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Modern technologies development in logistics centers: the case study of Poland

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Abstract

Nowadays, the growing role of logistics centers is observed within supply chains. These centers operate on the competitive market and face growing customers' requirements. Such occurrence forces these centers to implement various technological solutions in order to improve the quality level of their services. The article's aim is to investigate the actual development stage of modern technologies used in logistics centers, as well as identify the benefits and threats related to these technologies' implementation. The case study of logistics centers located in Poland has been considered. The current condition of technological development of logistics centers was analyzed based on questionnaire survey methodology. Based on survey's results, it was stated that domestic logistics centers are constantly evolving; nevertheless, the need for further development is observed.

Keywords: Modern Technologies; Logistics Centre; Marketing Research; Logistics 4.0

1. Introduction

Nowadays, the growing competition on the logistics services market is observed, Zhang et al. (2020). It is influenced i.e., by growing demands of customers who intend to receive comprehensive service proceeded timely and at the lowest possible costs by one particular company (e.g., a logistics center), Liu (2014). The ability to provide services tailored to the clients' requirements is a key factor which influences the success of a logistics center and whole supply chain in case of which a logistics center is one of its elements. The mentioned ability also motivates logistics centers to implement modern and innovative technologies in order to improve their efficiency and products processing, Dutta et al. (2020). Wide range of technological solutions for logistics centers is currently available on the logistics

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market. These solutions deal with particular areas of logistics centers operations, including warehouse operation, data transfer, goods identification and other, Kucharavy et al. (2018), Sun et al. (2017), Sutawijaya and Nawangsari (2020). Development of modern technologies in logistics centers is intricate and complex decision-making process. Although numerous publications on the development of logistics in companies have been released so far, however, there is a lack of up-to-date information concerning the last two/three years, especially in the case of currently applied technologies for logistics centers (with the main focus on the domestic market). This statement is proved in the literature review section and specifies the subject area of research. The logistics centers face various challenges while developing technical and technological facilities. On the one hand, there is a number of benefits of new solutions implementation. On the other hand, logistics centers deal with threats that may disrupt the implementation of modern technologies. Moreover, technological development of these centers may differ, and areas of new solutions' implementation may vary depending on the geographical region and economic environment. Therefore, current operational state and needs of such logistics facilities should be determined, and the prospectively identified solutions should be analyzed in detail. Before any analyses were conducted in the companies, a literature review on the technologies currently used in logistics facilities was done. This review was relevant to some sort of research question on the compatibility of academic dissertations and real-world companies' operations (certainly, the literature review is limited to chosen, essential, up-to-date publications only).

One of the paper's aims is an investigation of the development stage of modern technologies used in logistics centers. Another aim is an identification of benefits and threats dealing with new and modern solutions implementation. The case study of logistics centers located in Poland was considered. Based on the developed questionnaire distributed among the representatives of Polish logistics centers some significant results were obtained. These results are described in this paper in detail. The article consists of literature review both on the technologies and questionnaires, methodological description, results' discussion and conclusion.

2. Literature review

Supply chains efficient operation is complex problem that should take into account material and financial resources, as well as economic, environmental, technological, structural and other types of factors, Jacyna-Gołda et al. (2018), Kush et al. (2018), Semenov and Filina-Dawidowicz (2017), Yang et al. (2019), Zimon et al. (2019). Logistics and distribution centers, as important nodes of these chains, regularly develop their facilities and apply technological solutions in order to adapt to the global or regional market needs, Li (2019), Liu (2020). According to Hou et al. (2010), the operation efficiency of a distribution center usually significantly affects the performance of business operation and effective storage management may significantly enhance this performance.

