Digitalization and the Transformation of Industrial Work Systems in the Era of Industry 5.0

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Abstract: In the modern conditions of accelerated technological development, digitalization is one of the main drivers of the development of the industrial work system. In this sense, the concept of Industry 5.0 represents a new paradigmatic scheme of development that emphasizes the synergy between man and advanced technology in order to create more sustainable work systems. In this sense. not only does digitalization affect technological processes, but it also significantly changes the structure of work, the organizational environment and the competencies required of employees. Accordingly, this research examines the impact of digitization within Industry 5.0, on employees and the transformation of the modern way of working with special emphasis on employee motivation, development of digital skills, organizational support and balance between business and private life, whereby empirical research was conducted using the survey method, on a sample of employees in various industrial sectors, after which they were analyzed using descriptive statistics and exploratory factor analysis. The research results indicate the existence of five key dimensions, which describe employees' perception of digital transformation: motivation and readiness of employees for digital changes, technological aspects of digitization, balance between work and private life, organizational support and quality of the digital work environment. The obtained findings confirm that the successful implementation of Industry 5.0 requires an integrated approach that implies the simultaneous development of technological infrastructure, digital competencies of employees and adaptation of the organizational environment to new work models.

Keywords: Industry 5.0, digitization, digital transformation, transformation of work in industry, digital skills

1 Introduction

The way digital technologies are changing is really affecting how big companies and factories work. This is because of technologies such as artificial intelligence, the Internet of Things, big data, and cloud infrastructure. These infrastructures are

helping and becoming an integral part of how organizations function. It is also important to emphasize that these changes are not about technology, but also about the way people do their jobs and make decisions. People who work in these companies now need skills that are continually improved and acquired. Because digitalization is the area that is changing business models and the way companies work. This is what some authors, like Gorodetsky et al. (2020), discovered in their research [1]. Because of all these changes, something called Industry 5.0 is becoming really important. Industry 5.0 is, as it were, a way of thinking about how companies can use technology and acquire new ones, while still ensuring that people are happy and doing well. Industry 5.0 attempts to balance technology and people, which will be increasingly imperative in the future. As such, Industry 5.0 is emerging as an idea that is becoming increasingly popular over time.

In contrast to earlier industrial types which concentrated primarily on the mechanization and optimization of production processes, the most recent one recognizes the relationship between humans and intelligent machines as paramount. Human creativity, critical thinking, and problem-solving will complement the technological capabilities of robotics and digital systems [2]. The result of such synergies will be the realization of more flexible production systems and greater adaptability to market needs and the performance of personalized goods and services [3].

The Industry 5.0 signifies the introduction of advanced intelligent industry with the objective of enhancing the relationship between humans and industrial machines through the integration of sustainable advanced technologies and incorporation of the human touch. The implementation of these technologies not only has a major impact on the technological set-up of organizations but also significantly alters the working environment, the structure of work tasks and the competencies required of employees. At the same time, the application of the principles of Industry 5.0 is facing a series of new challenges. Data security, ethical use of artificial intelligence and privacy protection are becoming the subject of ever more scientific and professional discussions, while organizations are faced with the challenge of rebuilding the workforce to fit new technological working conditions [4]. It is becoming increasingly important to understand how employees comprehend the digital transformation and to what extent they are ready to accept the changes that the new way of carrying out the business in the industry will bring. As the theme of Industry 5.0 is increasingly reflected in the literature, empirical studies that investigate the impacts of digitization on employees and the transformation of work seem not to be yet so present. In particular, it is not known how well employees perceive digital transformation and how ready they are to adapt to new technological working conditions.

Based on the aforementioned theoretical framework, this paper aims to investigate to what extent digitisation within the concept of Industry 5.0 affects employees and the transformation of the modern way of working in organisations of various industries. In this sense, the paper explores how employees accept the impact of

digital transformation on work organization, and on the other hand, to what extent digitalization affects employee motivation and their professional development. Also, how important is having digital skills and how important is organizational support in the process of adapting to new technological working conditions. In addition to the basic factors, the research considers how digital transformation affects the balance between work and private life of employees in various industrial sectors.

