Preparedness for Industry 4.0: Challenges and Opportunities

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ABSTRACT:
Recently, we can hear a lot about Industry 4.0. Some companies are preparing for changes connected with Industry 4.0, others are only starting to get acquainted with it, and some are already implementing parts of it they consider useful or necessary. It is getting clear that there are certain trends in this technological revolution that are going to change not only the business world but also the world of the whole society. As we can learn lessons from previous industrial revolutions, we can expect that forth industrial revolution has the potential to bring many benefits and opportunities and improve the quality of life. On the other side, we also need to be aware of potential risks and threats coming with it. New technologies and progress have always brought fundamental changes to the society. The aim of this paper is to present general overview, challenges, risks and opportunities related to Industry 4.0, also certain evaluation of Slovak companies' preparedness and initiatives of Slovak government in connection to Industry 4.0. The surveys conducted on Slovak companies revealed a more significant penetration of the philosophy of transformation into the corporate culture of enterprises. Companies are beginning to realize the importance of a dedicated team to manage the transformation agenda. The recommendations resulted from the survey are focused on the biggest challenges of Industry 4.0.

ABSTRAKT:
V poslednej dobe možno často počuť rôzne názory a diskusie o priemysle 4.0. Niektoré podniky sa už aktívne pripravujú na zmeny súvisiace s priemyslom 4.0, iné sa len zoznamujú s touto problematikou a niektoré podniky už i využívajú rôzne koncepty, ktoré patria pod priemysel 4.0 podľa užitočnosti alebo už i nevyhnutnosti. V súčasnosti je už zrejmé, že táto technologická revolúcia prinesie také trendy, ktoré zmenia nielen podnikový svet, ale aj svet celej spoločnosti. Keďže sa môžeme poučiť z predchádzajúcich priemyselných revolúcií, môžeme očakávať, že štvrtá priemyselná revolúcia má potenciál priniesť veľa výhod a príležitostí a zlepšiť kvalitu života. Na druhej strane si musíme byť vedomí aj potenciálnych rizík a hrozieb, ktoré s ňou prichádzajú. Nové technológie a pokrok vždy priniesli spoločnosti zásadné zmeny. Cieľom tohto príspevku je poskytnúť základný prehľad o stave, výzvach, rizikách a príležitostiach týkajúcich sa priemyslu 4.0 ako aj určité vyhodnotenie pripravenosti slovenských podnikov a iniciatív Slovenskej republiky v súvislosti s prípravami na štvrtú priemyselnú revolúciou. Z prieskumov o slovenských firmách vyplynulo výraznejšie preniknutie filozofie transformácie do podnikovej kultúry podnikov. Spoločnosti si začínajú uvedomovať význam špecializovaného tímu pre riadenie programu transformácie. Odporúčania prieskumu sa zameriavajú na najväčšie výzvy priemyslu 4.0.

KĽÚČOVÉ SLOVÁ:
priemysel 4.0, výzvy, výhody, riziká, pripravenosť podnikov

KEYWORDS:
Industry 4.0, Challenges, Benefits, Risks, Readiness of Companies

INTRODUCTION

This paper deals with concept of Industry 4.0 (abbreviation I4.0) or fourth industrial revolution. The term „Industry 4.0" (Industrie 4.0) was firstly used at the fair in Hanover in Germany in 2011 and raised many controversial discussions and questions. (Drath, & Horch, 2014) It was initiated by the German government at the beginning of this decade to analyze the impact of new technologies on the country's economy. The aim was to bring industrial production back to Europe, naturally at the higher technological level. Important German concerns joined the initiative. Further, a „strategic initiative" led by the German government was formed in Germany and was subsequently adopted as part of the High-Tech Strategy 2020 Action Plan in November 2011. Since 2006, the German government has been implementing this strategy aimed at cross-sectoral coordination of research and innovation initiatives competitive position through technological innovation. (Kagermann et al., 2013) Later, industry 4.0 was popularized in 2016 through the World Economic Forum in Davos. And currently, this topic is discussed all around the world, as it is already influencing many industries and countries. Technological development in automation, robotics, nanotechnology and biotechnology, progressive materials, Internet of Things, Artificial Intelligence, 3D Printing, Big Data, etc., creates strong impulses for structural change in many sectors and industries and carries significant changes in society. The fourth industrial revolution is represented by the transition from a simple digitization phase to innovation based on mutual combinations of material, digital and biological. (Jeck, 2017) As Villagrán, Pesado and Marquez (2019) pointed out, this revolution is a great technological revolution, that is going to fundamentally change the way we live, work and communicate with each other. In its scale, measure and complexity, the transformation coming with Industry 4.0 will be as fundamental to humanity as no other technological change in the past. The aim of this paper is to present an overview of the status, challenges and opportunities related to Industry 4.0, also certain evaluation of Slovak companies' preparedness and initiatives of Slovak government in connection to Industry 4.0.

