THE INFLUENCE OF INDUSTRY 4.0 ON TRANSPORT AND LOGISTICS IN CONTEXT OF SUPPLY CHAINS

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Received: June 8, 2021
Received revised: July 8, 2021
Accepted for publishing: July 14, 2021

Abstract

Industry 4.0 was first mentioned in 2011 and is based on cyber-physical systems (CPS) that enable remote control and management of different systems. Other than CPS, there are several different technologies within Industry 4.0 such as artificial intelligence (AI), big data, cloud computing, etc. Mentioned technologies affect different industries such as transport, logistics and supply chain. Accordingly, this paper aims to analyse the impact of Industry 4.0 on the supply chain through the prism of transport and logistics. The paper is based on secondary research and used methods are synthesis and analysis, description method and comparison. Research finds that Industry 4.0 has an impact on transport and logistics by making related processes more flexible. There is also the possibility of creating an autonomous system that can be included in the supply chain, which is an intelligent system that can decide and implement different technologies that could mutually interoperate. Research also finds that with the advantages of such systems, some significant challenges and risks are mostly related to the security and reliability of the created system.

Key words: SMART logistics, SMART transport, digital transformation, supply chain management

1. INTRODUCTION

The fourth industrial revolution (Industry 4.0) is the common name for different technologies that are based on the digitalization and usage of digital technologies in business (Rahimi, et al., 2020). Industry 4.0 is primarily based on CPS (Cyber-physical system) that has possibilities for remote managing and for controlling

different systems. CPS can also transform physical system into a digital system (Kim & Park, 2017). Other than CPS, Industry 4.0 is also based on the usage of IoT (Internet of Things) technology that enables connecting of different systems in one network that exchanges information about processes, environment in which such system exists, etc. (Alcácer & Cruz-Machado, 2019). Furthermore, Industry 4.0 emphasizes the application of AI (Artificial Intelligence) that has the possibility of learning about the environment and conducting different operations regarding the identified knowledge (Lee et al., 2018), VR (Virtual Reality) that places the operator in the virtual world in which the operator can walk, interact with different objects, etc. (Liagkou, et al., n.d.), AR (augmented reality) that is related to the possibility of placing a different kind of virtual objects in reality (Damiani et al., 2018), DT (digital twins) that enables the translation of the physical world into digital and provides the possibility of modelling physical things in the digital sphere (Wagner et al., 2019) etc. All mentioned technologies could be used in various systems for managing and executing different kinds of tasks.

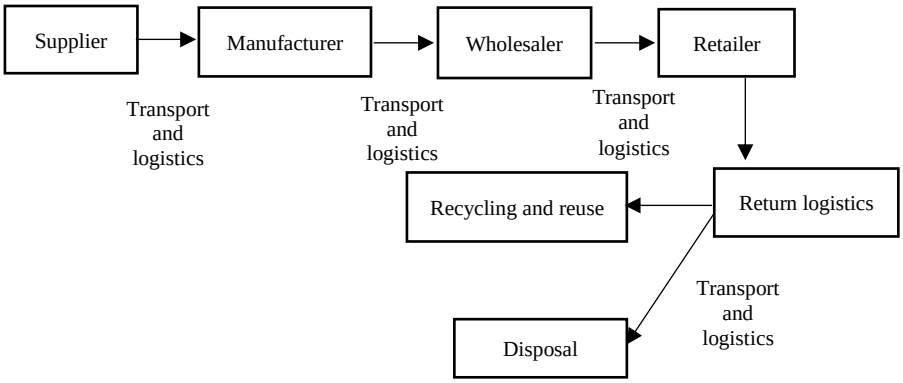
With the development of Industry 4.0, there are also possibilities to use developed technologies in different industries and such industries are logistics and transport. In logistics and transport Industry 4.0 can help in tracking packages, modelling complex objects such as warehouses, automatization of the process, some technologies such as AI can be used for decision making support, sensors can be used for collecting different types of data and creating big data that can be the basis for the analysis and predicting future trends. Industry 4.0 has also impacted the supply chain and all components i.e. organizations such as manufacturers, suppliers, etc. and activities that are related to operations and stakeholders in the supply chain (Müller & Voigt, 2018). In other words, Industry 4.0 technologies in the supply chain can be used for collecting data, usage of collected data for managing the supply chain, etc. The supply chain is a complex system that is made of several interconnected organizations such as manufacturers, suppliers, wholesalers, retailers, etc. For the normal functioning of such a system, it is necessary to establish a connection between all organizations i.e. stakeholders in the chain. Establishing such a connection is a primary activity for logistics and transport processes. Furthermore, managing such system could be challenging because organizations have different processes and exist in different business environments.

