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Industry 4.0 in Logistics Operations

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Abstract

This article emphasizes the importance of Industry 4.0 in the logistics and transport industry related to business management. We focused in more detail on the main principles and possibilities of its use in the managerial environment. At present, we experience a world full of modern technologies and digitization of things, people, machines, equipment, and the like. This new stage is called the Fourth Industrial Revolution—Industry 4.0—which brings along new requirements for business structures, processes, and logistics. The final sections of this article include a discussion laying down recommendations for managing and implementing Industry 4.0 in a company.

Keywords: Industry 4.0; logistics; transport industry; management

1. Introduction

This article concerns the use of the Industry 4.0 solution, analyzing the key areas of the issue. The application of Industry 4.0 in the transport and logistics fields was discussed. A specific example has been given of how the industrial revolution is affecting the sector and how it is responding to the new wave of Industry 4.0.

Industry 4.0 is changing managerial methods and approaches, influencing changes in business models, causing the emergence of new professions, as well as the closure of certain professions that will be replaced by smart machines and devices. The onset of the Fourth Industrial Revolution is defined as global development, whose implementation may take a longer time. Workforce skills, abilities, and education will need to be enhanced.

The new industry will bring a risk of replacing human labor when certain jobs will be lost, and some new ones will be created. Currently, as Industry 4.0 comes to the forefront, computers will be integrated to communicate with each other and ultimately to make decisions without human involvement.

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In logistics, Industry 4.0 technologies help optimize transport routes, make full use of storage capacity, and plan. One example is the Port of Hamburg. 140 million tonnes of goods are transshipped every year, and the number is likely to double by 2030. However, the port has not enough space. The Port of Hamburg leaders, therefore, faced the challenge of ensuring a faster transshipment of containers. People, trucks, containers, ships, cranes, and traffic management are all interconnected within Industry 4.0. All components communicate with each other and provide relevant data. The result of such a cooperation link is a synergy, for example, trucks reaching their destination faster, drivers know faster where they can unload their cargo, ship captains may plan their journeys in advance.

2. Industry 4.0 in Logistics

The fourth so-called digital industrial revolution is coming, affecting almost every industry around the world. It is a transformation of the entire production and management system. Industry 4.0 represents billions of opportunities, for example, in connecting people with smartphone devices, data storage capacities, and access to knowledge, which is almost unrestricted. These options stem from emerging trends such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, power storage, and quantum computing. (Stock and Seliger, 2016)

The combination of cyber-physical systems, the Internet of Things, and the Internet systems brings Industry 4.0 and smart factory into reality. Smart machines, which are ever more intelligent as they gain access to a large amount of data, make businesses more efficient and productive and reduce their costs. Ultimately, it is the network of these machines that are digitally interconnected, which creates and share information giving rise to Industry 4.0 impacts. Some companies are currently denying the massive benefits of Industry 4.0, which could change their business. On the other hand, some companies are already taking measures to prepare for the future, when smart machines will improve their businesses.

Industry 4.0 is often cited as the fourth major revolution in modern manufacturing, after the lean revolution of the 1970s, outsourcing revolution in the 1990s, and automation that began in the 2000s' (Roland Berger, 2014).

In countries with advanced economies, such as Japan and Germany, technology is changing the way industrial processes are designed and operated. By combining technology, they can create value for companies by connecting individuals and machines, allowing them to create, securely organize, and benefit from extensive data on production systems and networks (Kolberg and Zuhlke, 2015).

The Industry 4.0 strategic line was created in Germany in response to the decline in industrial production after the transfer of production workforces to cheap-labor countries. Leading German corporations, such as Siemens, Bosch, Schunk, and Volkswagen, have joined the initiative. The aim is to re-industrialize Germany with cutting-edge technologies capable of competing with even the cheapest workforce. At the same time, it will create many jobs for highly qualified people and expand opportunities for further research and development.