LITERATURE REVIEW

Definition of Industry 4.0

There is no precise definition for the term „Industry 4.0". The word „revolution" indicates a sudden and radical change. Revolutions have occurred throughout history, when new technologies and unusual ways of perceiving the world have caused serious changes in economic systems and social structures. Considering that history is used as a reference frame, it may take years to detect the sudden change. (Schwab, 2016)

Historically, scientific and technological development can be divided into several revolutions. The figure 4.0 in the title means that we are now in the fourth stage of the industrial revolution. To give a short overview of all industrial revolutions (Cejnarová, 2015; Kohnová & Salajová, 2019):

1. The first industrial revolution began in the late 18th century in England, respectively in 1784, when Edmund Cartwright invented the first mechanical weaving loom. It continued in the 19th century, when the transition from hand-made production to manufactory production was completed. At that time, new sources of energy, especially coal (or steam), began to be used in mass. Therefore, the traditional symbol of the first industrial revolution is a steam engine.
2. The second industrial revolution is associated with electrification and the emergence of assembly lines. It is mostly associated with two dates: 1879, when T. Edison invented the bulb, or 1870, when the meat-packing companies in Chicago and Cincinnati installed the first assembly lines which were later introduced by Henry Ford also in automotive industry. This invention brought further rapid development of mass production.
3. The third industrial revolution is the most often associated with automation, electronics and the expansion of information technology. This revolution is characteristic for technological innovation of electronics and IT for automation and production. During this revolution, communication was accelerated, and business contacts moved to new levels. It has resulted in creation of thousands of businesses and millions of jobs, laying the foundation for globalization in the 21st century. Companies had to invest in new technologies to fulfil the labor market demands.
4. The fourth industrial revolution is the revolution we are facing right now, 10–30 years. It is characterized by the expansion of the Internet and its penetration into virtually all areas of human activity.

While the first three revolutions were the result of a revolution in technology, electronics and mechanics, the current stage of industrial development can be described as a revolution of informatics and communication (Molnár, 2016). However, all four industrial revolutions had some features in common, especially massive technological and organizational changes, redefining the function of the family, changing the nature of work and leisure. (Stearns, 2012)

According to some authors (Brynjolfsson & McAfee, 2015; Schwab, 2016), the upcoming stage of technological development in the fourth industrial revolution is qualitatively different from the previous ones, mainly in three aspects: ICT exponentiality (speed, cost and energy efficiency); the digitalization of everything (creation and subsequent use of digital data), and the recombinability of innovation in material, biological and digital technologies.

Industry 4.0 is recognized as a broad concept and its content changes with the development of technology. According to Drath and Horch (2014) Industry 4.0 is closely related to the term „cyber-physical system" (CPS). To better understand the concept of CPS, these authors present three hypotheses (Drath and Horch, 2014):

1. Regarding the first hypothesis, the communication infrastructure in production systems is becoming more and more affordable and therefore expanded. It is useful in several areas: engineering, configuration, services, diagnostics, operation and service of products, field equipment, machinery and plants. It will become part of the production systems of the future. This trend is unstoppable and unforced – it is currently running in the same style as mobile phones (and smartphones) have found their way into our pockets.
2. The second hypothesis states that the field of equipment, machines and factories (even stand-alone products) will be increasingly connected to the network (for example, the Internet or the private Internet of the factory). They will be available as data objects on the network and will be able to store a real-time data. This makes them searchable, discoverable, and analyzable on the network. This will lead to explosions of available objects and data accessible from everywhere.
3. The third hypothesis is saying that the field of equipment, machinery, and factories (even stand-alone products) will be able to store documents and knowledge about themselves externally – outside their physical forms – in a network. This gives them a live virtual representation in the network with individual identifiers. They will keep documents, 3D models, simulation models, requirements, etc. This information, stored outside the physical object, is updatable and thus represents the latest available version. In addition to this data, various functions will behave like physical objects: negotiation functions, discovery functions, and so on. These data objects extend the corresponding „real" device and form its secondary identity in the network, where this data creates a knowledge base for a variety of applications.

Hermann, Pentek and Otto (2016) defined Industry 4.0 as a collective term for technologies and concepts of value chain organization and determined its key elements:

1. A cyber-physical system (integration of computing and physical processes; embedded computers and networks) monitor and control physical processes, usually with feedback);
2. Intelligent factories (integrating the previous three elements into one whole and based on the idea of decentralized production systems in which people, machines and resources naturally communicate with each other);
3. Internet services (abbreviation "IoS", meaning enabling service vendors to offer their services via the internet);
4. Internet of Things (abbreviation "IoT", meaning things and objects, such as RFID, sensors, actuators, mobile phones interacting or cooperating with each other). IoT can serve as a huge network of interconnected „things" (including people) in relationships: human-human, human-machine, or machine-machine.

According to Schwab (2016), Industry 4.0 is not just about smart and interconnected devices and systems, but it has a much greater reach – waves of breakthroughs from gene sequencing to nanotechnology, from renewable things to quantum computations all of which are occurring today. The fusion of these technologies and their interactions across physical, digital and biological domains are making the fourth industrial revolution fundamentally different from the previous revolutions.

