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# *Industry 4.0 – Development and Limitations in Large Manufacturing Enterprises in Poland. Analysis of Research Results*

**Keywords:** Industry 4.0; development of Industry 4.0; barriers to the implementation of Industry 4.0; correlation analysis; development of manufacturing enterprises in Poland

**JEL:** O32; O36; O39

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**Abstract**

**Theoretical background:** Industry 4.0 tools are an important element in achieving a competitive advantage, especially among manufacturing companies. There are numerous studies regarding this idea's level of implementation in companies operating in Poland.
**Purpose of the article:** The aim of the article was to verify the hypothesis regarding the existence of barriers and opportunities for implementing Industry 4.0 solutions among large manufacturing enterprises in Poland.
**Research methods:** The author presented the results of her own research carried out at the end of 2019 by means of the CATI method on 108 large manufacturing enterprises in Poland. She supplemented the state of knowledge and verified it by analyzing secondary research – two reports from research conducted in 2022 using the CAWI method.
**Main findings:** It was the basis for concluding that the results of the author's study did not lose their significance, and the analysis of the correlation between the results may support conscious decision-making as to which areas interact with each other and in what way.

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**Introduction**

In order to remain competitive, Polish enterprises are often obliged to effect development on the basis of guidelines and programmes present on the global market. One such concept subject to consideration is Industry 4.0 (the Fourth Industrial Revolution) introduced by the German government to improve the competitiveness of German enterprises (Dr. Wieselhuber & Partner GmbH, 2015). This concept features the following objectives (Podkarpackie Regionalne Obserwatorium Terytorialne, 2021):

1. Increasing the automation of manufacturing processes.
2. Creating the Internet of Things – an intelligent network of all machines involved in the process, which will be mutually subject to the process of communication as well as sharing information and making decisions.
3. Reducing human participation in the production process by bridging the gap between physical and digital systems. A human is supposed to change from a doer to a production process supervisor.
4. Transferring control of the entire production process from the control process to each intelligent machine that makes its own decision and can be controlled locally.
5. Improving the use of data in a closed-loop system, i.e. using models that improve performance on the basis of feedback from the process.
6. Increasing the customization of products to meet customer requirements.

It is noted that the development of the idea of Industry 4.0, despite the passage of time, has been of continuous interest to both practitioners and researchers. Therefore, there are numerous different studies regarding the development of this concept as well as competencies which are needed to support its development. As part of this article, it was decided to summarize the results of the original survey (in the fourth quarter of 2019) based on the CATI method ($n = 108$) and available reports from 2022 (Endress+Hauser ($n = 500$) and APA Group report ($n = 41$)) carried out using the CAWI method in the range of opportunities and limitations identified in enterprises in Poland related to the implementation of the idea of Industry 4.0.

The aim was to answer the question whether there are factors that correlate with each other and that may influence the existence of barriers and opportunities in the implementation of Industry 4.0.

The ultra-fast digitization associated with the development of Industry 4.0 is becoming a reality that affects Polish companies. According to the data from the report *Industry 4.0 Market by Technology and Geography – Global Forecast to 2026* (Markets and Markets, 2021), the value of the global Industry 4.0 market is expected to increase by about USD 100 billion from USD 64.9 billion in 2021 to USD 165.5 billion in 2026. Enterprises in Poland are looking for new development opportunities – also by opening up to cooperation with universities through various types of traineeship and internship programmes, dual studies or joint projects. Thanks to it, they are coping better and better with the implementation of tools brought by

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the idea of Industry 4.0. (Endress+Hauser, 2022b). As the assumptions of this idea indicate, one of the most important benefits in the application of the Industry 4.0 technology should be an increase in production efficiency while maintaining the high quality of products created. Thanks to automating processes, using robots and making decisions based on the most up-to-date and comprehensive data, one should ultimately achieve faster, more efficient and agile operation, adapted to the changing reality. In the context of the efficiency and improvement of processes, a variable loop related to data collection seems to be important, enabling better risk management as well as predictive maintenance – constant monitoring of machines allowing for early detection of irregularities in work or the need for maintenance before a failure occurs on the production line. Industry 4.0 (sometimes referred to in this context as Industry 5.0) also provides an opportunity for more sustainable production. According to the data from the Deloitte report (2022) entitled *Sustainable Actions Index: Consumers, Employees, Citizens – CE Perspective*. *Growing Concerns about Global Warming*, it is noted that more than half of the respondents are consciously planning to influence business with their consumer decisions to implement solutions that reduce the negative impact on the environment. An equally important issue shaping the decisions of companies concerning Industry 4.0 are strict EU regulations which, among others, oblige enterprises to achieve net zero emissions by 2050 at the latest.