Worldwide, markets are changing, the product life cycle is declining, product complexity is increasing, and the impact of global supply chains is critical. Therefore, companies strive to be more flexible, faster, cheaper, and able to respond to business trends. If companies want to meet these challenges thoroughly, Industry 4.0 is the answer. (Lendel, 2013; Jankalová and Jankal, 2018)

At present, customers place high demands on the purchase of products and services. Customers want to have an original product and thus encourage the company to provide prototype-based custom production. The Fourth Industrial Revolution has smart items, products, and machines that will allow manufacturers to produce a variety of products to meet customer requirements. (Xu et al., 2018)

Not only customers but also employees will be at the forefront of this digital industry. It will no longer be needed to perform mundane manual tasks in production lines. These tasks will be replaced by smart machines. Workers will play the role of machine coordinators, who will get involved when the machine prompts them to do so. Flexibility will be a key success factor. Staff will only be assigned where their help is needed. (Dubovec et al., 2016)

The overall Industry 4.0 revolution is that people, machines, equipment, logistics systems, and products are interconnected and can therefore communicate and cooperate directly. Everything will be connected. The reason why everything will be interconnected is to have the possibility of using a huge amount of yet uncaptured information for significantly faster and more correct decision-making in logistics. The integration of products, equipment, and people increases the efficiency of production machines and equipment, reduces costs, and saves resources. Business and their

logistics management will be able to respond flexibly and quickly to market changes thanks to intelligent tracking and transparent processes that provide them with constant supervision (Zraková, 2019).

The Industry 4.0 concept represents a huge growth in the development and deployment of information technologies and social media networks, which have greatly influenced consumers' perceptions of innovation, quality, diversity, and speed of delivery. For this industry, it is necessary to establish factories with self-service, self-control, self-benchmarking, self-reconfiguration, and self-sufficiency capacities. (Lee et al., 2014)

Industry 4.0 designs the industry of the future wherein machines are integrated into a single community. Several areas exist in logistics that affect the Fourth Industrial Revolution, such as (Lee et al., 2014):

- predicting machine wear
- reducing machine downtime
- ERP system for optimizing production management, scheduling service, and repairs, and ensuring machine safety
- the flow of information between the production line, business management, and supply chain management
- reducing costs of energy-savings, maintenance scheduling, and supply chain management.

Industry 4.0 means the organization of equipment and technology-based production processes that communicate with each other within the logistics chain. We can see the logistics of this industry as a 'smart factory' model, whereby computer systems monitor physical processes, create virtual copies of the physical processes, and make decentralized decisions based on self-organization mechanisms. It is increased automation of logistic production branches, where physical objects are seamlessly integrated into the information network. The main idea is a virtual copy of the intelligent factory, which is created by linking the sensor data with virtual device models and simulation models. Data are gathered and analyzed, then instantly assessed, and subsequently, immediate action is taken.

The outputs of Industry 4.0 are production systems connected vertically to factory and company business processes, and horizontally to the spatial arrangement of spreading value networks that can be managed in real-time. Industry 4.0 cannot distinguish between industry and services, because digital technologies are connected on cloud servers where all operations take place (Moravcik, et al., 2018; Ivaniga and Ivaniga, 2019). The 'Internet of Things' and 'Internet of Services' are also considered to be elements of Industry 4.0

Industry 4.0 does not mean just one thing, but a set of several pillars, which can be called Industry 4.0 pillars. The main pillars are (Hermann et al., 2016):

- 1. Internet of Things—it means in manufacture that all elements of production (robots, machines, sensors, cameras, etc) are integrated and share data.
- 2. Big Data—information obtained from production can be of a very large volume. The task of this pillar is not only to store the data but mainly to analyze and draw conclusions and suggestions for improving production or even predicting the failure of some machines.
- 3. Artificial Intelligence—a system that can learn and can be used in several areas, for example, to analyze 'Big Data'. This term also includes intelligent robots that can adapt to unknown conditions without the need for programming.
- 4. Autonomous Automation—robots on the line will not be just machines that need to be programmed precisely. Thanks to artificial intelligence, they will be able to learn and improve their procedures. Improved robots will be able to replace humans in every production activity.

By connecting and merging these four pillars, a completely new level of production is reached, which can itself change dynamically, adapt to current conditions, and improve.

Businesses are trying to prepare for the new Fourth Industrial Revolution by identifying opportunities. For instance, they identify computers integrated that collect a vast amount of data to inform about maintenance and performance, and also to analyze data to identify patterns and observations that a human would never be able in a reasonable amount of time. Producers can optimize quickly and efficiently their operations by knowing which element requires attention. (Marr, 2018)

Industry 4.0 is already proving its great potential in creating global value chains. For example, Coca Cola producers used a flexible packaging process in its 'Share a Coke' campaign, wherein companies worked together throughout the supply chain to help increase the company's soft drink sales in global markets (Isaiah, 2015).

