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The impact of digitalization and Industry 4.0 on the optimization of production processes and workplace ergonomics

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Abstract: Terms such as *Industry 4.0*, *Logistics 4.0*, *smart factory*, *smart logistics* as well as *digitalization* can nowadays be regarded as keywords in both scientific and economic practice. What is taking place at the moment is the beginning of the fourth industrial revolution, which is driven by rapid technological advancements, especially visible in the field of digital transformation, autonomous machines or fully automated warehouses. Strong competition on the domestic and foreign market and growing customer expectations suggest that manufacturing companies should not only increase production on a constant basis, but they should find also a way to personalize it, which means manufacturing short series of products designed to meet the needs of specific customers, but also personalizing human work itself. In this system, or a kind of set-up, the role of the human and the consequent workload associated with a given job change. Technology is increasingly replacing not only physical human work, but also human beings as decision-makers. It is giving rise to completely new situations, in which it is necessary to search for new forms of cooperation between human beings and the technological/ environmental ones. This kind of production is the ultimate goal of the fourth industrial revolution. The purpose of this paper is to analyze the impact of digitalization and Industry 4.0 on the optimization of production processes, supply chain and human work. The authors discuss the concept of Industry 4.0, hence the fourth industrial revolution concerning system integration and networking. They present the assumptions of Logistics 4.0 and include adaptive, resource-efficient and user--friendly approaches, concepts. The authors also discuss the application of Lean management in the concept of Industry 4.0, and the ergonomic inclinations of the individual pillars of Industry 4.0. The conclusion summarizes the considerations on the impact of digitalization and Industry 4.0 on the improvement of production processes and work ergonomics.

Keywords: Industry 4.0, production process, ergonomics at work

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1. Introduction

The *4.0* term is increasingly being used in various areas of human activity and in different fields of knowledge. Other related terms such as *Industry 4.0*, *Logistics 4.0*, *smart factory*, *smart logistics* as well as *digitalization* can nowadays be regarded as keywords in both scientific and economic practice. What is taking place at the moment is the beginning of the fourth industrial revolution, which is driven by rapid technological advancements, especially visible in the field of digital transformation, autonomous machines or fully automated warehouses. The influence of *Big Data*, a term referring to large, variable and diverse sets of data, is enormous and is making companies face tremendous challenges. A further level of complexity is appearing due to the inevitable transformation of various industries, companies and logistics, which forces a given company to adapt by introducing systems based on cyber-physicality and to remodel the whole structural organization and all techniques used within it. The purpose of this paper is to analyze the impact of digitalization and Industry 4.0 on the optimization of production processes, supply chain and human work, starting with placing orders and supplying manufacturing plants with components and finishing with shipping goods to customers. The processes of integrating systems and creating networks of deliveries as well as integrating the humans, machines and technology result in a synergy between the individual elements of production processes. In this system, or a kind of set-up, the role of the human and the consequent workload associated with a given job change. Technology is increasingly replacing not only physical human work, but also human beings as decision-makers. It is giving rise to completely new situations, in which it is necessary to search for new forms of cooperation between human beings and the technological/ environmental ones.

2. Industry 4.0 as a modern trend in the organization of production processes

At the moment a considerable number of companies are still uncertain and indecisive as to how to interpret the concept of Industry 4.0. This idea originates from the project *Forschungsunion Wirtschaft-Wissenschaft* and was presented for the first time during the trade fair in Hannover in 2011. Industry 4.0 is the ultimate goal of the German industry, which should be responded to globally. This strategy aims at protecting the technological leadership and the visionary role in the industrial production (Schäfer and Pinnow, 2015). This idea will undoubtedly become a revolution and will have an impact on the first half of the twenty-first century. Germans are particularly predisposed to the development of smart production and logistics that are referred to as 4.0.

The concept of Industry 4.0 aims at integrating smart machines, systems and making it possible to introduce changes in production processes. The purpose of this strategy is to increase performance effectiveness and introduce the possibility of flexible changes in the offered range of products. This concept does not rule out the creation of new ways of working and a new role of human recourses in the production process, and furthermore, it is a significant pillar besides technologies implemented into production processes by companies (Bousonville, 2017). The term *4.0* was secondarily developed for the needs of German business and it

is mostly used there, although it has already started to spread to other linguistic areas. In the English literature on the subject the terms such as *smart factory* or *smart manufacturing* are approved and most commonly used, and in some areas they are synonymous to the German concept of Industry 4.0 (Bounsoville, 2017).

