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AWARENESS OF THE CONCEPT OF INDUSTRY 4.0 AND ITS PARTS IN SOME CZECH COMPANIES: A FIRST MAPPING OF THE PROBLEMATICS

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Abstract. The purpose of this study is to research terminology of Industry 4.0 in some of the biggest companies in Czech Republic. The main objective was to find out whether they know about the concept of Industry 4.0 and the Fourth Industrial Revolution. Further goals were to find out which terminology they use in companies, and if they have practical experience with the technologies. Qualitative research was conducted via an online questionnaire. Results have shown some terms used by scientific literature are unknown in practice and that the view of companies on this topic might be different from the view of researchers based on their responses. This calls for more in-depth research for which we present recommendations.

Keywords: The Fourth Industrial Revolution, Industry 4.0, awareness, Czech Republic.

JEL Classification: O14.

Introduction

The technologies and procedures of Industry 4.0 are clearly defined in scientific world, but the perception of companies differs. In our previous research, we encountered discrepancies as companies stated they knew the concept of Industry 4.0 but didn't know some key terms or addressed different technologies as if they were the same – the research has shown a need for companies to be included in discussion in order to achieve diverse interdisciplinary dialogue as their point of view on the problematic seems to differ (Bakes et al., 2021). The lack of awareness is also mentioned by Ministry of Industry and Trade of Czech Republic (2017) which states it is one of the biggest barriers for implementation of Industry 4.0 concept. However, they do not present any further detailed information about the topic. In their research a Czech institution called "National centre of Industry 4.0" mentions lack of awareness as well, especially in smaller or medium enterprises. However, their research only mentions the importance of digitalization and Industry 4.0 for their respondent companies (National Centre of Industry 4.0, 2020). The hints of lack of awareness in our previous work and statements from beforementioned biggest Czech sources about the importance of the awareness lead us to creation of this paper.

The goal of this paper is to find out whether there is a gap between the companies and researchers in a more specific way than beforementioned initiatives did – including the most important technologies and procedures of Industry 4.0 concept. The second goal of this paper is to evaluate if the companies have practical experience with the technologies – this ultimately helps to fulfil the first goal as it reveals if they perceive some parts of Industry 4.0 differently than researchers.

The results will help shed some light into the awareness, which has not been sufficiently explored deeply enough, and lay foundation on which further quantitative research will be performed. Further research recommendations are described based on our results. The results will enable better coordination between researchers and companies.

Furthermore, the results help managers of the companies at decision making in the area of implementation of Industry 4.0 in a more efficient way than now, as the implementation in companies is often focused on immediate results with the use of singular technologies, rather than on implementation of the concept in a "big-picture way" – which is more relevant in longer run. Also, exploring the point of view of the companies and practice will enable better cooperation of companies and researchers in the spirit of information integration and

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knowledge convergence – both important parts of the Industry 4.0 concept and The Fourth Industrial Revolution respectively.

1. Theoretical background of Industry 4.0 and The Fourth Industrial Revolution

Changes in production systems in the past have been ex-post referred to as the Industrial Revolutions. These changes were so significant the entire society changed. This paper deals with just the industrial part of the concept. Thus, the following text sums the evolution leading to The Fourth Industrial Revolution and its industrial part – Industry 4.0.

During the First Industrial Revolution, production systems were upgraded to water and steam propulsion. It began in the late eighteenth century. There has also been a greater degree of process mechanization. During the Second Industrial Revolution, mass production was made possible by the electrification of production systems. During the Third Industrial Revolution, production systems were improved thanks to the first information technologies – it was mainly computerization and automation of work processes. It was the beginning of digitalization (Moll, 2021). The Fourth Industrial Revolution consists of changes in multiple areas. Every area that is changing is called smart. Thus, there will be smart cities and smart homes or smart industry, smart factories etc. *This smart industry is called "Industry 4.0" – a sub-part of the bigger concept of The Fourth Industrial Revolution*; and is also known as "Made in China 2025" in China; and in United States of America, it bears the name "Industrial Internet" (Chung, 2021; Potočan et al., 2021; Zhang et al., 2018).

