THE DEVELOPMENT OF THE INDUSTRY 4.0 CONCEPT IN SOUTH-EASTERN POLAND. THE PERSPECTIVE OF NON-GOVERNMENTAL ORGANIZATIONS AND LOCAL GOVERNMENTS

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Abstract: The concept of Industry 4.0 was formalized in Germany in 2011. It encompasses comprehensive changes in digital production, network communication, information technology, automation, and other areas of business activity. The process of technological transformation is not limited to the manufacturing sector, but is gradually spreading to public administration and non-governmental organizations. The aim of this article is to present the results of empirical research conducted among 68 representatives of local government and 44 representatives of non-governmental organizations from south-eastern Poland. The results obtained allow us to determine the level of knowledge and awareness of representatives of local government units and non-governmental organizations with regard to the technological transformation processes taking place within the Industry 4.0 concept.

Keywords: Poland; Industry 4.0; technological changes; non-governmental organizations; local government, peripheral areas

1 Introduction

Technological changes have always shaped the manner and structure of production processes in the industrial sector, while also having a significant impact on the functioning of public administration and the non-governmental sector. Many technological and organizational solutions that were created for the needs of business organizations have been implemented in the sphere of public administration and the non-governmental sector (see, for example, McAdam et al. 2005; Landry et al. 2013; Rochon et al. 2010; Bendul et al. 2015; Pandey et al. 2022). Groundbreaking technological changes in the literature on the subject are referred to as industrial revolutions (for more details, see, among others, Chalvantharan, 2023; Eason et al. 1955; Moloi, Marwala, 2020). In recent years, the global economy has been implementing a concept called "Industry 4.0," which is also referred to as the fourth wave of the industrial revolution. This revolution is intended to change the way industry operates in terms of technology through digitization. However, the assumptions and effects of "Industry 4.0" affect not only production processes in the business sector, but also extend more broadly to the functioning of the public and non-governmental sectors.

The concept of "Industry 4.0" was formulated in Germany as early as 2011 and was an attempt by the German government to respond to the negative effects of the economic crisis. The term Industry 4.0 first appeared in an article published in November 2011 by the German government, which resulted from an initiative concerning the high-tech strategy for 2020 (Ślusarczyk, 2019, p. 4). Currently, the term "Industry 4.0," referring to the fourth wave of the industrial revolution, has come to describe the digital transformation of the manufacturing process. There are many definitions of the Industry 4.0 concept in scientific literature, one of which, by H. Lasi, states that "Industry 4.0 describes the increasing digitization and automation of the manufacturing environment, as well as the creation of digital value chains to enable communication between products, the environment, and business partners" (Lasi et al., 2014, pp. 239-242). Thus, this paradigm of industrial change covers digital production, network communication, computer technologies, and automation, but also many other areas of activity of companies and public administration entities (see also, among others, Kiełtyka, Charciarek 2019).

The Industry 4.0 concept is based on the assumption of implementing digital technologies and automating manufacturing processes. The technologies used in the Industry 4.0 concept include, among others, technologies such as: Internet of Things, IoT; Big Data; Artificial Intelligence; Robotic Process Automation; Cloud computing; Virtual Reality; Additive Manufacturing (for more details, see Kaczmar-Kolny, Pośpiech 2023; Gajdzik, Grabowska 2018; Różanowski 2007; Szajna et al. 2018).

All these assumptions concerning the Industry 4.0 concept have been described in the literature on the subject (cf. e.g. Gajdzik and Grabowska 2018; Szum and Magruk 2019). However, the greatest weakness of these publications is the fact that they usually refer to the national or regional level, completely ignoring the conditions of the Industry 4.0 concept at the local level (county, municipality). Such analyses and studies at the local level may be of particular importance in the case of peripheral areas, distant from large urban agglomerations and industrial clusters. Undoubtedly, such areas also include the studied area of south-eastern Poland (cf. e.g. Kaczmarski and Frączek 2021; see also Wilkin 2003, Demaniuk and Szymańska 2016, Idczak 2013). There are many companies in the studied area that manufacture various products, often recognized nationally and internationally. Despite this, the area is characterized by a relatively low rate of economic development, and the Podkarpacie region itself ranks low in terms of industrial innovation. A barrier to the development of entrepreneurship in south-eastern Poland may be the lack of knowledge among local entrepreneurs, local government representatives, and non-governmental organizations about the need to modernize companies and public administration as part of the fourth industrial revolution.