The suffix 4.0 denotes the fourth industrial revolution (Figure 1) and is the beginning of the ubiquitous digitalization processes nowadays. The previously mentioned three industrial revolutions were caused by (Bauerhansl et al., 2014; Industry 4.0, 2018):

a) 1.0—the development and introduction of the steam engine, and the subsequent mechanization of production (partial replacement of human workforce with mechanical production) and the development of railroads in the second half of eighteenth century (the industrialization era);
b) 2.0—the use of electric power (steam engines were supplanted by electric motors) and a new division in forms of labour in the organization of mass production (the electrification era);
c) 3.0—production automation after the Second World War, achieved by the growing use of electronics and computer technology in the form of CNC machines and industrial robots (the digitalization era). Faster and more efficient computers or data processing systems had a significant influence on controlling machines by means of computer software. Thanks to such efforts machines became more efficient, whereas the digitalization process facilitated automation.

The factors that helped to achieve complete digitalization include: improvement in efficiency, miniaturization and a cost-effective manufacturing process with the use of sensor technology, data transmission technology and display screens. Thanks to such efforts, there has been an increase in capacities of storing, transferring or processing large amounts of data (Janewers, 2017). As a result, diverse data is accessible in a digital form nowadays.

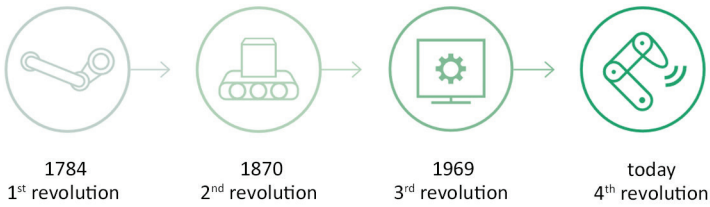

Figure 1. States in the development of the concept of Industry 4.0

S o u r c e: Astor, 2018.

The concept of Industry 4.0, which means the fourth industrial revolution, refers to the integration of systems and creation of networks. The crux of this approach is the integration of humans and digitally-controlled machines, with the simultaneous use of the Internet and information technologies. The benefits of implementing and acting in compliance with this concept result, above all, from coordination activities. The demand for effective production coordination that goes beyond a given company is treated as the background of high technological pressure in the industrial practice (Jahn, 2016).

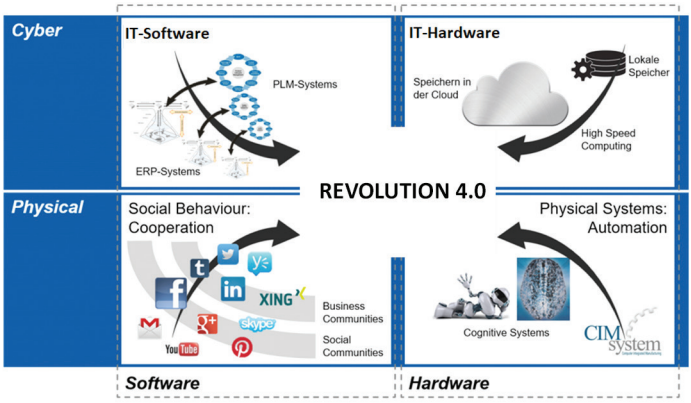

Figure 2. Areas of the fourth industrial revolution

S o u r c e: Voss (ed.), 2015.

In the literature on the subject it is sometimes claimed that Industry 4.0 can be understood as a potential of the fourth industrial revolution (Figure 2). Four technological areas of this revolution should be distinguished, namely (Prosence):

a) technological area 1—Single Source of Truth;
b) technological area 2—globalization of IT;
c) technological area 3—automation;
d) technological area 4—cooperation.