During the Fourth Industrial Revolution, deeper digitization is taking place, especially in the manufacturing sector. Industry 4.0 represents an advanced use of ICT in the form of integrated solutions (Jaehyoun, 2016; Rahanu et al., 2021; Xu et al., 2018). The fourth industrial revolution focuses not only on the automation of machines and processes, but digitization is extended to the entire enterprise and to the downstream enterprises that are integrated. This is the so-called end-to-end digitization (Xu et al., 2018). There will also be integration between different economic sectors. Thus, the integration of trade, logistics, and financial services also plays an important role (Lasi et al., 2014). The implementation of Industry 4.0 results in a smart factory (Chung, 2021; Ghobakhloo & Fathi, 2020), but Industry 4.0 is a concept that extends beyond a single factory, and even beyond national borders (Zhang et al., 2018).

1.1. Industry 4.0

The Industry 4.0 concept was introduced in Germany (Hanover) in 2011 (Li et al., 2017; Park, 2017). Its adoption by the German government contributed to the extension of the term Industry 4.0. Today, global developments indicate a shift to Industry 4.0 in supply chains (Lim et al., 2021; Szozda, 2017) and ICT will dominate future business models (Szozda, 2017; Xu et al., 2018).

Industry 4.0 is a concept of smart manufacturing that uses a combination of physical and virtual systems (Sari et al., 2020) and aims to contribute to the decentralization, integration, and automation of business processes (Lasi et al., 2014). The technologies which make up the concept of Industry 4.0 have great potential to raise productivity, lower production costs, reduce emissions and reduce resource and energy consumption and lower the amount of human labour needed (Dantas et al., 2021; Mavropoulos & Nilsen, 2020; Sachs et al., 2019), and reduce the impact on the environment (Awan et al., 2021). Dantas et al. (2021) state that application of the concept of Industry 4.0 will help minimize extraction of new raw materials and maximize utilization of already applied resources in the form of recycling. New digital technologies create opportunities in the utilization and "consumption" of resources and products (Angelis, 2019). Industry 4.0 will enable better utilization of data acquired from processes for their optimization. Information acquired from manufacturing processes will also enable optimized maintenance, which will be conducted based on actual wear and tear of production machines, which will save the production capital and prolong its life, and at the same time contribute to the prevention of major accidents in factories (Mavropoulos & Nilsen, 2020). Industry 4.0 has the potential to contribute to process safety (risk prevention) and environmental protection (Gobbo et al., 2018).

1.2. Industry 4.0 technologies

Industry 4.0 is based on several disciplines: electrical engineering, business administration, computer science, business and information systems engineering, and mechanical engineering (Lasi et al., 2014), data science, and data analytics (Xu et al., 2018). Modern technologies, concepts, business models, and various ways of integration are related to these fields and are needed to implement Industry 4.0.

The Industry 4.0 concept stands at the transition from embedded systems to cyber-physical systems (CPS) thanks to modern technologies called enabling technologies (Xu et al., 2018). According to each author, the technologies needed to implement the Industry 4.0 concept are different and authors attach different importance to each of them. Most of the authors do not mention every technology. Szozda (2017) states that there are more than 60 technologies that can be associated with the concept of Industry 4.0.

The most commonly mentioned technologies are: *Cyber-Physical Systems* (Gobbo et al., 2018; Lasi et al., 2014; Szozda, 2017; Xu et al., 2018; Odważny et al., 2019; Gajsek, 2020); *Internet of Things* (IoT) (Gobbo et al., 2018; Lim et al., 2021; Sari et al., 2020; Szozda, 2017; Xu et al., 2018; Odważny et al., 2019; Gajsek, 2020; Ellahi et al., 2019); *Ubiquitous Computing* (Chen & Tsai, 2017;

