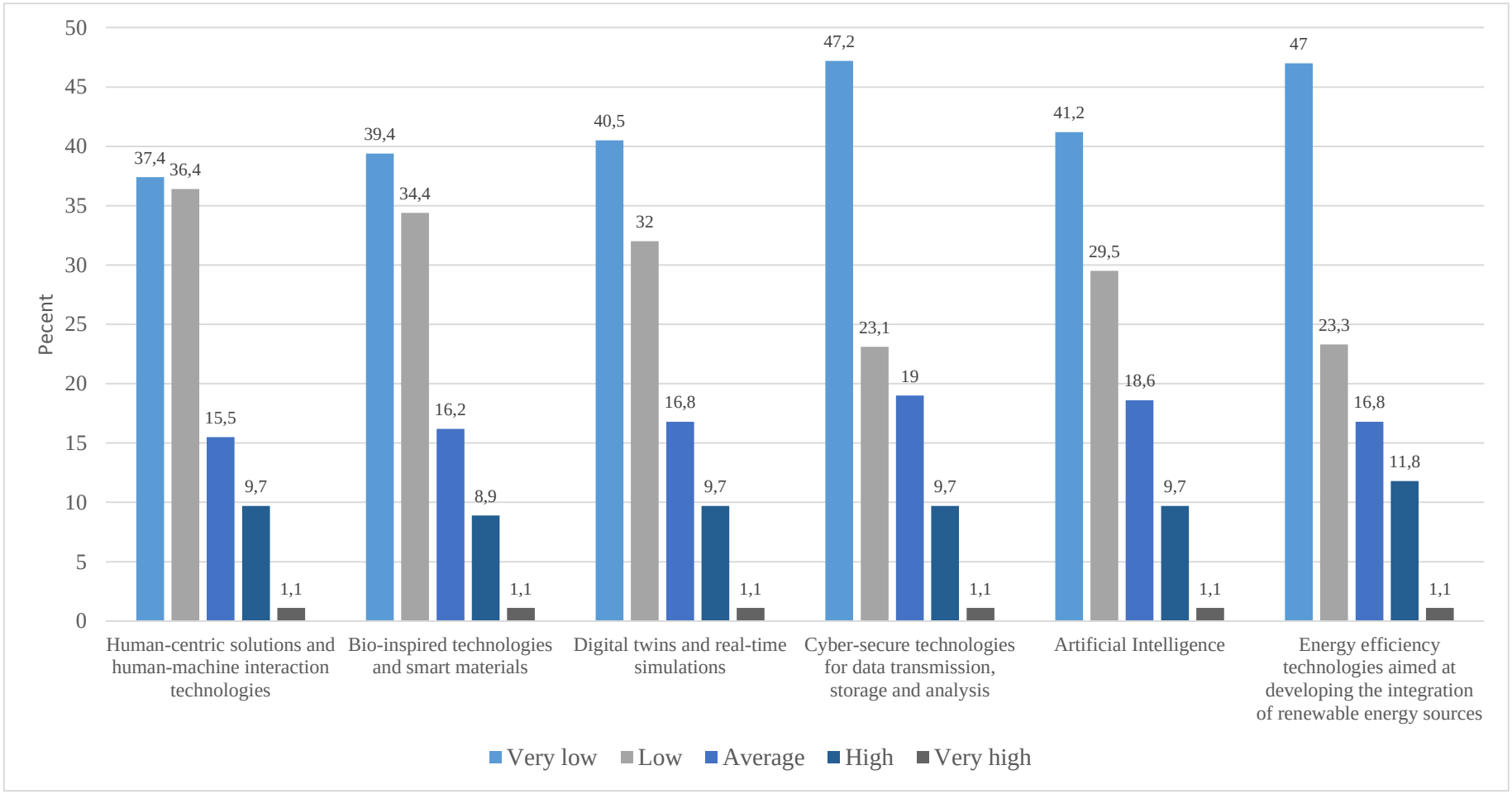

Figure 1. Complex systems of polygamous holes made from one cluster to several coal deposits.

Source: own study.

