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***Abstract**. The main objective of this article is to describe and analyze the development and implementation of Industry 4.0 in industrial enterprises in Slovakia.*

Keywords. Industry 4.0, information technology, digitalization, new way in industry

Introduction

Today, information technology is one of the most important factors in innovation in manufacturing and automation (Waidner, Kasper 2016).
The growing world economy and the demand for customized products are transferring the production process from the market of sellers to the market of buyers (Galletta et al. 2018).

The term Industry 4.0 was first used in 2011 in the strategic material of the Federal Government of Germany, in its action plan within the scope of the project of high technology strategy (German Trade & Invest 2016). The origins of this initiative allied the German government with Siemens to promote the development of new technologies not only for the automation of industry but also of households. Other European manufacturing companies and countries have also joined this initiative, creating a phenomenon that has unexpectedly stirred up the debate and, consequently, also the interest in using new automation and robotics technologies. Industry 4.0, together with the term IoT (Internet of Things), has unified the hitherto relatively unclear direction of technology development (Vojáček 2016).

The bases to the fourth industrial revolution comes from new models of human work activities and work activities through the Internet. The consequences for society as a whole will then lead to the formulation of an initiative called Industry 4.0. The basis of Industry 4.0 comes from the new socio-economic behavior of people and human society, whose consequence and concurrently precondition are the necessary steps in technological preparation using the latest cybernetic and other modern technologies and methods. (Kolektív autorov 2017).

In this context, the smart manufacturing enabled by Industry 4.0 is changing the whole production cycle of companies specialized on different kinds of products. On one hand, the advent of cloud computing and social media makes the customers' experience more and more inclusive, whereas on the other hand cyber-physical system technologies help industries to change in real time the cycle of production according to customers' needs (Galletta et al. 2018).

Industry 4.0 is characterized by a "blending of technology that blurs the boundaries between digital, physical and biological spheres" Industry 4.0 marks a shift in the manufacturing industry for digitization and decentralization of premises from production halls to office spaces and across enterprise networks (Bendová 2018).

Basic principles of Industry 4.0 concept

- Interoperability - the ability of CPS, people and all Smart Factories to communicate with each other through IoT and IoS;
- Visualization - the ability to link physical systems with virtual models and simulation tools;
- Decentralization - decision-making and management takes place autonomously and parallelly in individual subsystems.
- Capability of working in real-time - real-time compliance is a key condition for arbitrary communication, decision-making and management in real-world systems.
- Service orientation - preferences of the computational philosophy of offered and used standard services that lead to SOA architecture type (Service Oriented Architectures).
- Modularity and reconfigurability - Industry 4.0 systems should be maximally modular and capable of autonomous reconfiguration based on autonomous recognition of the situation (Kolektív autorov 2017).

Changes in education and research for Industry 4.0

Reforming the education system at all levels is essential for a smoother transition to the new era. Changes that need to be made in education are recognized by all countries that have joined Industry

4.0 initiative and have begun not only to discuss the steps to be taken, but also to implement them (Holoubek 2017).

Government measures aimed at research support and development are not sufficient, they are non-systemic and marked by unacceptable errors linked to the Eurofund programs and subsidy schemes. Today we are dissatisfied that Slovakia does not have a functioning ecosystem of research-development-innovation and secured development of human resources in the necessary areas. The direction of scientific and research activities of state institutions and universities does not correspond to business efforts. The problem is the lack of objective availability of capital for all stages and levels of serious research and development. The Slovak industry is so acutely lacking in research and development that would generate intellectual assets in businesses, develop innovations and push it to a higher level of production and services. Only well-established mechanisms of state support and education system will help Slovak companies move forward in innovations, keep pace with the competitive environment, develop and contribute to sustainable economic growth (Bendová 2019).