Andrade et al., 2017), *Pervasive computing* (Lalanda & Morand, 2018), *Ambient Intelligence* (Bisio et al., 2018); *Cognitive Computing* (Gajsek, 2020) and *Machine to Machine Communication* (Szozda, 2017; Salles et al., 2018); *Smart Sensors* (Lasi et al., 2014; Maiwald, 2016; Schütze et al., 2018); *Cloud Computing* (Lim et al., 2021; Sari et al., 2020; Xu et al., 2018; Velásquez et al., 2018; Gajsek, 2020; Ellahi et al., 2019); *Big Data Analytics* (Gobbo et al., 2018; Lim et al., 2021; Sari et al., 2020; Szozda, 2017; Velásquez et al., 2018; Ellahi et al., 2019; Queiroz et al., 2017); *Advanced Analytics* (Szozda, 2017; Queiroz et al., 2017); Data Mining (Szozda, 2017); *Artificial Intelligence* (Lim et al., 2021; Szozda, 2017; Ellahi et al., 2019); *Machine Learning* (Al-Gumaei et al., 2019; Li et al., 2017); *Deep Learning* (Villalba-Díez et al., 2020); *Artificial Neural Networks* (Fertsch, 2020); *Computer Vision* (Dias et al., 2020); *3D Printing* (Sari et al., 2020; Szozda, 2017); *Additive Manufacturing* (Sari et al., 2020; Szozda, 2017; Lasi et al., 2014); *Virtual and Augmented Reality* (Sari et al., 2020; Szozda, 2017; Kucukoglu et al., 2018); *Blockchain* (Lim et al., 2021); *Human-Machine Interfaces* (Szozda, 2017); *Wearable Technology* (Kucukoglu et al., 2018). KETs together form a network of *Smart Factories* (Lasi et al., 2014; Xu et al., 2018; Odważny et al., 2019; Shi et al., 2020; Bisio et al., 2018).

There are also certain often mentioned procedures that are necessary to implement Industry 4.0. These were included in the conducted survey, and they are: *Horizontal and Vertical Integration* (Sari et al., 2020; Xu et al., 2018; Odważny et al., 2019) and *Digitalization of products and services* (Lasi et al., 2014; Bisio et al., 2018).

2. Methodology

An extensive literature review has been conducted, and key terms have been identified. The literature review was followed by a qualitative survey conducted at the most important companies in the Czech Republic. A minimum of 4 respondents was set as sufficient return rate based on previous experience.

For the collection of data, a questionnaire method has been chosen. The structure of questionnaire was based on terms from literature review. The questionnaire was piloted by a diverse group of representatives from small and medium companies who work in positions in marketing, sales, project planning, and development of information technologies. After incorporation of their insights into the questionnaire, a survey was conducted on the main sample of respondents.

A method of online survey was used to address top one hundred companies based on turnovers in 2020 in Czechia. A list of these companies was obtained from "CZECH TOP 100" available at: https://www.czech-top100.cz/cs/projekty/zebricky. These best companies were selected as they are more likely to have experience with Industry 4.0 or with implementation of Industry 4.0 as they have enough financial means and erudition. It is therefore purposive sampling.

Data are based on publicly presented economic data of companies and Czech Statistical Office for 2020.

The turnovers ranged from the lowest: 9,642,893,000 CZK – to the highest: 424,292,000,000 CZK. Legal forms of the companies were mostly Public Limited Company or Private Limited Company as shown in Table 1.

Table 1. Distribution of legal forms of the companies of the general sample

Legal form	Number of companies
Public Limited Company	55
Private Limited Company	39
Funded Organization	2
State Company	1
European Companies	1
Public Company	1
Cooperative Companies	1

Companies operate in manufacturing, constructions, energetics, agriculture, food industries, logistics, public transportation, retail, trade, communications services and technologies, and healthcare.

Respondents have been identified on the web pages of selected companies – employees who are involved in long-term innovation processes within the company, responsible for ICT strategic development.

Data collection was performed in January and February 2022. There were 5 final respondents – exceeding the minimum required amount by one. Table 2 sums up characteristics of the respondents whose names were replaced by letters as the research was anonymous.

Table 2. Characteristics of the respondents

Company	Respondent	Business type	Legal form
A	Chief of the department for digitalization	Electrotechnical industries	Public Limited Company
B	Director	Commerce	Public Limited Company
C	Director	Telecommunications	Public Limited Company
D	Continuous Improvement Leader	Retail	Public Limited Company
E	Process Engineer	Automotive	Private Limited Company

The individual responses were summarized, tabulated (descriptive analysis part of the research), and evaluated within one enterprise, and then compared across enterprises. The responses regarding awareness of each technology were compared across companies and compared with related technologies (comparative and partly classification analysis part of the research). Discrepancies were identified and described in the following text (induction; formulation of conclusions in connection with the analysis).