When it comes to the design of the supply chain that determines its complexity, the supply chain can be divided into two basic formations, short supply chain, and long supply chain. The short supply chain does not have return logistics that is aimed at returning the used products, unlike the long supply chain that has this possibility. Besides the type of supply chain, for normal functioning, both must have transport and logistics processes.

Figure 1 shows the scheme of the supply chain and the position of logistics and transport processes within it. As shown in figure 1 all organizations that are involved in the supply chain are mutually connected through logistics processes that have tasks of ensuring efficiency and all resources that are needed for the normal functioning of the supply chain (Pečený et al., 2020). Besides, transport processes have the main task that is related to transporting goods, information, etc. between organizations in the supply chain.

Considering that logistics and transport have a very important task within the supply chain and that they can determine the functioning of the entire supply chain, technologies of Industry 4.0 such as CPS, IoT, AI, etc. can have a positive impact on logistics and transportation processes and supply chain at whole. Furthermore, with the usage of Industry 4.0 technologies in the supply chain, there is also the possibility of increasing efficiency and decreasing costs.

Figure 1. Supply chain



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When it comes to the costs in the supply chain, they can be divided regarding the type of supply chain and the organizations that are involved in the supply chain (Lapinskaitė & Kuckailytė, 2014). According to the system theory that describes relations between subsystems, i.e. organizations in the supply chain, increasing costs in one of the organizations in the supply chain can increase the total costs of the entire supply chain. Increasing the costs of the supply chain can lead to the increasing costs of final product and finally to decreasing efficiency of the entire supply chain. According to that fact, organizations in the supply chain must seek new ways for increasing efficiency and decreasing costs.

Furthermore, all actions and decisions that are made by one of the stakeholders involved in the supply chain can impact the entire supply chain. That is especially important regarding implementing new technologies. For example, if one of the stakeholders in the supply chain implements new technology and all other stakeholders not the efficiency of the entire supply chain is the same because increased efficiency of one stakeholder will be lost because of bottlenecks that are related to the using old technologies by other stakeholders.

Following everything stated, this paper aims to analyse the possibilities of implementing Industry 4.0 technologies into the logistics and transport processes in the supply chain and to transform the traditional supply chain with such technologies.

2. MATERIALS AND METHODS

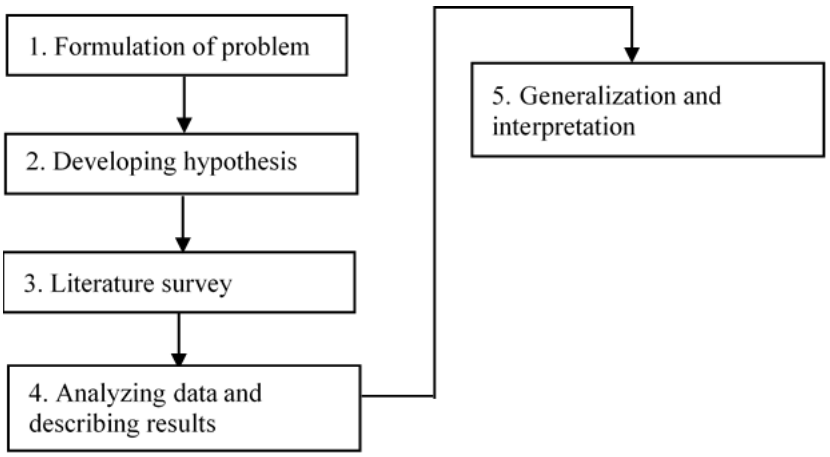
The Paper is based on conducted secondary research. The methodology of research is shown in figure 2. As shown in figure 2, the first step in the research was defining the problem of research that was how industry 4.0 impacts transport and logistics processes in the supply chain? Furthermore, goals that are set in research are:

- Identification technologies that are arising with the development of Industry 4.0
- Identification of what technologies could be used in transportation processes and what technologies could be used in logistics processes
- Identification of how Industry 4.0 technologies within transportation and logistics processes impact supply chain

Furthermore, in research was defined hypothesis: Industry 4.0 technologies have a significant impact on transport and logistics processes and can improve the functioning of the entire supply chain in the context of management and control.

Literature that was used in the research was not older than eight years. All literature references are scientifically and expert papers from proceedings or journals. All collected papers were categorized by keywords and then analyzed. The collected data is presented by the compilation method and description method.