2 Literature review

It is necessary to keep in mind that Industry 5.0 is actually a causal consequence of Industry 4.0. In the literature, it is often pointed out that industrial development took place through several technological phases that always arose as a response to changes and advances in industrial systems [5]. Industry 4.0, as the precursor and key driver of further advancements in digitalization and robotics, was fundamentally built upon transformative changes in the digitalization and automation of companies. The use of the Internet is becoming more and more expressive, and according to the authors [6], which is represented by the Internet of Things (IoT), as a technology that enables the connection of devices, machines and production systems via the Internet. In addition, the authors spoke about Industry 4.0 as an important phenomenon in the future, because it enables the integration of digital technology in the production and development of digitized factories and products [7]. While on the one hand robotic systems were widely applied within Industry 4.0, on the other hand, Industry 5.0 will introduce an approach that is more focused on the needs of end users, with the aim of satisfying their needs [4]. Such understandings lead to the fact that in fact, in addition to achieving an exceptional degree of digitization and modernization of the technological process, one of the main goals for the further development of Industry 5.0 is the achievement of cooperation between machines and workers. Machines participate together in work and achieving goals, thus significantly transforming work and the work process. This approach, leads more and more authors to engage in a more detailed analysis of the challenges and design principles of effective human cooperation and intelligent systems, as the authors did [8]. In their work, they analyze how technology can support workers instead of neglecting them, what are the principles of cooperation between people, employees and machines in the industrial system, as well as how to develop human centric production systems. And when it comes to performing tasks, Nahavandi (2019) highlights that routine, repetitive, and physically demanding work can be performed by robots instead of people [10]. At the same time, operational efficiency and increased productivity can be achieved by introducing new systems such as: a network of smart sensors, big data analysis, artificial intelligence. It is a fact that a greater degree of adaptation is required when

collaborating collaborative robots and humans. Robots need to be programmed according to industry needs, and people need proper training and support.

Artificial intelligence plays a crucial role in modern industrial systems, particularly in software architectures that enable the organization of algorithms for robot control and the optimization of production processes. These algorithms support monitoring, regulation, and continuous adjustment of operations, thereby contributing to the development of smart manufacturing. Alongside this, augmented intelligence emphasizes the synergy between human and artificial intelligence, aiming to enhance the capabilities of both in production environments [10], while earlier research has already highlighted AI applications in robotics, logistics planning, translation systems, and speech recognition [11]. In parallel, collaborative robots enable safe and efficient human–robot interaction within shared workspaces, where robots can adapt to human actions using sensors and intuitive communication interfaces, significantly improving tasks that require flexibility and partial automation [12]. Another key concept is digital twins, which represent dynamic virtual models of physical systems continuously updated through sensor data, enabling real-time monitoring, simulation, and analysis supported by IoT, big data, and AI technologies [13, 14]. Together, these technologies are transforming multiple sectors, including healthcare, logistics and supply chain management, energy systems, fashion industry, and education, where they enhance efficiency, personalization, sustainability, and decision-making processes. The application of smart systems is widely present in education and training. Specifically in the educational sector, modern technologies. bring new approaches to learning based on the personalization of the educational process.

The impact of Industry 5.0 is felt in all industries through the way they affect the transformation of work. Through the literature review, Industry 5.0 is still in the process of being introduced, various industries are still adapting and introducing new technology. New technology is not something that comes by itself, it is also necessary to invest in it, that's why available resources in the company play a big role. Resources in the company do not have to be only monetary, they also concern human resources. These events lead more and more authors to engage in research on Industry 5.0 and employees [15]. deal in their researc with the impact of digital transformation on the future of work, emphasizing that the development of technologies changes the structure of occupations, the organization of work and the requirements for skills in the modern age [16].