The basis of the concept is the availability of all the essential information in real time by connecting all the participating links inside and outside the company while the added value is assessed, and the ability to create optimal flow of materials and information from available resources at any time (Czaja, 2016). Connecting people, facilities and systems makes it possible to develop dynamic, time-effective and self-organizing networks for creating an added value. Such networks can be optimized on the basis of such criteria as costs, availability and resource consumption (Industrie 4.0, 2018).

The literature on the subject abounds with numerous definitions which touch the meaning of Industry 4.0 as a synonym for the development of production processes and value added chains by connecting the physical and digital worlds. From the technical point of view, this concept relies on the so-called cyber-physical systems (CPS) implemented into the communication structures within the Internet of Things and Services. The subject matter of the Industry 4.0 concept are physical components called entities (machines), which, in the process of being integrated with the computer capacity and being connected to the Internet, form CPS systems (Figure 3). Thanks to this an entity becomes an intelligent and active entity which perceives its surroundings and is able to influence them. Such entities are equipped with communication modules which make it possible to transmit and receive data. Owing to this, the integration of factors in the process of creating an added value within the manufacturing chain takes place at the moment of product lifecycle planning from pre-use to post-use inside or outside the company. In accordance with this observation, intelligent devices autono-

mously organize logistics production processes (Bayme vbm, 2018). Basically, the following features of CPS systems can be distinguished:

a) identification;
b) sensory data collection;
c) tracking position;
d) data processing and control;
e) network communication.

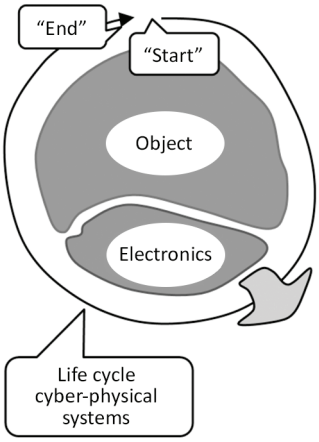

Figure 3. Cyber-physical system of the concept of Industry 4.0

S o u r c e: Fischer, 2016.

To sum up, a CPS system is concerned with the connection and synchronization between production in a physical meaning of the word and its digital representation. This process occurs in the centre by means of sensors which are able to communicate with each other. These sensors transmit their data to systems equipped with software where they can be processed, as a result of which information can be obtained. Apart from completely new business models, vertical networks of implemented systems offer considerable prospects in the field of production and logistics (Fischer, 2016).

3. Logistics 4.0—industry which is on the move

Nowadays logistics should be regarded as the crux of business processes. Globalization and digitalization enhance the flow of goods between companies, and even to final users (Pocket, 2016). Today's challenges faced by logistics are more serious. The digital revolution has accelerated not only communication between people, but it is also revolutionizing logistics. The development in information technologies used in logistics is a driving force of changes, digitalization or innovation. It can be witnessed in various functional areas of logistics, and especially in the area of fast-growing e-commerce. Owing to simplified ways of shopping, selling and distribution based on online trading platforms, there has been an increase in demand for supply and distribution structures not only in the area of industry, but

also in the area of consumer goods markets where networks of supply chains between manufacturing and sales markets are created. The trending decline in the significance of dominant factors, such as time and place, is being observed. It is mainly caused by transport processes, which take into account customer requirements, goods availability and the quality of deliveries. What should also be taken into consideration is the implementation of various modes of transport into the concept of shipment processes.

All the involved supply chains should be compared separately and depending on individual purposes. Supply chains in B2B and B2C models mix together and intersect each other, which implies an increase in their development complexity. Due to globalization processes and ubiquitous industrialization processes the following steps should be taken into account: time and cost optimization as well as reduction in the CO_2 emissions.

On the account of the changes in industry structure and organization, changes in services connected with industry, and especially with logistics and transport are also appearing. Such changes can be diverse. A number of more important aspects are given below (IND4LOG4, 2015):

a) digitalization contributes to a bigger integration of logistics and transport with industry, transport processes play an important role in production process management;
b) technology in the area of vehicle technology (conducted separately) and extensive automation of logistics operations (in connection with robotics) are changing the classic business models of logistics and transport economy and are leading to the consolidation within this line of business;
c) automation is leading to the disappearance of classic operations in the area of transport and logistics, the loss of less skilled jobs is taking place, although, on the other hand, it involves creating new jobs in the area of information technology.