Despite developments and long-term forecasts that the transition to Industry 4.0 will have a dramatic impact on the employment structure, not even 2018 did bring a major shift in addressing this issue. Lack of skilled workers, indifference to studying technical subjects, absent systems for

preparing school leavers for practical purposes, setting up retraining processes and lifelong learning programs are not only the most painful problems for employers, but have reached the level of alarming threat to the competitiveness of the Slovak industry. Automation and robotics of premises is beginning to be a solution to staff shortages. Companies are beginning to realize that if they want to be successful in the transition to Industry 4.0, employee education and training must become one of their key priorities. They are developing activities that will least partly help the unfavorable state, but without a functioning education system that reflects the needs of the practice, it will not work. Without well-trained people, we cannot talk about intelligent industry (Bendová 2019).

A decisive factor, that will enable active participation in the processes of the fourth industrial revolution will be an educated workforce in fields such as ICT and engineering, manufacturing and civil engineering. In 2015, the proportion of students in tertiary education (ISCED 5 - 8) in the ICT sector was 3.7% of all students, which was below the EU average of 4.4%. Slovakia ranks similarly in the sector of engineering, manufacturing and civil engineering, where it ranks among countries with a lower proportion of students. The below-average level of students in sectors ICT and engineering, manufacturing and civil engineering is also reflected in the lower number of graduates, where Slovakia is below average in comparison with the EU. The immediate imbalance in the labor market in the context of technological progress is stated by the ITAPA Association (IT Association Slovakia), which in October 2016 estimated the deficit of IT specialists in the Slovak labor market to be at 10,000. In 2020, this deficit is expected to rise to 20,000 IT specialists (SME 2016).

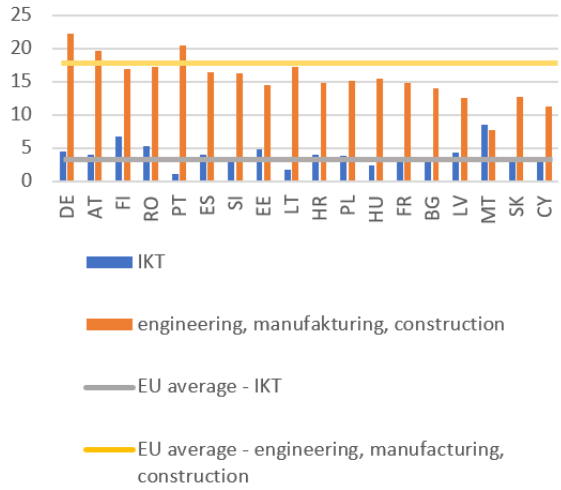

Figure 1. ICT and engineering, manufacturing and construction graduates (% of all university graduates) in European countries (Jeck 2017).

Transition to Industry 4.0

In the following section is a series of introductory solutions that help companies to manage the transition to Industry 4.0.

The solutions are divided into four steps - vertical networking, horizontal integration, so-called through engineering solutions, exponential technologies (Schlaepfer 2015).

1. Solutions of vertical networking

Figure 2. Solutions of vertical networking (Schlaepfer 2015)

Vertical networking solution	
IT Integration	The vertical networking of industry 4.0 requires new IT solution. New, combined solution need to be developed from a range of components from suppliers of sensors, modules, control systems, communications networks, business applications and costumer-facing applications.
Analytics and data management	Industry 4.0 will generate enormous quantities of data. Gathering, analysing and processing such big data will generate new insights, support decision-making and create a competitive advantage. Companies need to develop new specialist skills in the areas of analytics and efficient data management, and put new business processes in place on the basis of the insights that this analysis reveals.
Cloud-based applications	The simple networking of cloud-based solutions offers excellent opportunities to host and make efficient use of the big data generated by industry 4.0. Makes it simpler to gather, monitor, distribute and analyse data not only between factories but also across the entire global value chain network. This forms the basis for providing overarching market solutions that seamlessly integrate all stages from suppliers value chains to end customers and allows innovation beyond products.
„Operational efficiency 2.0“	The effective analysis, assessment and application of the data collected from machines and sensors enable rapid decision-making to improve operational safety, work processes, servicing and maintenance. Transparently not only makes development and production prosses more efficient but also offers substantial operational cost reductions for customers.

