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Intelligent supply chains from the perspective of benefits and costs for transport-forwarding-logistics industry

Inteligentne łańcuchy dostaw z perspektywy korzyści i kosztów przedsiębiorstw branży transportowo-spedycyjno-logistycznych

Abstract. The article presents the results of the literature review analysis regarding the solutions used that are characteristic of the concept of intelligent supply chain. Then, based on the available industry reports and pilot survey studies, the potential benefits and costs of the possibility of using these solutions in transport and forwarding enterprises were indicated.

Key words: transport-forwarding-logistics industry, intelligent supply chains, road transport

Synopsis. W artykule zaprezentowano wyniki analizy przeglądu literatury w zakresie wykorzystywanych rozwiązań charakterystycznych dla pojęcia inteligentnego łańcucha dostaw. Następnie na podstawie dostępnych raportów branżowych i pilotażowych badań ankietowych, wskazano potencjalne korzyści i koszty z możliwości zastosowania tych rozwiązań w przedsiębiorstwach transportowo-spedycyjnych.

Słowa kluczowe: branża transportowo-spedycyjno-logistyczna, inteligentne łańcuchy dostaw, transport drogowy

Introduction

Evidence for intelligence solutions in supply chains can be found in any logistics-related process or service from the basic to the complex. It is seen as new and advantageous to a particular focal audience [Flint et al. 2005] and it may also be fundamental for some companies, e.g., in the transportation industry [Wagner 2008].

Transport processes somehow bind all links in the supply chain. Undoubtedly, transport is one of the areas affecting the functioning of the supply chain, including through optimal utilization of capacity, route planning, logistics customer service standards and used communication tools connecting the supplier and customer of the load [Konecka et al. 2019].

The latest full CSO data on GDP – for 2017 – shows that the transport and storage sector has generated 5.8% GDP. In 2017, it was PLN 115.3 billion. It is worth noting that this result was the second largest in the concentrated service sector (the higher share in GDP – 15,.7% was obtained in the "trade; repair of motor vehicles" segment) [GUS 2019].

Polish carriers are also impressive compared to other European Union countries. A glance at the latest Eurostat data for 2018 shows that Poles accounted for over a fifth of international road transport in the European Union. In this respect, we have no equal in the entire Community. We are not only the leader of the ranking in terms of international transport volume, but if we compare the next two countries in the ranking – the Netherlands and Germany, then their combined result is smaller than the share of Polish transporters.

The entire volume of transported loads on the EU market was in 2018 1175 billion tons (data from 28 EU countries). Poles had the largest share in working out this result – 22.6%. international transport (266.7 million tons). The second place was taken by the Netherlands, which obtained a half result – 132.5 million tons [Kulikowska-Wielgus et al. 2019].

Therefore, an important research area is the potential of using intelligent solutions used in supply chain management, with particular emphasis on transport, forwarding and logistics processes.

Purpose and methodology

The main purpose of this article is to determine what solutions in the field of intelligent supply chains can be used in transport, forwarding and logistics activities. And also demonstrating the legitimacy of implementing such solutions for the activities of entrepreneurs in this industry from the point of view of potential costs and benefits.

The main research questions are:

1. What solutions in the field of intelligent supply chains can be used in transport, forwarding and logistics activities?
2. Do Polish transport, forwarding and logistics entrepreneurs treat intelligent technological solutions as a source of benefits for their enterprise? If so, which ones?
3. Are solutions in the field of intelligent supply chains in transport-forwarding-logistics activities treated by Polish transport-forwarding-logistics companies as an additional cost of operations? If so, what are the costs?

To answer these questions, a literature review was used, analyzing the Scopus database for the keywords "intelligent supply chains" including "transport". An analysis was also made of industry reports on the activities of Polish transport-forwarding-logistics companies and statistical data of the Central Statistical Office. Preliminary pilot surveys were also used.