On the basis of the abovementioned development tendencies, the concept of logistics digitalization, nowadays referred to as Logistics 4.0, can be formulated. The so-called fourth industrial revolution, which also influences logistics and transport processes in companies, is happening thanks to individualization (in serial production) or hybridization (connecting production and services) as well as the integration of customers and business partners. Logistics 4.0 should be understood, defined in a narrow sense, as a connection of processes, data and systems into a joint supply chain of all the participant companies. Collaboration and cooperation of all the participants in a given supply chain facilitates its optimization.

Logistics 4.0 includes approaches, concepts and adaptive technologies, which are resource-efficient and user-friendly. Their implementation has an influence on the development of sustainable forms of transport and logistics. The emphasis is placed on both horizontal and vertical integration of an added value. Connecting both digital and physical technologies is also essential in this case (Filler, 2014). In order to satisfy customers' high requirements in relation to individualization and flexibility, the following approaches are applied:

a) new automation concepts;
b) self-optimization, self-configuration, self-diagnosis;
c) Internet of Things, which combines all systems, vehicles, companies, employees, and customers.

The concept called Internet of Things is particularly important. Internet of things, services and data is currently becoming an infrastructure which defines the next industrial revolution.

Thanks to a consistent and continual process of making connections between digital and physical worlds, the growing dynamics and complexity are becoming exceptionally easy to control. The extent of decentralization and self-organization increases with the complexity of the system. The Internet of Things is a concept that involves connecting objects with the Internet, the purpose of which is to enable communication in the area of data exchange, transmission of warning messages or messages concerning failure rates (Sendler, 2018). The level of digitalization in selected countries is presented below (Figure 4). The factors which were subject to assessment include: strategy, product, sales and value stream mapping.

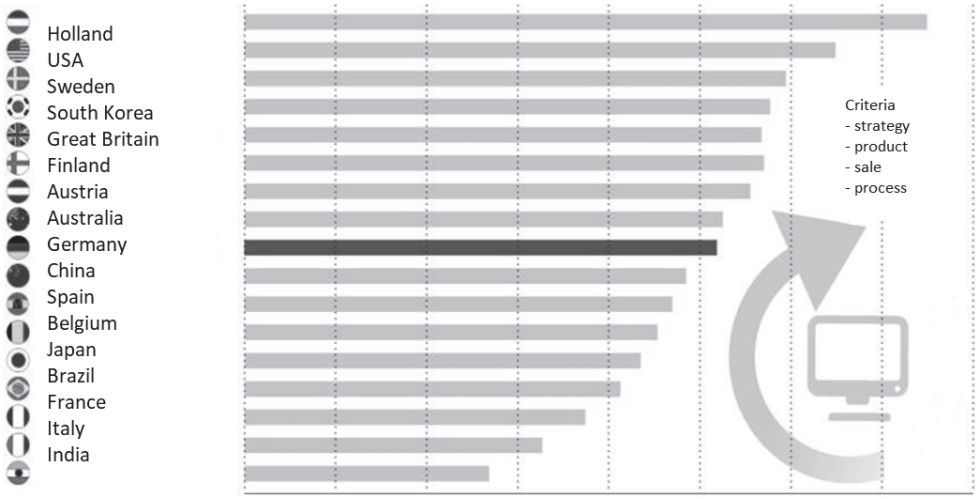

Figure 4. The index of digitalization in 100 leading companies carrying business activity

S o u r c e: Becker et al., 2017.

The process of digitalization should be perceived as a future trend for the development of industry and logistics. It is based on information systems which make it possible to increase functionality and create a network of contacts.

It is worth taking the opportunity here to pay attention on the individual activities and their characteristics implemented as part of the Logistics 4.0 and Industry 4.0. The concept of logistics is undoubtedly a significant factor in activating the concept of Industry 4.0. Logistics processes are subject to integrating and merging processes through the consistent use of Internet-based technologies. Apart from the main logistics processes, support systems and devices equipped with artificial intelligence are also included in the logistics networks. The use of the Logistics 4.0 concept enables the improvement in competitiveness by shortening reaction times and the flexible production of diverse and customer-tailored products with a minimum use of specific resources.

