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Barriers and the potential for changes and benefits from the implementation of Industry 4.0 solutions in enterprises

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Abstract
The implementation of Industry 4.0 solutions in Polish enterprises entails both certain barriers and significant potential for changes and numerous benefits. These barriers may result from the costs of implementation of new technologies, the need to adapt employees to new skills and concerns about data security. However, by overcoming these difficulties, companies can benefit from the enormous potential for changes such as increasing production efficiency, optimizing logistics processes or improving product quality. Moreover, the use of Industry 4.0 technologies can contribute to increased innovation, increased competitiveness on the global market and the creation of new jobs. As a result, the benefits of implementing these solutions support Polish enterprises to actively engage in digital transformation, despite the barriers they encounter. The objective of this article is to confront the benefits and potential for changes resulting from the implementation of modern technologies with the barriers that limit this process. The statistical assessment of the differences between the barrier assessment values and the assessment of benefits from the use of technology, as well as between the barrier assessment values and the assessment of the potential for changes, was based on the non-parametric Mann-Whitney U test. The study covered representatives of 236 enterprises who mainly held managerial positions at various levels of management staff or persons designated by them who were responsible for research and development activities in the surveyed entities. As a result, it was indicated that the level of involvement in technological transformation among Polish enterprises is moderate. Almost 67% of all the surveyed entrepreneurs can characterize specific Industry 4.0 solutions. Among them, only approximately 6% can be defined as highly digital companies that already have partially digitized operational processes. Moreover, enterprises see more potential benefits and potential changes from the introduction of Industry 4.0 solutions than barriers to their implementation. This study is dedicated to both authors dealing with Industry 4.0 issues and entrepreneurs implementing modern technologies in their companies.

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1. Introduction

Industry 4.0 (I4.0) is a complex technological system that is fundamentally shaped by communication, integration, and digitization of production, emphasizing the possibilities of integrating all elements in a value-adding system (Neugebauer, R., 2016). This concept includes digital production technology, computer technology and automation technology. Technological achievements regarding Industry 4.0 eliminate the boundaries between the digital and physical worlds, integrating human and machine factors, materials, products, systems, and production processes (Erol et al., 2016; Wiśniewska and Różycka, 2021; Suchacka et al., 2023; Androniceanu, 2023). Industry 4.0 enables rapid technological achievements in many areas, creating a new business logic that makes the current way of operating enterprises ineffective. However, implementing the solutions brought by this new industrial paradigm requires overcoming many barriers of various nature.

One of the main obstacles is the high cost of purchasing, implementing, and maintaining new technologies. Not all enterprises, particularly smaller ones, can afford such expenses (Kumar et al., 2023). Companies often wonder whether the return on investment (ROI) will be fast enough and at the expected level. Therefore, a realistic economic assessment of the

costs and benefits associated with the implementation of the I4.0 technology is necessary, considering long-term investments.

Industry 4.0 includes various technologies, but there are no uniform standards, which impedes the integration of various systems and communication between them (Marques et al., 2017). For companies that already use existing IT systems, the integration of new technologies may be difficult. It is therefore necessary to adapt to standards and ensure interoperability between various systems and devices, as well as to have appropriate technical infrastructure, including fast and reliable communication networks, data management systems and equipment compatible with Industry 4.0 technologies. Connecting multiple IT systems and the increased use of data increases the risk of cyber-attacks. Protecting data privacy is therefore becoming a key challenge (Khan, A. and Turowski, K., 2016). Some industries are subject to strict regulations and standards, which may limit the introduction of modern technologies. Understanding and compliance with local and international laws and regulations relating to your industry and data protection becomes crucial.

Modern technologies often require changes in organizational culture (Agostini and Filippini, 2019) by adapting it to openness to innovation, flexibility, acceptance of new business models and ways of working. This requires the development of a clear implementation strategy, including an action plan, objective, risk assessment and systematic monitoring of progress. Additionally, employees may fear losing their jobs or changes in their responsibilities due to automation and the implementation of new technologies, and consequently - the need to have expertise and skills. This results in the need to train employees and develop their competences in using modern technologies or employ new specialists (Mahyar et al., 2021; Wankhede and Vinodh, 2021; Karatas et al., 2022; Stareček et al., 2023). If the company's management is not convinced of the value of new technologies or is not involved in the implementation process, this may constitute another significant barrier.

Moreover, in order to effectively implement Industry 4.0 solutions, it is necessary to cooperate with business partners, customers and other supply chain participants, as well as to select appropriate technology, software and hardware suppliers that offer solutions consistent with the needs and requirements of the enterprise. Overcoming these barriers requires careful planning, understanding the specificity of the company and flexibility in adapting to changes. It is certainly not an easy and quick process, but the potential benefits may compensate for the financial or organizational expenses incurred.

I4.0 technologies have the potential to significantly increase the operational efficiency of enterprises, which may contribute to increasing their competitiveness on the market. Due to the data collected by cyber-physical systems, companies can adjust production to the individual needs of customers, which leads to the production of more customized products. Industry 4.0 enables constant monitoring and analysis of data, which promotes innovation through better understanding of the market and faster response to changing conditions. Optimizing production processes can lead to a lower consumption of raw materials, energy, and less waste, thus contributing to more sustainable development. The introduction of Industry 4.0 solutions may be revolutionary for many industries, but success requires careful analysis, planning and effective change management. Therefore, the objective of this article is to confront the benefits and potential for changes resulting from the implementation of modern technologies with the barriers that limit this process.

