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Industry 4.0 Implementation and Industry 5.0 Readiness in Industrial Enterprises

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Abstract
The current market situation shows that enterprises are still struggling to digitize their business through the integration of the Internet of Things (IoT), artificial intelligence (AI), cloud technologies and other more advanced technologies, but the fifth industrial revolution is knocking on the door. This article deals with the analysis and evaluation of the impact of Industry 5.0 on entrepreneurs. Industry 4.0 analysis provides results based on interviews with practitioners as well as sales representatives. The main part of the article focuses on the business situation, where the goal was to identify existing gaps along with opportunities and threats. This analysis also describes the best way how to transform in times of the next industrial revolution. Study addresses the approach of integrating human workers in the supply chain in cooperation with automated processes. The purpose of this study is to confirm or refute whether companies are ready for another industrial revolution.

Keywords
Industry 4.0, Industry 5.0, Digitalization, Digital Transformation, Industrial Revolution.

Introduction

In 2018, Bernhard Marr, a technology and business consultant of companies and governments, declared that companies are at the height of the Fourth Industrial Revolution (Marr, 2018). Nevertheless, even today, enterprises are still working hard to digitize their business processes so that they can compete with ever-evolving process automation to increase productivity, improve efficiency, and promote flexibility and agility. The goal of all this is primarily to create a better customer experience, and increase profitability and revenue (Bueechl et al., 2021). Despite the relentless digital transformation within Industry 4.0, there are entrepreneurs who are much more concerned about the future and do not perceive business processes as they are now but as they could be in the future. We don't have to mention the fact that technological development is moving forward by leaps and bounds and Industry 5.0 is more or less becoming part of the business environment. However, globalization, digitalization, agilization and other business parameters have the task of ensuring the constant transformation and development of society. A company that is able to search and anticipate future trends and necessary changes can become an innovative company and will undoubtedly succeed in the next step of the industrial revolution.

The aim of this study is to analyze the current state of acceptance of Industry 4.0 in various industries (small and medium-sized enterprises) in Slovakia, which will lead to further analysis, which aims to describe in detail the state of acceptance of the new Industry 5.0. The research methodology is based on a questionnaire-based survey developed with the support of C-level managers (a high-level company manager responsible for decision-making throughout the company such as the CEO, Chief Operating Officer (COO)) and Chief Information Officer (COO, CIO). Concise and clear definitions of basic terms provide a solid scientific basis, according to which it is possible to understand the dynamics of the problem. Existing opportunities and analyzed problems provide support for positive business development towards Industry 5.0.

Literature review

Industry 4.0

The first recognized mention of the Industrial Revolution 4.0 was in 2011 by the German government during the Hanover trade fair. This mention describes In-

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dustry 4.0 as an improvement in communication and information technology in manufacturing. The fourth step of the industrial revolution can also be characterized as a high level of automation through fully automated control machines, as well as high use of big data and cloud technologies (Ammar et al., 2022). Industry 4.0 consists of a wide range of concepts such as automation, digitization, standardization, secure and dynamic networks, and miniaturization but also general innovation and incremental mechanization. The role of Cyber-Physical Systems is to monitor physical processes throughout the supply chain through real-time communication and the Internet of Things (IoT) (Tonelli et al., 2021). The fundamental changes due to the Fourth Industrial Revolution are based on technological developments such as IoT, Data Analytics, AI, Robotics, Cloud Technology, Blockchain, Cryptocurrencies, 3D Printing and others (Hopkins, 2021). Industry 4.0 defines four design principles (Lachvajderová & Kadarova, 2021):

- Technical assistance – the use of computer tools with AI to support the efficiency and effectiveness of human workers;
- Information transparency – the ability of a computer system to create virtual copies of real-world objects;
- interoperability – integration of IoT tools, industrial machines and support of communication between machines;
- decentralization – the inclusion of technical systems that are able to perform tasks independently.