Companies should achieve a high degree of maturity in the following areas in order to be able to introduce subsequent stages of automation, merging and interpenetration of IT systems (Benfer, 2016):

a) management of permanent data (as the central assumption for each process controlling, these processes run in a decentralized and automatic way and are required in relation to completeness, correctness and up-to-dateness of data, the purpose of which is to transparently deal with situations on an ongoing basis);
b) product standardization (in order to be able to achieve the highest possible degree of flexibility, companies should appropriately adapt their product structures accordingly);
c) process-oriented organization of the company (the classic task of logistics optimization involves making fast deliveries of customer-oriented products, there are "agile" processes in keeping with the "lean management" philosophy as an ideal basis for further development of Industry 4.0);
d) IT support given in real time while orders are planned (transparency and up-to-dateness in the area of order entry and construction, procurement processes and after-sales service must be guaranteed in order to be able to make decisions concerning the goods flow and the production control based on simulations carried out in real time). Basically, Logistics 4.0 leads to higher complexity (Wegner and Wegner, 2016).

4. Industry 4.0 and lean management as the concepts of modern economy

The starting point for the following deliberations is a contrastive perspective on the relationship between Industry 4.0, the digital factory and lean management (Figure 5). Both digitalization of the factory (based on IT technologies and the concept of the Internet of Things) and the lean management tool (mainly focused on the process and organization) create a traditional assortment of tools with the help of which a significant improvement in productivity is possible.

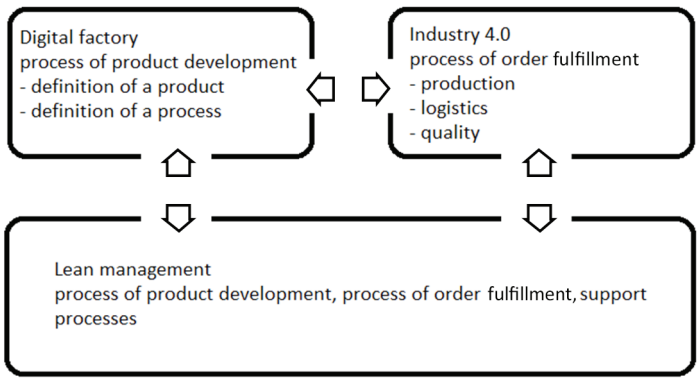

Figure 5. Instruments of production processes optimization

S o u r c e: Authors' own elaboration.

As far as machine-to-machine communication is concerned, individual machines exchange data among each other, and the same exchange takes place among robots in production processes. This communication, resulting from the interaction, offers possibilities of optimization or correction, and thus a reduction in complexity. Due to the fact that more and more

discussions about connecting machines to the Internet or using data clouds are being held, IT protection plays a significant role. In addition, if there is no connection to the Internet, appropriate measures should be taken to eliminate the spread of viruses on computers and possible damage that such viruses can cause (Andelfinger and Hänisch, 2017).

It is particularly important to carry out a factual and temporary integration of all the information, which means nothing less than information being matched within an appropriate period of time. Therefore, in order to be able to bring large amounts of data under control, it is necessary to use such technologies as InMemory or Big Data (Fasel and Meier, 2016). As far as integration processes are concerned, horizontal and vertical integrations should be mentioned. They are concerned with integration towards suppliers and customers, or, possibly, integration through individual processes within the company.

Whereas the basis of lean management and, in this case, lean production is the continuous process of eliminating waste, standardizing flows, reducing the level of stock to the absolute minimum and centralizing the customer service (only what the customer wishes is produced) and, as a consequence, it is achieving high flexibility.

Below there is a synthetic list of the common areas for the concepts of lean management and Production 4.0 and their selected discrepancies. As far as the common areas are concerned, the most important ones should include (Lödding et al., 2017):

a) standardization;
b) customer-orientated approach;
c) staff training;
d) flexible production;
e) decentralized production planning;
f) conservative handling of resources;
g) modularity and reusability;
h) high requirements in problem-solving skills.

It is worth noting that the above-mentioned concepts do not contradict each other but, on the contrary, they follow common goals. Industry 4.0 implements many principles of the concept of lean management, using the Internet consistently. Indeed, Industry 4.0 constitutes a further level of development in industrial production, which has its roots in the concept of lean management.