Intelligent supply chains

Practitioner research argues that, in the future, supply chains will be autonomous and will have predictive capabilities [IBM 2015, WEF 2018, DHL]. Using IoT sensors, quintillion bytes of data will be generated across supply chain operations. AI will be deployed

to analyse information in real time, monitor operations across the globe, predict the future with minimum error rate, and take actions to adjust to rapidly changing environments [Wu et al. 2016]. Smart supply chains collectively possess not only intelligent and innovative characteristics but also information in the next generation supply chain is overwhelmingly being machine-generated, for example, by sensors, RFID tags, meters, and many others [Wu et al. 2016].

Literature review shows that intelligent solutions that apply to supply chains in the literature of subject are discussed above all at the level of various types of algorithms – genetic algorithms or fuzzy-logic systems [Ngai et al. 2014], intelligent systems in intermodal transport [Mondragon et al. 2012], in urban and extra-urban transport [Ehlers et al. 2017], regarding the use of intelligent algorithms for flow management in the field of reverse logistics [Yan, et al. 2015], evolution of the ITS system [Wang, 2017] and safety of their use [Erdogan 2017], intelligent warehouse management system [Mao et al. 2018], Cloud of Things [Yan et al. 2014], RFID [Zhao 2017], Kiva robots [Bogue 2016], Voice picking and Pick-by-Light technologies [Fager et al. 2019], autonomous vehicles [Graham et al. 2019].

In spite of the promising benefits of the self-thinking supply chain found in practitioner literature, academic research on this and related topics is scarce. Calatayud, Mangan and Christopher [2019] in their systematic literature review found no articles exploring the self-thinking supply chain and only 28 articles referring to related concepts such as "autonomous", "predictive", "smart" or "intelligent" supply chain. These articles were spread across different fields, including SCM, computer science, engineering and economics. The analysis of the selected articles gave insights into in particular two new digital technologies that are associated with autonomous, predictive, smart or intelligent supply chains, namely, IoT and AI.

Among all critical resources, information systems continue to play a critical role in SCM as supply chain performance is often characterized and facilitated by the real-time collaboration and sophisticated integration. SCM would not even be possible without the advances in information systems and technology [Konecka and Maryniak 2019].

Intelligent supply chains versus transport

Thus, preliminary research and review of the literature on the subject of solutions used in intelligent supply chains shows that a significant proportion of the issues considered concern transport activities.

Analyzing the abstracts from Scopus database for two keywords "intelligent supply chains" in the "transport" 356 articles have been received. The oldest are from 2001. Considering the numerical distribution over the last 10 years, a significant increase in publications in this respect should be noted from 2014 – 34 articles, then in 2015 – 19 articles, in 2016 – 37, 2017 – 20, in 2018 –26 articles and the largest number in 2019, as many as 54 articles.

By analyzing in detail the abstracts of selected articles, the most frequently described tools were identified. Previously identified as part of intelligent supply chain management tools. The most frequently described technology – in 41 articles was RFID technology. Most often RFID is described as a technology enabling electronical and automatic

identification of vehicle, freight container, returnable transport unit and packing, track and tracing system using RFID technology, using RFID technologies in aircraft, in UK High Way Agency, using RFID in the fresh fruit transport and RFID in IT architecture of inteligent freight transportation.

Then often described technology are intelligent transport systems (ITS) – 14 articles. Internet of Things is almost as often discussed topics, among 356 articles identified, as many as 13 articles concerned this technology. In the next 9 articles ICT was discussed, in 8 articles artificial intelligence was described. Block chain and autonomous vehicles are presented in 3 articles. Automation as a technology for intelligent supply chains is discussed in 2 articles. Interestingly, the database of selected articles did not include anything about TMS (Transport Management Systems). The number of articles about subsequent tools is presented in Table 1.