The listed principles support the transformation of enterprises and mediate the transition to the Industry 4.0 scenario. In order for this transformation to take place successfully, the following three parameters are considered (Dinardo et al., 2018):

1. Vertical integration – through digitalization and interconnection of business units, cooperation is possible within different hierarchical levels of the organization. As a result, the company can be transformed into a smart factory with high flexibility by sharing data with accurate planning and in real-time.
2. Horizontal integration – values are created between organizations and businesses for effective financial management, increased product lifecycle as well as material flow through real-time data sharing and accurate planning.
3. End-to-end engineering – development and design process of services and products taking into account customer requirements with the integration of digital technologies.

Nowadays, customers' acquisition decisions are based on finding the best service or product that can meet their needs. This is associated with the continuous improvement of processes in the company, given the high quality, low price and immediate availability of their outputs. It is more than obvious that multicriteria process optimization is too demanding to implement, so Industry 4.0 seeks to compromise and provide benefits in six specific categories (Table 1). In addition, adding new technologies (eg IoT, AI) may shift the benefits to other levels and thus identify and predict possible future problems (Aly et al., 2021).

Table 1
Six business benefits in Industry 4.0

Benefit	Interpretation
Innovation	Because Industry 4.0 production lines are built to suit a large mix and low volume, they are ideal for launching new products and experimenting with design.
Efficiency	Fewer people and more automation manage the decision-making process faster and maintain high efficiency. Automation also tends to maintain high quality and keep manual production problems low.
Agility	With a focus on high standardization and small series, Industry 4.0 brings high flexibility to the production process.
Costs reduction	After the initial investment in the transformation, the costs will fall. Fewer quality problems lead to less material waste and lower operating and personnel costs.
Revenues	With lower costs, better quality and the ability to serve customers well, Industry 4.0 puts manufacturers on the road to being the preferred supplier for customers. Among other things, it offers ways to offer customized products, to serve larger markets, and higher-margin services to all customers.
Customer experience	The depth of information on customer requirements and existing problems, and the ability to respond promptly, can provide customers with the right products and services, sometimes in real-time.

In order to take advantage of Industry 4.0, it is necessary to appropriately determine the organizational structure in addition to the cyber-physical system and technical integration. Partner management, strategic workforce planning, as well as participation and sharing of technical standards, are the main foundations for companies (Hopkins J.L., 2021). When we talk about the fourth industrial revolution, in most studies the technical aspects are mostly discussed, but very little attention is paid to managerial approaches and organizational culture, which are the main aspects that complement the success of Industry 4.0 (Martínez-Caro et al., 2020). This obstacle can be cited as one of the key complications in cor-

porate transformation. In addition, however, there are insufficient skills and little knowledge in the implementation of new technologies (Lachvajderová & Kadarova, 2021). Other obstacles include workers' fears of job loss due to robotization and process automation. These include reliability issues, safety concerns, or concerns about IoT failures that lead to confusion and misunderstandings in society (Gažová et al., 2022).

Digitalization

The term digitization is used variously in many interpretations e.g. digital change, digital revolution, digital transformation, digital society, or digital business processes. However, the original, original term in the literature describes the transition from analog to digital, or otherwise, the transmission of analog information to digital data. Digitization aims to help transform all the information that comes into companies into a single digital whole/format. It also aims to process this information electronically, thus increasing flexibility, and efficiency and thus saving process costs and entering the market faster (Zhu & Wang, 2021). Digitalization in the context of transformation describes the implementation of digital technologies in business, society, and related changes in the connectivity of individuals and companies. In 2018, Urbach (Urbach & Roeglinger, 2018) describes commoditization and faster time to market as key driving force of digitization (Urbach & Roeglinger, 2018). On the one hand, digital technology includes technologies established on sites such as SMAC (social media, mobile computing, advanced analytics, cloud computing), and on the other hand, emerging technologies such as artificial intelligence, IoT, or Blockchain (Paschek et al., 2017).

A significant advantage of digitization is the availability of time- and place-independent data. This is made possible by the unrivaled speed of change and interconnection levels throughout the supply chain, which plays a dominant customer role (Urbach & Roeglinger, 2018). Digitization can also be expressed as a driving force for Industry 4.0 by several trends that underline the link between digitization and the Fourth Industrial Revolution: consumer connectivity, optimized manufacturing, empowered employees, and transformed products (Javaid et al., 2021).

