Digital Twin as a Tool for Supporting Logistics Coordination in Distribution Networks

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***Abstract*— We all witness changes in supply chains and distribution networks influenced by technological development. One of the trends is Digital Twins and outgoing outsourcing of logistics processes. According to mentioned trends, the following article is aimed to elaborate on the Digital Twin in the wide understanding logistics coordination concept. The research focuses on examining the 4 chosen distribution networks in which logistics service providers collaborate with manufacturers in the area of e-commerce activities. The novelty of the following paper focuses on the Digital Twin implementation case studies in the area of logistics operator activity in distribution networks connected with e-commerce activities. The results from the different simulation models were shown and the perspective of implementation of the Digital Twin was clarified.**

***Keywords*—** *logistics service provider, 3PL, distribution network, Digital Twin, logistics coordination*

1. Introduction

Key drivers for changes in logistics are technology advancements through ongoing automation and digitalization [1]. Usually, the logistics service providers (LSP, which in the following article will be called also 3PL – Third-party logistics) were not associated with the innovations and usage of advanced technologies. However in 2005 the innovation in logistics was summarized in a few words: "logistics research largely ignored the concept of innovation"[2]. It means that the innovation area was a poor consideration area, but for now the trend changed and we can be witnesses of more and more research papers connected with logistics and innovation. Currently still there is not a lot of research papers in the logistics field of study connected with innovations. Some researchers examined the top nine logistics journals and make the conclusion that the only from 1,15% to 8,10% research papers in the years 2000-2013 were related to innovations [3]. Other researches show that about 32% of research papers connected with innovations are based on case studies [4]. The acceleration of the technological route in the form of digitization, internalization, virtualization, and automation has resulted in the recalibration of economies and societies during the last century [5]. The current trends in research are usually connected with e-commerce, e-tailing or fresh products distribution [6] or the solutions supported the multi-, cross- and omnichannel distribution [7]. Another prospective solution is Digital Twin [8], this solution is the main topic of the following research paper (figure 1).

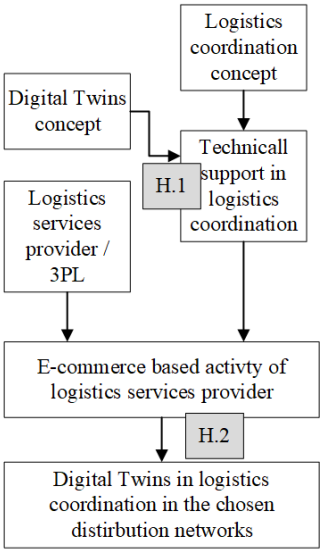

Figure 1. Concept of research paper

According to conception of the research two hypotheses were elaborated:
H.1: Digital Twin is the solution suitable for logistics coordination concept.
H.2: Digital Twin could support the activity of logistics service provider in e-commerce area
In the following article, the logistics service provider (LSP) will be treated as a equal company to third-party logistics (3-PL).

2. Literature review

2.1 Digital Twins in logistics

Digital innovations and digital technologies stimulate mobility in terms of access to information and its analysis [9]. Digitalization is a reflection of an object or analogy activity in binary form [10] and has been shown to be a powerful way to reduce the cross-border logistics friction [11]. Digital personel management is also state as a future solution for supporting logistics activities [12]. With the active use of digital technologies in the nodes of logistics networks starting 5–7 years ago, their implementation was carried out on the principle of replacing the people of operators on information flows [4] and one of the most trendy solution connected with digitalization is Digital Twin. Digital Twin usually includes: real space, virtual space and the spreading of data/information flow between real and virtual space [8]. Digital Twins could be supported by foresight support systems to predict the future information. Foresight support systems plays an important role in the modern supply chains [13]. The integration of various technologies is referred to as digitalization, a superordinate concept. Although technologies are a necessary pre-condition for digitalization, they do not have to be digital [14]. Digital Twin should consist of technological infrastructure and cyber environment [15] and is usually associated with logistics operator 4.0 [16], so the operator is able to provide services for the companies acting in Industry 4.0 reality. Digital Twins could be also treated as a technology and knowledge resource to achieve the competitive advantage in the activity of logistics service provider [17]. In the author opinion there is a need for considering the Digital Twin concept from the perspective of logistics coordination in the distribution networks.

2.2 Logistics coordination concept

Currently a lot of authors believe that coopetition actions, in which a logistics actions play a big role, is today considerate from the supply chain vs supply chain perspective than company vs company perspective [18], it means that the enterprises have a better chance to succeed by using a synergy effect and taking a holistic view on the whole supply chain or distribution network. Researches confirm among other the fact that lack of carrier coordination has a negative influence on the whole supply chain [19]. In the author opinion, the crucial issue in distribution network where the LSP occurs there is an issue connected with ability of such a entities to coordination. Logistic coordination, according to the author, can be defined as the coordination of activities related to the management of flows carried out by the logistics operator as part of the currently implemented activities, activities resulting from the possibility of demand management, the use of the necessary achievements of information technology as part of the use of the market, social and hierarchical network coordination mechanism (figure 2).