3. Results

All respondents stated they were familiar with the terms "Industry 4.0" and "The Fourth Industrial Revolution".

The awareness of the technologies linked to the concept of Industry 4.0 is summed up in Table 3, where U stands for "Using in our company"; P for "Planning to use in our company"; NP for "Not Planning to use in our company" (but aware of); A for "Aware of this technology" and 0 for "not aware of the technology".

Company A has shown good knowledge of the terms linked to Industry 4.0 – not knowing only 4 terms linked to IoT. Company B was familiar only with one technology – Virtual Reality and one operation – Digitalization of Products and Services. However, this respondent was included in our research as well as his awareness level is quite alarming and yields an important finding – one of the most successful companies in Czechia is lagging behind in knowledge of critical innovations. Company C has shown excellent results as respondent knew all of the 28 terms. Company D and E knew 12 and 13 terms, respectively.

Table 3. Awareness of the technologies of Industry 4.0

Company	A	B	C	D	E
Horizotnal and Vertical integration	U	0	U	U	0
Digitalization of products and Services	P	P	U	U	U
Cyber-Physical Systems	P	0	U	0	0
Smart Factory	U	0	P	0	U
Cloud Computing	U	0	U	U	U
Smart Sensors	P	0	U	P	P
Internet of Things	U	0	U	P	A
Machine to Machine Communication	P	0	U	0	A
Ubiquitous Computing	0	0	U	0	0
Pervasive Computing	0	0	U	0	0
Ambient Intelligence	0	0	P	0	0
Cognitive Computing	0	0	U	0	0
Big Data Analytics	P	0	U	U	0
Advanced Analytics	U	0	U	U	0
Big Analytics	P	0	U	0	0
Artificial Intelligence	P	0	U	U	A
Computer Vision	U	0	U	0	0
Data Mining	U	0	U	A	A
Machine Learning	U	0	U	U	A
Deep Learning	U	0	U	P	0
Artificial Neural Networks	U	0	U	0	0
3D Printing	U	0	U	0	U
Additive Manufacturing	U	0	P	U	0
Virtual Reality	U	A	P	0	A
Augmented Reality	U	0	P	0	0
Human-Machine Interfaces	U	0	U	0	0
Wearable Technology	U	0	P	U	A
Blockchain	U	0	NP	0	0

Integral concepts of Industry 4.0, that are quite common in scientific literature, and are often stated as cornerstones of Industry 4.0, such as: CPS and Smart factory and Horizontal and Vertical Integration, are not known to each company, with CPS only known to 2 companies. This confirms there might be a gap in perception of the concept of Industry 4.0.

The technologies that are part of these "big-picture" concepts are, on the other hand, quite known as only respondent B didn't show knowledge of them. Cloud Computing, IoT, Smart Sensors, Artificial Intelligence, and Virtual Reality were quite known with the exception of company B. On the other hand, Big Data Analytics was known less – only by 3 companies, which is surprising as it is often stated as a key technology to enable implementation of Industry 4.0.

Interesting is the response of respondent D, who didn't know the term 3D printing but knew the term Additive Manufacturing (both referring to the same technology). As the first term is more commonly known and often used in the scientific literature.

The lack of awareness of Augmented Reality is surprising, as it is often described in the scientific literature as a universal technology with lots of applications. The same goes for the technology of Blockchain. Very evident is a lack of awareness of concepts linked to IoT as Ubiquitous Computing, Pervasive Computing, Ambient Intelligence, and Cognitive Computing are known only by company C.