A separate area constituting the competitive advantage of companies implementing the idea of Industry 4.0 is offering products made to order placed by an individual customer, and at the same time characterized by high quality and a price similar to the price of a mass product. At the same time, research shows that 62% of customers are willing to pay more for products that are personalized and tailored to their needs and preferences (Ericsson Report, 2020). Also, regarding employment, it is noted that in the current situation it is becoming increasingly difficult for companies that do not keep abreast of the times to acquire experienced and qualified specialists, which means they cannot develop their activities and compete on the global market (APA Group, 2023).

## Literature review

The concept of Industry 4.0 was created to improve the competitiveness of German enterprises. It aims at accelerating the creation of smart factories based not only on network cooperation with the use of information and communications technology for the needs of linking machines, processes, systems, products, customers and suppliers, but also on offering customized products at the price of mass products (Stasiuk-Piekarska & Mrugalska, 2020; Bembenek, 2017). One should not overlook the role of employees, who instead of being a doer often start to act as a process supervisor. This is made easier because they receive information at any time and from any place (Stasiuk-Piekarska, 2020; Wyrwicka & Mrugalska, 2017). This

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idea defines a wide range of innovations in the areas of IT, production technology and materials science affecting the implementation of the concept of Industry 4.0. A particular role of the following is noted (Spath et al., 2015):

– flexibility of production processes,
– dealing with a large amount of data,
– enterprises' ability to introduce innovations.

This issue can be further extended by the complexity of business management and ensuring data security and the possibility of their proper reflection in the digital reality. This fact determines the need for employees to carry out new tasks, which, in turn, forces them to acquire different skills and competencies. It also expands the scope and possibilities of production control, with particular emphasis on the use of mobile devices and technologies. One can state that combining the virtual world with the real world is an extension of the concept of the human-machine system (Bendkowski, 2017).

Summing up, the most specific elements of the Fourth Industrial Revolution are: artificial intelligence, intelligent sensors, device mobility, the ubiquity of the Internet, the use of renewable energy sources or reduced cost of digital data storage (Podkarpackie Regionalne Obserwatorium Terytorialne, 2021).

## Methodology

The study used the CAWI method, which involves conducting a survey via telephone calls using a computer-assisted method, e.g. using a software system downloaded to a computer or mobile device (Survgo, n.d.). The advantages of the adopted method include: the ability to reach a diverse group of respondents and the speed of obtaining results that are easily subject to statistical analysis. The disadvantages of the adopted method may be: respondents' reluctance to take surveys, as well as their misunderstanding of the questions (Biostat, n.d.). The obtained results were subjected to statistical analysis using the Statistica software. The research hypothesis concerned the existence of opportunities and barriers in the implementation of Industry 4.0 solutions in large enterprises in Poland.

At the turn of November and December 2019, a survey commissioned as part of Young Staff supporting projects was carried out using the CATI survey method on a group of 108 respondents. Large manufacturing enterprises (with more than 250 employees) located in Poland were selected for it.[1] The study employed the diagnostic poll method. The research tool used was an own survey questionnaire. Participation in the study was voluntary and anonymous. The questionnaire contained both open-ended and closed-ended questions. Most of the respondents were employed in organizations as specialists, managers or directors. This article presents

[1] More can be found here: (Stasiuk-Piekarska, 2020; Stasiuk-Piekarska & Mrugalska, 2020).

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the most important results that may be relevant in the assessment of opportunities for development and barriers to the implementation of Industry 4.0.