2. Solutions of horizontal integration

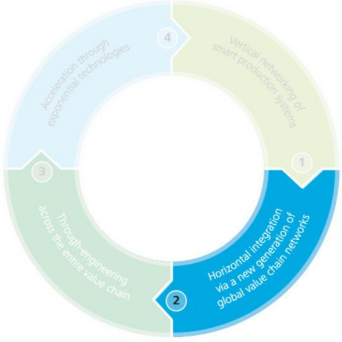

Figure 3. Horizontal integration solution (Schlaepfer 2015)

Horizontal integration solution	
Business model optimisation	Industry 4.0 means getting to grips with radical new approaches to business rather than merely making incremental improvements to established business models. Successful companies will develop new segments on the edge of their current business that will, in time, become central to the business.
Smart supply chains	The digital transformation will create a single database, making supply chains smarter, more transparent and more efficient at every stage, from customer needs to delivery. The most successful companies will use better communications to integrate suppliers and customers needs into all value-creation activities.
Smart logistics	In the wake of digitisation, logistics processes will have to become smarter right across new generations of global value chain networks. This applies to inbound logistics, intra-logistics and outbound logistics.
IT security management	Companies urgently need a tailored risk management system and security strategy geared to cyber security and aimed at improving operational security and protection from attack right across the value chain. New products, data, intellectual property and so on will have to be protected against unauthorised use and/or abuse.
New taxation models	In future 3D printing technology will allow the printing of products across countries and continents, with no physical crossing of national borders anymore. This will make new demands in terms of value-added tax and customs duty regulations.

New IP management	Management of intellectual property (IP) will also have to change as a result of the digital transformation to industry 4.0. New business models and new models for cooperation that arise as a result of industry 4.0 will require new, individual solutions to the digital IP issue.

3. Through engineering solutions

Figure 4. Through engineering solutions (Schlaepfer 2015)

Through-engineering solutions	
The „ten types of innovation“	Industry 4.0 will enable integrated and cross-disciplinary engineering throughout the value chain and throughout product and customer life cycles. Industry 4.0 applications are designed to help ensure that innovation is not limited to the traditional area of product innovation.
Efficient management of innovation	In project portfolio management, industry 4.0 solutions make it easier not only to track the return on investment (ROI) in innovation but also to identify risks by using global comparative project data for monitoring and remedial purposes. In the area of the product development, information technology can be used to speed up research and development. This transforms the sharing of information between existing technologies within global networks along the same lines as the „game networks“ that the global online gaming community use.
Efficient life cycle management	The digital transformation to industry 4.0 will make it possible to provide relevant data for life cycle management at any time and from anywhere. These data will comprise not only information and reports but also the results of big data processing to generate relevant early indicators through the use of artificial intelligence (AI). Al will use global cross-checking and assess the plausibility of generating relevant bases for decision-making supported by data.

4. Exponential technologies solution

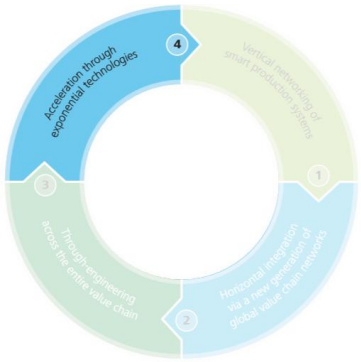

Figure 5. Exponential technologies solution (Schlaepfer 2015)

Exponential technologies solution	
Corporate venturing	Investing in start-ups enables companies to be involved in developing innovations and to secure their long-term competitiveness. Such investments allow early and convenient insight into new technologies. Companies need to give themselves more freedom to „look around the next corner.“ Only then, a new business area can be created that can become the new centre of the business in the future.
The learning organisation	Companies need to become learning organisations if they are to make full use of the potential of exponential technologies in achieving the digital transformation to Industry 4.0. The use and integration of exponential technologies need to be gradual but steady. Learning is the key to sustainable organisational development.

The Fourth Industrial Revolution and Slovakia

The Fourth Industrial Revolution is interacting with other socio-economic and demographic factors to create a perfect storm of business model change in all industries, resulting in major disruptions to labour

markets. New categories of jobs will emerge, partly or wholly displacing others. The skill sets required in both old and new occupations will change in most industries and transform how and where people work. It may also affect female and male workers differently and transform the dynamics of the industry gender gap. The *Future of Jobs Report* aims to unpack and provide specific information on the relative magnitude of these trends by industry and geography, and on the expected time horizon for their impact to be felt on job functions, employment levels and skills (World economy forum).