The following key areas are mainly responsible for the implementation of the 4.0 Industry concept (Göpfert et al., 2017):

a) robotics (increasing flexibility, easy and intuitive operation and programming, intelligent controlling);
b) automation technology and production systems (cyber-physical systems, decentralized controlling and the ability to self-configure, a complete connection of devices and machines with the production system);
c) IT (security, Big Data, InMemory, mobile solutions, real time enterprise, digitalization as well as vertical and horizontal integration);
d) logistics;
e) sensory integration (inherent and integrated intelligence, real time, reliability).

5. Industry 4.0, and ergonomics of work in a changing environment

Bringing about changes in work processes, Industry 4.0 is an extraordinary challenge for broadly defined ergonomics, and at the same time, it is an answer to earlier problems of ergonomics. It is not insignificant to note that it was Germany where the work on developing the concept of Industry 4.0 began. It is one of the oldest countries in the world, with an average age of over 47 (CIA, 2018). For this reason, dynamic changes brought about by the concept of Industry 4.0 can be considered both in terms of threats and opportunities for the ergonomic aspects of production processes. Table 1 lists the previously discussed pillars of approach with the opportunities and threats associated with them.

Table 1. Ergonomic inclinations of individual pillars of Industry 4.0

Pillar—impact area	Opportunities and advantages of implementation	Possible threats
Robotics (increasing flexibility, easy and intuitive operation and programming, intelligent controlling)	– Eliminating the physical and psychological burden imposed on the worker – Moving humans away from the production process or, in the field of cooperating robots, cooperating in order to supplement human abilities – Reducing production costs – Reduction of production time – Increase in capital from sales	– Dependence on technologically advanced robotics – Population-wide loss of human ability to produce things (in the event of a robot failure, it can not be replaced) – Introducing the robot into the production line where people are still working, it is necessary to take into account the differences resulting from the work conditions of individual units
Automation technology and production systems (cyber-physical systems, decentralized controlling and the ability to self-configure, a complete connection of devices and machines with the production system	– Psychological relief resulting from technological solutions derived from AI – Access to the latest solutions	– Increased complexity of systems – Dependence on qualified automation personnel – The most monotonous jobs will be carried out by robots, and people will take on the role of specialists who are to programme and supervise the processes carried out by the machines
IT (security, Big Data, InMemory, mobile solutions, real time enterprise, digitalization as well as vertical and horizontal integration)	– Relieving people of information processing tasks – The ability to filter information and to give operators only selected information using algorithms	– Loss of the ability by the operators to process information – Making it difficult to check whether the decision-making process has been carried out in accordance with the adopted criteria

Table 1. Ergonomic inclinations of individual pillars of Industry 4.0

Pillar—impact area	Opportunities and advantages of implementation	Possible threats
Logistics	– Eliminating dependency on cheap labour – Humanization of work—work will be more developmental – Reducing transport costs	– Lack of jobs for people with the lowest qualifications, including people who cannot acquire new ones (e.g. people with intellectual disabilities) – Higher costs of purchasing specialized machines
Sensory integration (inherent and integrated intelligence, real time, reliability)	– Bringing relief to the human sensory system – Eliminating long-lasting and monotonous supervisory work	– The system recognizes only the predicted types of situations (programmed errors, until the machines learn to recognize unpredictable and contextual situations)

S o u r c e: Authors' own elaboration.

A very important reason why human presence in production processes should be limited is that it reduces the risk of the human fallibility and the risk of exposing the human to situations where there is a high probability of committing mistakes by them (Butlewski et al., 2015). The consequence of the continuous pushing of humans out of production processes requiring skills possessed by machines, such as reaction speed, inability to get tired, repetitiveness should be an introduction of a new concept of cooperation based on the principle of sharing responsibility (Butlewski, 2017). Ultimately, technology aims to support the human giving them a sense of control, which will create reliable production systems.

6. Conclusion

High production efficiency, low costs, good quality assurance as well as a wide variety of products and the ability to easily change the scope of business activity are the main goals of today's manufacturing companies. Since the beginning of the industrial history, these goals have been achieved thanks to new technological solutions and human labour. Many of them have brought about revolutionary changes in industry, consequently leading to economic, social and cultural changes, as well as changes in work ergonomics.