The issues connected to implementation of technological solutions associated to internal logistics and distribution centers are widely described in the available scientific literature, Saktaganova et al. (2018). Selected solutions are briefly mentioned below. Furuya et al. (2019) payed attention to the development of storage location recommendation technology which enable sequential formulation of recommendations for storage location of incoming pallet load units to be stored. Jiang et al. (2020) studied in-depth three up-to-date technologies, namely: sensor network, big data and logistics technology. Their consideration concerned entire warehousing and distribution logistics process and resulted in proposition of monitoring system framework combining sensor network and big data based on the wireless sensor network software and hardware platform. Zou et al. (2019) aimed in the improvement of order picking process efficiency and the reduction of logistics cost that rely on the optimization of order picking process in distribution centers. The mathematical model together with a two-stage heuristic algorithm had been suggested to solve the problems, including order batching, Automated Guided Vehicle (AGV) routing and zone scheduling. Sutawijaya and Nawangsari (2020) noticed that technological support, namely the internet of things (IoT) and service (IoS) fundamentally changed the outlook for different operations and processes for companies and consumers. Considering a similar theme, Zhang et al. (2020) planed and designed the IoT-based transfer center platform. The advantages of the IoT-related technologies applied to the logistics industry were analyzed as well. Sun et al. (2017) reviewed the basic concepts of dense storage technology, including involved mode, scheme and technical equipment. Liukkonen (2015) discussed the Radio Frequency IDentification (RFID) technology which continuously is implemented in manufacturing and current challenges faced by companies in its application. Nayak et al. (2015) noticed that RFID allows to minimize the potential problems of companies. Liu (2020) mentioned RFID-based warehouse management

that allows to gain benefits, such as higher average inbound and outbound speed of a warehouse, lower labor cost and smaller loss rate of freight during its distribution, etc.

Various decision-making models and algorithms were developed to improve logistics centers operation. A heuristic algorithm for storage re-allocation operation had been proposed by Hou et al. (2010). A multi-objective logistics network model for the return products specifically pertaining to the Indian e-commerce market was developed by Dutta et al. (2020). Authors applied the weighted goal programming technique by weighing different objectives in order to minimize cost, environment impact and maximize the social responsibility.

To sum up, different groups of technologies and systems may be implemented in logistics centers. These groups may include i.e.:

- freight identification systems, e.g., RFID (Saadi et al. 2016), European Article Number (EAN), Automatic Data Capture (ADC), etc.,
- warehouse technologies, e.g., AGV (CEIT 2018, Hercko and Botka 2017), Automated Storage and Retrieval Systems (AS/RS) (de Koster et al. 2007), innovative equipment (Blatnický et al. 2020), etc.,
- order picking technologies, e.g., pick-by-voice (Cragg and Loske 2019), pick-by-light (Stockinger et al. 2020), pick-by-frame (Kulińska et al. 2018, Luca 2020a), pick-by-point (Kulińska et al. 2018, Luca 2020b), pick-by-watch (Kulińska et al. 2018), pick-by-scan (Charu et al. 2018), pick-by-HoloLens (Lang et al. 2019), etc.,
- IT systems and data transmission systems, e.g., Electronic Data Interchange (EDI) (Narayanan et al. 2009, Sidora 2017), Warehouse Management System (WMS), Enterprise Resource Planning (ERP), Manufacturing Resource Planning (MRP), Computer-Supported Cooperative Work (CSCW; Fjeld et al. 2002 mentioned in Grube et al. 2019), etc.,
- Virtual Reality simulation systems (Elbert et al. 2019), etc.

The questionnaires' investigations of the development stage of modern, to the times, technologies used in logistics enterprises raise interests constantly, both from academic, administration and business viewpoints. Tachizawa and Gimenez (2010) shared their results of how different sourcing practices are combined to form particular supply flexibility strategies in Spain. Dachs et al. (2019) investigated relations between backshoring of production activities and digital manufacturing technologies in Austria, Germany and Switzerland. Weihua and Hongwei (2011) analyzed various aspects of technologies and innovations in foreign trade-based logistics entrepreneurs of China after the financial crisis. Zhang et al. (2014) identified factors of significant effect on the adoption of green logistics in truck fleets e.g., incoming to/outgoing from logistics centers in China. There are plenty of such studies and research, however the authors have observed that logistics centers in Poland should be analyzed more in accordance with up-to-date technologies development.

3. Methodology

The methodology used in order to investigate the research consists of the following steps: a) literature review and observations of logistics centers operation, b) development of the questionnaire and its distribution among certain logistics centers in Poland, c) analysis of the results and drawing the conclusions.