In Slovakia, companies do not have the choice whether to accept Industry 4.0 or not. Its acceptance is directly proportional to the company's competitiveness, and at the same time they must realize that it is a continuation of their development. A crucial factor for competitiveness in the near future will be flexibility and adaptability. Ability to adapt to changes, focus more on the customer and be ready to give them what they need, and often even in advance, before they realize it. For most companies it's necessary to first look for opportunities to reduce costs and a better use of resources. Industry 4.0 is perceived as an evolutionary process. (Morháč 2018).

According to Jeck's research, Slovakia's largest barriers to the introduction of Industry 4.0 are those listed in chart 2 and represent 25% of the EU average and less. This category includes risk capital exposures (5.8% of the EU average 28), R&D corporate expenditure (27% of the EU average 28), product or process innovations of SMEs (21% of the EU average 28). In the field of intellectual property, industrial designs have a very low number (23% of the EU average 28). The low level of innovation can be the result of the existence of multiple barriers. In the case of the Slovak manufacturing industry, it turns out that non-innovating companies see barriers especially in the area of financial resources (Jeck 2017).

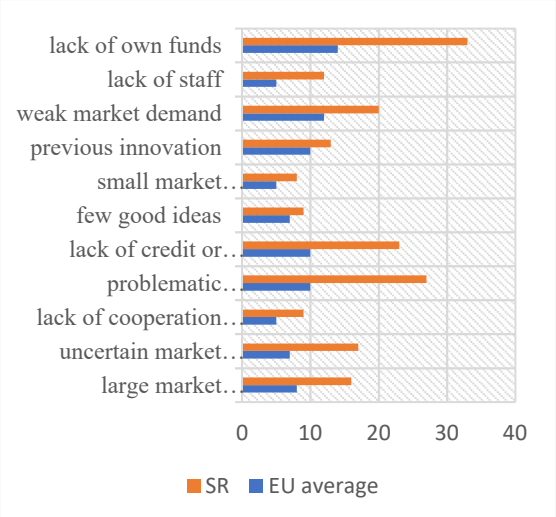

Figure 6. Slovakia's largest barriers to the introduction of Industry 4.0 (Jeck 2017)

As a result of unfavorable conditions created by the state, Slovakia has been for long ranking among the last in European innovation charts. The state should under the ever-increasing pressure of companies and global competitiveness demands realize in the short term that supporting innovation and science is an investment for Slovakia and a fundamental pillar of maintaining business competitiveness (SOVA Digital 2017).

In October 2018, the government of the Slovak Republic approved 35 measures to support the construction of infrastructure for the development of intelligent industry prepared by the Ministry of Economy of the Slovak Republic (MH SR). The measures are part of the Smart industry conception, which is an anticipated material responding to industry's current needs and development plans. Real and functional support from the state should be an impulse for starting up the next steps of enterprises in digitizing and automating operations and supporting their growth. In addition to comprehensive system measures for industry, which will regulate legislation and standardize the industrial environment, especially small and medium-sized Slovak enterprises need significant assistance from the state (Bendová 2019).

Evaluation of Industry 4.0 survey in Slovakia

The expert forum, which leads a long-term dialogue with Slovak companies on new technological trends, has conducted a survey on the application of the Industry 4.0 concept in Slovak industrial enterprises. Findings have revealed that Slovak companies understand the importance and impact of technological changes, and while many have already started implementation, there are still many that do not know how to handle the problematics and where to start. The survey captured the demands for even more discussion at the professional level and for guidance for both strategic and implementation phases to be strengthened (SOVA Digital 2017).

The figure 7 shows the opinion of companies on the importance of Industry 4.0. Two thirds of companies realize the importance of Industry 4.0 applications for their future development. However, a relatively large proportion of respondents consider the importance of Industry 4.0 applications to be less critical to the company's future. Industry 4.0 is still a mythicized issue and is being questioned from a variety of perspectives, bringing attitudes about not too big importance and impact on businesses. It is related to the understanding and interpretation of the concept itself, as well as to the misunderstanding of trends, but also to media interpretations and superficial presentations of the theme (Quark 2017).