Strong competition on the domestic and foreign market and growing customer expectations suggest that manufacturing companies should not only increase production on a constant basis, but they should find also a way to personalize it, which means manufacturing short series of products designed to meet the needs of specific customers, but also personalizing human work itself. This kind of production is the ultimate goal of the fourth industrial revolution.

References

Andelfinger, V., Hänisch, T. (eds.). (2017). *Industrie 4.0. Wie cyber-physische Systeme die Arbeitswelt verändern*. Wiesbaden: Springer Gabler. ISBN 9783658155568.

Astor. (2018). Official website [online, accessed: 2018-03-10]. Kraków: Astor. Retrieved from: www.astor.com.pl.

Bauernhansl, Th., ten Hompel, M., Vogel-Heuser, B. (eds.). (2014). *Industrie 4.0 in Produktion, Automatisierung und Logistik. Anwendung, Technologien, Migration*. Wiesbaden: Springer. ISBN 9783658046811.

Bayme vbm. (2018). Official website [online, accessed: 2018-03-10]. Retrieved from: www.baymevbm.de.

Becker, K. et al. (2017). *Digitalisierung des Einkaufs und der Logistik*. Kiel: Fachhochschule.

Benfer, D. (2016). Industrie 4.0 verwirklichen. *Logistik Heute*. 12–13.

Bounsoville, T. (2017). *Logistik 4.0. Die digitale Transformation der Wertschöpfungskette*. Wiesbaden: Springer Gabler. ISBN 9783658130121.

Braun, T. (2017). *Chancen und Risiken von Industrie 4.0 für kleine und mittlere Unternehmen*. Hamburg: Diplomica Verlag. ISBN 9783961465408.

Butlewski, M. (2017). Taxonomy of responsibility allocation in Human-Machine Systems with different levels of automation. *MATEC Web of Conferences*, *137*, 01002. DOI: 10.1051/matecconf/201713701002.

Butlewski, M., Jasiulewicz-Kaczmarek, M., Misztal, A., Sławińska, M. (2015). Design methods of reducing human error in practice. In: T. Nowakowski et al. (ed.). *Safety and reliability: Methodology and applications, proceedings of the European Safety and Reliability Conference, ESREL 2014, Wrocław, Poland, 14–18 September 2014* (pp. 1101–1106). London: CRC Press and Balkema Book. ISBN 9781315736976.

CIA. (2018). *The World Factbook* [online, accessed: 2018-03-22]. Washington, DC: Central Intelligence Agency. Retrieved from: https://www.cia.gov/library/publications/the-world-factbook/fields/2177.html.

Czaja, F. (2016). *Auswirkungen von Logistik 4.0 auf Mittelstand und Handwerk*. Hamm: Hochschule für Logistik und Wirtschaft.

Fasel, D., Meier, A. (eds.). (2016). *Big Data. Grundlagen, Systeme und Nutzungspotenziale*. Wiesbaden: Springer Fachmedien. ISBN 9783658115883.

Filler, I. (2014). *Auswirkungen von Industrie 4.0 auf die Informations- und Kommunikationssysteme der Produktions- und Lagerlogistik*. München: Grin.

Fischer, R. (2016). *Logistik 4.0: Herausforderung für Industrie und Logistikdienstleister*. Regensburg: Fraunhofer.

Göpfert, I., Braun, D., Schulz, M. (eds.). (2017). *Automobillogistik. Stand und Zukunftstrends*. Wiesbaden: Springer Gabler. ISBN 9783658111021.

IND4LOG4 (2015). *Industrie 4.0 und ihre Auswirkungen auf die Transportwirtschaft und Logistik*. Berlin: bmvit.

Industrie 4.0. (2018). Industrie 4.0 Plattform [online, accessed: 2018-03-10]. Berlin: Bundesministerium für Wirtschaft und Energie, Bundesministerium für Bildung und Forschung. Retrieved from: www.plattform-i40.de.

Industry 4.0. (2018). Industry 4.0. Portal nowoczesnego przemysłu [online, accessed: 2018-03-10]. Warszawa. Retrieved from: www.przemysl-40.pl.