Figure 2. Research flow diagram



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The problem was formulated after a survey of current papers related to the topics of Industry 4.0 impact on the system. After defining the problem and goals of the research, hypotheses were defined, and a literature survey begins. In the next phase, analyzing data and describing results, with description method and comparison method was presented current state related to existing papers. In the last phase, generalization and interpretation i.e. discussion, with synthesis and induction method was described the conclusion of the research.

3. RESULTS

Industry 4.0 has impacted transport, logistics, and the entire supply chain. In the context of logistics, different areas are affected and one of the examples are developing systems that enable more efficient picking in a warehouse, systems that can be used for automatization of processes in the warehouse, order processing, forecasting of orders, managing logistics process, developing of vehicles that are based on AI, etc. Furthermore, Industry 4.0 has an impact also on transport through the prism of the development of intelligent infrastructure that increases efficiency of resources transportation and has an impact on managing it. On the other hand, since logistics and transport are part of the supply chain that enables the normal functioning of the entire supply chain technologies of Industry 4.0 have also an impact on the supply chain. The main impact can be noticed in the usage of SMART factories, SMART warehouses, usage of AI for conducting a different kind of tasks, etc.

3.1. Changes in transportation and logistics driven by Industry 4.0 technologies

Transportation as such can be defined as the transport of goods, information, and people from starting point to the final point with help of infrastructure (roads, intersections, etc.) and suprastructure (trailers and towing vehicles) (Lanke & Koul, 2013). On the other hand, logistics can be defined as activities that are providing support for all processes. Such definition of logistics is related to the fact that logistics processes are related to ensuring all resources that are needed for the normal functioning of the process and such resources can be related to the raw materials, devices, machines, etc. (Anca, 2019). So, logistics as such is a significantly broader term than transport because for the normal functioning of transport, logistics need to provide all resources such as vehicles, fuels, and lubricants, etc.

An accurate definition of transportation and logistics is the basis when it comes to analysing how transportation and logistics can determine the normal functioning of the supply chain. Furthermore, the definition of logistics and transport can be used as the basis for analysing how Industry 4.0 technologies impact them.

As was described in chapter 1, Industry 4.0 has a significant impact on different industries so does on transportation and logistics. One of the most significant impacts of Industry 4.0 technologies is identified when it comes to the automatization of processes. With the development of the automatized system, logistics systems such as warehouses have possibilities to implement systems that enable the transport of pallets through the warehouse from the place where pallets are unloaded from the vehicles to the place where pallets will be stored (Coombs et al., 2020). This type of system is decreasing the need for human labor and can increase the efficiency of the process because of the possibility to work without a break and transport pallets at a higher speed. Furthermore, besides the usage of automation systems in intern transport, AR can be also used in the warehouse in process of picking. AR is providing pickers in the warehouse more accurately taking ordered items from the shelves (Matsumoto et al., 2019). In combination with automatization, pickers can use autonomous vehicles that have an implemented AR system that is showing to the picker where is the exact

item that the picker needs to take from the shelf. After the picker takes the pointed item, the trolley for picking is moving autonomously to the next point for picking.

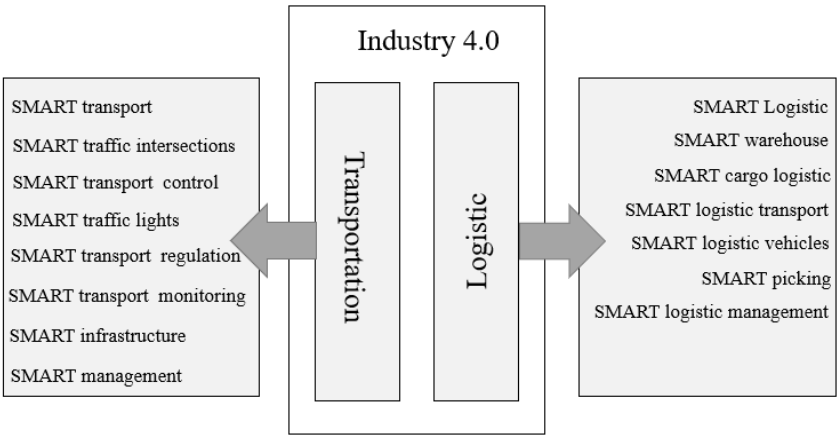
Besides the usage of AR and automation, the usage of AI in order prediction is also one of the new technologies in logistics systems. AI systems can, based on previously collected data, predict how the market will react in the future and based on that can suggest the amount of the items that need to be ordered (Kantasa-ard et al., 2019). Data mining techniques are related to the techniques for purification of the collected data, creating clusters of collected data, and giving collected data context in which, they can be viewed. Besides possibilities of forecasting demand, AI and big data can be used also for risk assessment. Risk assessment is based on the patterns in the big data and indicators that can signalize possible risks that can accrue (Paltrinieri, et al., 2019).