2 Materials and Methods

In order to analyze the level of knowledge and awareness of local government and non-governmental sector representatives regarding the technological transformation processes taking place within the framework of the "Industry 4.0" concept, a survey was conducted in 2025. The survey was conducted in four counties: Brzozów, Sanok, Lesko, and Bieszczady, located in south-eastern Poland. Due to their economic and social conditions, these counties can be considered peripheral areas. The research was funded by the Ministry of Science and Higher Education as part of the Science for Society II program. The study covered 112 representatives of local governments and non-governmental organizations, and the research tool was an extensive questionnaire containing 36 questions. The collected material was analyzed using IBM SPSS Statistics 29. The main objective of the research was to determine the level of knowledge and awareness of representatives of local governments and non-governmental organizations with regard to the technological transformation processes taking place within the framework of the Industry 4.0 concept. The research was also intended to identify the main barriers and determinants in the digital transformation of local governments and non-governmental organizations in peripheral areas, as perceived by the respondents, and to determine the relationships between individual variables.

3 Results of the study

The respondents participating in the survey were mainly women aged 40-49.

Tab. 1: Gender and age of respondents

Gender of the respondent	Number of respondents	Percentage
Female	79	71
Male	33	29
Final total	***112***	***100***
Age	**Number of respondents**	**Percentage**
up to 29 years old	12	11
30-39	24	21
40-49	45	40
50-59	20	18
60 years and older	11	10
Final total	***112***	***100***

Source: Own study

The vast majority of respondents had higher education (91 people, i.e., 81% of the total) and many years of work experience - over 20 years (48 people, i.e., 43% of the total).

The surveyed representatives of local governments and non-governmental organizations often worked as administrative employees (43 people, i.e., 38% of the total), but also often held managerial positions (37 people, i.e., 33% of the total) or expert positions (29 people, i.e., 26% of the total). This structure of the respondents' education, their length of service, and the positions they held may indirectly indicate that the representatives of local governments and non-governmental organizations surveyed should be aware of the importance of the technological changes currently taking place in production processes, but also in the public and non-governmental sectors. The majority of the survey respondents represented local governments (68 people, i.e., 61% of the total), while 44 respondents (39% of the total) represented the non-governmental sector.

In the case of local governments, most were entities employing between 50 and 249 employees (48 respondents, i.e., 42% of the total), while in the case of the NGO sector, most organizations employed between 10 and 49 employees (20% of the total number of respondents). The situation was similar in terms of revenue, with local governments having greater financial resources and the budgets of non-governmental organizations being relatively small. This means that in the case of the NGO sector, the implementation of digital revolution solutions may be significantly hampered due to the scale of revenue. On the other hand, local governments can more effectively implement technologies related to "Industry 4.0" in the functioning of public administration.

The type of activity carried out by the entities surveyed is presented in the table below.

Tab. 2: Type of activity among the surveyed local governments and non-governmental organizations

Type of activity Statistics Poland – by SECTIONS AND DIVISIONS	Number of entities	Percentage
Section A. Agriculture, forestry, hunting, and fishing	1	1
Section C. Manufacturing	3	3
Section D. Electricity, gas, steam, hot water, and air conditioning supply	2	2
Section F. Construction	1	1
Section H. Transport and storage	1	1
Section I. Accommodation and food service activities	1	1
Section J. Information and communication	1	1
Section K. Financial and insurance activities	1	1
Section M. Professional, scientific, and technical activities	3	3
Section N. Administrative and support service activities	4	4
Section O. Public administration and national defense; compulsory social security	54	48
Section P. Education	6	5
Section Q. Health care and social assistance	10	9
Section R. Cultural, entertainment, and recreational activities	10	9
Section S. Other service activities	13	12
Section U. Extraterritorial organizations and bodies	1	1%
Final total	***112***	***100***

Source: Own study

The entities surveyed were mainly involved in public administration (54 entities, i.e. 48% of the total), and to a lesser extent, mainly NGOs, service activities (13 entities, i.e., 12% of the total) and activities in the field of health care and social assistance (10 entities, i.e., 9% of the total).