Companies were also asked whether they have some experience with technologies and if not, whether they are planning or not planning to implement the technologies. Company C has experience and is using 21 technologies and company A 17, company D 9 and E only 4. Company B has experience with 0 technologies which corresponds with its lack of awareness, however they plan to digitalise their products and /or services in the future. Company B aside, it is a good sign for Czech industry that other companies are using technologies of Industry 4.0 and that they are not ignoring the trend. Companies A, C, and D have implemented Horizontal and Vertical integration, however only company A and C stated they have experience with CPS. Both of these concepts are quite tightly connected. Company D has no knowledge of CPS – thus there is a different view on the concepts as opposed to the scientific literature. Similar discrepancy can be seen in the company E's responses concerning Smart Factory, as they state they have experience with it – but they also don't know the concept of Horizontal and Vertical

Integration. In the economic sciences however, these have a different meaning than in Industry 4.0 terminology and are related to the acquisition of other companies. That could cause discrepancy in the answers – even if the questionnaire was clear about Horizontal and Vertical integration being part of Industry 4.0 concept. One way or another the point of view of respondents differs from company to company and confirms there is a gap between the two points of view – scientific point of view and the point of view practice. The most used technology is Cloud Computing. The technology that is the most planned to be implemented by companies is Smart Sensors (and company C already has experience with it).

Another discrepancy is obvious from Table 2 as well, and it concerns IoT. Company A has experience with IoT, however they stated they have only yet planned to implement Machine to Machine Communication, which is an important part of IoT. Company C for instance, stated they are using not only IoT but also Machine to Machine communication. Interesting is also the fact, that company A stated they know IoT but didn't know any other terms linked to it – such as Ubiquitous Computing, Pervasive Computing, Ambient Intelligence or Cognitive Computing; some scientific literature often sums all of these concepts as different terms for IoT. Company C presents opposite attitude, they stated they are using all of the mentioned technologies except for Ambient Intelligence, which is only planned to be used in the future, the company sees difference between the concept of Ambient Intelligence and other terms. All this shows a number of discrepancies between practice and research.

The same goes for Big Data Analytics, Advanced Analytics, and Big Analytics. Company A is planning to use Big Data Analytics; is using Advanced Analytics; and is planning to use Big Analytics. It seems they know the term Big Data, but they perceive Advanced Analytics as something else – not connected to Big Data. Company D stated they are using Big Data Analytics and Advanced Analytics but not Big Analytics, that would mean they don't use that term at all.

Artificial Intelligence is being planned for use in company A however, they stated they are already using Computer Vision, Data Mining, Machine Learning, Deep Learning, and Artificial Neural Networks – all different fields of Artificial Intelligence. This further adds to the list of discrepancies.

Company C also sees a difference between 3D Printing and Additive Manufacturing technologies, even though scientific literature clearly states they are the same. Company C is in direct opposition to that. This might be explained by the fact, that they perceive 3D Printing technology pragmatically – as enabler for large scale manufacturing process – additive manufacturing.

Conclusions and discussion

The response rate of 5 might be seen as relatively low. However, only 100 companies were addressed and the response rate of 4 respondents was set as sufficient for the qualitative research with the set goals.

As similar research concerning awareness about the concept, perception of technologies, and implementation at the same time, has not been conducted in Czechia, we propose further research paths.

Discrepancies in the point of view of companies and researchers have been confirmed, and are stated in previous text, thus the foundation for further quantitative large-scale research has been laid and main goal of this paper has been fulfilled.

Important finding is, that all of the companies stated they knew the concepts of Industry 4.0 and the 4th Industrial Revolution; however, some of them didn't know its integral parts. As the results have shown there is a gap between the perception of Industry 4.0 concept between companies and researchers. Companies approach the concept in a more practical way, and they are aware of individual technologies rather than "big-picture" concepts like CPS. This presents the need to find out how companies perceive these big-picture technologies and why they don't connect them to Industry 4.0.

An alarming lack of awareness of company B calls for quantitative research including more companies to find out if the Czech companies are not lagging behind in preparation for Industry 4.0. Especially concerning is the fact that respondent B stated they know the trend Industry 4.0 and the 4th Industrial Revolution. This is a critical finding as this could mean there might be some resistance to changes in the company and further in the future it could lead to serious problems with competitiveness of the company in the future. The research could be simpler than the one presented above, with only a few important technologies. Broader number of respondents would also be required, and companies of all sizes should be addressed.

Varying results of awareness (or the lack of it) in different "blocks" of technologies and terms such as terms connected to IoT or Big Data Analytics, and more, suggest that more specific and in-depth research focusing only on some parts and areas of Industry 4.0 might be needed. It could, for example, focus only on technologies of virtual character etc.

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