According to Gerbert et al. (2015), companies and countries will adopt to this industrial revolution at different rates and in different ways. Industries with a high level of product variations, such as the automotive and food industries, can benefit from a higher degree of flexibility that can generate productivity gains, and industries that demand high quality, such as semiconductors and pharmaceuticals,

will benefit from data analytics improvements, which reduces the error rate. Countries with experienced workers will be able to monetize this with a higher degree of automation associated with the demand for a highly experienced workforce. Many emerging markets for a young, technologically skilled workforce can also directly take advantage of the opportunity to create completely new production concepts. For actively shaping transformation, producers and system suppliers need to take decisive steps to master technological progress. They must also address the need for adaptation of appropriate infrastructure and education.

KPMG authors (2017) stated that the critical parameters of the introduction to I4.0 are the field design of processes and the identification of the qualifications of employee profiles that will be required in the future. This is prevented by the development of Industry 4.0's comprehensive strategic and investment plan. Many aspects of the technology used in I4.0 are already described, but some areas still need international binding standards. The complexity and cost of networking subsystems are also often underestimated. The most important point on the road to the „factory of the future" will be the commitment that entrepreneurs, management and the workforce invest in cooperation and acceptance of the new entity. This will require decision-makers who want this change, lead the introduction of new methods and processes step by step, and set up the entire organization on a gradual basis.

Challenges and opportunities of Industry 4.0

There are many authors commenting possible scenarios, effects, benefits and challenges coming with Industry 4.0. The KPMG India CEO Arun Kumar (2019) said that the I4.0 challenge is not to adopt impressive new technologies. It is a strategy and a challenge for the operational models, or rivalry for the acquisition of critical new capabilities, and especially a bridging business issue that goes beyond yesterday's innovations. As PWC (2014) stated, this revolution challenges companies with increase of digitization and interconnection of products, thus it will challenge their value chains and business models (BM). Based on their study (PWC, 2014), digital transformation of companies will require a considerable investment (estimated more than 50% of planned capital investments for the next five years), which will also bring benefits in form of:

1. higher productivity (increase in more than 18%);
2. digitalization and interconnection of product and services will strongly ensure competitiveness and promises additional revenues (2%–3% per year on averaged);
3. newly, emerging, digital business model offering significant additional value to customers through tailor-made solutions will contribute to better fulfillment of customer needs.

Jeck (2017) pointed out that the opportunities and benefits that can be expected can be far reaching: highly flexible mass production, real-time coordination, optimization of value chains, reduced complexity costs or the emergence of brand-new services and business models.

The implementation of Industry 4.0 will transform the conventional value chains and the emergence of new business models. According to Kagermann (2013) we can list all these main changes and benefits of the concept:

1. Satisfying an individual customer requirement – I4.0 allows the individual customer-specific criteria to be included in the design, configuration, ordering, planning, manufacturing and operation phases, as well as allowing last-minute changes to be recorded. In the I4.0 it is possible to produce disposable products and have a very small volume of production at the same time (a scale of 1 product) while still making a profit.
2. Flexibility – CPS-based ad-hoc networks allow dynamic configuration of various aspects of business processes, such as quality, time, risk, robustness, price and ecology. This supports continuous „trimming" of materials and supply channels. It also means that engineering processes can be set to be more agile; production processes can be altered, temporary deficits (e.g. due to the problems on the supplier's side) can be compensated and a large increase in output can be obtained within a short period of time.
3. Optimized decision making – In order to succeed in the global market, it becomes critical to make the right decisions, often in a very short time. I4.0 provides end-to-end transparency in real-time, enabling early design verification in engineering and more flexible responses to breakthrough and global optimization across all business locations in the production sector.
4. Productivity and a resource efficiency – The overlapping strategic objectives for industrial production processes are still applied to I4.0 – bringing the highest possible output of products from a given volume of resources (source productivity) and using the smallest possible resources to benefit an output (product efficiency). CPS enables optimization of production processes on a case-by-case basis across the entire value network. What's more, better than stopping production is the ability to continuously optimize systems during production in terms of their resources and energy consumption or reduce their emissions.
5. Creating a value opportunity through a new service – I4.0 opens up new ways of creating value and new forms of employment. Smart algorithms can be applied to a large amount of big data recorded by smart devices to provide an innovative service. There are particularly important opportunities for SMEs and start-ups to develop B2B (business-to-business) services for I4.0.
6. Responding to a demographic change in a work environment – In the conjunction with a work organization and the competence development initiatives, interactive collaboration between human beings and technology systems will give companies new opportunities to transform demographic change to their advantage. Faced with a lack of skilled workforce and an increasing diversity in workforce (in terms of age, gender and cultural background), I4.0 will enable a variety of flexible career paths that allow people to work and be productive for a longer period of time and inevitably change and shape the culture.
7. A work-life balance – The more flexible organization models of companies that use CPS means that they are in a good position to meet the growing demand of employees – the pressure to strike a better balance between their work and their private lives, as well as between personal growth and ongoing professional development. For example, smart assistance services will create new ways to organize your work by bringing a new standard of flexibility to meet your business requirements and staff needs. As the size of the workforce shrinks, CPS firms will gain a net advantage when the best employees are recruited.
8. A high-wage economy that is still competitive – The I4.0 dual strategy will allow the country to develop its position as a leading supplier and to become the main market for the I4.0 solutions.

