

-RESEARCH ARTICLE-

**INDUSTRY 4.0 IN POLISH SMEs IN THE ASPECT OF INNOVATION
POSSIBILITIES**

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-Abstract-

There is a chance that Industry 4.0 is not only a big change in the field of production and business solutions but the opportunity of many companies, mainly manufacturing, to get closer to the companies of developed economies -- in the case of Polish enterprises -- mainly the solutions used in Western Europe. In spite of widely analysed and discussed solutions in the field of Industry 4.0, there is no clear development of this issue, especially for the sector of small and medium-sized enterprises. The article is a cognitive query, and its purpose is to present and analyse the possibilities of implementing Industry 4.0 tools and solutions in small and medium-sized enterprises, mainly in Poland. The empirical part is based on secondary data, obtained from reports and surveys, carried out by state and research institutions. The presented hypothesis says that the scope of changes necessary for

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implementation in connection with Industry 4.0 is a difficult task but necessary for SMEs in Poland. The subject matter of this study is narrowed down to Polish enterprises. However, it was considered that at the moment, comparing detailed data is not justified due to too large discrepancies and completely different approaches of companies.

Key Words: Industry 4.0; Smart Factory; small and medium enterprises;

JEL Classification: O310, O320, L230, L210

1. INTRODUCTION

Enterprises, mainly the production ones, are currently facing serious challenges related to the need of using automation, robotization, processing and exchange of mass data, and implementation of various technologies allowing the creation of so-called cyber-physical systems that will change production methods and lead to the digitization of production (Ślusarczyk, 2018: 232-248). The complexity of these changes and the impact on all levels results in the lack of competences, technology and growing uncertainty of decision making in the case of small organizations. In addition, there are often shortcomings in relevant strategies, implementation methods and appropriate solutions to Industry 4.0.

The approach presented in this paper is Industry 4.0, which is a conceptual aggregate that includes several new technologies -- including Internet of Things, cloud computing, Big Data analysis, artificial intelligence, incremental printing and augmented reality or cooperating robots.

2. INDUSTRY 4.0 AND SMART FACTORY – LITERATURE REVIEW

The concept associated with Industry 4.0 (Berger, 2014; Runliang, 2018) is Smart Factory, or “intelligent factory”, or “autonomous factory”. The concept of production plant of this type is based on cyber-physical systems (CPS), Internet of Things, information clouds (Gao et al., 2015; Dou et al., 2018: 514-516) and other new methods. The connection of such technologies is to enable the aforementioned high level of personalization of products and production processes with a small share of employees at the most effective implementation of goals. What is important is the implementation of the production process begins from the order, through the technological preparation of production, ending with the delivery of the product to the recipient, service and its utilization after the end of the period of use. It is obvious that such a method of operation increases the complexity of production

processes (Piccarozzi et al., 2018), which is a kind of barrier, especially to SMEs. However, it should be noted that this approach may result in a stronger relationship with the customer and, as a result, an increase in the number of orders.

According to the new Industry 4.0 concept (Lee, 2018:1642-1646; Sanders and Ganeshan, 2018:1745-1748.), Cyber-physical systems are to be the leading technology within Smart Factory. These are “locally” structured and at the same time “virtually global”, and its production processes are designed to carry out all physical activities. However, activities such as the development of technological processes, monitoring their course, control of manufacturing processes should be implemented only virtually (cloud solutions). The true development of this technology is based on the constant development of ICT solutions and its security (Alesina et al., 2018: 41-78). It is also important to provide the appropriate logical infrastructure with sufficient data transmission capacity (communication), their acquisition (sensors) and analysis (calculations). These activities must be undertaken and implemented automatically, and the autonomy of actions must also involve making decisions as part of the control of production processes.

Digitalization of production and related processes allows both the implementation of new business models, such as those known from e-business (including product-as-a-service), as well as opens up new opportunities to provide services --the scope of data analytics or customer management of the machine park. In most cases, this is possible thanks to the use of digital data exchange technology and Internet communication. Product tracking capabilities (e.g. using RFID systems) and digitization of production and value creation chains (Schumacher,2016:161-166) enable comprehensive product lifecycle management, including digital design and prototyping (creation of the so-called Digital Twin). In addition, by implementing systems and methods of modern data analysis, companies can collect information about the use of products and services so that they can be better adapted to the future needs of customers.