When it comes to the impact of Industry 4.0 on the transport and transportation process, one of the technologies that can be used for managing transport flow is CPS. CPS enables remote control of the transportation process, traffic lights, or the traffic intersection. CPS can be also used for managing information flow or fluid flow through pipelines. Such systems are based on sensors and actuators that are implemented in pipelines or information infrastructure (Monostori et al., 2016). Sensors and actuators are connected to the internet and based on such connection operators can manage the system i.e. can change flow from one pipeline to the other, can stop flow through the pipeline, control flow, etc.

Furthermore, using sensors with AI results in creating autonomous vehicles that can transport items without the intervention of the operator. Such systems can be used in cargo transport or can be used for assisting operators i.e. drivers.

The development of Industry 4.0 technologies also enables the development of intelligent transportation systems (ITS). ITS is related to the usage of technologies such as sensors, AI, CPS, etc. for vehicle managing. Besides, ITS can be also related to controlling and managing infrastructures such as tunnels, bridges, intersections, etc. with help of the CPS and related technologies (Sumalee & Ho, 2018). All described technologies and possibilities that Industry 4.0 is providing to the transportation and logistics system result in creating the concept of SMART transportation and SMART logistics systems. Such systems consist of interconnected sensors that are collecting data and actuators that are used for managing the system. Furthermore, the usage of AI enables the possibility for complete automatization of the system. It should be highlighted that besides the degree of autonomy there is also a need for human intervention when it comes to the maintenance of such a system or establishment it. Figure 3 shows different kinds of SMART systems that appear with the development of Industry 4.0 when it comes to the transportation and logistics systems

Figure 3. Impact of Industry 4.0 on transport and logistics SMART concepts



Source: Authors

As shown in Figure 3, Industry 4.0 enables the creation of different kinds of SMART systems within transport and logistics. Such systems enable a different degree of automatization and different possibilities for managing systems.

It should be highlighted that for the normal functioning of all SMART systems showed in figure 3, the organization must create an appropriate ecosystem. The ecosystem contains different kinds of technologies that enable interconnection between systems such as sensors, internet connection, machines and devices, a system for managing and control, etc. In other words, the ecosystem is providing the technical and technological competence of the organizational system.

All technologies presented in Figure 3 are described in Table 1.

Table 1. Description of SMART concepts in transportation

SMART concept	Description
SMART transportation/management	In global, SMART transportation and SMART transport management is related to the system that enables tracking and controlling transportation, activating alternative ways through CPS, IoT, and sensors.
SMART intersections/traffic lights	SMART intersections and SMART traffic lights are a subgroup of the SMART transportation. This concept is related to tracking and controlling traffic flows through the intersection and managing traffic lights remotely based on the collected data or signals that may come from vehicles.

SMART monitoring/control	SMART transportation monitoring and SMART transportation control are related to the usage of cameras that can identify traffic accidents, vehicles that are violating traffic rules, drivers that are wanted by the police, etc. Furthermore, it can be used for tracking vehicle or goods through implementation sensors on them.
SMART transportation infrastructure	SMART transportation infrastructure is related to charging possibility of the electric vehicles through charging infrastructure that is implemented into the road. Furthermore, SMART transportation infrastructure is related to the, based on collected data from the sensors, to change traffic signs such as speed signs.

Source: Authors

As shown in Table 1, the most significant impact of industry 4.0 technologies on transportation are the automatization of the system and the possibility to track and manage the transport process or the infrastructure remotely. Automatization of transportation management is the most important benefit of industry 4.0 when it comes to urban transport because of the limited capacity of the human operator to control and track several complex flows. Furthermore, Industry 4.0 also has an impact on the usage of new ways of transport like drones that can be used for the last mile transport.

Besides automatization, there is also an impact on the development of autonomous vehicles. This type of vehicle does not need a human driver to operate them. Regarding human drivers, the autonomous system can independently drive through traffic and decide on its own based on the situation on the road (Martínez-Díaz & Soriguera, 2018). Industry 4.0 have also significant impact on creating SMART concepts in logistics. Some of the most significant SMART concepts in logistics systems are shown in Table 2.

Table 2. Description of SMART concepts in logistics

SMART concept	Description
SMART warehouse/picking	Most related to the managing warehouse through collecting data and use of CPS and IoT. When it comes to picking, SMART picking is related to the usage of AR and autonomous vehicles such as robots for independent picking or as help to the human operators.
SMART cargo logistics	SMART cargo logistics is related to the tracking of the cargo package or tracking of the cargo vehicles. Furthermore, SMART cargo logistics within it has technologies such as cloud computing that enables better communication and the possibility of controlling the package.