In their book 'The Second Machine Age', two economists, Erik Brynjolfsson and Andrew McAfee argued that the revolution could be accompanied by greater differences between people and disruptions on the labor market. It is not possible to predict exactly what the revolution will bring, but it is likely to be a mix of positive and negative effects with a predominance of positive ones.

2.1. Industry 4.0 in Slovakia

The Central European Institute of Technology CEIT in Žilina has been focusing on the development of Digital Enterprise tools for several years. Industry 4.0 in Slovakia has become an important driving force behind innovative solutions for engineering companies and car manufacturers, especially from the Volkswagen Group.

Mikuláš Luptáčik, Dean of the Faculty of Economics at the University of Economics in Bratislava, commented on Industry 4.0 in Slovakia as follows: 'Industry will influence the integration of information technology, various databases, and the robotic-dominated manufacturing process. Production will be completely done in the just-in-time concept, whereby individual deliveries will follow each other precisely. This is why companies are moving many productions back from Asia to Europe because they need to be more flexible—and this is only possible at shorter distances. Mass customization in production will be ever more popular. Product accuracy and quality will grow in importance. Siemens states that 500 defective pieces were produced per 1 million products in the past. Currently, the number of defective pieces has dropped to 11.5 at eight times higher production rates after automated controls were deployed. The number of employees remained the same. (Luptáčik, 2016)

3. Industry 4.0 Use in Logistics—Case Study

This case study deals with the application of Industry 4.0 technologies for Bottega Veneta, an Italian global luxury goods house, and the manufacturing process, especially concerning its supply chain. The framework design introduces a single data model used by all actors involved in the production process to collect and represent large amounts of data connected with the DSS production process (Decision Support System) to plan production and focus on different scenarios, ultimately leading to making better decisions.

Production planning can be modeled using discrete optimization techniques, especially MIP (Mixed Integer Programming) and CP (Constraint Programming); therefore, they have developed the prototype of this MIP tool, but they also plan to use CP techniques in the future. For each production order task, two main decisions must be made—who will execute it and when. To make these decisions, several and complex constraints need to be considered, some representing technological constraints and some representing supply chain aspects. Finally, several objectives need to be pursued, in particular—minimizing late deliveries and optimizing the use of resources available.

Another solution is the Decision Support Tool (DSS), which aims to help the user to make better decisions regarding the optimization of activities through the Bottega Veneta supply chain, which includes external raw materials of material supplies, in-house production facilities, and local subcontractors. The tool provides several views of the data analyzed and the solutions proposed in the given scenario. Specifically, the DSS provides a graphical representation of each production order with an emphasis on the complex links between the various tasks required by each other, resource analysis and plan reports with particular emphasis on resource utilization, and schedule compliance capacity reports.

This study has resulted in a knowledge and decision support system for the entire supply chain. The first step was to capture knowledge. An in-depth look at manufacture and production rules was taken in the first phase in close cooperation with production engineers involved in the decision-making process. The second step was to formalize such knowledge structures according to the ISA95 Standard. Finally, in the third step, a mathematical model was developed to solve the problem between all actors in the supply chain. The innovation proposed does not come only in the form of mathematical formulations of the original model, but it also includes the formalization of an approach to capturing and coding unstructured knowledge. [13]

4. Conclusion and Discussion

Through communication between the machine and the product on the production line, employees will be able to eliminate errors saving costs for the company. Workers will be able to deal with any issues that may arise immediately that will be alerted by the production line itself. Also, the connection with the customer and the smart factory concept will have a positive effect on the fact that customers will be able to choose products according to their idea, which will not pose a challenge for the company because it will use the smart factory concept. This means that such a company will have low production costs and will make full use of the just-in-time method.company will have low production costs and will make full use of the just-in-time method.

Industry 4.0 is beneficial for optimal decision making because the company will have a huge amount of data and information at its disposal, whereby better decisions can be made. As mentioned in the case study, the DSS tool will also help to make better decisions, helping the user to make their decision in real-time based on the large volume of data collected.