Table 1. The number of articles about subsequent tools of intelligent supply chain
Tabela 1. Liczba artykułów o poszczególnych narzędziach inteligentnego łańcucha dostaw

The selected tool of intelligent supply chain	Number of articles
RFID (Radio-frequency identification)	41
ITS (Intelligent Transport Systems)	14
IoT (Internet of Things)	13
ICT (Information and Communication Technologies)	9
AI (Artificial Intelligence)	8
Automation	2
TMS (Transport Management Systems)	0

Source: own work

Potential benefits and costs of using intelligent technologies

According to the results of the PwC "21st CEO Survey", as many as 68% of the CEO's and directors of global companies in the transport and logistics industry expect changes in key service technologies to have a breakthrough in their business. In this report, practitioners point out the basic benefits of using auto-autonomous vehicles. According to practitioners [PwC 2019] autonomy in the form of fully autonomous vehicles is key to filling the labor supply gap in the market will enable a reduction of transport costs by 28% after 2025 by replacing the costs of labor (drivers) with the costs of software, telematics, and remote control. Most economic, social or political and legal factors will most likely lead to an increase in costs in the industry, and autonomy can, therefore, be one of the few ways to reduce them. As many as 78% of representatives of global transport and logistics companies plan to take action to automate tasks and positions to ensure effective implementation of the company's goals. In turn, 31% of them plan to invest in automation by 2020 [PwC 2017].

The authors of the report [Wolak 2019] claim that, on the other hand, the global economy 4.0 is more and more clearly marked in the global economy, which assumes

the use of data to make better decisions and allocate resources faster. He assumes that algorithms, armed with a large amount of data, can perform these tasks more efficiently than humans. The transport industry seems to be still at the tail of these innovations. It is quite strange because it could be great benefit for transport. First, because it is a fragmented industry like no other. Transport resources, senders, recipients, intermediaries form a network that is difficult to efficiently handle using manual processes. Hence, paradoxically, one can hear that despite the lack of transport space, many carriers drive undercharged or empty. At the same time, transport generates huge amounts of data that can be used to optimize its performance. Modern telematics in vehicles send information on their location and condition on an ongoing basis, ERP, TMS and WMS systems have data on the content and purpose of the load. There are also all kinds of beacons installed more often in the loads themselves, toll collection devices, drivers' mobile phones, electronic documents, including waybills and many more. A huge amount of data that seems underestimated, which is properly stored and processed by algorithms, can contribute to a better matching of loads to the means of transport, to a better use of each cubic meter of the semi-trailer and each kilometer of the route. To make better use of existing resources when they cannot be enlarged enough and in anticipation of greater autonomy in supply chains.

At EU-28 level, fundamental changes are planned to the regulations concerning road transport, including the provisions of the Mobility Package, and changes to the provisions concerning the coordination of social security systems and other social regulations [Klaus 2019]. These changes will cause inter alia increasing the costs of transport networks – (due to reducing their efficiency) and labor costs, increasing risk and barriers – for conducting business, especially for small carriers due to the increase in regulatory complexity, increasing in the level of concentration – as a result of the collapse of small enterprises that do not have the appropriate share of transport in the country and on foreign markets in their activities.

The Mobility Packed can also cause potential problems not directly related to the use of intelligent tools. For example: decrease in revenues related to the restriction of market access – in the scope of crosstrade and cabotage services, and as a consequence also the handling of import and export of goods; moving services of Polish carriers – from EU markets to the Polish market; forced internationalization of carriers, who operate today in many foreign markets from Poland. Reducing transport performance in international transport services, e.g. by 20%, would mean a reduction in the total transport performance of Polish carriers by nearly 13%. The transport work carried out by Polish entrepreneurs in international transport constitutes as much as 64% of their total transport work, so the majority of Polish carriers' activity is threatened by changes in law.

The growing requirements in the scope of environmental protection (regarding lower CO_2 emissions and other pollutants, the use of more ecological drives and local restrictions on the movement of combustion vehicles) will also contribute to the increase in costs. Insufficient level of development of domestic law in the field of new technologies may hinder their implementation by Polish carriers, giving foreign advantage. Obtaining technological advantage by carriers from Western countries [PwC 2019]. The expected impact of technological changes is unprecedented, given that in recent years, apart from

increasing the efficiency of engines and increasing the volume of transport, no significant technological changes have been observed. The diesel engine, which has been used for decades, is a standard in the road transport industry in the EU-28. According to ACEA data, in 2016, among vehicles with GVW > 3.5 tonnes in the EU-28, over 96.1% were diesel vehicles, which means that the diesel engine continues to be the main solution in European markets. Currently, work is underway on the development of several alternative drives, but their popularization requires not only appropriate technology, but also the availability of charging or refueling infrastructure. Its absence, combined with the high cost of purchase, is a significant limitation for such vehicles. Reducing fuel consumption translates directly into savings in transport. Alternative drives also remain relatively expensive in relation to the investment capacity of small carriers. Concerns are also related to the government's policy on taxing various fuels.