SMART logistics management	It is related to the usage of AI, IoT, blockchain, and other Industry 4.0 technologies. For example, through blockchain technology, there is the possibility to increase safety during financial transactions. AI can be used for predicting and creating the base for decision making, etc.

Source: Authors

Table 2 showed some of the SMART concepts in logistics. Basically, the main impact of new technologies on transportation and logistics can be divided into the most important:

- Interoperability: interoperability is related to communication between two or more systems and the possibility of exchanging data. Technology that enables interoperability is mainly IoT. IoT can be used in both, transportation and logistics for different purposes such as managing process. Emergency services or vehicles that are transporting human organs for transplantation, blood, etc. can be equipment with IoT that will activate the green light on their pass before they go through the intersection. In logistics, IoT can be used for remote controlling and managing automatic systems for transport or picking (Burns et al., 2019).
- Transparency: mainly related to the usage of blockchain. Blockchain as such enables control of data in a decentralized way because of the design of blockchain. Namely, blockchain is designed as a network of computers that are validating and storing data in different areas. This approach results in decreasing the risk of deleting stored data. Besides blockchain, decentralization in managing systems using CPS and IoT is also one of the ways of increasing transparency (Chauhan et al., 2021).
- Support: related to the usage of different technologies such as AR or AI for supporting the human operator in the operationalization of different tasks. AI can increase the capacity of analyzing a big amount of data in a short period that can be significantly important for developing a competitive advantage. In another hand, AR can increase the capacity of human operators through navigation on how to perform tasks.
- Decentralization: with the usage of remote control and remote management of systems there is also the possibility of decentralization of the decision making (Gräler & Pöhler, 2018).

So, through the development of Industry 4.0 and implementing such technologies into the system, humans and digital systems can be functioning in symbiosis. Human operators use digital systems to support decision-making and increasing their efficiency. Furthermore, described technology and possibilities that such technology is providing can increase competitive advantage that is a significant factor for supply chain and organizations that are involved in the supply chain.

3.2. Impact of SMART transportation and SMART logistics processes on supply chain

Supply chain enables normal functioning of organization and society because it is ensuring all resources such as raw materials, products for the customer, etc. With the increasing of turbulence in the environment and requirements of the society there is also an increasing need for capacity and flexibility of the supply chain. Furthermore, all supply chains that are organized as global supply chains i.e. supply chains that are crossing two or more different continents, face challenges related to management and different business environment.

Changes in transportation and logistics processes, that were described in chapter 3.1, also have an impact on the supply chain, but before taking into consideration how changes in the transport and logistics process based on the changes that are driven with Industry 4.0 have an impact on the supply chain, it is necessary to analyse how Industry 4.0 changes the supply chain as such.

Mainly, Industry 4.0 have four main impacts on the supply chain:

- SMART factories: With the development of automated systems and AI, there are significant changes that are related to the manufacturing process. SMART factories have technologies such as cloud computing that enables exchange of information, Industrial Internet of things (IIoT) that is like the IoT but involves interaction between manufacturing equipment, usage of robots for production, usage of AI in design and testing products before the product goes to the manufacturing process, etc. Besides, there is also possibility to create such called ghost factories that for normal functioning only have robots and autonomous systems. In such factories, human operators are only support for the process (Radziwon et al., 2014).
- Advanced analytic: for analyzing data it is necessary to collect data. For data collection, there is a possibility to implement different kinds of sensors on the machines and devices. Such sensors can collect data about the state of the machine and its performance. With creating and collecting a large amount of data, the organization can create big data from which AI can provide different kinds of predictions through data mining techniques (Khan et al., 2017).
- Efficiency: With the usage of robots and automatic systems there is also the possibility to increase the efficiency of the system regarding the capacity of such system when compared to the humans and their capacity. Furthermore, such systems can be used for performing more tasks in a shorter time (Ferrera et al., 2017).
- New products: Industry 4.0 can provide new ways of manufacturing products. Regarding that, organizations can produce products that enable ensuring added value to the customers (Nunes et al., 2017).

The impact of industry 4.0 technologies on the supply chain is mainly determined with type of supply chain. The table 3 shows how different technologies can impact supply chain activities. Table 3 shows traditional way of performing activities and technologies that disturb it.