The implemented solutions within the presented concepts allow reducing operating costs, especially in SMEs, and often functions as the main decision criterion. Potential savings for different production areas, according to calculations

(Schröder, 2017), range from 10 to 70 percent, while complexity costs may be the most limited.

Table 1: Evaluation of potential benefits (Schröder,2017)

Type of cost	Total value
Inventory costs	-30% to -40%
Manufacturing costs	-10% to -20%
Logistical costs	-10% to -20%
Complexity costs	-60% to -70%
Quality costs	-10% to -20%
Maintenance costs	-20% to -30%

Smart Industry activities allow companies to transfer market competition from offering a simple product to delivering products with high added value and competing with process excellence (Bonilla et al., 2018: 37-40). Cooperation with potential recipients from the virtual product design stage, through simulations, production optimization and its monitoring in real-time to after-sales service allow the use of recipients' knowledge and significantly reduce research and product development costs.

A study conducted in Hungary show (see more at Nick, 2016) that the spread of real-time data across companies gives the availability of appropriate analytical tools and methods that can have a significant impact on the entire company. In the case of CPS (Cyber-Physical System) and Big Data Technologies, companies using them have been evaluated as having a higher level of logistic service, more efficient processes with their partners, improved cooperation between certain logistic functions, and higher market and financial performance and competitiveness. Applying more efficient production processes, and achieving better productivity and economies of scale might also result in increased economic sustainability. Furthermore, authors have found that companies have started on the path to digital evolution, and investments of this type have already begun (Nagy, et al., 2018).

3. SMEs IN THE ASPECT OF INNOVATION

The sector of micro, small and medium enterprises is undoubtedly the largest in Poland. According to the research of Polish Agency for Enterprise Development (Report on the state of the sector... 2017), in 2017, SMEs accounted for 99.8% of all enterprises in the country. However, the share of this sector in generating GDP in recent years have accounted for over 50%. SMEs are also the largest employer in the Polish market.

The growth of innovativeness of the Polish SME sector and its transformation to the level of Industry 4.0 is strongly dependent on the degree of diffusion of knowledge (Bauernhansl, 2014: 5–35) in terms of possibilities borne by Industry 4.0 solutions, as well as changes in the ways of managing enterprises. SMEs in Poland have difficulties with the acquisition of highly qualified employees; they often do not have sufficient financial resources to invest in emerging technologies, and they are too risky ventures (too early). Thus, such organizations invest in focusing on obsolete technologies not adapted to Industry 4.0. Such an approach, additionally without the support of state institutions and top-down solutions (Erol et al., 2016); however, it prevents the overall change of the business model. Companies, however, need to acquire knowledge in the areas that require a highly developed industry, because it is demanded by recipients, suppliers and technologies that they use (Yan et al., 2018: 36-53). The global competition in which production counts according to the new digital standards (Fallera et al., 2015) is also important.

The low level of maturity of Polish enterprises to implement and apply the concept of Industry 4.0 is confirmed by the results of research, saying that 76% of factories in Poland are partially automated and only 15% fully implements production in the automatic system. In 59% of companies, data for information systems is entered manually, and only 36% of cases use the automatic acquisition of technological data. Paper documentation of technological processes is still carried out by 16% of companies. In many industrial plants, work is always based only on estimated data, and technical documentation is not standardized. Still, only a small part of the factories use IT systems for operational management and production control (MES class systems -- Manufacturing Execution System) (Researching degree 2016). In

these companies, production processes are not described or parameterized, and process maturity is at a low level. The subject of process maturity is closely related to readiness to implement Industry 4.0, which is more broadly presented in earlier studies by the author (see Pyplacz, 2018).

According to research carried out on the German market (Industry 4.0. Study for the ITRE Committee 2016), 35% of SMEs state that digital technologies play no major role for them. For the smaller companies in the sample, the respective share was 52%. For the future, 28% still believed that such technologies would not play a major role for them. On the other hand, for 49% of respondents, digitalization is part of their business strategy. Activities aimed at monitoring the digital adoption technologies used by 21-25% of companies surveyed include using key performance indicators, benchmarking and exchange in chambers of commerce and industry associations.