The developed questionnaire was distributed among the logistics centers located in Poland between November 2019 and February 2020. It was sent in electronic form to 20 logistics centers and as a result 11 responses were received. The questionnaire was filled by representatives characterized by the experience in management of logistics centers. Responses were received from the following voivodeships: Kuyavia-Pomerania (kujawsko-pomorskie), Lublin (lubelskie), Lubusz (lubuskie), Lesser Poland (małopolskie), Greater Poland (wielkopolskie), Pomerania (pomorskie), Silesia (śląskie), West Pomerania (zachodniopomorskie). Discussion of the obtained results is given in the next section. Likert scale were used in this research, Joshi et al. (2015). In the questionnaire the representatives were asked about:

- identification of the groups of technologies with modern solutions used in logistics centers that they represent, as well as the groups of technologies that are necessary to be improved,
- assessment of the importance level for use of modern warehouse technologies and, separately, assessment the level of technological development in logistics centers,

- indication of the benefits of implementing modern technologies in a warehouse,
- ranking the threats that can arise when using modern technologies.

4. Results

Respondents were asked to indicate the groups of technologies with modern solutions used in logistics centers that they represent, as well as the groups of technologies that are expected to be improved in their organizations (the results are presented in Fig. 1). Based on the obtained answers, it was possible to match several groups. The results revealed that different kinds of systems are implemented in certain logistics centers. The greatest part of surveyed logistics centers implements modern cargo identification systems. Almost the same interest is shared when order picking processes and technologies intended for these processes are taken into consideration. The attention was attracted to the fact that analyzed logistics centers had implemented up to date technologies aimed to improve technical and executive activities related to cargo handling and operations that influence time and costs of cargo service.

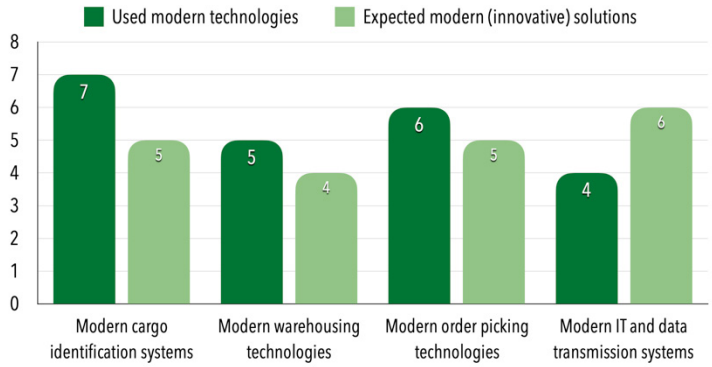

Fig. 1. The groups of modern technologies already used and demanded to be implemented in analyzed logistics centers (the height of columns is equal to number of responses).

Moreover, it should be noticed that representatives of these centers declared the necessity to modernize IT technologies and data transmission systems. It may be due to the fact that analyzed centers' managers noted the need to introduce digital solutions to streamline data flow and communication between employees working at different departments of a particular enterprise, as well as between center itself and other participants of the supply chains.

In case of another issue, the respondents were asked to assess the level of importance for usage of modern warehouse technologies in logistics centers. The four-point assessment scale was used, where note "4" means that a particular company's level of importance for usage of modern warehouse technologies in logistics centers is very high and usage of modern warehouse technologies is very important for the warehouse functioning, and note "1" means that it is irrelevant for the warehouse functioning. The results connected to levels of importance to use warehouse technologies are noted as dark green columns in Fig. 2.

It should be noted that warehouse equipment of analyzed logistics centers was quite varied. In case of certain facilities AGV and AS/RS solution have already been used, unlike the others. As one might have supposed, a significant part of respondents believe that it is very important to use modern technologies for warehouse operation.

The respondents also expressed their opinion on the level of technological development of their companies, where note "4" means that the level is assessed as very good and note "1" means that the level is assessed as very bad. The technological development of a particular respondent's company is noted as light green columns in Fig. 2. Most of respondents indicated that the level of their companies' technological development is assessed as good, which means there still are certain expectations for improvement.