Table 3. Impact of Industry 4.0 on activities in supply chain

Activities	Traditional way	Disturb technology	New way
Transactions	Bank transfers	Blockchain	With help of blockchain transaction between supply chain stakeholders are easier and much safer.
Communication	Information system, e-mail, telephone	Cloud computing	Enables not only communication between stakeholders but also the exchange of files.
Last mile delivery	Small trucks	Drones	Drones can be used for last-mile delivery with programming to deliver goods to the buyer's doorstep and return them to the sender.
Risk analysis	Experts and special tools	AI	AI can be used for analysing a large amount of data and based on conducted analysis to predict possible risks in the future
Products	Without possibility of interaction with costumer	IoT	IoT provides the possibility to exchange data between different devices and to provide costumer the possibility to manage such devices through one device. Furthermore, products are more personalized.
Marketing	Traditional marketing through media, creating plans and segmentation done by the marketing specialist	AI	AI can provide faster analysis of the market and to personalize marketing campaign through showing different segments of the market different advertisement

Analysis	With help of tools and methods, experts	Big data, AI, data mining techniques	Big data, AI, and data mining techniques can provide faster analysis and analysis that is related to a large amount of collected data.

Source: Authors

As shown in the table 3, Industry 4.0 can be used for different purposes in the supply chain from predicting, analysing, simulating, producing, etc. It should be highlighted that almost all described technologies are disturbing technologies that enable creating competitive advantage if the organization in the supply chain uses such technologies.

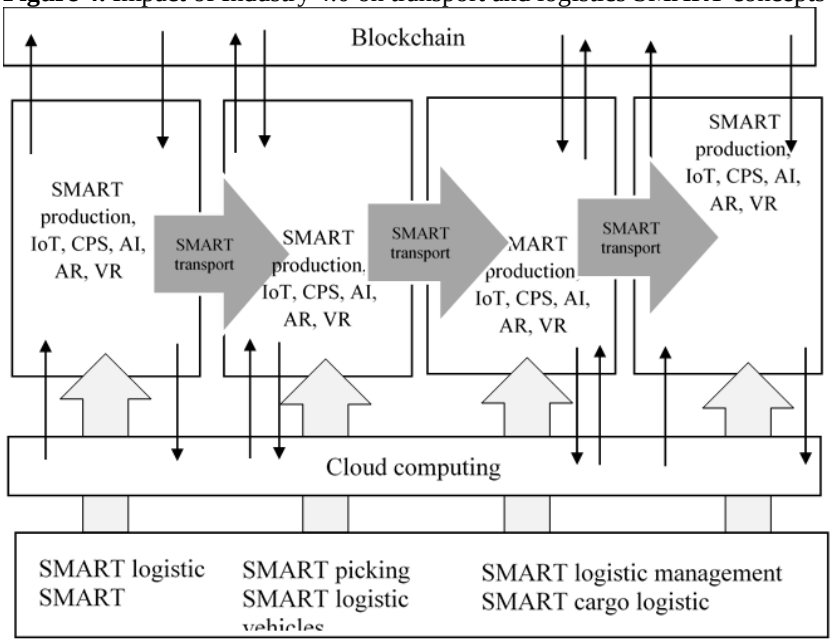
Furthermore, since logistics can be viewed as a support process and in the context of supply chain support processes it can be related to ensuring normal functioning of the warehouse, picking, cargo, etc., SMART logistics processes are support processes for normal functioning of the supply chain that is ensuring efficiency. Without warehouses and related logistics infrastructure and suprastructure, the supply chain could not function efficiently. Within all organizations that are involved in the supply chain many different technologies could be used, and examples of such technologies are described in the table 3. But it should be highlighted that for making supply chain SMART it is necessary to conduct digital transformation in all organizations in the supply chain. Also, all organization must ensure all four components of competence.

On other hand, in case that only one organization have developed and implemented SMART solutions like SMART transportation or SMART logistics, the entire supply chain does not have to be affected by changes, which is supported by the general system theory. In other words, for increasing efficiency and making the entire supply chain SMART, all organization in the supply chain must implement SMART solutions. So, the main impact of SMART logistics and SMART transportation on the supply chain can be view through the usage of technologies described in the table 3 for increasing performances of transportation and logistics processes. One of the characteristics of SMART systems such as SMART logistics and transport is the usage of different ways of exchanging information between devices. One of the technologies that enable exchanging of information is RFID (Radio-frequency identification) that can also store limited amount of data. RFID tags can be placed on the products and scan with an RFID scanner that could be connected to the machine or device. Regarding the data stored in the RFID machine or device could perform operations. Such a system is enabling the automatization of the production system (Zhong et al., 2013). Such a system of production requires antennas and controllers that are placed on the machine and devices and read data from the RFID. Besides production, RFID tags could be placed on the package and enable tracking of the package during transport.