According to Kranz (2017), new technologies such as wearables, 3D printing, drones, connected and autonomous vehicles, and more, along with new business models, will virtually transform all of today's industries as well as create new industries and segments that we can't even imagine. In addition, thanks to the IoT, industry is rapidly evolving into a world of partner ecosystem and customer co-creation.

As Agostini and Filippini (2019) said, entrepreneurs and managers need to be aware that the path toward I4.0 requires not only

focusing on the application of the I4.0 technologies, but also on the development of a series of organizational and managerial practices that become key to face the Industry 4.0. This will have not just the social implications but rather significant cultural implications as well. We can foresee various cultural implications, as I4.0 will influence almost every part and aspect in today's modern society. As Kiel et al. (2017) indicated, I4.0 is not purely technological or IT related challenge to the relevant industries. The changing technology will also have far-reaching organizational implications, bringing the possibility of developing new corporate and business models, thus encouraging greater employee involvement.

Maynard (2015) pointed out that the technology and evolution of the Industry 4.0 have so far only „disrupted" their anticipated impact and offer the promise of a massive spread of changing social, economic and environmental advances – from disease elimination, environmental protection and supply of energy, food and water to reducing injustice and empowering individuals and communities.

Risks of Industry 4.0

According to Kiel et al. (2017) the current effects and implications of I4.0 are still uncertain as researchers, politicians, consultants and experts make contradictory statements for their potential benefits and risks – despite the perspective of economic, social and environmental benefits, each technology presents individual challenges and risks.

As Kohnova et al. (2019) pointed out, radical changes resulting from this revolution are already strongly affecting industrialized European countries and due to the new new characteristic technologies of Industry 4.0, it will be essential for companies to make the necessary changes in areas such as employee education and training, organizational culture, strategy, or organizational processes in order to stay competitive.

Schwab (2016) describes his concerns in general, he feels that the required levels of leadership and understanding of the change across all sectors is small in contrast to the need to rethink our economic, social and political systems as a response to the fourth industrial revolution. As a result, at national and global levels, there is a need for an institutionalized framework for managing the diffusion of innovation and facilitating breakthroughs, which are at best inadequate and at best completely absent. Therefore, the world lacks a consistent, positive and routine narrative that marks the possibilities and challenges of the Industry 4.0. A narrative that is essential if we want to strengthen a diverse set of individuals and communities and avoid popular negative responses against fundamental transitional changes.

Záležáková (2017) identified these main areas of risks:
1. IT risks: terrorism, hacking, security (data) costs, virus protection, protection of sensitive information and business secret, encryption, firewall protection of servers, automatic scanning,
2. Manufacturing risks: problems with achieving and maintaining a high degree of reliability and stability of the communication, integrity of the production process with regard to less human factor supervision,
3. Human resources risks: loss of high-paid jobs, systematic lack of experience and manpower to set up and implement these systems,
4. Investment and expenditure risks: expected increase in spending on virtual reality and augmented reality by 2021, investments in education, research, development and infrastructure, investments to create a favorable business climate.

These risks put pressure on requirements, particularly in the areas of cybersecurity, standardization and finance. As far as automation and the fear of high unemployment are concerned, we may remain calm since the changes will not be that drastic, according to the OECD report (2018). In the latest research OECD is saying that only one in seven jobs can disappear from the market, others can change dramatically. However, new technologies and advances will also require higher qualifications from low-skilled people and graduates, which can bring about changes and reforms in education.

IT risks are addressed in the EU by the European Union Agency for Network and Information Security (ENISA), according to which I4.0 is closely associated with cybersecurity, because the rapid emergence of I4.0 protection incidents make the need to strengthen cybersecurity more than necessary. This is all more important as the potential impact can range from compromising physical security through production downtimes, product failures, to equipment damage or subsequent financial and reputation losses (Enisa, 2018).

Production data are determining the production processes and today they are as important and rare as the design plans themselves. They contain accurate and unique information about the product and its production. Whoever owns this information needs only the right equipment and the pirated or fake product is ready. While design data is very well protected from unauthorized outside access, production data often lies exposed and unsecured in machines by assisted computers. An infected computer counts, or USB key is all that thieves need to steal data. Hackers can also attack directly on the IT network – for example, through unsecured network components such as routers or switches (Fraunhofer, 2014).

Regarding the financial and investment risks, Schwab (2016) admits that in low-income countries, I4.0 can cause global producers to outflow to advanced economies, which is quite possible if access to cheap labor ceases to be a driver for business competitiveness. The ability to develop strong manufacturing sectors to serve a global cost-based economy is a widely used way for countries to accumulate capital, transfer technology and increase revenue. If this path is closed, many countries will have to rethink their models and strategies for industrialization.