Jahn, M. (2016). *Ein Weg zu Industrie 4.0. Geschäftsmodell für Produktion und After Sales*. Gruyter de Oldenbourg. ISBN 9783110449518.

Janewers, J. (2017). *Auswirkungen von Logistik 4.0 auf das Controlling*. Hamburg: Tredition GmbH. ISBN 9783743986091.

Lödding, H., Riedel, R., Thoben, K.-D., von Cieminski, G., Kiritsis, D. (eds.). (2017). *Advances in production management systems: The path to intelligent, collaborative and sustainable manufacturing*. Cham: Springer Nature. ISBN 9783319669229.

Pocket, B. (2016). *Logistik auf der ersten und letzten Meile im Wandel*. Berlin: Beuth. ISBN 9783410268604.

Schäfer, S., Pinnow, C. (2015). *Industrie 4.0. Grundlagen und Anwendungen. Branchentreff der Berliner Wissenschaft und Industrie*. Berlin, Wien and Zürich: Beuth Verlag GmbH. ISBN 9783410257806.

Sendler, U. (ed.). (2018). *The Internet of Things: Industrie 4.0 unleashed*. Berlin and Heidelberg: Springer Vieweg. ISBN 9783662572146.

Voss, P. (ed.). (2015). *Logistik – eine Industrie, die (sich) bewegt. Strategien und Lösungen entlang der Supply Chain 4.0*. Wiesbaden: Springer Gabler. ISBN 9783658106096.

Wegner, U., Wegner, K. (2016). *Einführung in das Logistik-Management. Prozesse, Strukturen, Anwendungen*. Wiesbaden: Springer Gabler. ISBN 9783658136741.

Wpływ cyfryzacji i przemysłu 4.0 na usprawnianie procesów produkcyjnych oraz ergonomię pracy

Abstrakt: Pojęcia takie jak: *Przemysł 4.0*, *Logistyka 4.0*, *smart factory*, *smart logistics* oraz *digitalizacja* są aktualnie słowami kluczowymi zarówno w nauce, jak i w praktyce gospodarczej. Obecnie ma miejsce czwarta rewolucja przemysłowa, której początki obserwujemy i która jest napędzania przez gwałtowny rozwój technologiczny, szczególnie w zakresie transformacji cyfrowej, autonomicznych maszyn czy w pełni automatycznych magazynów. Silna konkurencja na rynku krajowym i zagranicznym i rosnące oczekiwania klientów sprawiają, że nie tylko należy nieustannie zwiększać produkcję, ale także znaleźć sposób na jej personalizację, czyli wytwarzanie krótkich serii wyrobów zaprojektowanych pod kątem potrzeb danego klienta, lecz i samej pracy człowieka. W tym systemie lub rodzaju konfiguracji rola człowieka, a co za tym idzie – obciążenie pracą związane z danym stanowiskiem, zmieniają się. Technologia coraz częściej zastępuje nie tylko pracę fizyczną człowieka, ale także samych ludzi jako decydentów. Daje początek zupełnie nowym sytuacjom, w których konieczne jest poszukiwanie nowych form współpracy między ludźmi a technologią i środowiskiem. To właśnie taka produkcja ma być efektem czwartej rewolucji przemysłowej. Celem artykułu jest przedstawienie wpływu digitalizacji i Przemysłu 4.0 na optymalizację procesu produkcji, łańcucha dostaw i pracy ludzkiej. Autorzy omawiają koncepcję Przemysłu 4.0, a więc czwartej rewolucji przemysłowej, dotyczącej integracji systemów i tworzenia sieci; przedstawiają założenia Logistyki 4.0 – podejścia, koncepcje adaptacyjne, zasobooszczędne i przyjazne dla użytkownika. Autorzy prezentują także zastosowania *lean management* w koncepcji Przemysłu 4.0 oraz ergonomiczne inklinacje poszczególnych filarów Przemysł 4.0. Zakończenie zawiera podsumowanie rozważań dotyczących wpływu cyfryzacji i Przemysłu 4.0 na usprawnianie procesów produkcyjnych oraz ergonomię pracy.

Słowa kluczowe: Przemysł 4.0, proces produkcyjny, ergonomia pracy