

INDUSTRY 4.0 – ARE WE READY?

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Abstract: The concept of Industry 4.0 is a new reality of the modern economy, because innovation and technological development play an important role in each organization. Industry 4.0 significantly changes products and production systems concerning the design, processes, operations and services. Certainly, the implementation of this concept has further consequences for management and future jobs through creating new business models. The objective of the present paper is to present the attitude of entrepreneurs to Industry 4.0, to indicate readiness for implementing the elements of the concept and to point out the barriers, which may possibly threaten enterprises in the effective achievement of a higher technological and organizational level. The research conducted in the paper is based on secondary data, obtained from many professional reports and studies, carried out by State institutions, consortia or enterprises. The international analyses coming from those documents show a significant interest in challenges imposed on companies by the Fourth Industrial Revolution. The majority of the respondents recognize the concept of Industry 4.0 as a great opportunity for development and improvement in competitiveness, although the state of preparations for its implementation varies widely depending on country, sector, or even an individual company.

Key words: Industry 4.0, 4th industrial revolution, 4IR, new technologies

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Introduction

The latest technologies, primarily related to digitization, already affect the condition of some industries and sectors of the economy. These processes take place at a different pace, mostly associated with the degree of maturity of the economy, its investment opportunities and culture of innovation, although the trend is clear and its key importance – unquestionable.

The concept of Industry 4.0 assumes blurring the differences between the work of people and the work of machines. Like the first industrial revolution improved the operation of manufactories, the second one introduced electricity into the industry and the third one automated the uniform tasks of line workers, the fourth one improves information management and decision-making.

The fourth industrial revolution differs from the previous ones with the fact that it relates to all fields of life. Within its framework, the industry processes and commercializes the exchange of information between people, between people and objects and also between objects themselves. The concept of the Internet of Things

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allows for carrying out the order, production, implementation and delivery of the product without human participation at any time in the course of the process. If industrial companies do not want to miss the trend, they must invest in modern technologies and management models in order to reach new customers and new staff. Therefore, the objective of the present paper is to present the attitude of entrepreneurs to Industry 4.0, to indicate readiness for implementing the elements of the concept and to point out the barriers, which may possibly threaten enterprises in the effective achievement of a higher technological and organizational level (Oláh et al., 2017; Oláh et al., 2018; Stverkova and Pohludka, 2018).

Literature Review

The term of Industry 4.0 (German Industrie 4.0), commonly recognized nowadays, occurred in the public domain in 2011 at the Hanover Trade Fair as the name for the common initiative of the representatives of business, policy and science promoting the idea of strengthening the competitiveness of the German industry (Müller et al., 2018; Rao and Prasad, 2018). The German Federal Government liked the idea so much that they decided to make Industrie 4.0 an integral part of the government initiative “High-Tech Strategy 2020 for Germany”, whose objective is to promote Germany as a global leader of technological innovation (Pereira and Romero, 2017; Zhou et al., 2015; Jabbour et al., 2018; Androniceanu, 2017a). A new idea, being in the central position of the government strategy for the development of the German economy, began to live its own life and only then it gained a large number of publications defining what Industrie 4.0 is to be. Industry 4.0 has also become a very popular slogan lately, used to define changes, which affect the industrial sector at the times of formation of a new stage of development called the 4th Industrial Revolution. In the concept of Industry 4.0, cost reduction, improvement in performance and also offering improved products and services, taking into account the preferences and behavior of consumers are to be achieved due to the automation of production based on the use and exchange of data in real time, using artificial intelligence (Pieriegud, 2016; Androniceanu, 2017b).

For some time, the term of Industrie 4.0 spreads only in German-speaking areas. In other regions of the world, similar concepts appear, among others Industrial Internet promoted by General Electric. Similar ideas occur under the names of Integrated Industry, Smart Industry or Smart Manufacturing.

The 4th Industrial Revolution (4IR) is happening globally and concurrently. In Europe, Germany (Industrie 4.0), France (the Nouvelle France Industrielle), Sweden (Produktion 2030), Italy (Fabbrica Intelligente), Belgium/Holland (Made Different), Spain (Industria Conectada 4.0) and Austria (Produktion der Zukunft) are all actively taking an interest. The US (Industry Connected 4.0) and Chinese manufacturing sectors are also readying themselves for this change, driven by different strategic objectives.

The development result of the concept of the discussed phenomenon in different countries is a range of terminological synonyms also in the scientific literature. Therefore, the decision has been taken to analyze the number of publications indexed in the databases of WoS, Scopus, and Google Scholar in years 2011-2017, including the most popular synonyms. Due to the specificity of searches in the analyzed databases, searching included different areas (Table 1).