Industry 5.0

In the case of Industry 5.0 analysis, we have some uncertainties about what it entails and how it will affect the business. As society and companies are still in the early days of the Industrial Revolution, it is difficult to predict which direction it will take so we can only rely on the hypotheses and studies that have been carried out so far. In 2018, Østergaard pointed out that the next step of the industrial revolution was necessary given the high consumer demand for product individualization (Østergaard, 2018). He also represented this statement in a study published in Bloomberg, which states that a German car manufacturer gives more space to people in production plants, noting that adaptation is an important factor for modern consumers (Mattioli et al., 2020). Precisely because of such claims and various others, Industry 5.0 appears to be an intensified collaboration between intelligent systems and people, wherein in Industry 4.0 the company focused more on automation itself than on collaboration. Thus, machines have the potential to take on all repetitive and monotonous tasks, while people's role will be to take on the creative side and thus take on more responsibility and increase oversight of the systems, which should increase the quality of production in general. In addition, Østergaard stated that products with a strong mark of human care and craftsmanship are the ones where customers pay the most. This demand for human contact will increase much more in the future as consumers try to express their individuality through the products they buy. This outlines a new kind of personalization, a sense of luxury that business has to deal with (Østergaard, 2018).

In addition, the European Commission, in the context of Industry 5.0, in its January 2021 report describes the Fifth Industrial Revolution as better meeting the economic as well as special environmental requirements of "green production" for carbon-neutral, energy-efficient industry (European Commission, 2021). They further state that over ten years, Industry 4.0 has focused less on the original principles of social justice and sustainability and more on digitization and AI-driven technologies to increase production efficiency and flexibility. The Industry 5.0 concept aims to provide a different focus and emphasize the importance of research and innovation to support the industry in its long-term service to humanity within planetary borders (European Commission, 2021). Another study describes Industry 5.0 as more interesting, faster, and scalable than previous ones, mainly because of the type of technology they have at its disposal (Maddikunta et al., 2022). The mentioned effective synergy between technology and man will also affect the ecology, the economy, and the social world (Demir et al., 2019). These effects are accompanied by a waste prevention perspective applied in industrial upcycling (Maddikunta et al., 2022):

- Process waste – overproduction, empty trucks on the road, restocking;
- Urban waste – insufficient infrastructure, vacancies;
- Social waste – people willing to work but without opportunity and people who are not willing to work;
- Physical waste – ordinary waste and waste from production lines and logistics.

These four perspectives for the prevention of excessive waste point to enormous economic and environmental impacts in reducing waste of materials and resources, as manufacturers are interested in reducing material costs and minimizing the social impact of industrial processes (Lu et al., 2022). Synthesis of artificial genes (artificial DNA or DNA printing from synthetic biology), and sustainable use of resources or new raw materials are other dimensions of Industry 5.0 characterization with potential business impacts. These areas also bring the human factor to the fore in relation to nature and physical integrity (ElFar et al., 2021).

Evaluation of the scientific status

The analysis of the scientific literature showed a very good basis for characterizing the fifth industrial revolution, also on the basis of the literature based on Industry 4.0. Simply put, all researchers and scientists agree that they see Industry 5.0 as a key feature of the human touch, which is to come back to the center of decision-making through human-machine collaboration. In addition, Industry 5.0 leads to:

- Waste reduction and waste prevention activities;
- Strong bioengineering and biotechnology affect business and society;
- Development of global society.

The most important benefits of Industry 5.0 include increased agility, profitability and productivity, better preparedness for change, overall cost reduction, and a responsive work environment (Maddikunta et al., 2022). The following advantages could also be considered:

- Spare time in addition to supporting technology without fear of losing jobs by automating new business models, as well as an evolving global society that will be an important part of the ongoing digital transformation in business or the creation of open and well-skilled forward-thinking employees;
- Reducing waste within the four types mentioned in order to save costs, create sustainability, protect the environment and gain better contact with society.