The "Transport of the Future" report also indicates the potential benefits and costs of transport and forwarding activities from the use of intelligent technologies. According to its authors only the current increase in costs and shrinking margins in the industry become the reason why companies are looking for technological solutions, starting from digitization.

The transport and logistics sector is characterized by a huge space for development through digitization, because the technologies that serve it are already mature. Digitization is not just about administration, accounting processes and internal processes. It also enters the sphere of creating new business processes (e.g. related to the control of physical conditions in the transport process, electronic clearance of goods in terminals), and even affects the change in the manner of cooperation with customers and conclusion of contracts (visible in the "platformisation" of service transactions).

Transport companies indicate that a significant barrier to the development of digital solutions by entrepreneurs is the shortage of people with competences in the field of digital technologies. According to 58% of representatives of transport and logistics companies surveyed, it is difficult to recruit people with the skills necessary to develop digital technologies. It is also important to change the behavior of consumers and enterprises, in particular as regards shifting the ordering of services and trade in goods to the internet, and the increasing availability of (already considered simple) internet technologies, applications, databases and ERP class systems.

Platforming is also an opportunity and a threat for small carriers. On the one hand, new platforms will be potential sources of revenue. On the other hand, they can start to exert a strong influence, e.g. on price levels on the market, which is visible in the case of platforms for transporting people, which are currently lowering prices to attract customers. Small carriers will not create platforms themselves due to low investment resources, therefore they will have to rely on external solutions in this respect.

Intelligent Transport Systems (ITS) are systems built with the use of telematics/internet of things solutions supporting the management of urban traffic, public transport, passenger and goods flow, fleet and cargoes as well as collecting and reporting vehicle traffic information. From the perspective of transport entrepreneurs, they enable better remote vehicle management. According to forecasts, by 2022 the turnover of companies

offering solutions for intelligent transport systems (ITS) in road transport will be globally more than USD 72.3 billion, growing at a rate of 7.9% in 2016–2022.

Access to collections of various data from sensors of production or transport machines gives the possibility of continuous analysis of the condition of devices. Also allows use the data to avoid failures or deficiencies. In transport, predictive repairs can play a key role in minimizing breakdowns that have a huge impact on vehicle safety.

Blockchain (DLT) technology solutions allow the transport and logistics industry to achieve many benefits, such as e.g. increased: security – product identification and the possibility of auditing while maintaining privacy using shortcut keys, efficiency – reduced demand for document processing (due to automation), transparency – easier and more reliable tracking and checking of sources, reliability – after entering information into the network it cannot be easily changed.

Transport and logistics and the automotive industry are two of the four industries that, according to PwC [Report "What's the real value of AI for your business?"] research, show the highest benefits from the implementation of artificial intelligence solutions. Full autonomy of heavy goods vehicles will undoubtedly change the transport market thoroughly, but it will only take place on a massive scale within 10 years. In the period of 5 to 10 years, however, the first implementations of partial autonomy in combination with platooning can be expected. Autonomous transport will also enable a reduction of transport costs by 28% after 2025 by replacing labor costs (drivers) with software, telematics and remote control costs. This is particularly important because most economic, social or political and legal factors will most likely lead to an increase in industry costs, and autonomy may therefore be one of the few ways to solve this problem.

As a result, the transport industry is beginning to recognize the importance of autonomy. As many as 78% of representatives of global transport and logistics companies plan to take actions to automate tasks and positions to ensure effective implementation of the company's goals. In turn, 31% of them plan to invest in automation within three years from the date of the survey [PwC Digital IQ Survey 2017]. From the perspective of a road carrier, autonomy will mean the possibility of reducing costs, but also the need to learn how to use new technologies and develop new business processes that will be necessary for this.