Table 1. Scientific Papers Using Selected Terminology of Industry 4.0 in Bibliometric Databases during the Years 2011-2017

	Web of Science Core Collection (title, topic)	Scopus (title, abstract, keywords)	Google Scholar (all fields)
<i>Industry 4.0</i>	1311	2022	14700
<i>Industry of the Future</i>	25	52	1490
<i>4IR = 4.0 (Fourth Industrial Revolution</i>	235	976	6500
<i>Production of the Future</i>	7	22	539
<i>Intelligent Manufacturing</i>	383	579	17200

The most extensive database is Google Scholar, followed by Scopus, where most journals relate to the technical area. The most common term in all the databases is Industry 4.0. A larger number of papers including the term of “Intelligent Manufacturing” in Google Scholar refer however to other aspect than the ones indicated in the concept of Industry 4.0.

The number of papers shown in Table 1, relating to the concept of industry 4.0 indicates a significant interest in this issue, which results in numerous attempts to define it. According to Lasi et al. (2014) “*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, their environment and business partners*”. Hermann et al. (2016) define Industry 4.0 as “*a collective term for technologies and concepts of value chain organization*”. Oesterreich and Teuteberg state that, from the technical point of view, this new industrial paradigm can be described as the manufacturing environment’s increased digitization and automation in addition to an increased communication enabled by the creation of a digital value chain (Oesterreich and Teuteberg, 2016). A number of definitions are also collected in their article by Müller et al. (Müller, 2018). Based on the papers in this research category, Lu (2017) claims, that “*Industry 4.0 can be summarized as an integrated, adapted, optimized, service-oriented, and interoperable manufacturing process which is correlate with algorithms, big data, and high technologies*”. In addition to the definitions proposed by scientists, being so important for understanding the concept of Industry 4.0, it is also interesting to find out how this phenomenon is understood by manufacturers, who the industrial revolution will apply to. Table 2 shows their opinions.

Table 2. Manufacturers' Understanding the 4th Industrial Revolution
(*The 4th Industrial Revolution...*, EEF The Manufacturers Organisation)

How manufacturers describe the 4IR (in their own words)
<i>"Not just about tech but how you join up the tech to work better – more productive, efficient, more insights and information"</i>
<i>"Communication and data analysis"</i>
<i>"Optimization for efficiency gains – smarter ways of working"</i>
<i>"Use data to provide answers more quickly"</i>
<i>"Next step in optimization and efficiency"</i>
<i>"Will become essential for competitive manufacturing"</i>
<i>"Real time data availability and information"</i>
<i>"Provide better solutions for customers"</i>
<i>"Information management from data – data on its own isn't helpful"</i>
<i>"Information flow and exchange"</i>
<i>"Help to integrate service and product"</i>
<i>"Connecting up 'buckets' of work areas – information flow"</i>
<i>"Managing data and systems to improve competitive edge"</i>
<i>"Product/process/supply chain – joining up and smarter ways of working between areas"</i>
<i>"Enhancing service provision"</i>
<i>"Information to help to optimize products"</i>
<i>"An enabler of ultimate ambition and goals"</i>

Industrial Revolution - Historical Approach

Significant technological breakthroughs echoed triggering the so called industrial revolutions, which brought about significant changes in the structure and organization of production (Fig.1). The first industrial revolution took place in England in the mid-18th century and was strengthened by the invention of the steam engine (Lu, 2017). The cottage industry and manual work were replaced with mechanical production using water and steam energy. In the second half of the 19th century there was the second industrial revolution in Europe and the USA. That revolution was characterized by mass production and replacement of steam with chemical energy and electricity. In order to meet the growing demand, a range of technologies in the industry and mechanization was developed, such as an assembly line with automated operation, allowing for an increase in performance. This period also saw a number of developments of management programs that made it possible to increase the efficiency and effectiveness of manufacturing facilities. Division of labour, where each worker does a part of the total job, increased productivity (Zezulka et al., 2016). The first two industrial revolutions led to an increase in employee wealth and urbanization. In the late 1960s, advances in computing and electronics allowed production to be increasingly optimised and automated, known as programmable logic control systems, leading to greater efficiencies and improvements in quality and the third revolution in production (*Industry 4.0 Testlabs in Australia...*, Müller et al., 2018).