During the research, it was established that the vast majority of local representatives of local governments and non-governmental organizations are not familiar with the term "Industry 4.0." (70 people, i.e., 63% of all respondents). This means that this lack of knowledge about the changes brought about by the digital revolution ( ) may be a significant barrier to technological change in peripheral areas of Poland.

The most well-known technologies related to the concept of "Industry 4.0" among respondents were: Big Data and AI (142 responses, i.e., 16% of the total; number of responses ≠ number of respondents, multiple-choice question) and Cybersecurity (141 responses, i.e., 15% of the total; number of responses ≠ number of respondents, multiple-choice question). At the same time, only 22 respondents (20% of the total) indicated that the concept of "Industry 4.0" is a very important issue and will certainly have a significant impact on industry, public administration, and the surrounding reality in the future.

The survey also identified which competencies will be most important in the future in the opinion of respondents.

Tab. 3: The most important competencies of the future for employees in the opinion of respondents

The most important skills of the future for employees in the opinion of respondents	Number of responses	Percentage
cognitive skills	32	29
social skills	38	34
technical skills	42	38
Final total	***112***	***100***

Source: Own study

The respondents indicated that technical skills will be the most important in the future (proficiency in the use of new media, information overload management, ability to integrate robotic workstations, ability to work on the human-machine line, programming; 42 people, i.e. 38% of the total).

During the research, it was not possible to clearly determine whether, in the opinion of the respondents, the main barriers to the implementation of various solutions related to the "Industry 4.0" concept in peripheral areas were different from those in central areas (*Yes - the main barriers to Industry 4.0 in peripheral areas are different from those in central areas*: 50 responses, i.e., 45% of the total; *I have no opinion on this*: 55 responses, i.e., 49% of the total; *No - the main barriers to Industry 4.0 in peripheral areas are different from those in central areas*: 7 responses, i.e., 6% of the total).

Many authors conducting research on the concept of "Industry 4.0" have pointed out that the high financial costs of implementing these solutions may be a barrier to digitization and technological progress.

Tab. 4: Main barriers to the development of Industry 4.0 in peripheral areas in the opinion of respondents

Barriers	Number of responses*
Inadequate technological infrastructure	140
Limited availability of skilled labor	178
Low level of investment	195
Low technological awareness	144
Poor cooperation between companies and research institutions	142
Problems with the integration of production systems	83
Logistical constraints	123
Lack of an ecosystem supporting innovation	127
Lack of appropriate local regulations	147
Fear of change and job losses	133

Note: **The number of responses does not equal the number of respondents, as the question was multiple choice.*
Source: Own study

Similar opinions were also expressed by employees of local governments and non-governmental organizations. The biggest barriers to digital transformation in peripheral areas were: low level of investment, e.g., high implementation costs (195 responses), limited availability of skilled labor (178 responses), low technological awareness, e.g., lack of knowledge about the benefits of implementing "Industry 4.0" (144 responses), and poor cooperation between companies/organizations and research institutions.

A worrying fact that was established during field research was the lack of interest among representatives of local governments and NGOs in the digital transformation of their own organizations.

Tab. 5: Stage of digital transformation of respondents' organizations

Stage of transformation	Number of responses	Percentage
We are at the beginning of the transformation	24	21
We are at an advanced stage of transformation	2	2
We are in the process of developing our transformation	23	21
We use digital technology on a daily basis in almost every aspect of the organization's operations.	13	12
We are not planning a transformation.	50	45
Final total	***112***	***100***

Source: Own study

Almost half (i.e., 50 people) of respondents said they do not plan to digitally transform their organizations, and 24 people (21% of the total) indicated that they are currently at the beginning of their digital transformation. Only 2 respondents (2% of the total) indicated that they are currently at an advanced stage of transformation. This means that without an external system supporting the technological transformation of local governments and non-governmental organizations, e.g., through financial incentives, local entities may not participate in the digital transformation and modernization of their own organizations. The main barriers to the introduction of the "Industry 4.0." concept in the surveyed organizations were: budget constraints (74 responses; number of responses≠ number of respondents, multiple-choice question) and employee resistance to change (37 responses; number of responses≠ number of respondents, multiple-choice question). At the same time, respondents who participate in the technological transformation of their own entities indicated cost reduction (31 responses; number of responses≠ number of respondents, multiple-choice question), improved communication (23 responses; number of responses≠ number of respondents, multiple-choice question), and automation of repetitive tasks (26 responses, number of responses≠ number of respondents, multiple-choice question).