4. RESEARCH AND METHODOLOGY

The above theoretical assumptions prove that the 4th Industrial Revolution is also a necessity for many small and medium-sized enterprises that, although operating locally, are subject to global competition. The considerations presented in the article are based on secondary data obtained from reports and results of raw research carried out by state institutions (e.g. Ministry of Enterprise and Technology) and business entities.

Survey of Smart Industry Poland was carried out in April 2018 on a nationwide sample of 200 companies from the industrial or production sector (N = 85 - light industry, N = 115 - heavy industry) with the number of employees up to 249 employees. The study was carried out using pre-arranged interviews using the CATI (Computer Assisted Telephone Interviewing) technique. The sample includes micro, small and medium enterprises, respectively: N = 60 - micro-companies (1-9 employees) N = 90 -- small companies (10-49 employees) N = 50 - medium enterprises (50 - 249 employees).

These studies were carried out systematically, hence the presence of references to various periods and populations, including aspects related to transformations, opening markets and making available technology. In many areas, the data on

which the inference is based are estimated data or the results of simulations and approximations.

5. RESEARCH RESULTS

Globally, according to the Global Innovation Index 2017, Switzerland, Sweden, the Netherlands, the United States and the United Kingdom remain the most innovative countries in the world. The report also indicates a group of countries that performs better than the rest of the countries at the same level of development, including India, Kenya and Vietnam. According to the study by Moyano-Fuentes, Maqueira-Marín, Bruque-Camara, from 2018, in Spain, a total of 68.5% of surveyed companies reported that they had developed new processes or technologies in the last three years. In Poland, according to GUS (Central Statistical Office) data (GUS Innovations in industry and Innovations in the services sector implemented in 2017) new or significantly improved products or processes were introduced by only 18.7% of industrial enterprises and 13.6% of service enterprises, i.e. by 1.1 pp, respectively and 3.8 pp, more than in 2013-2015. Among industrial innovations, industrial enterprises most often implemented new or significantly improved methods of product manufacturing (10.6%), and service entities -- new or significantly improved methods supporting processes in the enterprise (6.3%). Expenditure on innovative activity in industrial enterprises in 2016 amounted to PLN 28304.7 million, and in-service enterprises -- PLN 10706.2 million, which means less by 9.0% and 15.3% respectively than in 2015. In industrial enterprises, investment expenditures predominated, which constituted 76.1% of all expenditure on innovations. Service enterprises spent most of their funds on research and development (41.0%) and investments (24.8%). In the structure of expenditures on innovative activity by sources of financing, in industrial and service enterprises, the largest share was own funds (71.6% and 88.2% respectively). Bank loans were much smaller (respectively 6.7%, 4.2%) and funds obtained from foreign funds (1.8% and 2.8% respectively).

Among the pro-innovative activities, the purchase of new machines is most often planned (93% of responses) and cooperation with companies from related industries (69.1%). Over 58% of enterprises cooperate with other units, either from

their group or industry. However, only 41% cooperate with foreign units. This shows that Polish enterprises are hermetic, and although they notice a gap in relation to the foreign market, they do not get much knowledge and experience from it. This fact should be combined with a great rift between the degrees of concept development in foreign entities, including those belonging to the same group.

The main reasons for the implementation of innovative technological solutions, in line with the objectives of Industry 4.0 are the desire to optimize production costs (35.5% of responses) and obtain a competitive advantage (22.6%). Respondents show only, to a small extent, strictly market-related premises related to the client. Respondents take into account both price and quality; however, this is only about 10% of responses. In the aspect of earlier considerations about the role of the client in SME, companies should be made aware of the fact that the client should be a strong market argument that can bring measurable, what is most important for small entities, quick results. At the same time, a small percentage of indications confirm the possibility of changing the way the company operates (3.2%). This confirms the need to consider and perceive the idea of Industry 4.0 as a comprehensive and affecting the change of the business model.