In I4.0, we should be aware of ethical and legal aspects, which can make it significantly more difficult or even impossible to implement. It will be critical to decide to what level we will allow machines and artificial intelligence to control us and the world around us. From a legal point of view, many countries have anchored in their laws that man is needed to control machines (Hilgendorf & Seidel, 2017). Logically, criminal responsibility makes sense for natural persons, whereas robots driven by artificial intelligence will find it difficult to find a culprit for any misconduct. The I4.0 concept involves number of processes that will have to be legally reviewed or new standards developed, for example in the case of systems insurability or the protection of business secrets.

Gogoll and Müller (2017) focused in their work on the development of autonomous cars and the ethics of their use, describing the problem in the following example: "Imagine that you are sitting in your autonomous car driving at a constant speed into a tunnel. A bus with children on board is approaching against you with the same speed. In the left lane right next to you is the car with two passengers. For some reason, the bus will brake sharply in front of you and your car will not be able to brake in time to prevent a collision with the bus, causing crashes and loss of life on the bus. There are three different strategies that your car can use: first, brake and collide with the bus, resulting in the death of passengers on the bus. Second, it points to the car on your left, pushing it into the wall and causing the death of two passengers in the car, but it will save your life. Third, it can direct itself (and you)

to the wall to your right, sacrificing you but saving the lives of all other participants".

Based on the following, we can call for the introduction of obligatory ethical settings of cars (through state regulations) over personal ethical settings, as the morale level of each person is different, which may also be reflected in the personal settings of individual cars. This can result in situations in which selfishness does not allow minimizing harm to all affected people (comparable to the second strategy in the tunnel problem mentioned above).

To some extent, the lack of awareness of the I4.0 concept is also a limitation in its development and implementation. The development of this concept and innovation is monitored only by a certain group of people. Others cannot even explain what lies behind this term.

RESEARCH

Slovak Republic and Industry 4.0

As it was already mentioned, Industry 4.0 originated in Germany. It was initiated by the German government at the beginning of this decade, analyzing the impact of new technologies on the country's economy. As industrial revolution, it can bring as a crucial societal change affecting industries, technical standardization, security, education, legal framework, research, interconnection, to social systems, labor market and demands on workers, their education and specialization. And thus, the state needs to play an important role in the implementation of Industry 4.0, especially in the case of a coherent concentration of support, education and training of experts and ensuring cooperation between education and industrial practice. Part of our research was to study initiatives of Slovak government in connection to Industry 4.0 and present strategic objectives and activities to support Industry 4.0 development in Slovakia.

Inspired by similar initiatives implemented in Germany, the Ministry of Economy of Slovak Republic first presented the Smart Industry concept for Slovakia at a high-level conference in March 2016 as a result of the decision of Slovak government to pursue the development of local smart industry. The Ministry of Economy of the Slovak Republic has established the Intelligent Industry Platform with the aim of drawing up the Intelligent Industry Action Plan of the Slovak Republic with the participation of representatives of state administration, universities, business and industry. The aim of the Intelligent Industry Action Plan of the Slovak Republic is the support for industrial enterprises, service and trade enterprises, regardless of their size, aimed at creating better conditions for the implementation of digitization, innovative solutions and increased competitiveness: programs and the labor market, co-financing research, creating Digital Innovation Centers (CDIs), etc. It acts as a central authority coordinating the various efforts and is comprised of a working group of multidisciplinary experts from industry, academic and government. Its aim is to bring the nation's business community – particularly industrial companies – closer to the principles of Industry 4.0. The Intelligent Industry Action Plan of the SR provides a set of measures that should be implemented by the end of 2020 (Ministry of Economy, 2018). Its strategic objectives were formulated as follows:

- Increase the competitiveness and anchorage of key industries through the conditions for successful business digitization.
- To create conditions for the development of new technologies, methods and applications aimed not only at supporting domestic industries, but also for export, developing the digital industry.
- Linking multinational, large enterprises and SMEs with university incubators and science parks on a financial, technological and mentoring basis to increase the knowledge of students and graduates of technical universities and thus ensure their competitiveness in the labor market or the possibility of their own business. These companies, or start-ups, will become partners of the industry and perfectly combine the automated value chain.
- Ensure the necessary quantity and quality of human resources for the digitized and digital industries.

As stated by the Ministry of Economy (2018), in order to meet these strategic objectives, action needs to be taken in five major areas:

- Research, development and innovation,
- Basic principles of IT security implementation of intelligent industry,
- Labor market and education,
- Reference architecture, standardization and development of technical standards, framework European conditions and national legal conditions,
- Information and promotion.