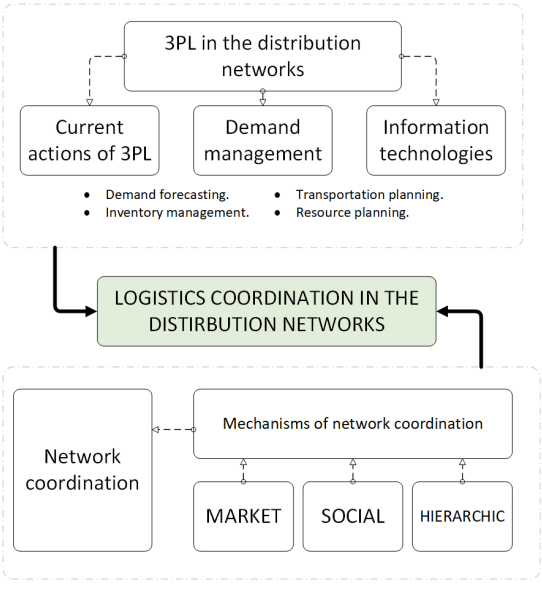

Figure 2. Logistics coordination concept
Source: [20]

The crucial elements of logistics coordination could be inventory management and transportation planning n the whole distribution network acting by 3PL [21] and LSP in logistics coordination is able to support manufacturers' demand plans [22]. A properly constructed information exchange system

and the willingness to exchange information between different enterprises is the basis of an efficiently functioning enterprise network. A properly created information exchange system is also recognized by some authors as one of the key elements of the coordination of entire supply chains [23]. Very often, even when basing mainly on human decisions when planning activities, these activities are supported by advanced decision support systems [24]. Information flows and the possibility of using them in an appropriate manner are inextricably linked with the necessity to implement solutions of digital and computer technologies. Digital technologies and computer technologies that support the flows in networks are extremely important. We can distinguish, for example, electronic exchanges, which allow you to easily coordinate some transport activities [19] and which are one of the simpler mechanisms of such coordination. So, the Digital Twin is the solution that seems to be suitable for logistics coordination conception which allows confirming the H.1 (Digital Twin is the solution suitable for logistics coordination concept).

3 Methods

For the analysis, there were chosen the 4 distribution networks were characterized by the following features:

- There is a 3PL company acting in the distribution network which provides logistics services as outsourcing to the manufacturer in the network.
- 3PL is also acting as the e-commerce value-added service in the distribution network.
- 3PL has its own warehouse, transportation, and IT infrastructure.
- 3PL has the features which are needed for taking the actions connected with centralized demand forecasting (according to [25]).
- 3PL data flow is based on cloud computing infrastructure.

Analysis construction is shown at figure 3. The forecasting tool is part of a centralized demand forecasting system which is treated as a new, prospective function for LSP or 3PL in distribution networks. According to the research, these kinds of entities, when they have some specific functions, are able to create demand forecasts and provide actions connected with demand management in distribution networks [25]. Chosen for analysis 3PL is the international outsourcing company which provides logistics and value-added services for the huge amount of manufacturers and handle with the different types of products both food and non-food. The logistics service provider is also able to create and implement the simulation models of their activity.

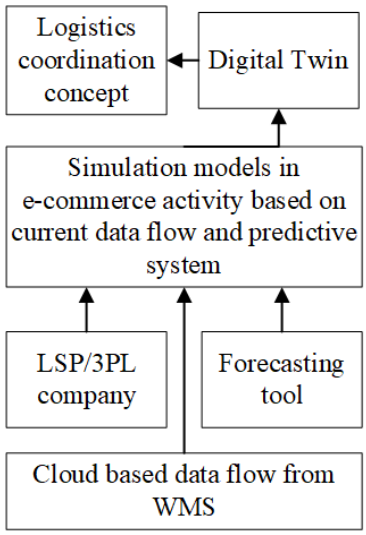

Figure 3. Analysis construction

These models could be very effective as support of managerial decisions. According to the research, mentioned forecasting tool could be used as a prediction system for resource planning in the area of warehouse management, where the processes of establishing the resources could be a computer model [26] and there is also an option for modelling the activity strictly connected with e-commerce packing line. In this second case, LSP is also able to create, implement and make conclusions from such a model [27]. Mentioned simulation models could be used as a based of Digital Twin. In the following research paper there will be checked the models elaborated and implemented by the author to the 4 chosen distribution networks. In the end the influence of simulation models to logistics coordination concept will be show.