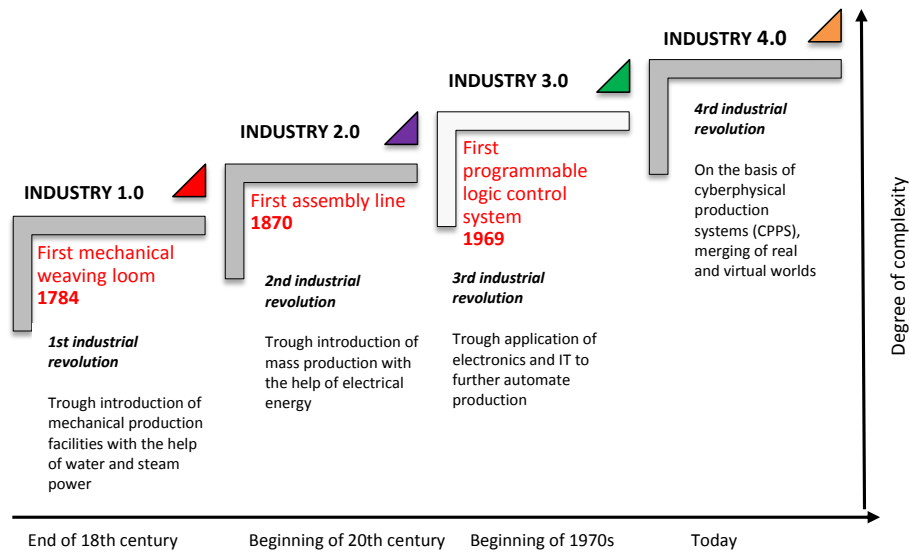


Figure 1. Industrial Revolutions (*Industry 4.0 Testlabs in Australia...*, p.6)

Key Features of Industry 4.0

The objective of Industry 4.0 is to achieve a higher level of operational effectiveness and productivity and also a higher level of automation. The most prominent characteristics of the concept are: digitization, optimization and personalization of production; automation and adaptation; human-machine interaction (HMI); value-added services as well as automated data exchange and communication (Roblek et al., 2016; Posada et al., 2015; Kovács and Kot, 2017; Veselovsky et al., 2018; Abbas, 2018). These characteristics are not only strongly correlated with the Internet technologies and advanced algorithms but also indicate that Industry 4.0 is the industrial process of adding value and knowledge management.

The 4th Industrial Revolution is associated with three phenomena (Paprocki, 2016):

- common digitization and ensuring constant communication between people themselves, people and devices and between devices themselves,
- more and more frequently implemented disruptive innovations, which allow for a stepwise increase in efficiency and effectiveness of the operation of the socio-economic system,
- the achievement of such development of machines that they gain the ability for autonomous behavior through the use of artificial intelligence in the process of their control.

Industry 4.0 makes use of technologies as the Internet of Things (IoT) and services (IoS), Cyber Physical Systems (CPS), industrial automation, continuous connectivity and information, cybersecurity, intelligent robotics, PLM, semantic technologies, industrial big data and computational vision to improve the productivity of manufacturing industrial systems (Baena et al., 2017; Posada et al., 2015; Dallasega et al., 2018; Rao and Prasad, 2018).

The listed technologies characteristic of Industry 4.0 may affect the way of product manufacture and also the perception of the product value by customers. The designed products will possess the unique electronic identification in order to follow the product life cycle and this will enable the collection of data concerning the use. Therefore, enterprises will better understand the patterns of consumption and will be able to improve the adjustment of products to the requirements of users. Moreover, the links between machines, devices and elements of the supply chain, with the help of co-shared information, will provide an opportunity to rapidly modify the priorities of orders (by requirements of customers or maintenance requirements), monitor and control the performance of assembly lines, track deliveries and also improve logistics routes (Jabbour et al., 2018).

Research and Methodology

The above theoretical assumptions prove the arrival of the 4th Industrial Revolution. The concept of Industry 4.0 is the inevitable future operation of most enterprises. On the other hand, a very interesting issue is the cognition of the practical aspect of the perception of this trend and the possibilities of the application of its tools in activities of enterprises.

The research conducted in the paper is based on secondary data, obtained from many professional reports and studies, carried out by State institutions, consortia or enterprises. It was necessary to initiate the accomplishment of the objective set in the paper with the verification of opinions on the significance of Industry 4.0 for enterprises (Fig.2).

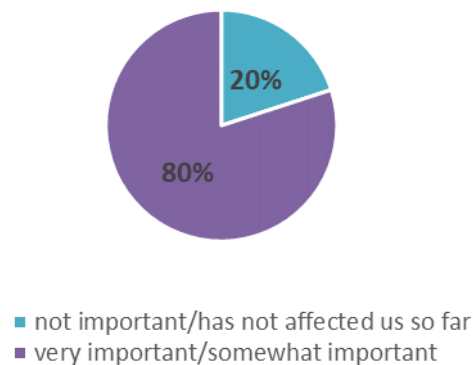


Figure 2. The Importance of Industry 4.0 for Companies
(2017 Global Industrial Survey..., p.21)

The majority of the surveyed companies notice the significance of Industry 4.0. Only for 20% of the respondents, the 4IR is not important and has not affected their operation so far. The companies, which found Industry 4.0 vital for their operation, may perceive the development and application of new technologies as an opportunity or threat for their activity and position in the market. In Figure 3 shows the approach to the issue in United States, Germany and Japan.