2. Literature review

The literature on the subject abounds in studies devoted to identifying barriers to the implementation of the Industry 4.0 concept. In one of them, they can be found divided into four groups (Elhusseiny and Crispim, 2021): technical, technological, organizational, and legal. Ghadge et al. (2020) distinguished organizational, legal and ethical, strategic and technological barriers. In another manuscript, the following classification of barriers is mentioned: economic and financial, cultural, competence, legal, technical, and related to the implementation process (Orzes et al., 2018). It seems that these classifications are only a matter of convention since most authors list mostly the same barriers in their studies and, depending on the topic, focus on selected or more of them (Attiany et al., 2023; Vigneshvaran and Vi- nodh, 2021; Raj et al., 2020). The indicated technical barriers include, among others: insufficient information and communication technology infrastructure (Kumar et al., 2021; Andro-niceanu et al., 2021), lack of standards, uncertainty about the reliability of systems, and difficult interoperability/compatibility of devices. Technological barriers, among others, result from the fact that Industry 4.0 is based on advanced technologies supporting innovation in business processes (North et al., 2020; Janasz et al., 2022; Afonasova et al., 2019), and there is still a noticeable lack of knowledge regarding using them. An additional issue is the complexity of maintaining or using applications - such as processing complex or unstructured data. Organizational barriers constitute the most extensive group, as they include economic and financial, cultural and competence issues. The implementation of modern technologies often requires large investments, and enterprises often do not have sufficient financial resources for their implementation (Hughes et al., 2022). The financial sphere as a significant element of the economic system should be directly involved in the formation and implementation of the concept of Industry 4.0 (Bilan et al., 2019). This may lead to a limited ability to respond to changes in demand. The initiatives often encounter a lack of support from management, there are no qualified employees with appropriate digital skills, and their resistance to change is due to fear of losing their jobs (Halse and Jæger 2019). A. Kuzior (2022) devoted special attention to this issue, writing about technological unemployment, which results from technological progress and the development of innovative technologies, which, when implemented in various industries and services, usually result in lower demand for human labor. Enterprises often have no research and development infrastructure that would support the implementation of I4.0 solutions, which results in the need to find an appropriate research partner

(Miśkiewicz, 2019). Legal barriers most often include data security considerations (Raut et al., 2018; Phuyal et al., 2020), while strategic barriers are related to the process of implementing modern technologies in enterprises. These include the lack of an Industry 4.0 strategy or long-term vision, lack of digital culture and unclear economic benefits. Therefore, it is necessary to implement new business models and make a major effort to coordinate the company's existing systems with modern ones.

In the literature on the subject, one may also come across a distinction between external barriers that slow down or completely limit the development of modern solutions and those of internal origin (Rudawska, 2017). Matusiak and Guliński (2010) point to four broad categories of difficulties in adapting Polish enterprises to innovative solutions. They listed:

• structural barriers - resulting from the inappropriate allocation of EU funds and the low level of competences at public administration levels and, among others, refer to European funds, the business environment, the economic sector, science and the region;

• systemic barriers – closely related to an excessive number of legal acts that are not adapted to the challenges of the modern market and the constantly changing economy. Barriers also refer to the imperfections of the law and its ignorance;

• barriers to awareness and culture in society, which include people's behavior related to lack of trust in modern solutions, following stereotypes, as well as low acceptance of innovation. This group also includes people's reluctance to work in a team, lack of willingness to take risks, cognitive conservatism and lack of ability to use their own capabilities;

• employee competence barriers - refer to the problems of administrative units, scarcity of public aid and problems related to intellectual property protection issues (Cegiełko, 2021).

Identifying barriers related to the implementation of the Industry 4.0 concept can help improve the company's readiness to implement modern technologies. The introduction of these technologies depends on the maturity level of each company's capabilities (Govindan and Arampatzis, 2023; Panayiotou et al., 2019). Therefore, companies can expect a significant improvement in their current competitive position. Increased productivity is one of the most anticipated improvements of the I4.0 transformation (Duman and Akdemir, 2021). The adaptation of more efficient and faster production systems will enable faster process implementation, cost reduction, shorter delivery times and faster time to market for new products and services. Moreover, they can reduce process and product variability, ensuring their higher consistency and quality, while engaging the consumer in a more proactive and intensive way (Fonseca, 2018). The adoption of Industry 4.0 solutions has a significant direct impact on the company's supply chain competencies and operational performance (Chauhan et al., 2021; Yüksel, 2022).

Fonesca (2018) also cites tangible benefits resulting from digital transformation, which were collected in the EU document "Digital transformation of European industry and enterprises" (2015). These include claims that companies using new technologies perform 10 times better than their competitors, and those that use Big Data technologies and services can become by 5 to 6% more productive. The online economy has the potential to create 1.5 million new jobs in the European Union, and with digitization, European production may increase by 15-20% by 2030.