Industry 4.0 will help increase safety at work because employees will no longer have to perform strenuous tasks, which will be performed by machines. Machines will be controlled by artificial intelligence and will communicate with workers concerning their maintenance or failures, thus ensuring a smooth flow of production. We list the following negative aspects:

- The big risk that may occur as a result of the new Fourth Industrial Revolution is hacker attacks, because the industry will be hit globally by digitization, and all data and information on equipment, machines, people, business management decisions, stakeholders, and the like will be shared.
- Another negative aspect is that many people will lose their jobs because they will be replaced by smart machines; on the other hand, new jobs will need to be created. Company management will have to decide whether to retrain its employees or hire a new workforce that is sufficiently qualified.
- This poses a financial challenge for the companies that will be needed to be incorporated when implementing Industry 4.0.

Despite the legitimate risks associated with the Fourth Industrial Revolution, we are in favor of introducing Industry 4.0 into businesses, as digitalization is growing enormously, and it is only a matter of time before everything is interconnected, and business has to prepare for this new phase already and get all resources required for implementation.

Development in the field of information and communication technologies with a connection to Industry 4.0 will intensively affect all business areas in the coming years. It will not only be a change at the process level of the company production activities, but it will also affect other processes in the company and the entire society. One of the most important changes in the social environment will be labor market changes. Deployment of the Industry 4.0 concept requires several experts in the field of industry, digitization, and informatization. For this reason, it is possible to expect an increased demand for employees with high IT qualifications. It is therefore possible to assume an increase in the level of ICT education, the disappearance of some professions (with will be replaced by automated solutions of Industry 4.0), and the emergence or development of new professions in the field of informatics, data analytics, and the like. At the same time, the business management model will change as the Industry 4.0 concept requires more extensive work with available data, and it is possible to assume the transition to a data-driven organization at all levels of business management.

The future operation of companies in the market (business activities, processes, equipment, and management) that carry out business in the industry will depend on five aspects:

1. Competition
2. Management Structure
3. Innovation
4. Interoperability
5. Flexibility

4.1. Competition

Technology advances allow for rapid progress and innovation, especially with small and medium-sized enterprises. This process is also simpler and more economical in smaller business structures than in large companies. This aspect can cause losses to large companies. The speed of adaptation to new technological trends (e.g. Industry 4.0) will be key for large companies in terms of market competitiveness.

4.2. Management Structure

The company management structure is often implemented through a hierarchical arrangement of jobs with individual powers and responsibilities. This management structure is not sustainable in the long term within the Industry 4.0 concept due to the demands and possibilities of a data-driven organization (e.g. access to data at all times, adjustment of the production processes based on real-time data, work at home possibilities, and the like). Production company management within the Industry 4.0 concept represents an opportunity for companies to move their management from the past to the future, and to discover and implement various process optimization measures within the entire company.

4.3. Innovation

The Industry 4.0 concept brings the possibility of its customized production and logistics management based on market demands. This can be achieved mainly through integration as part of the Internet of Things and the communication of individual stakeholders who enter the production process and influence the shopping behavior of customers. One of these stakeholders may come in the form of other technologies (e.g. artificial intelligence), whose data may be used to drive product and service innovations according to market demands in line with the company production capacities in the industry.

4.4. Interoperability

It follows from the prerequisite of having an own production and logistics management based on the market needs and requirements that the interoperability of various devices and systems will be key to achieving a fully autonomous way of production management with the Industry 4.0 concept. Here the company's readiness is critical in the form of a sound modern and redundant IT infrastructure, a converged communication platform with the help of the Internet, and a standardized interface for operating and controlling human (users) to machine and machine to machine communication.

4.5. Flexibility

The idea of a change in management within the entire company under the Industry 4.0 concept can be challenging for companies not only in technological terms but also in management terms. For the management perspective, it mainly includes the powers and competencies of business managers, as well as the skills needed to operate in a data-driven organization. Continuous and gradual IT training at all management levels will allow companies to prepare and possibly move the company to a level consistent with the Industry 4.0 concept.

The basic task of companies today is to ensure the readiness of infrastructure, processes, management, and employees for change in managing business processes at all management levels. The Industry 4.0 concept points out what needs to be available in a manufacturing company for this change to be implemented and effective.

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