The majority of the enterprises in all three countries treat Industry 4.0 as an opportunity, not as a threat. In USA and Germany, such an opinion is expressed by over 90% of those surveyed. Entrepreneurs from Japan are slightly less optimistic in relation to the 4th Industrial Revolution, however, also among them, the majorities recognize its positive dimension.

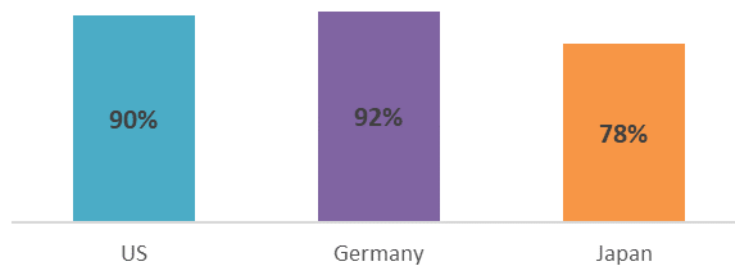


Figure 3. Treating Industry 4.0 as an Opportunity Not a Risk
(*Industry 4.0 after the initial hype...*, p.26)

The perception of Industry 4.0 as an opportunity theoretically should result in the implementation of its tools. However, it occurs that the level of preparation of enterprises to individual dimensions of the 4IR and the ability to use the benefits of Industry 4.0 are lower than expected, taking into account the positive attitude towards new technologies. The data concerning these issues are presented from Figures 4-7.

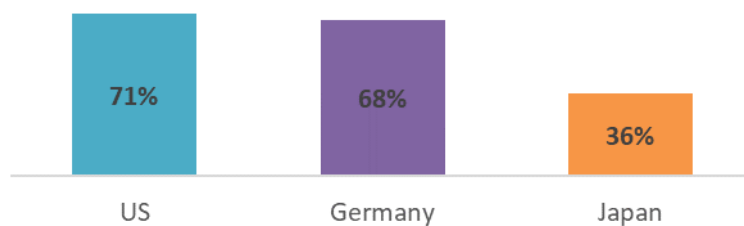


Figure 4. Share of Companies with High Level of Preparation for Industry 4.0 in US, Germany and Japan (*Industry 4.0 after the initial hype...*, p.28)

Enterprises from Germany and United States indicate a similar degree of preparation for challenges related to Industry 4.0 – about 70% of them consider themselves as well-prepared for this issue. The percentage of Japanese enterprises declaring a high level of preparation for the 4th Industrial Revolution is twice as low. This is rather surprising and it is difficult to categorically state what this results from. This may be the result of a slightly different perception of the idea of Industry 4.0 or setting higher requirements in this field than in other countries since it seems unlikely that enterprises from Japan are at a much lower level of technological development than their counterparts from Germany and United States.

The highest level of implementation of the solutions related to Industry 4.0 is shown by enterprises from Germany (Fig.5). Only in the case of software integration, the level of implementation or planned implementation is higher in Poland, although the difference is small. The poor results of enterprises from USA may be striking – only the use of autonomous robots is not at the lowest level there, although the difference between USA and Poland is only 2 percentage points, it cannot be recognized as significant. Autonomous robots are the least popular solution in all three countries, however, in Germany, even in their case; it deals with over 50% implementation (or planned implementation).

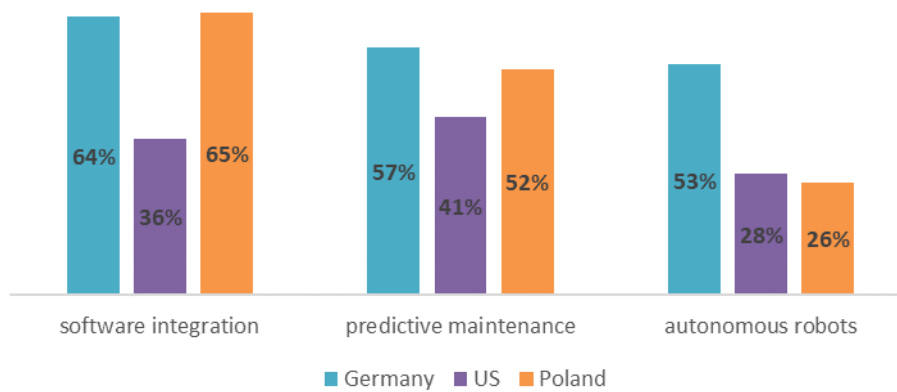


Figure 5. Industry 4.0 Technology Solutions already Implemented or Planned within 1-2 Years in Germany, US and Poland (*Przemysł 4.0 PL...,BCG, p.28*)

The level of preparation of enterprises for challenges related to the implementation of Industry 4.0 can be generally assessed as the low one (Fig.6). Only 20% of the respondents assess themselves as being ready for the application of new supply models. The level of preparation for blurred lines between industries (17%) is even lower as well as using smart and autonomous technologies (15%) (*The Fourth Industrial Revolution is here...*).