The conducted considerations allowed the formulation of two research hypotheses:

- H1 - Enterprises see more potential benefits from the introduction of Industry 4.0 solutions than barriers to its implementation;
- H2 - Enterprises perceive more potential changes in the areas of their operations following the implementation of Industry 4.0 solutions than barriers to its implementation.

3. Experimental

The primary data were collected based on the surveys conducted using the CATI method. The study was conducted in the second quarter of 2021. The survey respondents were representatives of enterprises who held mainly managerial positions at various levels of management or persons designated by them who were responsible for research and development activities in the surveyed entities.

The selection of the sample for the study was carried out in several stages. In the first step, the statistical population was determined, which included all enterprises registered in Poland. The sampling frame was the *"Report on the state of the small and medium-sized enterprises sector in Poland"*. The study excluded micro-enterprises which, according to the *"Smart Industry Polska 2018"* report, most often among other enterprises do not know what the idea of Industry 4.0 is and do not plan to implement it in their company's development strategy (90% of micro-enterprises declare this). At a later stage, entities that suspended their business activities were also removed from the study. Then, the minimum sample size was estimated, which took into account the following assumptions:

- size of the analyzed statistical population on average per year = 67100 companies;
- confidence level, i.e. the degree of certainty of the obtained results $\alpha = 0.93$;
- value calculated from normal distribution tables for the adopted significance level = 1.96;
- fraction size = 0.5;
- maximum error estimated at the level e = 6%.

The size of the minimum research sample was estimated as follows:

$$N_{min} = \frac{N_P(\alpha^2 \cdot f(1-f))}{N_P \cdot e^2 + \alpha^2 \cdot f(1-f)} = \frac{67100(1.96^2 \cdot 0.5(1-0.5))}{67100 \cdot 0.07 + 1.96^2 \cdot 0.5(1-0.5)} = 196 \quad (1)$$

where:

N_{min}- minimum sample size

N_p – approximate size of the population the sample was drawn from

α – confidence level

f – fraction size

e – maximum error estimated

The minimum level of the research sample under the adopted assumptions is 196 entities, therefore the surveyed number of 239 enterprises can be assumed as representative of the surveyed population for the level $\alpha = 0.93$. Determining the minimum surveyed number of enterprises made it possible to apply the obtained results to the entire research population, reflecting the analyzed features and conditions of running a business while entering a new era of technological development.

4. Results and discussion

The study compared the benefits and potential for changes resulting from the implementation of modern technologies with the barriers that limit this process. For this purpose, the multivariate analysis was carried out, which involved the use of the method of comparison of response rates in a given class. For the purposes of the statistical analysis, only a group of respondents who, in response to the question about their knowledge of the Industry 4.0 concept, declared such knowledge at least at the level of its features, planning or implementation, was selected for further analysis. The structure of the list of these indications is presented in Table 1.

Table 1. Structure of indications on the knowledge of the Industry 4.0 concept

Response	Number	%
Yes, I know the details of this concept	131	54.85
Yes, I know the details of this concept and we are planning to implement it in our company	13	5.36
Yes, we are introducing its assumptions/technologies in our company	14	5.98
TOTAL	158	66.20

In total, this group of respondents amounted to 158, which constituted almost 67% of the entire research sample. Subsequently, the barriers, potential and impact of using I4.0 solutions in enterprises were analyzed in terms of only those classes of responses that express a strong impact of the studied areas on their functioning.

As a result, among the classes of responses characterizing barriers to the implementation of the I4.0 technology, the ones that express a fairly large and significant impact (class H4-5) of a given barrier on difficulties in implementing modern solutions and tools were selected. The structure of the highest ratings for all the considered restrictions in the group of selected companies is summarized below.

Table 2. Summary of the structure of indications for barriers broken down by the fairly large and significant difficulty in implementation

Barrier type	Largely impeding the implementation		Significantly impeding the implementation	
	Number	%	Number	%
Lack of skilled workers	56	**35.40**	60	**37.93**
Costs too high	36	22.57	68	**42.99**
Financing problems	56	**35.40**	37	23.49
Uncertain return on technology investment	43	27.18	36	22.82
Employees' resistance to changes	47	29.71	25	15.85
Complexity/intricacy of technology	44	27.82	28	17.74
Difficulty in figuring out where to start	43	27.18	26	16.15
Problems with analyzing/determining needs	32	20.23	35	21.99
Lack of a long-term development strategy	49	30.97	16	10.14
Cybersecurity	39	24.66	21	13.12
Data integration problems	59	**37.30**	3	10.74
Black of appropriate technology providers	41	25.91	12	7.39
Lack of incentives from public institutions	46	29.07	7	4.63

Among the respondents who know the concept of Industry 4.0, the major difficulties in implementing innovative solutions are most often too high costs of the implementation process (42.99%) and lack of qualified staff (37.93%), while quite significant problems also result from data integration (37.30%) and problems with financing the purchase of modern technological tools (35.40% each). The graphical summary of the table is presented in Figure 1, which shows the cumulative percentage of responses for each assessed barrier.