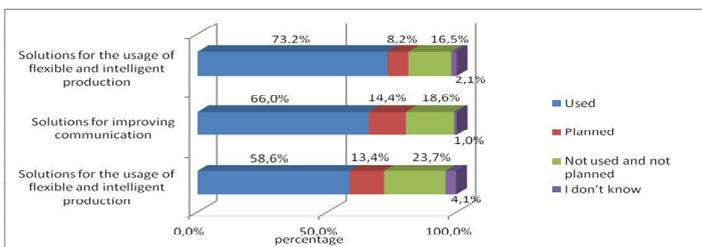
The vast majority of SME respondents (68%) believe that the level of advancement of Polish industry in their branch is only close to the level for this sector in Western Europe. About 7% of respondents said that this level is higher. 19.6% of respondents said that their branch is less developed than in Western Europe. The worrying fact is that as many as 60.8% of respondents do not wait for the elements of control systems to get old and amortize, only to exchange them regularly. The approach to innovation based on the exchange of control elements only in relation to their aging was declared by 39.2% of respondents.

The key aspect of the fourth industrial revolution is Smart Industry, which, like Industry 4.0, is based on three pillars: digitization of information enabling the creation of a more effective value chain and more efficient management of production processes at all levels, flexible and intelligent production technologies (i.e. which can be influenced on a regular basis and quickly respond to changing

customer expectations) and modern communication using technologies and the capabilities of modern networks between market participants, systems and end-users. The diagnosis of the innovativeness of the Polish economy shows that the Polish industry is only a small part of entering the era of Smart Industry. Most companies are just considering the possibilities of using solutions offered by Industry 4.0. Only 25% of representatives of domestic production companies admitted knowledge of the Smart Industry concept and the use of technologies and solutions constituting components of intelligent factories. Research of the level of automation of Polish production plants proves that for the managers of Polish factories, the challenges of the third industrial revolution related to microelectronic technologies remain mostly up-to-date.

The most commonly used solutions are in the field of information digitalization, enabling optimal and effective production management at all levels (Value Chain Management) - approx. 73%, and solutions improve communication using modern technologies and networks inside and outside the company (66%) and solutions in the field of using flexible and intelligent technologies in production (it means - which can be influenced on a regular basis and quickly respond to changing customer expectations) - 58.8%. As can be concluded, these solutions are the basis for development and entry into the era of Industry 4.0.

Figure-1: Solutions used in the SME



Source: Smart Industry Poland - survey. 2018.

Taking into account previous considerations regarding the current activities of companies and the factors affecting decisions on the implementation of new solutions, it is necessary to analyse solutions and technologies that support the innovativeness of enterprises. As the most important respondents mentioned

automation of production lines (on average, this solution is used by 52% of companies). Second place takes data analytics focused on production optimisation (51%) and software reducing the costs of prototyping and introducing new products (32%). These technologies were also considered to have the greatest impact on improving profitability (88.7% - automation of production lines, 86.7% - data analytics, 84.8% - software reducing the costs). Most of the mentioned technologies are more willingly used by medium-sized companies (in the case of automation of production lines and data analytics, it amounts to as much as 70% of responses). This testifies to the higher technological advancement of this group of companies against the rest of the surveyed group.

In small entities, the tendency described in previous considerations is noticeable. These companies are working in niche areas and are offering personalized products, therefore more often than medium-sized entities use 3D printers (23% of micro-enterprises declared using this technology).

The relatively low percentage of responses to Big Data and Cloud Computing solutions is interesting (9% and 10%). Enterprises collect data (even when they do not process it) and use software that is not always based on their own IT infrastructure. At the same time, nearly 66% of respondents recognized Big Data as technologies that improve profitability and competitiveness. Therefore, the area of further diagnosing the level of entrepreneurs' awareness of the potential of available solutions and the scope of their use in particular activities or economic processes is important. There is a lack of knowledge about applied or discussed solutions too. Respondents do not always know, associate that their solutions are part of the 4.0 concept. Moreover, if you can talk about intuitive management, it does not transfer to the implementation of new Industry 4.0 news, which seems to be a necessity.

In the area of relevance and accessibility to technological solutions, the issue of ease of implementation in a company is often a point affecting the possibility of implementation. The respondents considered data analytics in order to optimize production activities as the easiest solution to implement (41% of respondents). The second technology was 3D spatial printing (39% total of answers), and other software reducing the costs of prototyping and introducing new products (38%). In the case of solutions considered as the most difficult, respondents indicated

artificial intelligence (in total 67% of answers “rather difficult” and “very difficult”) and digitization of production (51%). It can be concluded that perceiving them as difficult results from the lack of diagnosing the needs of the company (including the lack of process maturity described previously). However, robotization of the production line has been deemed difficult to implement (49% of answers), which is associated primarily with high implementation costs.