4 Results and discussion

Models were elaborated as a BPMN 2.0 (Business Process Modelling and Notation 2.0) standard and implemented in this shape to the computer environment. This kind of model considers the parameters like activity time,

resource parameters, schedule of work, and automatic data flow. Simulation models are commonly used in some cases to analyze the supply chains [28]. The data flow is based on cloud-based WMS information which is automatically imported into the models. For each situation, there were established the main KPI (Key Performance Indicator). KPIs were created with the collaboration of top management which is involved in the modeled processes. Table 1 shows the brief assumption for the particular models.

Table 1. Brief characteristics of the models

DN	Modeled e-commerce activity description
1	B2B and B2C distribution packing line in the warehouse (for the orders from POS and customers) – household chemicals products.
2	B2C picking process and distribution (preparing for release to carrier company after picking) – non-food products.
3	B2C packing line in the warehouse (preparing orders for distribution) – non-food and food products.
4	B2C picking processes with resource planning and predicting the future orders level in non-food products.

KPIs which were chosen to assess the models are the time of processing one customer order, mistakes in releasing in percentage, and work overloading of human labor. The changes of the particular KPIs to the based value (before implementation of the simulation model) were shown in figure 4.

The KPI with the smallest positive percentage change (in the range from 0 to 20%) was the mistakes in releasing in percentage. The reason for that is to achieve better results in this case, in the author's opinion, are needed additional process analysis and process improvement, not just the simulation model. The improvement, obviously, could be based on simulation analysis, but it is a further step. The rest of KPIs have the following positive percentage change:

- Time of processing one customer order from 3% to 20%.
- Work overloading of human labor from 10% to 40%.

The last KPI, work overloading of human labor, could be optimized by the proper model which allows for resource consideration and gives tips for better resource planning to managers.

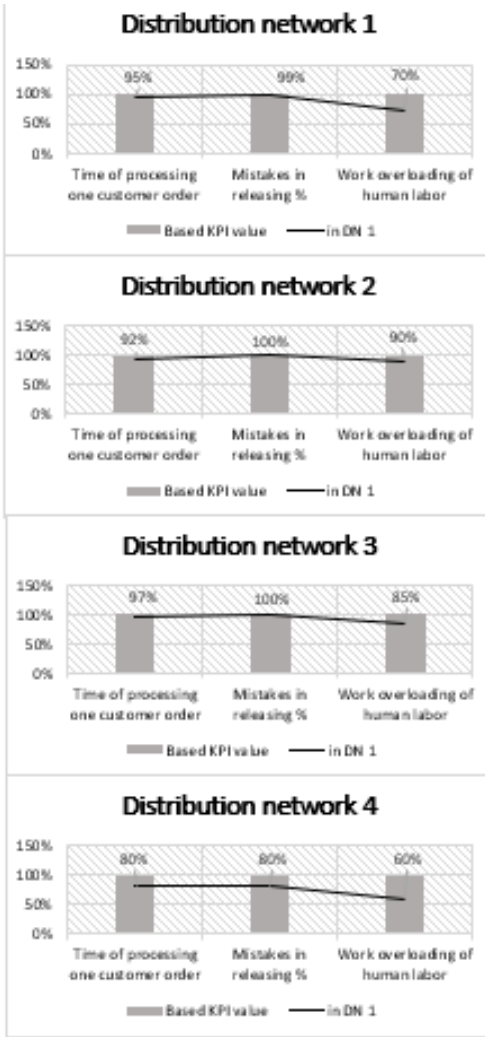

Figure 4. Changes of KPIs after implementation of simulation models

According to mentioned cases, the Digital Twin could support the activity of logistics service providers in the e-commerce area in the aspects of improving managerial decisions about resource planning and could also shorten the time of the process. The H.2 was confirmed.

The proposed solution could support the managerial decision by providing real-time information and warning about the future based on the simulation model. This kind of model could be also another VAS a logistics service provider could offer to their customers as an additional, outsourced service. It is one of the future ways to develop the research – to check the possible added value which could be generated for customers by 3PL company supported by Digital Twin.

Another direction of future research is to expand the solution of providing logistics services from distribution networks to the whole supply chain. It seems to provide good results is the area of Internet of Things technologies examinations in the condition of supply chains [29]. It could be a good direction to test the possible support of such technologies to Digital Twins in the activity of logistics operators.

5 Conclusions

The proposed methodology brings the possibility of adopting the simulation models with real-time data flow and building the basis for Digital Twin for logistics service providers. The research allows confirming the two hypotheses: H.1 (Digital Twin is the solution suitable for logistics coordination concept) and H.2 (Digital Twin could support the activity of logistics service provider in e-commerce area). The analyzed cases were connected with 4 distribution networks, but the future research could be expanded on the whole supply chain and analysis of value creation by Digital Twin usage. However, the paper shown the importance of digital technologies to current logistics operators actions and provides the knowledge about the profits from implementation of such a tools in the activity of outsourcing company. It is also well-known that activity of logistics outsourcing companies has a big impact on performance of whole supply chain [30], so proposed solution could improve the performance of other companies connected in the material flow.

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