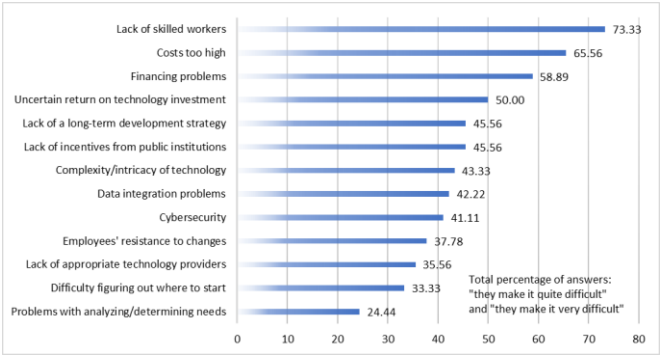

Fig. 1. Graphical summary of the structure of implementation difficulties among entities that know the concept of Industry 4.0 broken down by two classes of responses

The average percentage of the barrier assessment for the adopted responses amounted to 45.90%. Most of the barriers constitute a fairly large and significant difficulty for less than half of the respondents who have the knowledge of the Industry 4.0 concept. These are most often organizational and technical barriers. For more than half of the respondents, the greatest barrier to the implementation of I4.0 solutions is lack of employee competences, lack of financial resources for the implementation of the investment, its high costs and uncertainty of return. This means that the surveyed enterprises more often perceive serious implementation problems related to the financial dimension and external support. However, they are better able to minimize constraints that depend primarily on their internal management. The study also confirms that lack of qualified employees is a greater obstacle to the digital transformation of the surveyed companies than the limited availability of financial resources.

Among the classes of responses characterizing the impact of using the I4.0 technology, the ones that express an average, fairly large and significant impact (class G3-5) of the implemented solutions on obtaining specific benefits in the activities of the surveyed enterprises were selected. The structure of indications for these benefits is summarized below.

Table 3. Summary of the structure of indications of the impact of using the Industry 4.0 technology on the functioning of enterprises broken down by the medium, large and significant level of this impact

Type of impact	Medium impact		Fairly large impact		Significant impact	
	Number	%	Number	%	Number	%
Increased productivity	19	12.22	65	41.11	65	41.11
Better information	33	21.11	49	31.11	54	34.44
Increased competitiveness	33	21.11	63	40.00	51	32.22
Reducing operating costs	65	41.11	53	33.33	28	17.78
Increased profitability	42	26.67	69	43.33	33	21.11
Improvement of quality	35	22.22	74	46.67	37	23.33
Increasing process execution capacity	39	24.44	67	42.22	46	28.89
Increased innovation	25	15.56	58	36.67	72	45.56
Increased flexibility	30	18.89	79	50.00	35	22.22
Increasing customer satisfaction	49	31.11	56	35.56	26	16.67
Increasing the ability to adapt products and services	33	21.11	67	42.22	35	22.22
Reducing labor costs	33	21.11	67	42.22	35	22.22

The respondents who declared the knowledge of the Industry 4.0 concept simultaneously observed that reducing operating costs is only partially the result of technology implementation (41% - medium impact), its impact is more often observed in the case of increasing the flexibility of the company's operation (50% - fairly large impact). The implementation of I4.0 solutions is the greatest determinant of the increase in the level of the innovation of the company and, only slightly less frequently, also the return on productivity (respectively 46% and 41% - significant impact).

The graphical summary of the table shows the cumulative response percentage for each possible benefit. At this stage, two cases were analyzed, regarding the impact of the use of technology among the percentage of respondents who have the knowledge of the Industry 4.0 concept (N = 158):

- Case 1: for the classes of responses: medium, fairly large and significant impact (G3-5) (Fig. 2);
- Case 2: for the classes of responses: large and significant impact (G4-5) (Fig. 3).

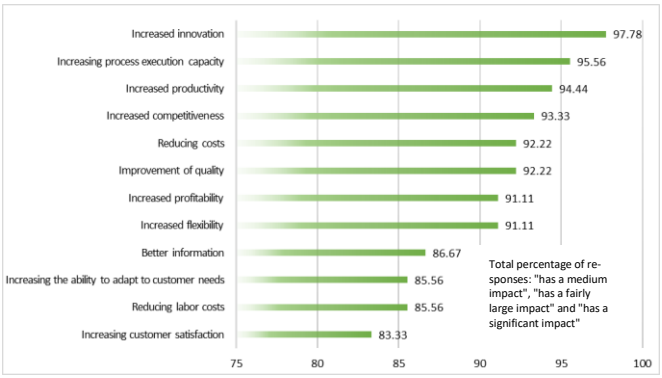

Fig. 2. Graphical summary of the structure of the impact of using technology on the functioning of enterprises that know the concept of Industry 4.0 for case 1

Considering three classes of positive responses, the average percentage of assessment of the impact of the implementation of modern technologies on possible benefits for the accepted responses was 90.74%. The total response rate in the surveyed area indicated that the most common effect of implementing the tools of the fourth industrial revolution is increased innovation, increased ability to implement processes and increased productivity in these enterprises. In turn, slightly less frequently, this type of implementation contributes to increasing the ability to adapt to customer needs and improving their satisfaction with the product or service, as well as reducing labor costs.