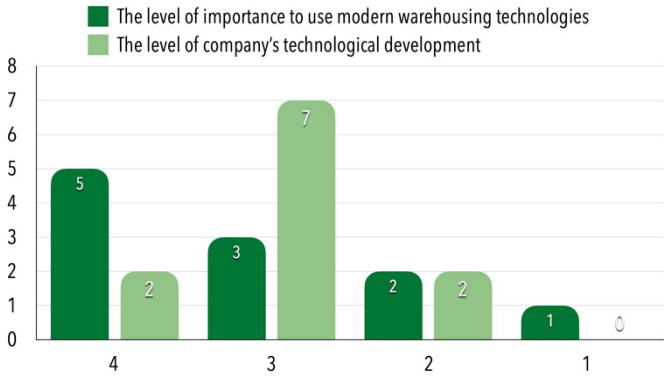

Fig. 2. The levels of importance to use warehouse technologies and the technological development of a particular respondent's company (number of responses).

The representatives of logistics centers were also questioned about the benefits of modern technologies implementation in a warehouse. The benefits indicated by them are presented in Fig. 3. It was possible to rate individual benefits on a five-point scale, where note "1" stands for the least important benefit and note "5" stands for very important. All the results presented in Fig. 3 are given after computing average values of each particular kind of benefits. It could be noticed that the most important benefits are the increasement of customers satisfaction and reduction in time of order processing, which was actually expected after several years of this paper's authors experience with domestic logistics market. The less attention was paid to the increasement of productivity and better use of storage space, although the spatial aspect of a logistics center's design affects operational activities undoubtedly. However, it could deal with the fact that existing solutions allow to ensure good productivity level and the space in warehouse is well organized.

Benefits of using modern technologies are one side of the coin. On the other hand, some concerns and worries can be observed among the analyzed group of entrepreneurs. These worries may cause cautious behavior of logistics centers managers during decision making on assessment a particular idea, selection of innovative solutions and a way of their implementation.

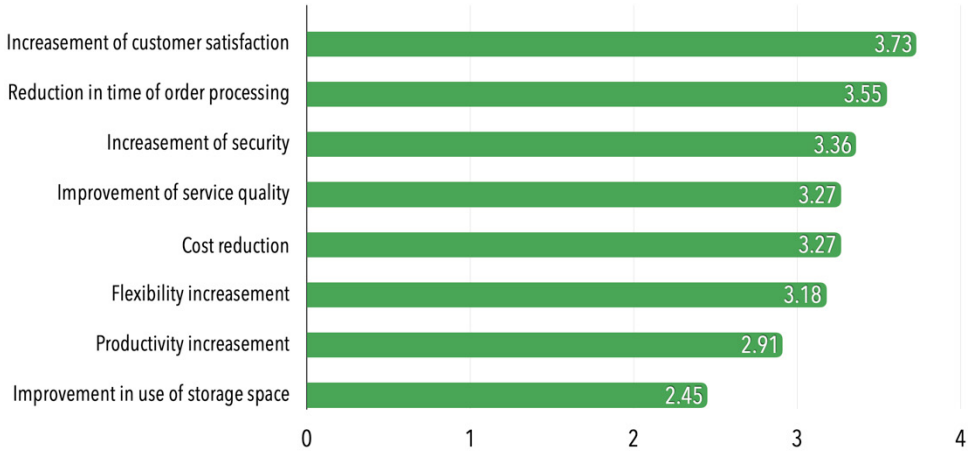

Fig. 3. The benefits of implementation of certain modern technologies in logistics centers (average value).

The respondents had an opportunity to rank the selected threats that can arise when using or planning usage of modern technologies. The particular options could be pointed on a scale from "1" to "5", where note "1" stands for

the least important issue and note "5" stands for very important ones. The threats and risks indicated by representatives of logistics centers are presented in Fig. 4. As in the case of benefits analyzing, also all the results presented in Fig. 4 are given after computing average values of each particular kind of threat. The respondents believe that long-lasting duration to implement a particular modern technology and connected with its capital freezing are the most inconvenient options that may occur during introduction of new technological solutions in logistics centers. Moreover, the failure of technology implementation seems to be one of the biggest concerns of logistics centers representatives as well. The respondents are equally concerned unreliability of technical systems and devices, and fast imitations in development of modern technologies by their competing entrepreneurs. The respondents consider the increasement in operation costs unlikely to threaten the investment in new technology development, however this concerns representatives least of all other threats.