3 Research methodology

The goal of this paper is the analysis of the key aspects of digitization within the concept of Industry 5.0 with a special focus on its impact on employees and the transformation of modern work. The research is of a quantitative nature, based on a

survey conducted via the online platform Google Forms. The way the survey was conducted enabled the anonymous participation of respondents and the inclusion of a wider population of employees from various industrial sectors. The collected data, on the other hand, provide insight into the attitudes and experiences of employees in relation to the digitization and implementation of Industry 5.0. Analyzing the results of 270 respondents, who are employed in various industrial sectors, provides clarity and contributes to a better understanding of digital transformation in the modern random environment. The research process was carried out in accordance with the ethical standards of scientific research, which means that the respondents were informed about the purpose of the research, while their participation was completely anonymous and voluntary. Anonymous surveying made it possible for all previously collected data to be processed in a way that does not provide the possibility of identifying individual respondents.

Survey questionnaire consists of closed questions, harmoniously organized, in five thematic areas, which include different dimensions of the impact of digitization and Industry 5.0. The questions in the survey were rated using a Likert scale. For the purposes of the research, it was formed on the basis of five levels, where the respondents expressed the degree of agreement with the offered statements. The statements were formed according to the principle from completely disagree to completely agree. After data collection, data were adjusted for further analysis. Analysis of the obtained data followed with the help of the IBM SPSS Statistics software package. Descriptive statistics were applied to show the basic characteristics of the sample, as well as exploratory factor analysis (EFA), which was used to identify latent dimensions that describe employees' attitudes towards digitization and work transformation. Exploratory factor analysis was carried out using the Principal Component Analysis (PCA) method with Varimax rotation, in order to enable a clearer interpretation of factor structures and relationships between variables. The suitability of the data for the application of factor analysis was checked by applying the Kaiser-Mayer-Olkin (KMO) sample adequacy test and Bartlett's specificity test, which confirmed the statistical justification of the application of the method. Based on the aforementioned analysis, key dimensions were identified that describe employees' perception of digitization and its impact on the transformation of work within Industry 5.0.

First section of questions consists of demographic characteristics. Demographic characteristics are shown in Table 1. Based on the results, according to the age structure, the largest share of respondents belongs to the age group from 25 to 34 years (37.4%), followed by the group from 35 to 44 years (31.5%), while other age categories are represented in a smaller percentage. In terms of gender structure, 57% of men and 43% of women are represented in the sample, which represents a good ratio for the interpretation of the results. In the job position section of respondents, the largest number are operational workers (37.8%), which is very significant for the research, followed by employees in the positions of managers or supervisors (18.1%), as well as specialists and experts (12.2%). We must not ignore the first

part of the sample, which includes respondents who were classified as "Other" (31.9%). The "Other" category confirms the claim that there are no job positions that are isolated from the wave of new changes in organizations.

The presented results indicate that the respondents come from different industrial sectors, and the sample enables an overview of the perception of digital transformation and the implementation of Industry 5.0 principles from multiple professional perspectives.

Measure	Items	%
Age	<25 years	10
	25-34 years	37.4
	35-44 years	31,5
	45-54 years	14,1
	55 years or older	7
Gender	Male	57
	Female	43
Industry/sector in which you work		
Your current position	Operational worker	37,8
	Manager/Supervisor	18.1
	Specialist/Expert	12,2
	Other	31,9

Table 1
Demographic characteristics (N = 270)

4 Results and discussion

There are several methods that can be applied within Exploratory Factor Analysis (EFA). EFA analysis was applied in order to identify the basic dimensions that describe employees' perception of digitalisation and its impact on the transformation of work within the Industry 5.0 concept. This method provides the possibility of determining the factor dimensions, which explain and connect the mutual relations between a large number of observed variables. The method that was implemented in the EFA analysis is principal component analysis, i.e. Principal Component Analysis (PCA) with Varimax rotation. In this way, a clearer separation of the factor

structures as well as a simplified interpretation of the results is possible. For the purposes of data processing, a criterion was used to retain factors whose eigenvalue is greater than 1. Factor loadings, which were used to interpret the results, are greater than 0.50. According to the recommendations of [17], such values are considered as an "acceptable threshold". Based on the mentioned facts, the presented factorial limitation will represent the usual threshold for the interpretation of factor analysis results in this paper. EFA results are shown in Table 2.