Dependent variables determined by opinions – category-related variables described in the 5-point Likert scale. Rank values were assigned to responses: 1 – *I strongly disagree*, 2 – *I rather disagree*, 3 – *I have no opinion*, 4 – *I rather agree*, 5 – *I strongly agree*. On this basis, the degree of agreement with the opinion was determined on the scale of 1–5.

**Discussion of results**

In terms of competencies, the majority of the respondents claimed that they strongly agreed (36.1%) or rather agreed (27.8%) with the statement that their organization[2] had the skills to program the process, define procedures and transfer the entire initiative to machines. At the same time, over 50% of the respondents stated that they strongly agreed that in their organization they were able to indicate processes which could be carried out without human participation/supervision (24.1% of the respondents rather agreed). The majority of the respondents believed that their organization was rather ready or ready (28.7% of the indications, respectively) for the analysis of big data sets.

In the area of supervision/regulations/intellectual protection, one notes that more than 1/3 of the respondents strongly agreed that the idea of Industry 4.0 supports environmental protection (and 28.7% of the respondents stated that they rather agreed). At the same time, almost 1/3 of the respondents had no opinion regarding this issue. Almost 40% of the respondents declared that their organization implemented solutions related to cybersecurity.

At the same time, when examining statements concerning technology, almost 1/3 of the respondents did not have an opinion on having full database integration in the value chain (and 30.6% stated that they rather agreed with the fact of having it). What is particularly important in the area of Industry 4.0 implementation is the fact that more than half of the respondents declared that their company had the ability to control processes in real time, and over a quarter stated that it rather had such a possibility. At the same time, 47.2% of the respondents stated that they strongly agreed that their organization was introducing the possibility of processing information in real mode, but over 40% of the respondents did not know whether their company was introducing the digitization and integration of vertical and horizontal value chains. Approximately 18% of the respondents respectively were certain or rather certain of such activities. In terms of introducing the digitization of products and service offers, the majority of the respondents (28.7%) rather noticed such activities in their organization, the next slightly smaller group (almost ¼ of the respondents)

[2] It is a certain mental shortcut used throughout the article.

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definitely confirmed the enterprise's development in this area. At the same time, over 70% of the respondents strongly noted the company's focus on technological development. In addition, in terms of activities related to the implementation of the idea of Industry 4.0, almost 1/3 of the respondents (32.4%) rather agreed with the statement regarding the assessment in the range of striving for the introduction of autonomous machines, and slightly fewer people (30.6%) strongly agreed with it. The last area studied in the area of technology was the assessment of the use of simulations in processes carried out in the enterprise. The majority of the respondents (31.5%) strongly agreed with this statement.

When examining another element subject to redefinition in Industry 4.0, i.e. products and two statements related to this area, the following opinions of the respondents were established:

– more than 66% of the people strongly agreed that the organization should allow a product to be customized to meet customer requirements,

– at the same time, almost 1/3 of the respondents rather noticed the introduction of limitations on product variants.

Regarding human resource management, it was estimated that over 40% of companies (42.6%) were ready for organizational changes, and almost 1/3 (30.6%) were rather prepared for it. As for employees striving after acquiring new competencies, more than half of the respondents declared that training courses in new technologies for employees and increasing their competences in the area of process supervision were definitely planned in their company.

Another area to be studied was leadership, in which the respondents expressed their opinions on the following topics:

– readiness of the management to take risks related to organizational changes in the enterprise – almost 77% of the respondents stated that they rather or completely noticed such a phenomenon in their company,

– at the same time, 1/3 of the respondents did not know whether the company had secured funds for the implementation of the automation process and the introduction of new technologies, and almost 1/3 (31.5%) definitely confirmed the existence of such a pool of resources.

The last of the surveyed topics was a study on the implementation of the strategy of Industry 4.0, where over 60% of the respondents indicated the readiness of the organization to constantly interact with customers and suppliers (in the range of building supply networks) and the integration of business networks. At the same time, as many as 37% of the respondents did not know whether the enterprise was introducing the digitization of business models and customer access – slightly more than ¼ of the respondents declared that this was rather the case. The above result may indicate the lack of knowledge of the respondents – despite their initial selection in the field of interest and dealing with the subject of Industry 4.0.