Poor preparation for the implementation of new technologies is also related to a low level of readiness for gaining benefits generated by these technologies.

Only slightly over 20% of enterprises understand well in what way new technologies will change their labor force and organizational structure. A similar percentage of the respondents are aware of the impact of new technologies on the change in the way of delivering goods and services by them. Only 16% of enterprises know how to integrate own solutions with the external infrastructure and only 8% possess strong business grounds for the applied new technological solutions.

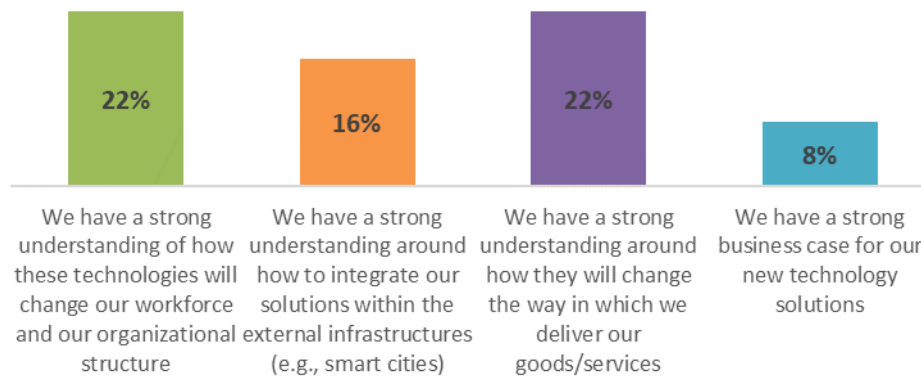


Figure 6. Organization's Readiness to Benefit from New Smart and Autonomous Technologies (*The Fourth Industrial Revolution is here..., p.16*)

The implementation of the solutions of Industry 4.0 requires capital expenditure on new technologies. Enterprises approach this issue with different attitudes and the catalogue of the conditions encouraging them to incur capital expenditure related to the 4IR is rather extensive. The most important investment conditions are presented in Figure 7.

There are a lot of conditions determining investments of enterprises in advanced technologies. The ability to integrate new technologies with the already possessed solutions and the ability to make them the foundations for new business models have the largest impact. The least frequently indicated factor is the ability to win quickly, which can be interpreted as the awareness of managers that investments in new technologies are long-term and the benefits resulting from them can be expected within a longer period.

While implementing the mechanisms of Industry 4.0, enterprises have all sorts of expectations associated both with reduction in operating costs and improvement in competitive position, an increase in operational effectiveness or improvement in business model. The level of these expectations is often different depending on the country or economic sector, which is presented from Figures 8-10.

Enterprises expect that the implementation of mechanisms of Industry 4.0 will bring them the average savings of 3.6% p.a.

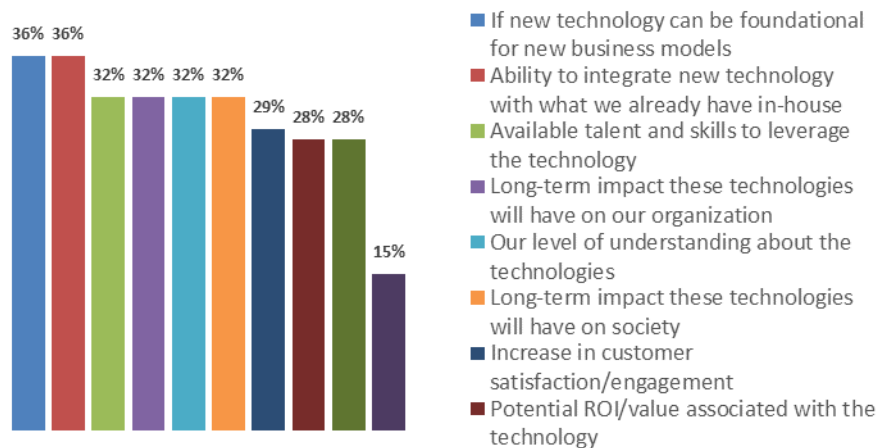


Figure 7. Issues Influence Organization's Investment in Advanced Technologies
(*The Fourth Industrial Revolution...*, Deloitte, p. 17)

The entities from the sector of Forest, Paper & Packaging have the highest expectations whereas; the enterprises from the sectors of Transport & Logistics and Metals have the lowest ones.