For managing logistics and transportation processes there is the possibility to implement DT technology. DT enables translation of the physical system to the digital system and provides the possibility of making a different kind of simulations. Such

simulations could be used for the improvements and testing how different solutions could impact the system and its functionality (Stark, et al., 2019). For example, in the logistics system, DT can be used for the virtualization of the warehouse and examination how the process can be improved or for presenting to the customer how the final product will look i.e. presenting how the new warehouse will function.

Figure 4. Impact of Industry 4.0 on transport and logistics SMART concepts



Source: Authors

Technologies of Industry 4.0 have mainly impact on automatization and usage of automatic systems for different activities such as picking, transportation, etc. In other words, the traditional supply chain with the development and implementation of Industry 4.0 becomes SMART and that can result in increased efficiency and effectiveness.

4. DISCUSSION

With digitalization there is a significant impact on the decreasing number of documents that are needed in the processes and supply chain (Zhang et al., 2020). On another hand, less bureaucracy in the supply chain can result in increasing flexibility, decreasing errors in the package, increasing efficiency, and decreasing the costs of delivery. However, for the digitalization of documents, it is necessary to provide the adequate infrastructure that is related to the computers and other devices that enable entry of data and browsing such data. For the normal functioning of such a system is necessary to ensure a secure connection between stakeholders and to implement an

information system that enables the entry of data from all workplaces. One technology that can provide a good base for the digitalization of documents is RFID or QR (Quick Response) codes because RFID and QR can contain information that can be showed to the reader (Durak & Ozeskin, 2016). Usage of RFID and QR decreases the need for documentation that tracks the shipment or enables easier paying. For example, a shipment i.e. package can contain a QR code with information such as a delivery note or the bill that the recipient must pay. Scanning QR with QR reader there is the possibility of paying the bill for delivery, overview delivery note, etc. Also, such a way can be used in warehouses for receiving and tracking goods.

Digitalization as such is also related to the challenges such as risks of information leak or risk of endangering the informational system of the organization or digitalized documents (Fenz et al., 2014). This kind of risk is significantly important because all Industry 4.0 technologies are using internet connection to communicate with each other and to exchange data that is necessary for the normal functioning of such a system. So, the main challenge of digitalization of the system is related to the risk of cyber-attacks that will as a result have a leak of information or could lead to financial losses (Antonescu & Birău, 2015). One of the possible answers to such risks is implementing different kinds of security protocols that enable encrypting of data or use technologies such as blockchain. Financial risks and risks of cyber-attacks are one of most important risks when it comes to the supply chain because it may endanger financial transactions and data that is exchanged between stakeholders in supply chain. Cyber-attacks also can impact autonomous systems that could stop functioning or will be misused if such attack accrue. So, development measures such as creating security protocols, encryption of data and communication between stakeholders is imperative when it comes to the normal functioning of supply chain and autonomous systems in transport and logistics.

Besides, with implementing different technologies and creating a system that consists of different kinds of partial systems there is also the risk of decreasing the reliability of such a system. Reliability is related to the possibility of the normal functioning of the system i.e. providing tasks for which the system is designed. In different words, because most of the technologies are interconnected, the shutdown of one device can lead to decreasing the possibility that all other devices that are connected to the one that stopped to work can perform their tasks (Lazarova-Molnar & Mohamed, 2019). Such a problem can be solved by implementing sensors that can be used for predicting errors in devices or can signalize that one of the devices has variability that will result in a shutdown (Fujishima, et al., 2017). Such sensors can collect data that can be stored in databases i.e. can create big data. With the usage of AI for data mining in the created database there is the possibility to predict when the device will stop working. So, big data analytics can be used for predictive maintenance that could result in increased reliability. Predictive maintenance have is significant when it comes to the SMART factories and transport and logistics vehicles.

One of the main advantages of using Industry 4.0 technologies is the possibility of interoperability. In other words, different kinds of technologies could be used for creating a system that can perform tasks without the intervention of the human operator. In other words, the autonomous truck can be used for the transportation of goods or raw materials between the factory and the warehouse (Lelli, 2019). In the

warehouse, autonomous vehicles can be used for transporting goods to places where goods will be stored. Finally, picking operators, with help of the autonomous vehicles that are equipped with systems like AI and AR, can use this technology for navigating where the picked goods need to be placed. When it comes to transporting goods to the customer, drones and autonomous vehicles can be used with the help of AI (Cunneen et al., 2019). Interoperability and autonomous systems can also help human operators in their tasks. For example, autonomous vehicles can transport goods to the human operator that can perform the task on delivered goods without significant stress of the operator to raise or lower the load. When it comes to the usage of drones, drones can be programmed to transport items from the warehouse to the customer autonomously and back to the warehouse when items are delivered (Pugliese et al., 2020). One of the advantages of using drones for such purposes is the possibility to fast delivery and to deliver items in areas in which there is a lack of traffic infrastructure.