The implementation of the Intelligent Industry Action Plan by 2020 is creating the basic prerequisite for the successful transformation of the Slovak economy responding to the digitalization of industry, with the assumption that the digitization process will start in most companies. Several central government authorities, headed by the Ministries of Economy, Finance, Education, Labor and Social Affairs and the Office of the Deputy Prime Minister for Investment and Information Technology, should apply 35 measures to develop smart industry. The measures should affect almost 24,000 enterprises operating in Slovakia (Ministry of Economy, 2018).

Other activity supported by the Ministry of Economy of the Slovak Republic, is the platform Industry4UM which have a several roles (Industry4UM, 2018):

- to be an independent, expert, opinion-forming authority in the field of digital business transformation,
- to bring together industry for common objectives in Industry 4.0,
- to increase the awareness and expertise of businesses in Industry 4.0, digital transformation and innovation development,
- to educate and raise public awareness of Industry 4.0,
- to bring together experts and provide them with an opportunity to exchange and share expertise,
- to support the development of young researchers and start-ups focused on digitization and innovation,
- to provide qualified opinions on trends in the digital transformation of industry and innovation,
- to cooperate with professional, scientific and academic institutions for the needs of the manufacturing industry,
- to be a partner for state institutions in directing the development of industry digitization and innovation in Slovakia.

To understand the view of businesses, the Industry4UM (2019) Expert Initiative also carry out surveys. They have published the third annual survey focusing on the access of Slovak companies to Industry 4.0, which was attended by 52 respondents in 2019 from industrial companies. The results were compared with those from 2017 and 2018 as a response to monitoring trends in the Industry 4.0 and evaluating the readiness of Slovak companies for the opportunities and technology that I4.0 brings. The initiative concludes that most companies consider the I4.0 theme to be important and that companies' real involvement is growing, with companies starting to make small experiments and build their own know-how. It also recommended continuing to make minor changes and gathering experience, and to look for ways to address I4.0 implementation not on their own, but rather using the platforms provided by the government and other organizations.

In consonance with this survey (Industry4UM, 2019), the number of companies in Slovakia starting with Industry 4.0 is growing. However, the level of transformation varies. Small and medium-sized enterprises are beginning to enter the first phases of the application. Most of them are implementing previously isolated optimization measures without a more comprehensive strategy. The implementation has progressed, but on the other hand, there is a relatively high uncertainty among SMEs about what the Industry 4.0 implementation really requires and how to grasp it.

According to the survey findings (Industry4UM, 2019), 40% of companies are already taking steps towards digital transformation. This represents a 100% increase compared to last year's survey. The same percentage of companies is actively preparing for the application and will begin executing the implementation strategy soon. (Figure 1) The proportion of companies that work systematically on the implementation of the strategy is also increasing. While in 2017 and 2018 approximately one third of companies had adopted the implementation strategy, in 2019 it was already half of them. In its creation, a larger share is attended by separate departments and specialized teams in charge of strategy and application Industry 4.0. To a much greater extent, we are creating a corporate culture built on innovative management. Two thirds of enterprises apply Industry 4.0 in their own direction, but they are gradually starting to cooperate with multiple suppliers. The transformation rate is partly hampered by the lack of innovation potential, especially in the case of small and medium-sized companies with Slovak capital. A functioning innovation management system that brings real and significant improvements is now in place for 33% of companies. For the future, it is necessary to focus on accelerating the building of the innovation environment. Therefore, innovation is one of the most important components of both the industrial and governmental agenda and, accordingly, both sides should create the conditions for their development.

It is very important for the future of companies that the top management of companies should start to deal intensively with the strategy and management of transformation. Currently, only 25% of all respondents think that, and only less than 20% of top managers. One of the most pervasive and long-term problems that urgently needs the state to tackle is the lack of industry digitization experts. The market rightly claims to create new fields of study and support existing ones focusing not only on technology but also on processes and increasing the level of interconnection of the education system with practice at all levels of education. At the same time, more attention needs to be focused on raising the level of in-house training and staff development and the constant influx of information related to Industry 4.0 (Industry4UM, 2019).

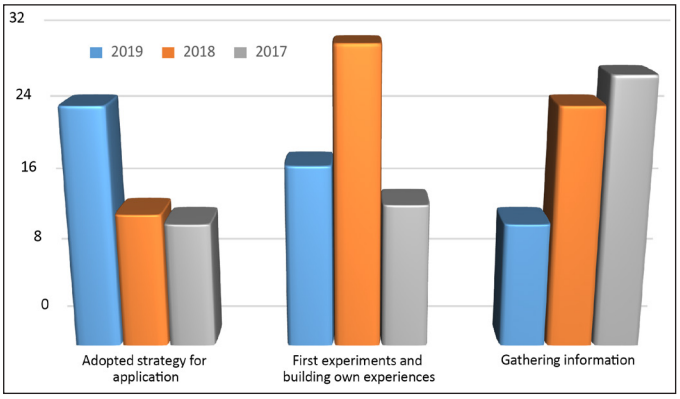

Fig. 1: The phase of application I4.0 within 2017–2019. ©Authors based on Industry4UM

Comparison of Slovak and German companies in the areas of opportunities and challenges within the application of I4.0

In order to find out the specific benefits and challenges of I4.0, we aimed our research at the survey in 2019 on 103 Slovak companies that are interested in I4.0 and want to use or already are using some components of I4.0. Currently, we present results with the response rate 27%. These companies had opportunity to express their attitudes to I4.0 readiness through structured questionnaire in 2019.