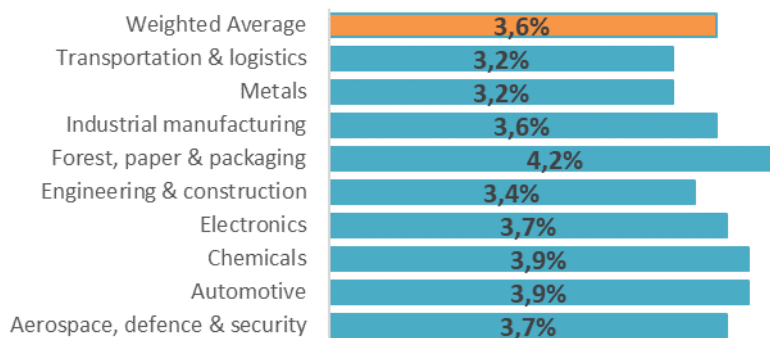


Figure 8. Expected level of Cost Reduction from Digitalization (in % p.a. until 2020)
(*Industry 4.0...*, PwC, p. 13)

More than half of enterprises expect that Industry 4.0 will contribute to an improvement in their competitiveness (Fig.9).

The most optimistic in this field are entities from USA. A large group of enterprises think that the 4th Industrial Revolution will not significantly affect their competitiveness. The percentage of entities seeing a threat for their competitiveness in Industry 4.0 is not very large, and the highest is in Germany.

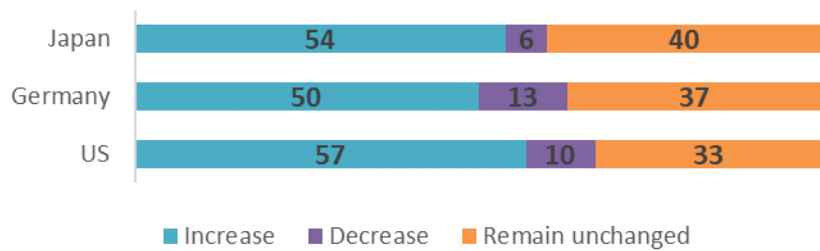


Figure 9. Expectations concerning how Company’s Competitiveness will develop due to Industry 4.0 (*Industry 4.0 after the initial hype..., p.27*)

Interestingly, over 90% of German entrepreneurs treat Industry 4.0 as an opportunity, therefore, the attitude of some of them is inconsistent since they recognize the 4IR as an opportunity and, at the same time, they predict that it will affect a decline in their competitiveness. On the other hand, the opposite situation can be observed in the case of enterprises from Japan.

Enterprises from United States are the most optimistic both in terms of the impact of Industry 4.0 on operational effectiveness and business models (Fig.10). Also in Germany and Japan, the expectations in this field are very high – in each case more than ¾ of enterprises assume a positive impact of Industry 4.0 on the surveyed areas. These data strongly support the aforementioned opinion (Fig.2) that the 4th Industrial Revolution is overwhelmingly treated as an opportunity not a threat.

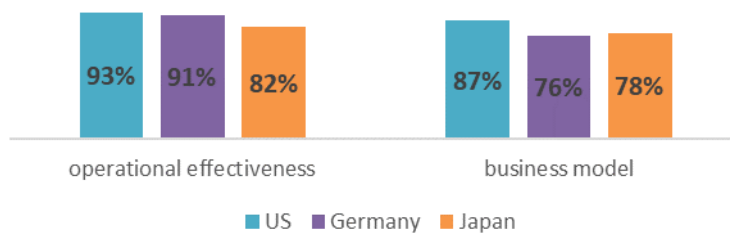


Figure 10. Expectations Concerning Company’s Operational Effectiveness and Business Model Increase due to Industry 4.0 (*Industry 4.0 after the initial hype..., p.27*)

The implementation of Industry 4.0 may bring a lot of benefits to enterprises; however the process does not run without problems. There may be indicated many barriers, which impede the transformation and implementation of new technologies. Figure 11 shows the most important challenges.

From the global perspective, the most important challenges while implementing the Industry 4.0 are a lack of digital culture and training, which is indicated by half of the respondents. Lack of clear vision or support from managers, unclear economic benefits from investments in digital technologies and high financial investment

requirements are also important. On the other hand, the least frequently indicated barrier is the fear of losing control over the intellectual property of the company. The situation looks slightly different when it is considered from the perspective of individual countries since, in each of them, different barriers are pointed out. In Poland, the most important one is high financial investment requirements, in South Africa, it is lack of digital culture and training, in Japan, the issue of unclear economic benefits from investments in digital technologies is most frequently raised, whereas, in Germany – lack of properly qualified staff. In many cases, the barriers which can be found the key ones in one country play a minor role in another one. These differences indicate a different level of awareness in the field of requirements of Industry 4.0 and a different approach to the issues related to the 4IR.