On the other hand, the factors that, in the respondents' opinion, may determine the implementation of digital technologies within the framework of the "Industry 4.0" concept in peripheral areas were: access to capital, e.g., external financial support (172 responses; number of responses≠ number of respondents, multiple-choice question); human capital and education, e.g., access to a skilled workforce and education at the local level (171 responses, number of responses≠ number of respondents, multiple-choice question); and local awareness, e.g., readiness for change (169 responses, number of responses≠ number of respondents, multiple-choice question).

During the analyses, an attempt was also made to determine the statistical relationships between variables that may influence the implementation of the "Industry 4.0" concept in peripheral areas in south-eastern Poland.

Analyses were carried out to check whether variables such as the gender of the respondent influence their knowledge of the concept of "Industry 4.0." A Chi-square test analysis for local governments indicated that there is a statistically significant relationship between gender and familiarity with the concept of "Industry 4.0" ($\chi^2 = 4.685$; $p=0.030$; Cramér's $V = 0.262$). This relationship is not very significant, as indicated by the value of Cramér's V. In the case of non-governmental entities, no statistically significant relationship between these variables was found ($\chi^2 = 3.750$; $p=0.053$). During the analyses, an attempt was also made to determine whether factors such as age, education, position, and the location of the entity from which the respondent came were statistically related to the variable "knowledge of the concept of Industry 4.0." Unfortunately, in the case of both local governments and NGOs, there were no statistically significant relationships between these variables.

A check was also made to see whether there were statistically significant correlations between the variable "importance of the Industry 4.0 concept to the respondent" and variables such as gender, education, position held, location of the entity from which the respondent came, and the respondent's knowledge of the concept of "Industry 4.0." The Chi-square test analysis showed that there are no statistically significant relationships between these variables.

4 Conclusion

An analysis of the available literature indicates that the concept of "Industry 4.0" in peripheral areas is still important and requires further scientific exploration. The significance of this concept should not be limited to the manufacturing sector, as "digital changes" will also be relevant to sectors related to public administration and non-governmental organizations.

The representatives of local governments and non-governmental organizations participating in the surveys were mainly women aged 40-49, with a high level of education and long work experience. As a rule, these people worked as administrative employees, but they also often held managerial or expert positions. The vast majority of respondents represented local governments. A worrying finding was that most of the people participating in the survey were unfamiliar with the term "Industry 4.0," which may be the first barrier to the implementation of "digital revolution" solutions in peripheral areas of Poland. The awareness of local government representatives and non-governmental organizations about the importance of technological solutions within the concept of "Industry 4.0" may also be worrying. Only 20% of all respondents indicated that these changes will have a significant impact on industry, public administration, and reality in the future. The biggest barriers to digital transformation in local government administration and NGOs in peripheral areas are high implementation costs, limited access to a skilled workforce, low technological awareness (e.g., lack of knowledge about the benefits of digital transformation), and poor cooperation between these entities and research institutions.

Another worrying finding was the lack of interest among representatives of local governments and NGOs in the digital transformation of their own organizations and the fact that these organizations are only at the initial stage of this transformation or do not plan to undertake it at all. This means that without an external (supra-local) system supporting digital transformation, e.g., through financial incentives, local governments or non-governmental organizations may not participate in the digital transformation and modernization of their own organizations or may delay this process. Furthermore, in peripheral areas, it is necessary to have a local system in place to support innovation and cooperation between public administration and the non-governmental sector with the scientific sector. Empirical research indicates that in peripheral areas, the knowledge of public administration and NGO employees about the concept of "Industry 4.0" and their attitude towards digital transformation may be a barrier to the socio-economic development of peripheral areas in Poland.

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