According to the time of change for business as stated in Economy Report 4.0, Industry 4.0 solutions are for the SME sector companies above all the opportunities and challenges in the area of the company, the economy and the aforementioned consumer. The following table 2 summarizes the considerations, as well as analyses and shows how entrepreneurs can and should see opportunities and what challenges they face. The tabular summary confirms the hypothesis that the scope of changes necessary for implementation in connection with Industry 4.0 is a difficult but necessary challenge for SMEs in Poland.

Table 2: Chances and challenges related to Industry 4.0 for Polish SMEs.

	FOR A CONSUMER	FOR COMPANIES
CHANCES	Individualised satisfying of consumption needs	Improvement of productivity.
	Chance to improve work-life balance through more effective and better-paid work	Optimization, inventory reduction, shorter downtime, improved resource allocation and product quality. Creating new products with high added value
	New professions, new possibilities of work in line with interests	More accurate response to consumer needs by designing products for individual orders and shortening production series
	New possibilities of education and acquisition of further skills	Development of new branches, change of business models in traditional sectors – a chance to enter for new market players
CHALLENGES	The need to adapt to changing conditions	
	The need to develop soft competences	The advantage of foreign 4.0 solution providers thanks to an earlier start and taking the risk of investments
	Different form of work security (not through full-time but skills and self-employment)	

In Poland, on average, companies spend 14.5% of revenues on the implementation of technologies based on computerization and process automation. About 47% of companies spend on technology implementation supporting production processes

from 10 to 30% of revenues, about 30% of enterprises devote less than 10% for this purpose, and about 13% do not spend any money on it.

6. CONCLUSIONS

Industry 4.0 is a kind of modern production concept based on the digital transformation taking place in the entire global economy. As predicted, market success will only be achieved by enterprises that build “spot-on” strategies based on digital innovations and implement them quickly enough.

The presented research results clearly indicate that the level of readiness of Polish companies from the SME sector to implement industry solutions 4.0 is at a low level. Some optimism may be felt by the fact that among entrepreneurs, one can observe a willingness to keep up with the enterprises of the Western Europe economies. Due to the evolution of the approach to Industry 4.0 and the related change in research methodology, as well as dynamic market development, the presented research gives only an approximate picture of the state of innovation and readiness of Polish companies from the SME sector to the 4th industrial revolution and entry into the era of Industry 4.0. It can be concluded that companies combine their innovative development with the activities of the Industry 4.0 concept. Industry 4.0 activities are considered difficult to implement (this barrier is clearly indicated); therefore cooperation and the transfer of knowledge from advanced units is necessary.

Due to the evolution of the approach to Industry 4.0 and the related change in research methodology, as well as dynamic market development, the presented research gives only an approximate picture of the state of innovation and readiness of Polish companies from the SME sector to the 4th industrial revolution and entry into the era of Industry 4.0.

It can be concluded that companies combine their innovative development with the activities of the Industry 4.0 concept. Industry 4.0 activities are considered difficult to implement (this barrier is clearly indicated), therefore cooperation and the transfer of knowledge from advanced units is necessary.

The results of the research indicate that managers see both, the opportunities and threats associated with the implementation of new solutions. In the area of

organizational changes, one can notice the possibility of better matching market requirements, faster response to changes, shortening the time of designing and introducing products to the market (time-to-market). These activities should allow for improvements in the integration of production processes, warehouse or logistic processes, as well as give new opportunities to use modern business models. Consequently, this should lead to better control over the life cycle of the product. In the area of production, the most important benefits are better planning and monitoring of production processes, optimization of production costs by identifying losses and monitoring costs, producing “smart” products that ensure traceability, greater production scalability or more accessible use of crowd-sourcing platforms.

The authors notice the necessity of further research; standardized and methodologically uniform. A particularly interesting area seems to be the analysis of SMEs in terms of the industry in which the entity operates. Respondents have pointed to their position in the industry, seeing in this area the possibilities of increasing competitiveness through the use of methods and standards of Industry 4.0. At the same time, subsequent works should be devoted to the situation of Polish SMEs with similar organizations in Europe and the world. It can be assumed that Polish SMEs are moving towards solutions tested on global markets, and by this fact, they will be comparable.

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