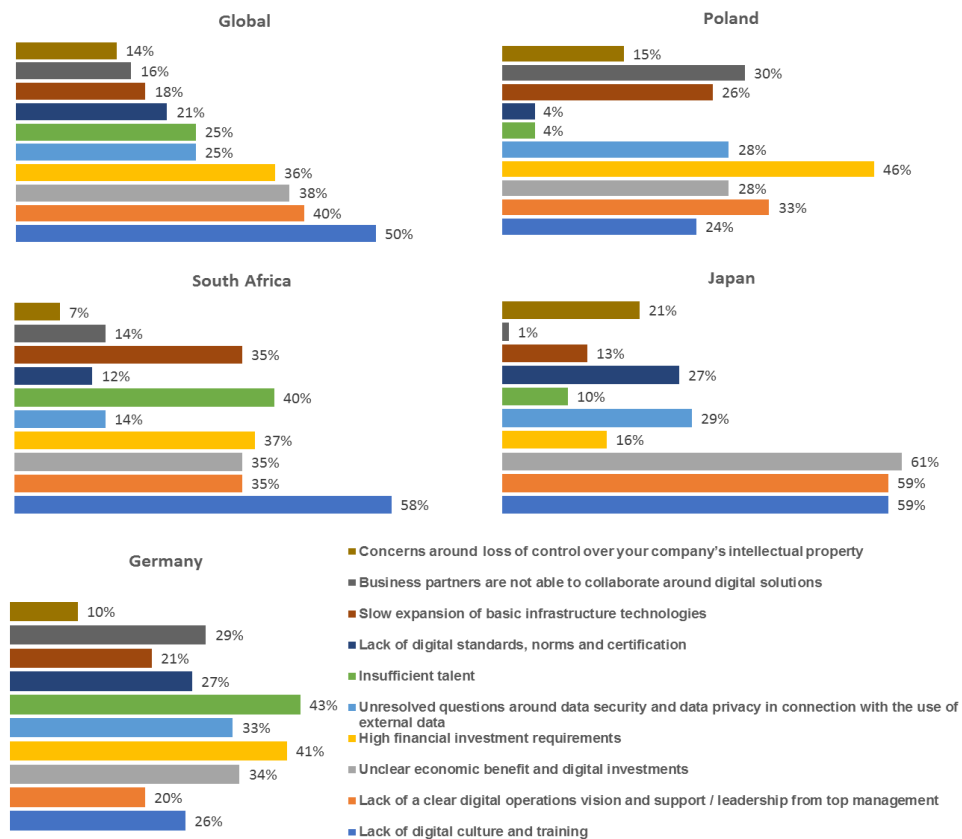


Figure 11. The Biggest Challenges or Inhibitors for Building Digital Operations Capabilities (*Industry 4.0... Global Industry 4.0 Survey, PwC, p.17; Przemysł 4.0..., PwC, p. 34; Industry 4.0... South Africa highlights, PwC, p. 7; Building Digital Enterprise..., p. 13*)

One of the important barriers to the implementation of Industry 4.0, particularly in Germany and South Africa, is the shortage of qualified staff. The shortage is manifested, with varying intensity, in individual areas of the activity of enterprises. Moreover, it is differently perceived by the entities, which fully implemented the assumptions of Industry 4.0 and in a different way by the ones which only intend to do so or do not think about it at all. In Figure 12, the data concerning the shortage of qualified staff experienced in individual areas of the company activity broken by the entities in total and the companies with fully implemented Industry 4.0 are presented.

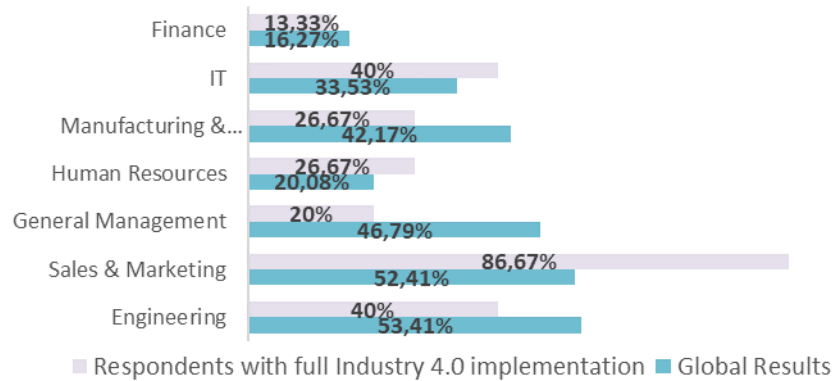


Figure 12. Perceptions of the Talent Shortage in IT
(2017 Global Industrial Survey..., p.17)

The data presented in the figure indicate large differences in the field of perception of the shortage of talents by the enterprises, which fully implement the assumptions of Industry 4.0 and the entities in which the implementation is at a different stage. This can be best seen on the example of the area of; Sales and Marketing – shortage of qualified staff is indicated by nearly 87% of enterprises with fully implemented assumptions of Industry 4.0, compared with only slightly over 52% result in the case of all the enterprises. Significant differences can be also observed in the area of Manufacturing and Operations and Engineering. The entities characterized by the full implementation of mechanisms of the 4th Industrial Revolution observe the talent shortage more often than other enterprises in the areas such as; IT, Human Resources and Sales and Marketing. In the other cases, their results are lower than the average.