In Poland, most road transport companies are small and medium-sized enterprises. That is why it is worth looking at inteligent solutions, a specially autonomous transport from their perspective. The results of pilot research carried out among road transport operators in Greater Poland in 2019 indicate that [Różniewicz 2019]. According to 58% of respondents, by 2030 autonomous cars will normally functioning on Polish roads, only 16% were skeptical about such implementation prospects. 76% of respondents declared their willingness to participate in courses enabling better understanding of the topic of autonomous vehicles. 82% of respondents are willing to replace trucks and vans in their own fleet with self-steering ones. Among the benefits that the respondents saw in the introduction of autonomous cars, cost optimization was 58% first. It was to consist of getting rid of the costs of drivers' salaries, faster covering the route – without mandatory breaks in accordance with the „Act on the driver's working time", timely delivery. 32%

of respondents noticed the benefit of being able to constantly monitor a vehicle, its location and, technical parameters. Only 14% of respondents saw the benefit of eliminating a significant number of accidents caused by drunk drivers.

Questions about the potential benefits of using autonomous vehicles as well as threats were multiple-choice questions. Respondents perceived threats more often. They considered the biggest threat to the lack of trust in the 36% system, they are also afraid of software errors and the inability to respond to such obstacles from vehicles. 64% of respondents indicated that autonomous vehicles were not adapted to the psychological aspects of other road users – for example, the behavior of drunk pedestrians. Another threat is what has also been indicated as an advantage, i.e. reduced employment of drivers – 44%, also in the context of retraining or acquiring new skills, piloting an autonomous vehicle.

The number of technological solutions used in enterprises employing respondents may also affect the perception of automation. The vast majority of respondents declared that their enterprises use the most popular solutions, i.e. GPS (Global Positioning System) – satellite navigation system, working time controller and driving speed controller. Twenty three people indicated that they worked with the help of cargo tracking, and three people less – with a fuel consumption meter. The least respondents got acquainted with the functioning of the tire pressure sensor and temperature sensor. Awareness and ability to use individual tools also results in answering previous questions. People who worked with the fuel consumption meter, work time controller, GPS indicated that they are in favor of the introduction of autonomous cars because it will facilitate their work because the above devices will cease to need them.

Most, because 96% of respondents would like to use the latest technologies at work. 60% of respondents believe that inteligent solutions in transport are an expensive solution. In this issue, the most important were the responses of employees who use the latest technologies at work. They are the ones who have the greatest awareness and have broader knowledge than others. After careful analysis, it was this group of people who fully opted for autonomous transport. And 40% of those surveyed believe that an investment in autonomous rolling stock will pay off and begin to bring benefits in a few years.

Modern autonomous transport models are the result of many compromises, not least because of the need to provide value in environmental, social and economic terms – as indicated above. This is one of the main reasons why their implementation has been so slow. Another reason is the lack of mechanisms for the integration of sectoral policies implemented in self-government administration bodies, as well as systematic identification of cooperation, especially between sectors.

Summary and conclusions

In summary, the questions posed in the introduction to this article should be answered. It should be noted that the most often described in the literature tool for intelligent supply chains that can be used by transport and forwarding companies are: evolutionary versions of ITS, RFID, cloud of things and IoT, blockchain and IoT. Their use can take place in both intermodal transport and urban transport.

Industry reports show that the future technologies for this industry are: digitalization, platformization, intelligent transport systems, blockchain, autonomous transport. The implementation of intelligent solutions brings both potential benefits and costs. They were discussed in the article, however, they require a different perspective – social, environmental and economic costs and benefits, as well as from the perspective of the entity to which they relate. For example, increasing road safety by introducing intelligent tachographs is an undoubted benefit. However, by small entrepreneurs it will be treated as a cost, additionally forced by law. Thus, in addition to the three perspectives mentioned above, benefits and costs should be examined and compared in the group of small and medium-sized enterprises, large logistics operators and from the perspective of legislative entities.

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