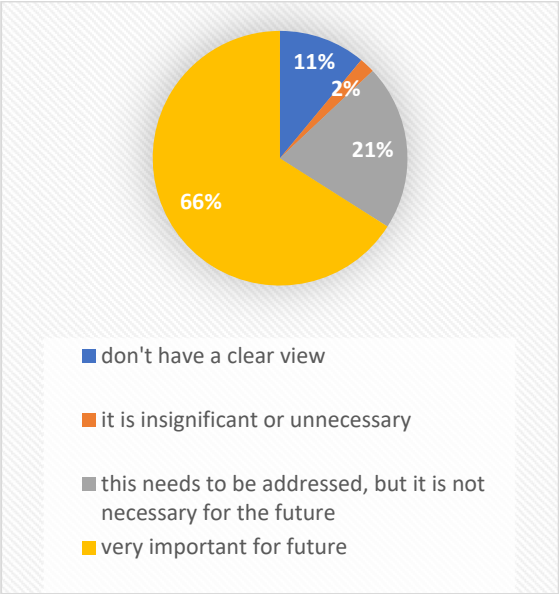

Figure 7. The opinion of companies on the importance of Industry 4.0 (Own processing based on SOVA Digital a.s.)

Revue industry analyst Martin Jesný said that the specificity of the survey was based on the fact that it was prepared by a team of experienced specialists who have long been dealing with issues of innovation, technological development and Industry 4.0. Initial survey enabled to start monitoring on an interesting group of businesses, how the use of the intelligent industry principles in practice is progressing. Industry4UM will be monitoring over the long term and findings will be used to plan actions that will accelerate progress in this important industrial phenomenon (SOVA Digital 2017).

Currently, two thirds of companies in Slovakia have reached the stage where they are in the real implementation of Industry 4.0. Martin Morháč, as chairman of the board of directors of SOVA Digital, reports that Industry 4.0 implementation is in progress, but the pace is not equal in all processes and technologies. This means that, despite the fact that Industry 4.0 is becoming a priority in most businesses, it is not yet perceived as a necessity, and a large proportion of companies are just beginning to think about solutions (SOVA Digital 2017).

The figure 8 shows the implementation rate of Industry 4.0 in Slovakia.

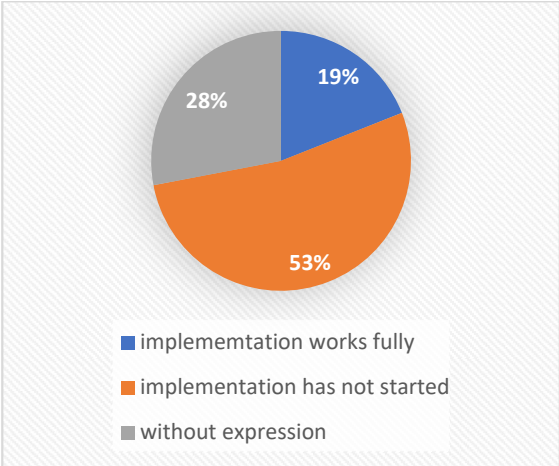

Figure 8. The implementation rate of Industry 4.0 in Slovakia (Own processing based on SOVA Digital a.s.).

Industry 4.0 forecasts in 2019 in Slovakia

In the current year, we expect continuity in the transformation processes under way, the visions of company development and the development of more comprehensive Industry 4.0 strategies. On them, companies will place primary emphasis on manufacturing and logistics processes and maintenance issues. We expect increasing pressures on education, labor market and support of research and development apparatus. There will be even more urgent demands for changes to the organization and management of businesses in the context of area changes, as well as the establishment of specialized departments and teams in charge of preparation of Industry 4.0. In the segment of small and medium-sized companies with Slovak capital, we expect a more sophisticated approach to preparation of transformation strategy and its implementation concepts. Overall, the introduction of the baseline measures of the action plan for the Smart industry conception of the SR into reality should help the market. In 2019, Industry4UM will continue to carry out the transfer of knowledge and usable information to companies in the form of Industry4UM discussion meetings, as well as other targeted educational and information formats, also aimed at secondary schools and universities. It will also continue in the analyses and surveys of the implementation of Industry 4.0 into Slovak enterprises. Industry4UM experts are ready to continue to help ensure the implementation of the action plan for 2020, and to participate in the preparation of further systemic measures to support smart industry (Bendová 2019).