1. The first area of the questionnaire was focused on the benefits of I4.0.

The evaluations showed that more than 50% of companies chose as the main benefits: minimizing costs / low stock levels, flexibility, product / solution personalization and real-time monitoring of key areas / digitization. The less important benefits (under 10%) were identified: reduction of waste, use in building/facility management and increased protection in the case of accidents. This creates room for products and solutions that would cover these benefits, as predictive maintenance is becoming increasingly popular with manufacturing companies.

The advantage of predictive maintenance is to detect failures that are not visible to the naked eye and can thus increase plant productivity by 5 to 20%, as well as extend machine life or avoid costly production interruptions (Roubaud, 2017).

2. In the second important area, we investigated the risks of applying I4.0 technologies.

Around 50% of respondents reported terrorism and the risks associated with hacking attacks, as well as the risk of increasing IT security costs. Almost 47% of surveyed companies selected virus protection and early detection of virus penetration and finally over 45% stated data security and protection of sensitive information and business secrets.

Companies are aware of the need to protect themselves from external attacks, as the loss of sensitive data and know-how can have liquidation consequences. They also copy the concerns of global manufacturing companies, where 54% of respondents fear operational disruptions due to the security breaches (PWC, 2016). They also attribute a high level of risk and uncertainty (30%) to investment in education, research and development in relation to I4.0.

3. Other questions were addressed to the areas that companies perceive as a challenge or need for change in the preparation and application of I4.0. The need for change in the form of technical advancement is not surprising, especially if it is followed by the possibility of recruiting and developing new talents. This is largely related to the mentioned lack of technically educated staff and the shortcomings of the school system in Slovakia. According to the KPMG study (2018), Slovakia gained the lowest index in the human development factor – only 3.88 out of 10 which is significantly below average score (all other V4 countries gained 6.6 points or more). Companies often must settle for a less skilled employee, who is additionally trained, which affects additional cost. Another challenge for companies is the area of change, whether strategy or corporate culture, as well as changes to the overall business model.

In summary, we present the different areas of challenges selected by Slovak companies.

In order to know the specific benefits and challenges of German companies, we will mention Kiel et al. (2017) who conducted their own research in 2017, including 46 interviews with German business executives predominantly in the mechanical engineering sector. We summarized first 5 areas which were commonly perceived as the main benefits of I4.0 (Figure 3):

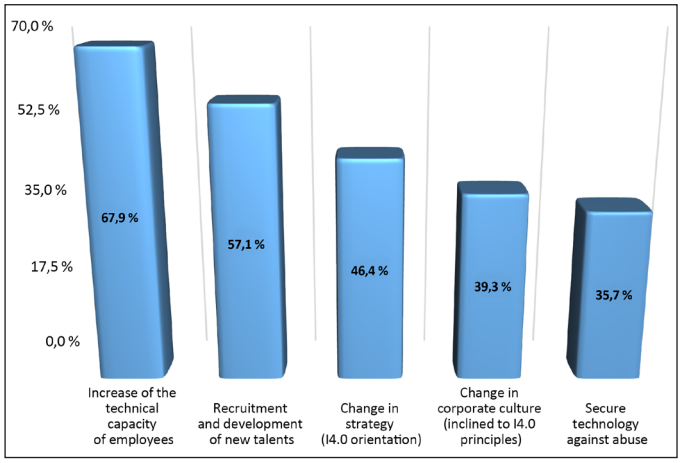

Fig. 2: The areas of challenges selected by Slovak companies. © Authors.

- competitiveness: namely expansion and protection of market shares, improvement of market dynamics enables to gain technological and market pioneering position, strategic differentiation and competitive advantages based on innovative offers.
- finance: improving value creation and increasing sales volume, potential for several cost reduction possibilities.
- overall equipment efficiency: product and process quality optimization, higher productivity, availability of machines, production processes and robustness of outputs, lower levels of waste / scrap and failures, self-optimization of machinery.
- new business models: value offerings based on hybrid product / service solutions, integration of software solutions, pay-for-use or platform-based models.
- resource efficiency: resource utilization optimization, digital simulations, continuous data and autonomous control loops allow for leaner process settings, reduced manual activities due to higher levels of automation.

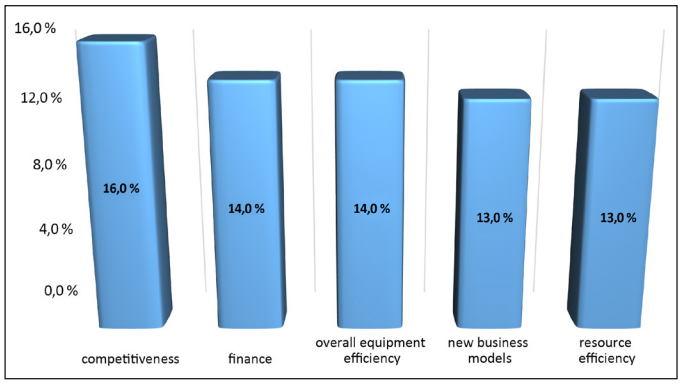

Fig. 3: The main benefits of I4.0. ©Authors based on Kiel et al.