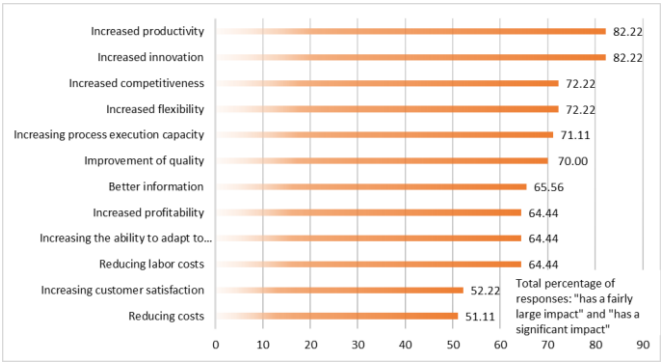

Fig. 3. Graphical summary of the structure of the impact of using technology on the functioning of enterprises that know the concept of Industry 4.0 for case 2

The average percentage of assessment of the impact of digitalization on possible benefits for the two classes of responses adopted was 67.78% for case 2. The process of implementing the I4.0 technology has a fairly large and significant impact, most often on increasing the productivity and innovation of the surveyed enterprises. In turn, the least visible impact of digitalization is observed in terms of reducing costs and increasing customer satisfaction of these companies.

Comparing both cases for two different summary indices of response classes, some similarities are observed between them. Certainly, technological progress implemented in enterprises increases their level of innovation and productivity, in turn, it less frequently determines reduction in labor costs and improvement in the level of customer satisfaction.

Subsequently, similarly to the above, from among the classes of responses relating to the assessment of the potential for changes resulting from the use of the I4.0 technology, the ones that express medium, large, and significant potential (class I3-5) of the implemented solutions for changes in individual areas of activity of the surveyed enterprises were selected. (Table 4).

The respondents who declared the knowledge of the Industry 4.0 concept believe that changes in the area of marketing may only partially result from the implementation of modern technologies (33% - medium potential), their fairly large impact is more often visible in changes made in the area of supplies and sales (respectively 43% and 41%). A significant potential for changes as a result of digitalization is observed in the area of production (49%).

Table 4. Summary of the structure of indications of the potential for changes in the areas of enterprise activity as a result of the implementation of the Industry 4.0 technology broken down by the medium, high and very high level of potential

Potential for changes in the area:	Medium potential		High potential		Very high potential	
	Number	%	Number	%	Number	%
Research and development	40	25.56	47	30.00	54	34.44
Supplies	30	18.89	69	**43.33**	33	21.11
Production	25	15.56	42	26.67	77	**48.89**
Logistics	42	26.67	56	35.56	54	34.44
Marketing	53	**33.33**	54	34.44	21	13.33
Sale	46	28.89	65	**41.11**	35	22.22
Services	32	20.00	60	37.78	40	25.56
Process management in the company	39	24.44	53	33.33	62	38.89

The cumulative percentage of responses for individual areas in which changes are possible as a result of the implementation of modern tools and solutions is presented in Figures 2 and 3. At this stage, two cases were analyzed regarding the potential for changes in the areas of enterprise activity among the percentage of respondents who have the knowledge of the Industry 4.0 concept (N =158):

- Case 1: for the classes of responses: medium, high and very high potential (I3-5) (Fig. 4);
- Case 2: for the classes of responses: high and very high (I4-5) (Fig. 5).

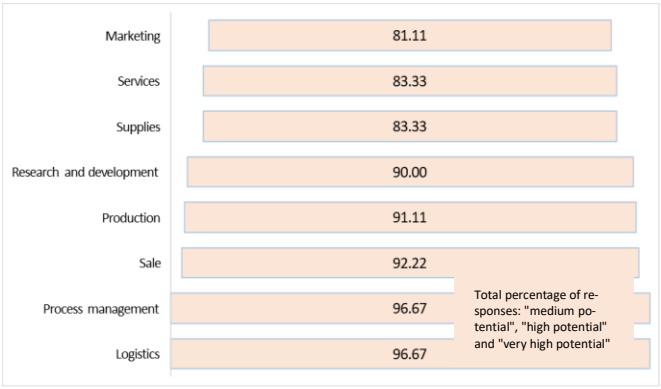

Fig. 4. Graphical summary of the structure of the potential for changes in the areas of activity of enterprises that know the concept of Industry 4.0 for case 1

Considering the three classes of positive responses, the average percentage of assessment of the potential for changes for the adopted responses was 91.74%. The total response rate in the surveyed area indicated that the implementation of the tools of the fourth industrial revolution most often forces changes in the areas of logistics and process management in the enterprise. However, the functioning of the areas of supplies, services and marketing much less frequently requires changes due to the implementation of innovation.

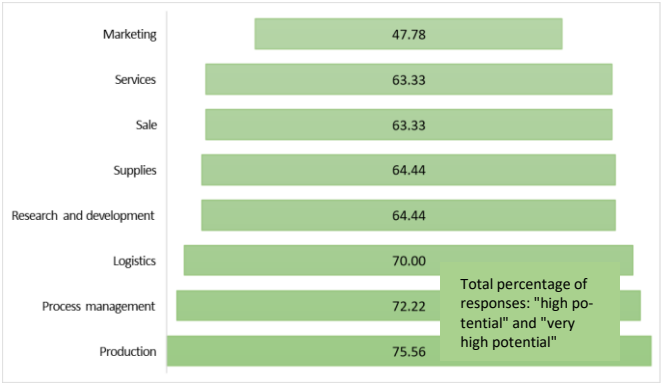

Fig. 5. Graphical summary of the structure of the potential for changes in the areas of activity of enterprises that know the concept of Industry 4.0 for case 2

Considering only the two adopted classes of responses, the average percentage of assessment of the impact of digitalization on potential changes in the areas of enterprise operations was 65.14%. The technology implementation process has a large and significant impact on changes in the areas of production and process management in the enterprise. Less than half of the respondents declared that the importance of the impact of Industry 4.0 also forces changes in marketing.