Since the afore-mentioned report from the author's own research comes from 2019, it was decided to verify the information provided in the range of problems and

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opportunities for the development of enterprises based on the guidelines related to Industry 4.0. Seeking the most up-to-date data, it was decided to refer to two reports analyzing the situation of enterprises in Poland in the area of the implementation of Industry 4.0. For this purpose, the afore-mentioned reports from 2022 were used. The first one – the Endress+Hauser report in cooperation with Insight Lab entitled *Technologies, Services and Products Changing the Polish Industry* and concerning Industry 4.0 – was prepared on the basis of the results of surveys collected using the CAWI method and supplemented with in-depth interviews. The research group consisted of 500 respondents representing 500 representatives of the Polish industry. The basic barriers in the implementation of Industry 4.0 solutions were the lack of the effectiveness of activities carried out by the management (only 34% of the respondents positively assessed the effectiveness of the management in the implementation of Industry 4.0 solutions) and budgetary limitations (45% of the respondents' indications) (Endress+Hauser, 2022a, 2022b). At the same time, it is worth mentioning that on the basis of the data from the Future Industry Platform, the Digitization Index of enterprises in Poland in 2021 was at the level of 2.4 points out of 4 points possible. This is not a value that can be considered satisfactory. Yet, compared with 2020, where this indicator was 1.8, there has been a significant increase in value. At the same time, 90% of the respondents declared that their organization participated in digital transformation, and over 40% of the respondents indicated that their enterprises were at a fairly advanced level in the implementation of digital solutions. In turn, 32% of the respondents believed that their companies were at the beginning of transformation and 10% of the organizations were not interested in this issue at all (Endress+Hauser, 2022a).

In the area of enterprise development, the main aspect increasing interest in the implementation of Industry 4.0 solutions is the need for optimizing and introducing improvements. The respondents listed the following: increasing the efficiency of processes (74% of the indications), reducing or optimizing costs (68% of the indications) and facilitating reporting (56% of the indications). At the same time, in terms of barriers to implementation, the most important of them concern: budgetary limitations (45% of the indications), employees' reluctance to change (33% of the indications), 27% of the indications concerned limitations in employee competencies and IT security in the establishment and/or the need for protecting sensitive or strategic information. At the same time, ¼ of the respondents pointed to the issue of the complicated coordination of changes introduced in different departments, and slightly more than 1/5 had difficulties in translating problems and needs into digital solutions (23% of the indications) and insufficient knowledge about the most favourable solutions for the company (21% of indications).

When examining the level of development of enterprises in Poland on the basis of the results contained in the afore-mentioned Endress+Hauser report, almost 40% of the respondents declared in their organizations the comprehensive or almost comprehensive integration of data with digital tools and systems that make autonomous decisions both

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in the range of resource planning and production processes as well as planning sales of finished products. At the same time, the respondents declared the highest degree of automation in the area of the implementation of production processes (11% of the indications for full automation, which does not require interference from employees, and 38% of the indications for almost full automation in this area) as well as in the area of the administration and management of the company (11% and 33% of the indications, respectively). When analyzing the individual results, one should consider what the respondents understood by automation, e.g. in the area of business management.

The respondents also assessed: the effectiveness of the management in implementing Industry 4.0 solutions (the lack of opinion on this subject in 37% of the respondents is puzzling), training of employees in this area (as many as 56% of the indications concerned serious objections to training) and the manner of cooperation between teams within the implemented projects (40% of the respondents were of the opinion that the teams' activities were too dispersed).