References

Bendová, A. (2019). *Čo priniesol slovenským podnikom rok 2018 v Industry 4.0.* Retrieved from https://industry4um.sk/co-priniesol-slovenskym-podnikom-rok-2018-v-industry-4-0/; (Accessed: 06 June 2019)

Galletta A. et al. (2018). *A Cloud-Based System for Improving Retention Marketing Loyalty Programs in Industry 4.0: A Study on Big Data Storage Implications.* Retrieved from http://www.ieee.org/oublications_standards/publications/rights/index.html; (Accessed: 06 June 2019)

GERMAN TRADE & INVEST, SHARMA Asha-Maria. (2016) *Industry 4.0*. ISBN 978-92-823-8815-0. Brussels. Retrieved from http://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf; (Accessed: 06 June 2019)

HOLOUBEK, J. (2017). *Zavádení Prumyslu 4.0 bude v menších firmách postupné*. In Moderní řízení. Praha: Econimia, roč. 52, č.3, s. 18-19. ISSN 0026-8720

Jeck, T. (2017). *Slovenská ekonomika a štvrtá priemyselná revolúcia: faktory a predpoklady*. Retrieved from http://www.ekonom.sav.sk/uploads/journals/373_wp_4_priemyselna_a_sk_final.pdf; (Accessed: 06 June 2019)

K Industry 4.0 your smart (r)evolution (2018). *O Industry 4.0*. Retrieved from http://industry4.sk/industry-4-0; (Accessed: 06 June 2019)

Kolektív autorů. *Průmysl 4.0, Vzdělávaní 4.0, Práce 4.0 a Společnosť 4.0.* Praha. Českomoravská konfederace odborových svazú. ISBN: 978-80-86809-23-6

Morháč, M. (2018). *Priemysel 4.0 zásadne zmení trh. Šikovní to využijú.* Retrieved from: http://www.ezisk.sk/clanok/priemysel-4-0-zasadne-zmeni-trh-sikovni-to-vyuziju/4322/; (Accessed: 06 June 2019)

QUARK.(2018). *Industry 4.0 na Slovensku*. Retrieved from www.quark.sk/industry-4-0-na-slovensku/; (Accessed: 06 June 2019)

Schlaepfer, R. et al. (2015). *Industry 4.0 Challenges and solutions of digital transformation and use of exponential technologies.* Zurich: Deloitte AG.

SME Ekonomika. (2016). *Slovensku chýba asi 10-tisíc IT špecialistov.* [online]. Retrieved from https://ekonomika.sme.sk/c/20359845/slovensku-chyba-asi-10-tisic-it-specialistov.html; (Accessed: 06 June 2019)

SOVA Digital a.s. (2017). *Vyhodnotenie prieskumu Industry 4.0 v SR*. Retrieved from: https://www.plasticportal.sk/sk/vyhodnotenie-prieskumu-industry-40-v-sr/c/4676/; (Accessed: 06 June 2019)

Vojáček, A. (2016). *Co se skrýva pod výrazy Industry 4.0/Průmysl 4.0?* In: automatizace. Retrieved from https://automatizace.hw.cz//mimochodem/co-je-se-skryva-pod-vyrazy-industry-40-prumysl-40.html; (Accessed: 06 June 2019)

Waidner M., Kasper M. (2016). *Security In Industry 4.0 – Challenges and Solutions for the Fourth Industrial Revolution.* Published by: 2016 Design, Automation & Test in Europe Conference & Exhibition (DATE)

World economy forum. (2018). *The Future of Jobs.* Retrieved from http://reports.weforum.org/future-of-jobs-2016/?doing_wp_cron=1561702766.1271970272064208984375; (Accessed: 06 June 2019)