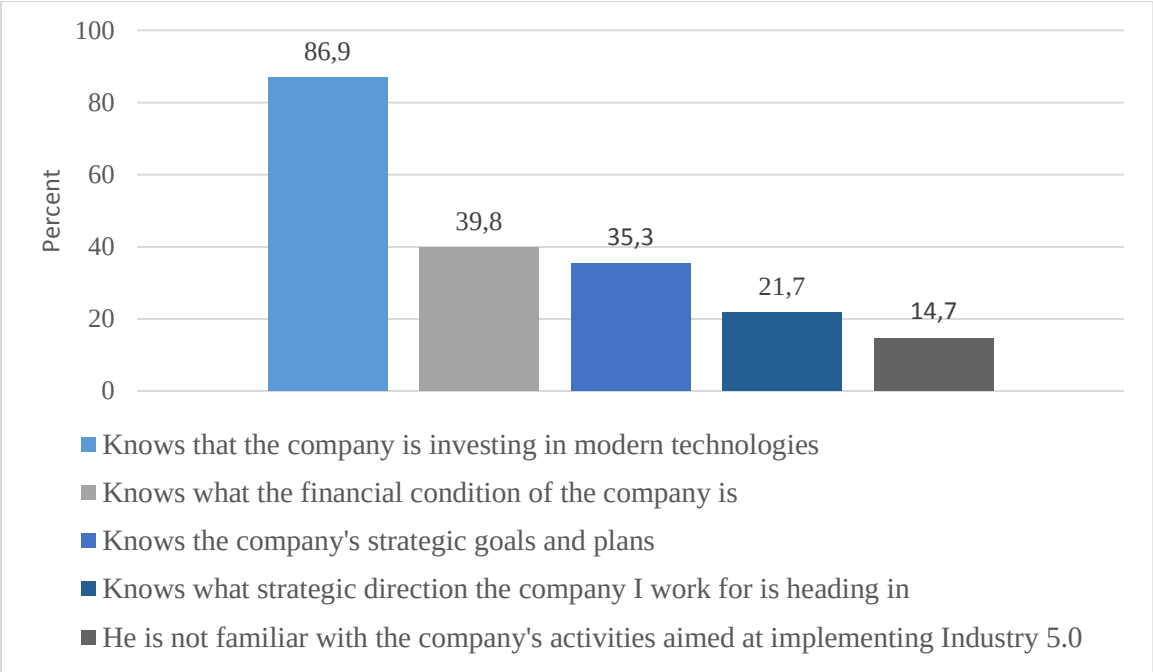

Figure 2. Employees' knowledge of the company's current activities aimed at implementing the Industry 5.0 concept.

Source: own study.

5. Conclusion

The dehumanization of industry by focusing exclusively on the implementation of Industry 4.0 technologies has caused numerous concerns among workers, governments and societies about new working conditions and the role of humans in industry and the economy. Industry 5.0 complements and extends the distinctive features of Industry 4.0. It emphasizes aspects that will be decisive factors in the placement of industry in future European society. Numerous scientific studies point to the need to include the key role of human beings in the development assumptions of future industry. The humanization of the technological environment of Industry 4.0 was one of the first factors in the evolution of Industry 4.0 towards the concept of Industry 5.0. The new approach of the fourth industrial revolution focuses on the interaction between humans and intelligent machines. Industry 5.0 will continue the emphasis on more advanced human-machine interfaces using artificial intelligence (AI) algorithms. This will mean better integration, enabling faster, better automation coupled with human brain power, but it will also mean changing the demands placed on managers and engineers. However, as surveys conducted among employees of manufacturing companies show that the level of awareness of Industry 5.0 technologies is very low. Most of the surveyed employees are aware that the company where they work is investing in modern Industry 4.0 technologies. A large proportion of respondents know what financial condition the company is in, and are

familiar with the company's goals and strategic plans. On the other hand, the least number of employees declare that they know in what strategic direction the enterprise they work for is heading, or are not aware of the enterprise's activities aimed at implementing Industry 5.0.

These results show how many barriers there are still to overcome in enterprises in order for a strategy involving the implementation of the Industry 5.0 concept to become fully operational at every level of the company. The results of the research are particularly valuable for managers implementing the concept of Industry 5.0, they show how to support employees to overcome their resistance to change.

As a limitation of the study, it can be pointed out that it was conducted in Polish conditions and only in relation to them can the conclusions drawn from it be read. Thus, it would be reasonable to conduct similar studies in other cultural contexts in more and less developed countries. At this point it is also necessary to mention an important limitation of the survey, which is the subjectivity of the respondents.

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