The second of the reports – significantly different from the first survey on the implementation of Industry 4.0 – is the *State of Industry 4.0 in Poland* study, which was conducted in October and November 2022. The partner of the study was the APA Group, hence in this article the report is called the APA Group report (2023). This study was attended by respondents from the following groups: specialists in managerial positions and C-level numbering 41 people – representatives of production companies operating in Poland from the group of small, medium and large companies (APA Group, 2023). One of the most important observations from this document is the fact that although 1/3 of the respondents had heard of the idea of Industry 4.0, they did not know what it was in practice, and as many as 34% of the respondents did not deepen their competencies in this area. It is all the more important because nowadays we even talk about Industry 5.0, which additionally covers the subject of sustainable development of the organization. Perhaps the size of the enterprises from which the respondents came meant that despite the above results, the respondents noted that the implementation of Industry 4.0 allowed to increase the company's competitiveness in the industry, and about 25% of the respondents indicated that digital transformation was an activity that was a prerequisite for development and survival on the market. In turn, one of the barriers was not only the financial scope, but also the lack of knowledge in the field of introducing changes and choosing technologies for implementation in the enterprise. The respondents indicated automation, Big Data, analytics using artificial intelligence as well as cloud computing as the most popular and most beneficial aspects.

When analyzing the respondents' positions on the challenges related to the implementation of Industry 4.0, as many as half of the respondents declared the lack of clear information regarding return on investment – both the conditions and time of return. Almost as many respondents reported having difficulty in convincing decision-makers to invest in innovation. At the same time, more than 1/3 of the respondents saw an obstacle in the implementation of Industry 4.0 in the existing information noise – lack

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of knowledge in the area of technology selection as well as in the weak organizational structure. More than ¼ of the respondents complained about the excessive costs of implementing new technologies as well as the unification with the lack of solutions tailored to a specific company. Entering the path of implementing Industry 4.0 tools is a major change and may involve very high costs. Some researchers and practitioners point out that in the context of costs, the answer to the question should not be "if" but "how much" – this may be crucial in the context of future profits. The respondents declared that in the next two years their organizations were planning to spend 21–30% of the total budget on innovation regarding investments in the area of Industry 4.0. This is on average 10% more than they invested in the same activities in 2021. This may be based on the results contained in the PwC report entitled *Digital Factory Transformation Survey*, which indicated that only high expenditures on innovation lead to equally high returns (investments at the level of 3% of annual revenues are the absolute minimum allowing for quick results and return on investment). It is estimated that the probability of success of organizations spending 3% on investment in innovation is 2.5 times higher than in the case of companies that invest less than 2%.

In the above-mentioned reports, it is noted that the issues related to incurring costs as well as resistance regarding the scope of changes appear in every study. In turn, when examining the development of the idea of Industry 4.0 and its implementation, some kinds of two paths of development and declaration in this area can be observed. This may be related to the selection of the group of respondents for the research. However, the results allow to believe that the study conducted at the end of 2019 is still valid, which makes it possible to continue drawing conclusions based on them. Correlation analysis is all the more important because the search for relationships can be the basis for further inference in terms of the impact of factors on each other and could probably be used, for instance, in the methodology of network thinking.

The following are those that, after using the Spearman's test with the Statistica software package, were considered statistically significant ($p < 0.05$). This may be an indication of which elements are worth exerting influence on in order to develop the concept of Industry 4.0 in the organization.

In addition, when analyzing statistical significance, what can be considered statistically significant is the relationship between the size of the factory (the division included a group of respondents according to the size of their organization: up to 499 people, 500–999 people, from 1,000 people) and the declaration of readiness for analyzing Big Data. In addition, one confirmed the significance between the declaration in the area of interest and implementation of Industry 4.0 and:

– focus on technological development (0.0100),

– striving to introduce autonomous machines (0.0141),

– the management being ready to take risks related to organizational changes in the enterprise (0.0378),

– readiness to constantly interact with customers and suppliers (building supply networks) – integration of business networks (0.0265).

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These analyses were carried out using the Mann–Whitney *U* test.

When examining the degree of correlation between the statements, statistically significant associations were identified (according to the Spearman's rank test, $p < 0.05$). All correlation values were positive, but correlations with a weak strength of data interaction were deliberately omitted. This text indicates correlations with at least an average relationship between the data (correlations with the value of min. 0.4).