The comparison of two different summary response class indicators shows some similarities. Undoubtedly, the digitization of enterprises most often forces changes in the area of enterprise process management and least often in the area of marketing.

The statistical assessment of differences between the values of the assessment of barriers and the assessment of benefits from the use of technology, as well as between the values of the assessment of barriers and the assessment of the potential for changes, was based on the non-parametric Mann-Whitney U test. The level of significance for all the examined relationships was set at $\alpha = 0.05$. This test allows for comparing two groups of variables in terms of another quantitative variable. The following database was prepared for testing purposes, the contents of which are presented in Table 5.

Table 5. Database that was used to test differences between the studied groups of variables

	Barriers	Technologies_1	Technologies_2	Potential_1	Potential_2
1	73.33	97.78	82.22	81.11	75.56
2	65.56	95.56	82.22	83.33	72.22
3	58.89	94.44	72.22	83.33	70.00
4	50.00	93.33	72.22	90.00	64.44
5	45.56	92.22	71.11	91.11	64.44
6	45.56	92.22	70.00	92.22	63.33
7	43.33	91.11	65.56	96.67	63.33
8	42.22	91.11	64.44	96.67	47.78
9	41.11	86.67	64.44		
10	37.78	85.56	64.44		
11	35.56	85.56	52.22		
12	33.33	83.33	51.11		
13	24.44				

The study finally identified the following groups of variables:

1. Barriers - on a scale from fairly high to significant degree of difficulty in the technology implementation process (in

class H4-5);
2. Technologies_1 - on a scale from medium to significant impact of the use of technology on the benefits for the functioning of the entity (Case 1 in class G3-5);
3. Technologies_2 - on a scale from large to significant impact of the use of technology on the benefits for the functioning of the entity (Case 2 in class G4-5);
4. Potential_1 - on a scale from medium to very high potential for the use of technology for changes in individual areas of the functioning of the entity (Case 1 in class I3-5);
5. Potential_2 - on a scale from high to very high potential for the use of technology for changes in individual areas of the functioning of the entity (Case 2 in class I4-5).

First, the results of testing the differences between the groups of variables - "Barriers" and "Technologies_1" were presented (Figure 6).

Sample 1	
Variable	Barriers
Sample 2	
Variable	Technologies_1

	Sample 1	Sample 2
Sample size	13	12
Lowest value	24,4400	83,3300
Highest value	73,3300	97,7800
Median	43,3300	91,6650
95% CI for the median	36,7399 to 54,1649	85,7518 to 94,2482
Interquartile range	37,2250 to 52,2225	86,1150 to 93,8850

Hodges-Lehmann median difference	47,7700
95% Confidence interval	38,8900 to 53,3300

Mann-Whitney test (independent samples)

Average rank of first group	7,0000
Average rank of second group	19,5000
Mann-Whitney U	0,00
Test statistic Z (corrected for ties)	-4,246
Two-tailed probability	P < 0,0001

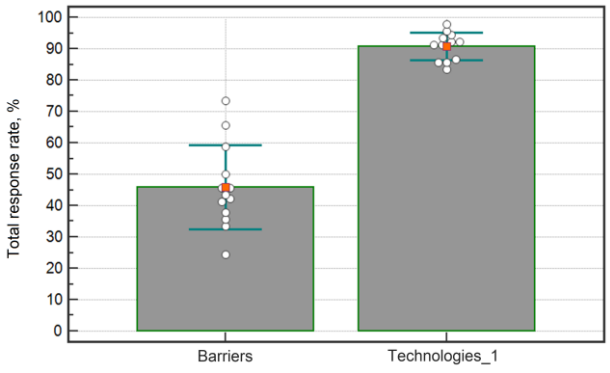

Fig. 6. Result of testing the differences between the "Barriers" and "Technologies_1" variables

Based on the adopted significance level α = 0.05, it is observed that the impact of the "Technologies_1" variable assessed by the sum of the percentages of ratings on the adopted scale is statistically significantly greater (p < 0.0001) than the "Barriers" variable assessed by the sum of the percentages of ratings on the adopted scale. The average rank for barriers is 7.00 and is much lower than the average rank for benefits from implemented technologies, which is 19.5. This means that for the surveyed entrepreneurs, the potential benefits to be obtained as a result of the implementation of modern technologies, observed already at the medium level, are more important than large and significant difficulties associated with their implementation. Thus, the hypothesis H1 can be confirmed: Enterprises see more potential benefits from introducing Industry 4.0 solutions than barriers to its implementation.

Another step was to test the differences between the groups of variables – "Barriers" and "Technologies_2" (Figure 7).