Research methodology

To evaluate the impact of Industry 5.0 on the business structure, an analysis of the state of implementation of digitization, resp. Industry 4.0 through questionnaires. The data and information obtained to set the starting point for the evaluation and benchmark on behalf of several attributes, such as company size by the number of employees, industry, customer segments, products, business models, etc. Based on these parameters, and analysis of the business situation was performed, the main goal of which was to examine the existing weaknesses and parameters of threats in implementation and realization in comparison with other companies. The analysis includes questions focused on the company's vision for the future and the assessment of readiness for the fifth industrial revolution.

The goal and topic were introduced at the beginning of the interview, and after a brief introduction, the initial requirements that were required of each respondent regarding general information about the company, such as the number of employees or business model and customer groups, were continued. The core of the conversation was in the spirit of questions about the implementation, knowledge, implementation, and use of Industry 4.0 technology, but also about the advantages, disadvantages, and possible barriers. Furthermore, the interview moved towards the vision and current state of implementation of Industry 5.0. Open-ended questions with examples of grouping were used, with the intention of obtaining more information from the answer of the interviewed person.

The interview included small, medium, and large enterprises in Slovakia. 250 company representatives were contacted and 39 agreed to the interview. The target persons for the interview were mainly Chief Technology Officer (CTO), Chief Digital Officer (CDO), Chief Information Officer (CIO), Chief Execution Officer (CEO), and Chief Automation Officer (CAO). In the case of large companies, representatives for communication or middle management also responded to the interview.

Research results

The following part of the article presents and evaluates the results of the interviews. 39 representatives of companies from eight different industries within the business-to-business and business-to-customer segments were interviewed (Table 2). These

can be divided into 15 small (< 50 employees), 21 medium-sized (51–249 employees), and three large enterprises (> 250 employees).

Table 2
Companies by type of segment

Industry	Number
Manufacturing	12
Technology	10
Construction	5
Telecommunication	4
Commerce	3
Transport/Logistics	2
Energy	2
Chemical	1

Figure 1 is the result of an analysis of the transformation of Industry 4.0 in the examined sample. The category of the industry that transforms the most includes the technology, manufacturing, transport, and telecommunications industries. The transport industry lags far behind the telecommunications industry, which in this case is leading. In third place is the technology industry, followed by the trade and production sectors at the same level. The last three sectors can be considered critical, mainly construction (barely 25%). The energy industry ranked seventh ahead of the chemical industry in terms of the level of transformation.

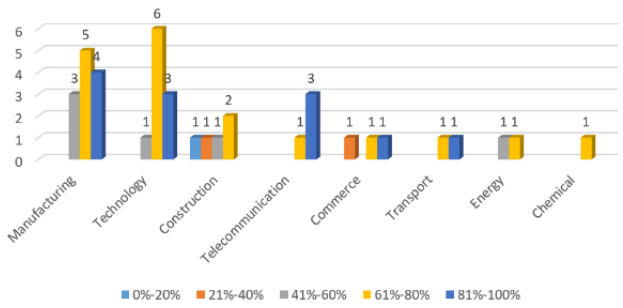

Fig. 1. Industry 4.0 transformation level in a selectedsample of respondents

This assessment of the analysis confirms the theoretical assumption that the digital transformation, which is an integral part of Industry 4.0, is still taking place in some industries and is slowly being adopted. The main reasons and obstacles to these phenomena can be seen in Figure 2.

From the sample of companies analyzed, most companies are struggling with a lack of digital competence. When implementing new technology, the company is required to have a prompt approach to adapting employees or to accept the need to take measures and responsibilities associated with the transformation. In such a case, a functioning corporate culture and executives have the potential to suppress these shortcomings in the background. After all, a well-functioning corporate culture is not the only solution. Employees who are able to anticipate and learn are also very important, and their interest in new technologies goes hand in hand with their implementation. According to the analysis, the second biggest problem is considered to be the lack of technology and infrastructure (50%). The lack of technological and transformation skills combined with excessive costs and investment congestion together constitute an obstacle to corporate process transformation. However, it should also be borne in mind that unclear business visions as well as unformulated business goals (41%) lead to an unclear road map and hinder the overall transformation of the company.