One of such relationships was the relationship between the implementation of cybersecurity solutions (supervision) and the introduction of the digitization and integration of vertical and horizontal value chains (technologies) – 0.421. Presumably, enterprises implementing digitization consciously protect their resources from the implementation of tools for the sake of cybersecurity. Another statement regarding the relationship between supervision and technology is the correlation between having full database integration in the value chain and introducing the possibility of processing information in real mode (0.441). The strongest, although still medium correlation in these two areas is the assessment of the relationship between possessing the ability to control processes in real time and the introduction of the ability to process information in real mode (0.537). The relatively small strength of the relationship between these statements may be puzzling, because having implemented real-mode information processing capabilities, organizations should ultimately strive to have process control also in real time. The lack of such a relationship may constitute a significant waste of resources and the lack of conscious decision-making based on facts, and thus proper risk management in the company's operations.

Other issues in which at least medium-strength relationships between the statements were identified are the focus on global competition (implementation of the Industry 4.0 strategy), and the ability to control processes in real time (supervision) – 0.508. This result may indicate that companies with real-time control are able to react faster to the changing situation, or the desire to stay in the global competition market forces them to constantly improve their production management and search for areas where it can be done.

In turn, in the area of technology, the following relationships with medium strength were identified:

– "it introduces information processing capabilities in real mode" from "it introduces the digitization and integration of vertical and horizontal value chains" – 0.445,

– "it introduces the digitization and integration of vertical and horizontal value chains" from "it introduces the digitization of product and service offers" – 0.403.

Looking for further areas where there is at least a medium strong correlation, it was calculated that in the issues related to the relationship between technology and people: the statements "it is focused on technological development" from "it plans training in new technologies for employees/increasing their competencies in the field of process supervision" obtained the level of 0.410. It can be seen that when striving after technological development, one often encounters a competency gap and one

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of the possibilities to reduce it is to invest in training and supporting employees in acquiring new knowledge and new skills.

With regard to analyses in subsequent areas (technology with leadership), the following relationship is noted: the focus on technological development is related to having financial resources to implement the automation process and the implementation of new technologies – correlation at the level of 0.405. This relationship is most likely based on a situation where enterprises wanting to develop themselves must have necessary financial resources to implement new solutions. At the same time, being focused on technological development, the organization is often able to acquire new, additional funds or acquire new customers by offering competitive, modern products.

The next areas to be compared were technology with the implementation of strategy 4.0. One identified correlations between the introduction of the capabilities of processing information in real mode and the introduction of the digitization of business models and customer access – 0.477 and the enterprise's focus on global competition – 0.445. In addition, the following relationships were established as significant from the point of view of the correlation force adopted for the purposes of this article:

– "it introduces the digitization and integration of vertical and horizontal value chains" from "it introduces the digitization of business models and customer access" – 0.419,

– "it introduces information processing capabilities in real mode" from "it is oriented towards global competition" – 0.445,

– "it introduces the digitization of product and service offers" from "it introduces the digitization of business models and customer access" – 0.401,

– "it is oriented towards technological development" from "it is ready to constantly interact with customers, with suppliers (building supply networks) – integration of business networks" (0.515) and from "it is oriented towards global competition" (0.514).

Analyzing the area of issues defined as products and people, the following correlations were obtained: "it allows to customize the product to meet customer needs" from "it plans training in new technologies for employees/increasing their competencies in the area of process supervision" – 0.611. This result is the highest correlation value in the analysis. There is a relationship between employees' competencies and their readiness to take over the role of a supervisor instead of a doer, and the possibility of implementing customized production, oriented and launched on the order of an individual customer.

Another relationship analyzed are statements such as: "it allows to customize the product to customer needs" (product) and "it is oriented towards global competition" (implementation of the Industry 4.0 strategy) – 0.428. As various studies indicate, the focus on global competition should be related to the focus on a high degree of customization of production in order to meet individual customer requirements.

One of the analyzed areas where, among others, medium correlation values were identified were: people and leadership, where the following statements: "it is ready

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for organizational changes in the unit" and "the management is ready to take risks related to organizational changes in the enterprise" obtained the value of 0.534. This is an additional confirmation of the previously cited reports, in which one of the most important barriers was the lack of readiness of the management to take risks and actions in the area of implementing Industry 4.0 tools as well as the general lack of readiness for changes among employees. It is leaders who should set the direction of change and implement it in such a way as to consciously manage change while building employee engagement.