Sample 1	
Variable	Barriers
Sample 2	
Variable	Technologies_2

	Sample 1	Sample 2
Sample size	13	12
Lowest value	24,4400	51,1100
Highest value	73,3300	82,2200
Median	43,3300	67,7800
95% CI for the median	36,7399 to 54,1649	64,4400 to 72,2200
Interquartile range	37,2250 to 52,2225	64,4400 to 72,2200

Hodges-Lehmann median difference	23,3300
95% Confidence interval	12,2200 to 31,1100

Mann-Whitney test (independent samples)

Average rank of first group	8,3462
Average rank of second group	18,0417
Mann-Whitney U	17,50
Test statistic Z (corrected for ties)	-3,296
Two-tailed probability	P = 0,0010

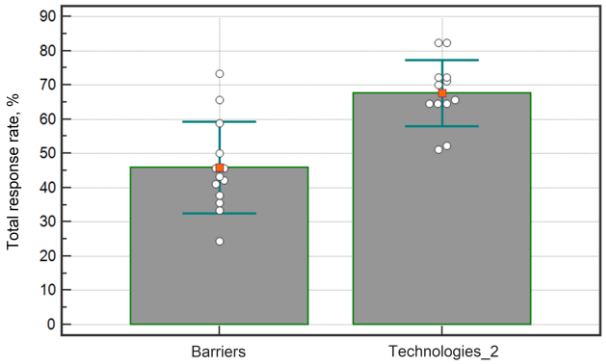

Fig. 7. Result of testing the differences between the "Barriers" and "Technologies_2" variables

The testing results show that the impact of the "Technology_2" variable assessed by the sum of the percentages of ratings in the adopted scale is statistically significantly greater (p = 0.0010) than the "Barriers" variable assessed by the sum of the percentages of ratings on the adopted scale. The average rank for barriers is 8.34 and is much lower than the average rank for benefits from implemented technologies, which is 18.04. Thus, it is confirmed that the respondents considered the potential benefits to be obtained due to the implementation of modern technologies, observed on a large and significant scale, to be more important than large and significant difficulties associated with their implementation.

The second stage of the research was testing the differences between the group of variables - "Barriers" and "Potential_1" (Figure 8).

Sample 1	
Variable	Barriers
Sample 2	
Variable	Potential _1

	Sample 1	Sample 2
Sample size	13	8
Lowest value	24,4400	81,1100
Highest value	73,3300	96,6700
Median	43,3300	90,5550
95% CI for the median	36,7399 to 54,1649	82,9098 to 96,6700
Interquartile range	37,2250 to 52,2225	83,3300 to 94,4450

Hodges-Lehmann median difference	45,5500
95% Confidence interval	33,3300 to 54,4400

Mann-Whitney test (independent samples)

Average rank of first group	7,0000
Average rank of second group	17,5000
Mann-Whitney U	0,00
Test statistic Z (corrected for ties)	-3,770
Two-tailed probability	P = 0,0002

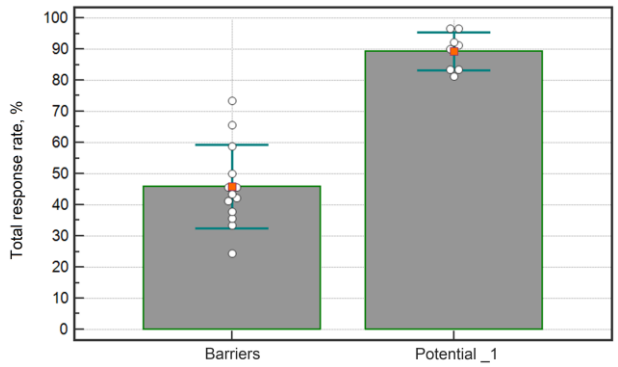

Fig. 8. Result of testing the differences between the "Barriers" and "Potential_1" variables

Sample 1	
Variable	Barriers
Sample 2	
Variable	Potential _2

	Sample 1	Sample 2
Sample size	13	8
Lowest value	24,4400	47,7800
Highest value	73,3300	75,5600
Median	43,3300	64,4400
95% CI for the median	36,7399 to 54,1649	60,3870 to 72,8521
Interquartile range	37,2250 to 52,2225	63,3300 to 71,1100

Hodges-Lehmann median difference	21,6650
95% Confidence interval	6,6600 to 30,0000

Mann-Whitney test (independent samples)

Average rank of first group	8,0769
Average rank of second group	15,7500
Mann-Whitney U	14,00
Test statistic Z (corrected for ties)	-2,755
Two-tailed probability	P = 0,0059

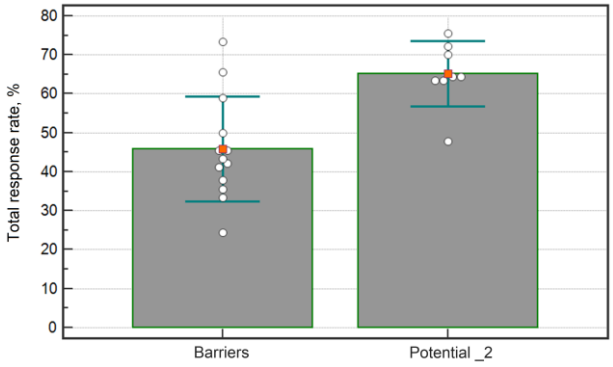

Fig. 9. Result of testing the differences between the "Barriers" and "Potential_2" variables

The "Potential_1" variable assessed by the sum of the percentages of ratings on the adopted scale is statistically significantly greater (p = 0.0002) than the "Barriers" variable assessed by the sum of the percentages of ratings on the adopted scale. The average rank for barriers is 7.00 and is significantly lower than the average rank for the potential for changes due to implemented technologies, which amounts to 17.5. It can therefore be concluded that for the surveyed enterprises, the possibilities of changes in individual areas of enterprise activity due to the implemented Industry 4.0 technologies play a much greater role than large and significant difficulties associated with it. This confirms the second hypothesis, according to which enterprises perceive more potential changes in the areas of their operations following the implementation of Industry 4.0 solutions than barriers to its implementation.