Conclusions

Nowadays, innovation and technological development play an important role in each organization. However, the progress in digital transformation and growing mutual connections constitute new challenges for the organization since Industry 4.0 significantly change products and production systems concerning the design, processes, operations and services. Certainly, the implementation of this concept

has further consequences for management and future jobs through creating new business models. These, in turn, has a large impact on the industry and markets while efficiently affecting the whole life cycle of the product, providing a new way of production and conducting a business, which allow for an improvement in processes and an increase in competitiveness of enterprises.

The research presented in the paper shows the attitude of entrepreneurs to the concept of Industry 4.0, indicates readiness for the implementation of its tools in enterprises as well as indicates the barriers which may threaten the achievement of a higher level of development. The international analyses coming from numerous reports show a significant interest in challenges imposed on companies by the Fourth Industrial Revolution. The majority of the respondents recognize the concept of Industry 4.0 as a great opportunity for development and improvement in competitiveness, in particular since its implementation is probably unavoidable. This is confirmed by a significant number of theoretical studies and reports devoted to this issue and it must be mentioned that the first references on Industry 4.0 appeared in 2011. The research referred to, although secondary in its nature, allows the indication of directions of further research in this field. Since each of the reports presents the data gathered according to a different methodology, the comparison of the results could be only indicative. Therefore, when using past experience, in order to achieve tangible results, there is a need to conduct uniform research among entrepreneurs in the future, relating to the implementation of the concept of Industry 4.0 broken by industries or limited e.g. to small and medium enterprises, which are known to constitute an integral part of the total number of enterprises in each country. In addition, they do not always possess sufficient funds to invest in modern technologies. Therefore, the research into the opportunities for implementing the tools of Industry 4.0 in these entities would be a very interesting project.

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PRZEMYSŁ 4.0 – CZY JESTEŚMY PRZYGOTOWANI?

Streszczenie: Koncepcja Industry 4.0 to nowa rzeczywistość współczesnej gospodarki, gdyż postępy w transformacji cyfrowej i rosnące wzajemne połączenia będą stanowić nowe wyzwania dla wielu organizacji. Industry 4.0 znacząco zmieni produkty i systemy produkcyjne dotyczące projektowania, procesów, operacji i usług. Z pewnością, wdrożenie tej koncepcji będzie miało dalsze konsekwencje dla zarządzania i przyszłych miejsc pracy poprzez tworzenie nowych modeli biznesowych. Celem niniejszego artykułu jest prezentacja nastawienia przedsiębiorców do Industry 4.0, wskazanie gotowości na wdrożenie elementów charakterystycznych dla tej koncepcji oraz wskazanie barier, które potencjalnie mogą zagrozić przedsiębiorstwom w efektywnym osiągnięciu wyższego poziomu technologiczno-organizacyjnego. Przeprowadzone w niniejszym artykule badania opierają się na danych wtórnych, pozyskanych z wielu profesjonalnych raportów

i opracowań, realizowanych przez instytucje państwowe, konsorcja czy przedsiębiorstwa. Pochodzące z wielu raportów międzynarodowe analizy, wskazują na znaczące zainteresowanie wyzwaniami, które stawia przed firmami Czwarta Rewolucja Przemysłowa. Większość badanych widzi w koncepcji Industry 4.0 ogromną szansę na rozwój i poprawę konkurencyjności, chociaż stan przygotowania do jej wdrożenia jest bardzo zróżnicowany w zależności od kraju, branży, czy nawet indywidualnego przedsiębiorstwa.

Słowa kluczowe: Przemysł 4.0; Czwarta Rewolucja Przemysłowa, 4IR, nowe technologie

工业4.0 - 我们是否准备好了？

摘要：工业4.0的概念是现代经济的一个新现实，因为创新和技术发展在每个组织中都起着重要的作用。工业4.0显著改变了有关设计，工艺，操作和服务的产品和生产系统。当然，通过创建新的商业模式，实施这一概念对管理层和未来的工作产生进一步的影响。本文件的目的是向企业家介绍工业4.0的态度，表明准备实施这一概念的要素，并指出可能威胁企业有效实现更高技术和组织水平的障碍。本文所做的研究是基于从国家机构，财团或企业进行的许多专业报告和研究中获得的二手数据。来自这些文件的国际分析表明，对第四次工业革命给企业带来的挑战表示出浓厚的兴趣。大多数受访者认为工业4.0的概念是发展和提高竞争力的绝佳机会，但其实施准备状态因国家，部门甚至个别公司而异。

关键词：工业4.0，第四次工业革命，4IR，新技术