In turn, when analyzing the relationship between people and the implementation of the Industry 4.0 strategy, a correlation above 0.4 was obtained for the following statements: "it is ready for organizational changes in the unit" and "it is ready for continuous interaction with customers, with suppliers (creating supply networks) – integration of business networks" (0.420). Building relationships with customers and suppliers in the changing and dynamic world of business relations forces enterprises (entrepreneurs) to be ready to respond to changes and adapt to them. As the recent situations related to both the pandemic and the situation on the eastern border of Poland have shown, companies must constantly adapt to changes on both the macroeconomic and microeconomic scale. In addition, a relationship was identified between the statements related to planning training in new technologies for employees/increasing their competencies in supervising processes and focusing on global competition as a correlation with the value of 0.402. Probably, companies striving to compete on the global market must respond to emerging situations, also by training their employees and building their competencies. At the same time, having qualified staff, they are able to offer their customers better products that will translate into their competitive advantage.

In the following areas – leadership and implementation of the Industry 4.0 strategy – the following correlations, important from the point of view of this analysis, were determined:

– "the management is ready to take risks related to organizational changes in the enterprise" and "it is ready to constantly interact with customers, with suppliers (creating supply networks) – integration of business networks" – 0.459. It is possible that creating supply networks as well as continuous interaction with customers and suppliers require the management to offer responses at the level of reorganizing the company's operations. In the APA Group report, one of the barriers was the weak organizational culture and the reluctance of managers to make decisions regarding changes, which only confirms the importance of this aspect and the importance of such a link between the assessed statements;

– "it has financial resources to implement the automation process and introduce new technologies" and "it is ready to constantly interact with customers and suppliers (creating supply networks) – integration of business networks" – 0.427. When analyzing the above relationship, it is noted, for example, that if you want to implement new solutions in the area of creating supply networks or integrating business networks, one should be set on incurring necessary costs.

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The last area in which correlations between the studied issues were identified was the implementation of the Industry 4.0 strategy. Significant relationships in this area were formed between readiness to constantly interact with customers, with suppliers (creating supply networks) – integration of business networks and the organization's focus on global competition – a correlation with the value of 0.546. In addition, a link was identified between the declaration regarding the introduction of the digitization of business models and customer access and the focus on global competition – a correlation equal to 0.443.

The above correlation analyses covered relationships of at least medium strength, i.e. with the value of min. 0.4. Due to the relatively small sample, some results could have different values. However, not only this affects the achieved values. The selection of experts, as shown by the results of previous analyses of reports, may also be relevant. At the same time, certain trends are noticed, which allows for drawing conclusions in the studied issue.

## Conclusions

On the basis of the conducted analyses, it can be noted that despite diverse survey methods, various industries and years of conducting studies (end of 2019 and 2022), the obtained results to some extent overlap. It can be assumed that this was influenced by the pandemic and the war near the eastern border of Poland as well as the associated (and not only) economic uncertainty and high inflation. On the one hand, the pandemic forced an increase in the degree of digitization among companies and the use of online tools, and on the other hand, it may have caused a decrease in interest in investments and more conservative decision-making.

Summing up, financing innovation and an unspecified investment return period were indicated as the basic barrier for all research. In addition, the negative attitude towards changes, including the management, according to the declaration, is another problematic element that hinders the development of the organization regarding the implementation of Industry 4.0 tools. At the same time, it is worth being aware of the links between elements that may support the implementation of this strategy. One of them is the correlation between the focus on global competition and both financial and mental support realized by the management, or consciously building a relationship based on exchange and cooperation between the company and suppliers or the company and its customers.

As mentioned earlier, it is expected that the value of the global market related to Industry 4.0 will increase significantly in the coming years. Hence, in order to build a strong position on the global market for the exchange of goods and services, enterprises located in Poland will have to implement new technologies and promote openness to changes in their teams. These aspects, however, must be based on adequate employee competencies and reorganization of their work, which can be a challenge for enterprises also in the financial aspect.

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The article presents existing correlations and analyzes their possible connections, indicating what may constitute a barrier and what may constitute an opportunity for large manufacturing enterprises in Poland.

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