Digital twins' (DT) technologies can be used by all organizations in the supply chain, logistics, and transport for simulating and testing what changes to the system will result in a significant increase in inefficiency (Agostinelli et al., 2020). Also, DT could be used for testing changes in demand. For example, changes in market demand could be tested in DT because DT can represent a physical system i.e. supply chain. According to the result in the DT simulation, the physical supply chain can be adjusted. If DT is connected to big data and AI, AI can use big data to simulate and test how the physical system will perform, and through generation, improvements can be defined. Besides the supply chain, DT can be also used in the warehouse for the same purposes. DT can be used for modelling transport and logistics processes before the logistics process is launched in the logistics system. In combination with VR, DT can be used also for educational purposes (Lu, et al., 2020). Operators that will work in a logistics system that is digitalized with DT can see and be educated about all processes within the system. In other words, DT can enable the virtual walk-through logistics system, interaction with machine and devices, possible testing what will happen if device or machine stop to work, etc.

One possible usage of DT is also testing supply chain, logistics, or transport for resilience or simulating how different risks could impact the supply chain. When performing such testing there is the possibility to create a continuity plan for the system or to create measures that will decrease the risk of interruption of the process. Besides the supply chain, DT can be also used in transport and logistics. For example, in transport DT enable testing and optimization of transport routes that can impact the efficiency of the supply chain (Reed, et al., 2021). For such testing, DT is enabling viewing of different routes and identifying which route is optimal. Adding in such a system AI, AI can faster and more accurately test and optimize transport routes that will impact the entire system.

So, usage of Industry 4.0 technologies can result in creating of SMART system. The main characteristics of the SMART system are interoperability, transparency, and possible decentralized management. When this is applied to the supply chain, transport, and logistics global, AI can be used for conducting complex analysis, predictions, optimizing systems, and data mining of data collected by interconnected devices by IoT (Liao et al., 2017). Furthermore, transport vehicles could through IoT communicate and exchange data about tasks that are performed and, because transport

is part of the logistics process, this can result in increased efficiency of the entire logistics system i.e. supply chain when it comes to performing tasks. Also, the usage of AR can help human operators in their tasks related to production, picking, development of the product, etc.

So, when comparing traditional supply chain technologies that are mainly analogue to the Industry 4.0 supply chain technologies (same for the transport and logistics) there is a significant difference that is mainly seen through time, costs, efficiency of the process. The traditional supply chain is mainly based on humans and human labour efficiency that can be challenging especially with complexity increasing, but it may be more reliable than the autonomous systems because humans have a creative component in thinking and performing activities. In other words, digital systems that are based on Industry 4.0 technologies can have a problem with decision-making and creativity or emotions.

Global, when it comes to the advantages of Industry 4.0 technologies in logistics, transport, and supply chain, main advantages are increasing efficiency and the possibility to develop a system that can be more resistant and reliable in the context of the fulfilment of customer needs. On other hand, the main disadvantages can be related to the costs of implementing Industry 4.0 technologies i.e. conducting digital transformation and system security.

5. CONCLUSION

Industry 4.0 imply different industries. Transport and logistics processes need to use the possibilities of Industry 4.0 that are mostly related to implementing AI and automatic systems. Furthermore, one of the most significant advantages of the Industry 4.0 is the possibility of the interconnection of the different kinds of technologies. Interconnection could increase the autonomy of all connected systems because all systems can be used for different purposes.

For implementation and usage of such systems, it is necessary to conduct digital transformation of the system and to ensure technical, technological, structural, and competence of human resources. Usage of Industry 4.0 technologies in transport and logistics could result in increased flexibility and increase in the efficiency of the system i.e. transport, logistics, and supply chain. It is necessary to highlight that with all advantages of the usage of industry 4.0 technologies some risks are related to information security and cyber-attacks. But, when compared, the advantages of digital transformation and usage of Industry 4.0 technologies are higher than risks.

Results of this research can be based on the development of SMART logistics system in practice i.e. supply chain in the context of possibilities that are provided by different technologies described in research.

Recommendation for future researchers in this area is to focus on efficiency of usage of described technologies in this paper in practice and to compare the efficiency of Industry 4.0 technologies with efficiency of the conventional way of conducting activities in the supply chain. Limitation of this research are related to access to literature. Through research authors identified that there are many different papers that are describing Industry 4.0 technologies but there is lack of papers that are

describing possibility of combing different kind of technologies in one compact system i.e. models.

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