Fig. 2. Barriers and threads of digital transformation in a selected sample of enterprises

These barriers and threats need to be avoided in future or ongoing transformations by clear and unambiguous business visions and a conscientious approach to innovation through an open corporate culture and a sustainable recruitment process. In addition, investment troubles can certainly be avoided by setting a clear corporate strategy. In the case of technology infrastructure, the business has less impact. In this area, companies must put pressure on the government itself. Other issues of the analysis focused exclusively on the readiness and ability to adapt to the Fifth Industrial Revolution. The results are shown in Figure 3.

It is obvious from Figure 3 that the technology, manufacturing, and communications industries, whose business processes are either aware of or already undergoing transformation, are experiencing favorable results. On the contrary, companies from the con-

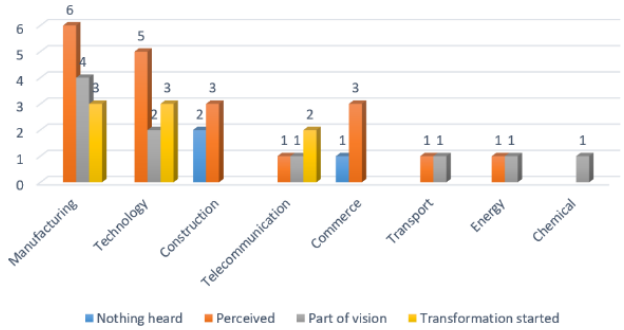

Fig. 3. Industry 5.0 Readiness

struction industry as well as the commercial, chemical, and transport industries either did not hear about the latest industrial revolution or heard very little, resp. they just perceived him. In the case of the surveyed companies from the technology, manufacturing, and communication industries, they perceive the presence of Industry 5.0 and most companies are already at the beginning of a transformation or the company has in their visions and goals.

Discussion

The analysis shows that some industries have a greater impact on the stages of industrial transformation and thus create their new visions and goals in connection with Industry 5.0. On the other hand, there are also industries (the chemical or energy sector) that have other important priorities and have a problem with the latest trends and the adoption of a new industrial revolution.

It can be considered a very alarming phenomenon that not all industries and companies are looking ahead and are still in the initial process of Digital Transformation Industry 4.0. These technologies form a solid foundation for the fifth industrial revolution. We must not forget to forget the fact of the presence of a pandemic in the last 2 years, which significantly affected the speed of digitization and the actual implementation of Industry 4.0 in business processes. It can be said that this pandemic had a very bad impact on society, but a positive impact on the speed of adoption of new technologies in companies. Industry 5.0 will change business and management in the coming years, as well as cooperation between smart technologies and people.

However, when we talk about this topic, it is important to keep in mind that the definition of the Industrial Revolution says that it is the use of sophisticated machines to make people's work easier and faster (Xu et al., 2021). Therefore, companies and individual industries should look to the future, participate in the improvement of ongoing or new processes, and at the same time follow the new trends and developments that Industry 5.0 brings.

Conclusions

Industrial revolutions and technological advances are happening faster and faster, and therefore companies need to set clear visions and goals for the company, as well as a clear mindset for transformation. The company must be able to support and take steps that lead to a successful business in the future. According to the analysis, we found that some companies are still working on the implementation of elements of Industry 4.0 and have not yet heard of Industry 5.0. Companies need to realize that guaranteed success comes only when companies innovate their processes, respond to market changes, and thus be able to provide quality products and services according to customer requirements.

Industry 5.0 represents a significant change in automation that is leading to a process of increasing the ability of human workers to achieve personalization by adapting the product to the next level. Therefore, in the future, it is appropriate to focus on the issues that would be addressed: the skills that need to be developed, the rules between machines and humans, and it is appropriate to define how AI can affect people.

Finally, it is time for lagging companies to wake up and start their transformation processes, because the future is happening now, and if the company is to prosper, we must meet the challenges responsibly and face them.

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