The verification of the second hypothesis was also based on testing the differences between the group of variables - "Barriers" and "Potential_2" (Chart 9).

The testing results allowed for observing that the "Potential_2" variable assessed by the sum of the percentages of ratings on the adopted scale is statistically significantly higher (p = 0.0059) than the "Barriers" variable assessed by the sum of the percentages of ratings on the adopted scale. The average rank for barriers is 8.07 and is much lower than the average rank for the potential for changes due to implemented technologies, which amounts to 15.75. Therefore, enterprises are not so afraid of the greatest difficulties in implementing modern technologies as to give up potential changes in individual areas of their activities.

5. Summary and conclusions

In order to compare the benefits and potential for changes resulting from the implementation of modern technologies with the barriers that limit this process, the quantitative research was conducted in enterprises hiring more than 10 employees.

As a result, it was indicated that the level of involvement in technological transformation among Polish enterprises is moderate. Nearly 67% of all the surveyed entrepreneurs can characterize specific Industry 4.0 solutions. Among them, only approximately 6% can be defined as highly digital companies that have already partially digitized operational processes. This means that 30% of small, medium, and large enterprises do not have the basic knowledge to take an active part in the fourth industrial revolution. This conclusion can also be

supported by the research results cited by Ślusarczyk and Pypłacz (2020), which indicate a low level of readiness of Polish companies from the SME sector to implement Industry 4.0 solutions, but it is optimistic that entrepreneurs are willing to keep pace with technologically stronger enterprises.

Additionally, the research conducted by Jankowska et al (2022) indicates that slightly over 30% of enterprises have prepared specific strategies to meet the challenge of the implementation of the I4.0 technology, but according to the authors, this number suggests that only few companies managed to introduce a fraction of revolutionary technologies and solutions.

The conducted analyzes also show that human resources are not perceived as the driving force of digital transformation, but as the main obstacle in the process of implementing Industry 4.0. This conclusion is also confirmed by Ingaldi and Ulewicz (2020). Currently hired employees lack the necessary competences and skills that would effectively support the process of implementing modern solutions. As in the case of human resources, financial resources are not perceived as a factor driving the development of Industry 4.0, but as a barrier to achieving the effective digitization of the enterprise. At the same time, digital transformation leads to more complex tasks and processes, therefore qualified and educated employees and financial outlays are an important condition for the success of this process in the future, which is confirmed by this research. Most enterprises are looking for financial support from the government, while universities, users and suppliers of Industry 4.0 solutions should, according to the study, provide assistance in terms of technological issues.

The limited level of knowledge and experience of the organization, lack of competent staff and low financial support may hinder an effective innovation process and thus constitute a limitation in increasing the full potential of Industry 4.0 in Polish enterprises. Increasing the productivity and efficiency of processes and increasing their innovativeness are the main motivation for the implementation of the Industry 4.0 concept in companies. According to them, production and logistics are the areas in which changes most frequently occur due to the implementation of digital solutions. This is consistent with the assumptions of the digital industrial revolution, which indicates that most I4.0 solutions are aimed mainly at the manufacturing area. In turn, the type of technologies implemented is mainly a consequence of the requirements of customers or business partners, and less often the needs of employees.

A good sign resulting from the conducted research is the fact that enterprises are ready to face the difficulties associated with implementing Industry 4.0 solutions to obtain favorable results and positive changes in the management of their enterprise.

Such conclusions can be drawn from testing the differences in the benefits and the potential of technology implementation in relation to the barriers that hinder this implementation. The research conducted in this area can be considered a new aspect of deliberations on the implementation of the Industry 4.0 concept in Polish enterprises.

The results presented in the article are not without limitations, mainly due to the period of the research conducted in the context of dynamic progress in the implementation of the Industry 4.0 concept in enterprises, which is highlighted, among others, in the "Industry 4.0 for inclusive development Report" (United Nations, 2022). Nevertheless, the obtained results can certainly constitute a basis for comparisons in the event of reconducting the research in the future or confronting the results obtained by other authors. Since digitization is inevitable for enterprises nowadays, each such study can be an interesting repository of knowledge for them. Mastering and implementing digital technologies will help these entities develop cooperation, effectively collect and process data and search for innovative solutions, saving time and money.

Global economic development forecasts indicate that many of today's challenges and their consequences will be important in the future. Hence, further directions of research on the barriers and benefits resulting from the implementation of the Industry 4.0 concept should not ignore: geopolitical crises, disruptions in supply chains, potential further pandemics while constantly respecting the need for sustainable development of enterprises and economies.

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