The results of the evaluation of selected challenges and opportunities revealed interesting findings in the following areas (first 3 areas):

- 17% technical integration: implementation of modern IT infrastructure for intra-company and inter-company connection, integration of standardized communication protocols for data interfaces for industry, implementation of immature technologies threatens the quality of products and processes, as well as robust production.
- 15% organizational transformation: creating an adaptable and flexible corporate culture and hierarchical structure, engaging top management and the ability to convince internal corporate partners or stakeholders, such as interdisciplinary departments and employees from all hierarchical levels, interdisciplinary communication requires a consistent semantic understanding of I4.0.
- 13% data protection: data and information protection with respect to vertical and horizontal links across value chains, unsecured data makes companies vulnerable to cybercrime and industrial spying.

When comparing Slovak and German companies in the area of defined benefits, we can notice the difference in percentage evaluation of relatively similar areas. Slovak companies (with more than half of answers) mentioned cost minimization, lower stock levels and greater flexibility in terms of digitization. On the other hand, German firms agreed unambiguously in the field of competitiveness, whose higher level is achievable precisely using technology and innovation. Finance and overall resource efficiency have been identified as a major benefit resulting from process optimization, increased value added, waste reduction and others. Consensus on the results of both countries was the combination of resource efficiency through technology, automation, digitization and overall flexibility.

The second area focused on assessing the potential and opportunities of the I4.0 factors. In Slovak companies, the lack of technical skills of employees was clearly dominated, and therefore managers see the opportunity to increase the technical skills of employees. The potential is thus shown in the recruitment and development of employees. Another interesting area is the change in strategy and corporate culture that is inclined to the I4.0 principles. German managers cited technical integration from the perspective of implementing modern IT infrastructures as sources of potential. There was a consensus in response to improving corporate cultures set up to understand and apply I4.0 platforms. German managers put on the third place of I4.0 challenges data protection as an area for improvement and a challenge for the future.

CONCLUSION

Most people consider the I4.0 to be important and the real involvement of companies worldwide is growing, with companies starting to make small experiments and build their own know-how. As for Slovakia, the number of Slovak companies starting with Industry 4.0 is increasing. However, the level of transformation is different and varies from the size of companies and the business model itself. Small and medium-sized enterprises are beginning to enter the first phases of the application. The reason for this was identified as the lack of awareness of the I4.0 concept which is also a limitation in its development and successful implementation. Last survey revealed a more significant penetration of the philosophy of transformation into the corporate culture of enterprises. Companies are beginning to realize the importance of a dedicated team to manage the transformation agenda. They are also starting to create departments for innovation and smart solutions.

The Intelligent Industry Action Plan of the SR provides a set of measures that should be implemented by the end of 2020 (Ministry of Economy, 2018), the strategic objectives are clear and can be very helpful to motivate Slovak companies to raise awareness about the necessity of I4.0 concept.

In our research we focused on benefits, opportunities and challenges for companies resulting from application of I4.0. We asked managers to evaluate the benefits, among the most important the cost minimizing, product personalization and real-time monitoring were mentioned. As for challenges, they see the great potential in recruiting technical skilled employees, development of new talents and they perceive

as an opportunity change in strategy and corporate culture. These areas should be aligned with the principles of I4.0. The second part of questionnaire was aimed at risks and limitations of I4.0. As a big threat the companies stated the terrorism and hacking attacks, as well data protection. On the other hand, they expect that the costs for IT security will increase, which is a major limitation as well. When compared to German companies in the similar areas, we found out some small differences. German managers listed as great benefits the increasing competitiveness due to strategic differentiation and innovation potential. Moreover, they see huge challenge in implementing modern IT infrastructures and data protection. The similarity of both countries was in creating an adaptable and flexible corporate culture.

Industry 4.0 is closely tied to the corporate strategy and is therefore a topic designed for top management. As for recommendations resulting from the surveys, following steps should be taken:

- Every company should quickly start to deal with the principles of Industry 4.0, start with unpretentious, short-term projects, with a high probability of quick contribution.
- Adopt and apply the Intelligent Industry Strategy Action Plan of the Slovak Republic, which will support the development of Industry 4.0 in the Slovak industry.
- Integrate Industry 4.0 into the education system of secondary schools and universities to prepare experts.

By implementing all the measures adopted under the Intelligent Industry Action Plan, the Slovak economy will move towards a knowledge-based, innovation-oriented economy, but this also depends on the activities of the enterprises themselves. Businesses should be aware that investing in the training of their employees is an essential foundation in moving to successful digitization.

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