At the end of this section, it is worth mentioning by names the ten biggest threats to internal and external logistics analyzed and discussed by Scottish Business Resilience Centre, Hurry (2019). These are grouped as the following keywords: geopolitics, compliance, cyber-attacks, infrastructure, capacity, reputational, unexpected incidents, theft, insider treats and terrorism. This paper is not intended to compare similar analyses, nevertheless it is worth recognizing the concerns and threats raised by entrepreneurs and researchers from other parts of the world.

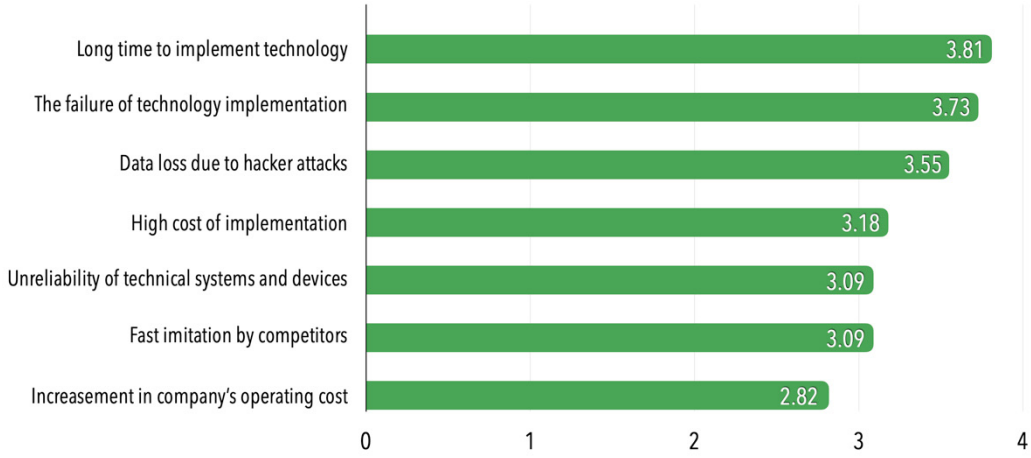

Fig. 4. The threats and risks that can arise when implementing and using modern technologies (average value).

5. Discussion and conclusions

Based on the presented research, it could be stated that logistics centers operating in Poland are well-equipped and developed, however representatives of this entrepreneurs observe the necessities to implement modern technologies and apply innovative solutions. Research results revealed the development stage of modern technologies used in analyzed logistics centers, as well as needs for new solutions implementation. The modern technologies implemented so far primarily aimed to improve cargo handling and operation, using cargo identification systems and order picking technologies. The current areas of future development are connected mainly with IT systems and data transfer systems implementation. The results show new look on stage of technological development of logistics centers in Poland.

Benefits and threats of modern technologies implementation were also investigated. The highly ranked benefit related to implementation of modern technologies was the increase of customers satisfaction. In turn, they believe that long-lasting duration of technologies to their implementation and the capital freezing were stated to be the most threatening factors of new and modern technologies application. This information may be of interest for transport and logistics companies, as well as decision-makers planning investments in new technologies development in Poland and other regions.

It should be noted that the achieved results may be influenced by limited, however, representative number of examined entrepreneurs, as well as specific environment of the analyzed region (Poland). Analyzed centers serve

different hinterland (local and international) and type of clients (individual or group) that may influence the needs for technologies development. Moreover, the results are achieved for specific economic conditions. Therefore, it is worth repeating the research enriched with opinions of logistics centers representatives in other conditions, e.g. after COVID-19 occurrence. Only the full knowledge of such kind allows to assess the compatibility of academic dissertations and real-world companies' operations. Nevertheless, it was possible to investigate the logistics centers representatives attitude related to the issue of modern technologies development, as well as to identify the current state and demands for new solutions.

Our future research will focus on more detailed investigation of modern technologies needed to be implemented in logistics centers located in Poland and abroad, as well as development of decision-making models allowing to take rational decisions related to implementation of modern and innovative technologies in logistics centers. Such an investigation is of urgent necessity, especially that the presented results should be treated as preliminary ones. Moreover, the future research may be proceeded in similar manner in several other countries in the region, as well as consider their geopolitical and economic environment.

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