Prior to conducting the Exploratory Factor Analysis, the adequacy of the data for factor analysis was assessed using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity. The results indicate a very high sampling adequacy (KMO = 0.938), which is well above the recommended threshold of 0.60, confirming that the dataset is highly suitable for factor analysis. In addition, Bartlett's Test of Sphericity was statistically significant ($\chi^2 = 3733.861$, df = 276, $p < 0.001$), indicating that the correlation matrix is not an identity matrix and that sufficient correlations exist among variables to proceed with factor extraction.

The analysis identified five factors, and according to [17], the results of the factor analysis are interpreted through several key numerical indicators. They explain how factors represent relationships between variables and how statistically acceptable the model is. The factors in this case describe the structure of the employees' perception regarding digitalization and transformation of work within the concept of Industry 5.0. Furthermore, the obtained factors include various aspects of digital transformation, including employee motivation, technological changes in the random environment, organizational support, digital skill development and work-life balance.

Observed variables	**Factors**				
	1	2	3	4	5
MS3	0.833				
MS2	0.801				
MS5	0.719				
MS4	0.665				
MS1	0.633				
TR3	0.614				
TR1	0.573				

TR2	0.517				
TA1		0.753			
TA2		0.733			
TA3		0.678			
TA4		0.612			
WB2			0.735		
WB3			0.716		
WB1			0.689		
WB5			0.688		
WB4			0.634		
WE4				0.661	
TR4				0.640	
TR5				0.608	
WE2					0.818
WE1					0.621
WE3					0.547

Table 2
Exploratory Factor Analysis (EFA)

The adoption of Industry 5.0 is not unidimensional, but encompasses multiple interconnected aspects, as confirmed by the results obtained. The five identified factors indicate key elements of work transformation in modern organizations that are introducing digitalization. By including motivation, employee satisfaction, work-life balance, and changes in work processes, a clearer picture is obtained of the direction in which organizations should develop in order to improve the working environment. The results also show that the application of Industry 5.0 principles is necessary for further improvement of industrial and technological infrastructure. It is particularly important to develop digital competencies of employees and adapt them to new working conditions. Digitalization is a key factor of modern business, and success depends on the ability of an organization to balance technological progress with the needs of employees, with adequate support in the adaptation

process. It is also important to encourage organizational learning that is based on teamwork, because the organization is built by all employees, not by an individual.

Conclusion

The aim of this paper was to examine the extent to which digitalization within the framework of the Industry 5.0 concept affects employees and the transformation of the modern way of working in organizations of different industries, as well as their motivation and professional development. The conducted factor analysis identified five key factors that explain employees' perception of digital transformation.

The results obtained indicate that the acceptance of Industry 5.0 is not based solely on technological aspects, but also on human and organizational factors. The domains related to digital change, technological aspects, organizational support, balance between private and professional life and the quality of the digital work environment were particularly highlighted.

These findings confirm that digital transformation is a socio-technical process in which technology and the human factor are interconnected. Accordingly, the successful implementation of Industry 5.0 requires a coordinated development of digital technologies and digital competencies of employees, as well as continuous organizational support.

The practical contribution of the research is reflected in the emphasis on the role of management in creating an environment that supports learning, adaptation and well-being of employees. The results show that technology alone is not sufficient for the success of digital transformation, but that employees and their willingness to actively participate in change play a key role.

The limitations of the research relate to the relatively limited sample and focus on certain sectors, which reduces the possibility of broader generalization of the results. Future research should therefore include a larger sample and different industrial contexts in order to obtain more comprehensive insights into the impact of Industry 5.0.

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